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Joint Conference of

ICTACEM 2021, APCATS 2021, AJSAE 2021

and AeSI 2021

December 20 -22, 2021

TECHNICAL PROGRAM
AND
BOOK OF ABSTRACTS

CONFERENCE ORGANIZER AND HOST INSTITUTION

Aerospace Engineering Department, Indian Institute of Technology Kharagpur, India

CONFERENCE CO-SPONSORS AND OTHER SUPPORTING INSTITUTIONS

The Aeronautical Society of India (AeSI)

Asian-Pacific Conference on Aerospace Technology and Science (APCATS)

Asian Joint Symposium on Aerospace Engineering (AJSAE)

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FOREWORD

The department of Aerospace Engineering, Indian Institute of Technology, Kharagpur (IIT Kharagpur) is hosting International Conference on Theoretical, Applied, Computational and Experimental Mechanics (ICTACEM) every three years since 1998. It is indeed a great pleasure that the 8th edition of ICTACEM in 2021 is being held jointly with Asia Pacific Conference for Aerospace Technology and Science (APCATS), Asian Joint Symposium on Aerospace Engineering (AJSAE) and the annual symposium of Aeronautical Society of India, Kolkata Chapter and Aerospace Engineering Department, IIT Kharagpur is privileged to host the joint conference. ICTACEM was conceived to bring together the researchers in all disciplines of mechanics to exchange and share knowledge between people from different parts of the world. A special focus is always given to the recent advances in Aerospace science and technologies. The Joint Conference 2021 has taken extra care to highlight the latest aerospace researches and developments with an emphasis on the developments in the Asian countries. With more than a dozen plenary talks from renowned personalities and over 150 excellent contributory papers the ICTACEM-APCATS-AJSAE-AeSI joint conference 2021 will definitely be enriching and motivating to the participating academician and researchers and in particular to our young researchers. Let the three days of intense scientific discussion helps our participants to come closer and hone their scientific quest.

Prof. K.P. Sinhamahapatra

Organizing Chair

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- Prof. K. P. Sinhamahapatra, Conference Chair, Department of Aerospace Engineering, IIT Kharagpur, ictacem@aero.iitkgp.ac.in
- Prof. C. D. Kong, Conference Chair, International Visiting Professor, Department of Aerospace Engineering, IIT Kharagpur, cdgong@aero.iitkgp.ac.in
- Prof. B. N. Singh, Conference Vice-Chair, Department of Aerospace Engineering, IIT Kharagpur, ictacem@aero.iitkgp.ac.in
- Prof. Amar Nath Mallick, EC Member, AeSI, Kolkata Chapter & Professor, Department of Mechanical Engineering, NIT, Durgapur, amarnath.mullick@me.nitdgp.ac.in

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- Prof. Mahir Dursun, Gazi University, mdursun@gazi.edu.tr

TECHNICAL PROGRAM

		Venue SL1				Duration
		Inauguration Of Joint Conference -- ICTACEM 2021, APCATS 2021, AJSAE 2021 and AeSI 2021				
20 December	8:40	**Welcome Address By Chairman -- Prof. K. P. Sinhamahapatra**				0:05
	8:45	**Opening Address By Secretary -- Prof. R. Joarder, Prof. Anup Ghosh**				0:05
	8:50	**Address on behalf of APCATS & AJSAE -- Prof. C. D. Kong, Honorary Chair**				0:10
	9:00					0:05
	09:05	**Address by President AeSI -- Shri A.S. Kiran Kumar**				0:10
	9:15	**Address By Chief Guest, Director, IIT Kharagpur -- Prof. V. K. Tewari**				0:10
	9:25	**Address By Guest of Honour -- Prof. P. K. Dutta** **Vote Of Thanks by Vice Chairman of Conference -- Prof. B. N. Singh**				0:05
	09:30	**Plenary Session -1:** ***Fundamental features of perturbation/fluctuation growth in high-speed compressible shear flows*** **Prof. Sharath Girimaji, TAMU, USA** **Session Chair: Prof. Somnath Ghosh** **Ms. Swagatika Pradhan**				0:45
	Venue	SL1		SL3		
	10:15	**Plenary Session -2:** ***Spray-Swirl Interactions: Some Insights*** **Prof. Saptarshi Basu, IISc Bengaluru, India** **Session Chair: Prof. S. Karmakar** **Mr. Saugata Mandal**		**Plenary Session -3:** ***Thermal control system design and test for APSCO SSS-1 satellite*** **Prof.Shenyan Chen, Beihang University, Beijing, China** **Session Chair: Prof. S. Bhattacharyya** **Mr. Narendra Kumar**		0:45
	Venue	SL1	SL2	SL3	SL4	
		Session Chair: Prof. Somnath Ghosh **Ms. Swagatika Pradhan**	**Session Chair: Prof. P. Jana** **Mr. Raj Kumar**	**Session Chair: Prof. S. Karmakar** **Mr. Saugata Mandal**	**Session Chair: Prof. S. Bhattacharyya** **Ms. Reshma G**	
	11:00	Scaling law for core length in supersonic free jets	Dynamic Modelling of a Porous Functionally Graded Rotor-bearing System for Different Temperature Distributions	Design and Numerical Study of Variable Geometry Scramjet Inlet for Mach 5 to Mach 7	APSCO SSS-1 Communication System Design and Implementation	0:15
		Arun Kumar Perumal and Ethirajan Rathakrishnan	Aneesh Batchu, Bharath Obalareddy and Prabhakar Sathujoda	Shivashree S	Hao Tian, Jikai Wang and Hai Huang	
	11:15	Parametric study of bio-inspired corrugated airfoil geometry in a forward flight at Reynolds number 80000	Free Vibration Analysis of a Rotor-bearing System having Corrosion Defect	Unsteady Simulation of Frontal Cavity in Supersonic Flows	Development of a Flight Simulator for Low-End Computers	0:15
		Yagya Dutta Dwivedi, N Lakshmi Narasimhan, Jayendra Rajanala and Kameswara Sridhar Vepa	Bharath Obalareddy, Aneesh Batchu and Prabhakar Sathujoda	Jayraj Deshmukh, Dinesh Bajaj, Devabrata Sahoo and Ashish Vashishtha	Amish Jindal, Manini Mittal, Gandharv Jaggi and Abha Gupta	
	11:30	**Break**				0:15
		Session Chair: Prof. Arnab Roy **Mr. Pranay Kumar**	**Session Chair: Prof. M. R. Sunny** **Mr. Raj Kumar**	**Session Chair: Prof. Amardip Ghosh** **Mr. Saisantosh Iyer**	**Session Chair: Prof. S. Bhattacharyya** **Ms. Reshma G**	
	11:45	AERODYNAMIC STUDY ON AIRFOIL WITH U-SHAPE TUBERCLE GEOMETRY	A numerical study of integrity of Z-pinned laminates	Study of effect of rotational rate of a cylinder on the volume fraction of vapor formed during nucleate boiling phenomenon of water	Design and Analysis of Active Phased Array Antenna for 80 kg-Class Micro-Satellite SAR	0:15
		B Sudarshan, V Viswanath, S Mukund, J V Sujan and S Suhas	Arun Kumar, Sourabh Borchate and C.S. Upadhyay	Manjunath S V, Maharana Sarat	Chan Mi Song, Seung Joo Jo,	

				Kumar and Abdul Sharief	Chang Hyun Lee, Myeong Jae Lee, Seung Hun Lee, Sung Chan Song and Hyun-Ung Oh	
	12:00	An Improved Unsteady CFD analysis of combined pitching and plunging airfoil using OpenFoam	Assessing post impact mechanical characteristics of glass fiber laminates by using beam coupons: A simplistic approach	LES of a Swirl-Stabilized Turbulent Kerosene Spray Flame in a Model Combustor	Robust Navigation with NavIC Software Receiver using Vector Delay Lock Loops	0:15
		P Srinivasa Murthy	Manoj K. Singh and R. Kitey	Kaidi Wan, Yunzhe Huang, Zhenxun Gao, Yong He and Chongwen Jiang	Ravindar Reddy Dadapur, Chittimalla Srinu and Laxminarayana Parayitam	
	12:15	Numerical Simulation of flow over blunt body with Passive Control Technique	Performance Analysis of Circular and Lemon Bore Hydrodynamic Journal Bearing Considering Surface Roughness and Shear Thinning Effect	Experimental and Numerical Simulation for Residence Time Distribution of Deactivation Tank	Linearized control of an axisymmetric spinning top to a regular precession trajectory	0:15
		M V Nitya, Vineeta Bhat, Sai Swaroop and Snehal U M	Kuldeep Narwat, Vivek Kumar, Simran Jeet Singh, Abhishek Kumar and Satish C Sharma	Prince Kumar Jain, Samiran Sengupta, Vimal Kotak, Kajal Dhole, Nilesh Gohel and Sujay Bhattacharya	Anirudh Chandramouli and Abhijit Sarkar	
	12:30	Near - Wake Flow Structures of a Rectangular Wing at the Onset of Stall	Performance analysis of rough surface multi-recess porous hydro-static thrust bearing	Theoretical & experimental study on a miniature jet pump with low area ratio	Satellite topology and continuous size optimization based on Two-level multi-point approximation method	0:15
		Aritras Roy and Rinku Mukherjee	Pushpendra K Kushwaha, Vivek Kumar, Vinay Vakharia and Satish C. Sharma	Vimal Kotak, Samiran Sengupta, Anil Pathrose, Sugilal Gopalkrishnan and Sujay Bhattacharya	Shuanjun Liu, Hai Huang, Shenyan Chen and Jiayi Fu	
	12:45	Flow modifications & capacity augmentation due to streamwise deployment of longitudinal vortex generators in a finned tube bank	Al/epoxy adhesion strength by a modified butt joint test configuration	Numerical Performance Studies of a Small Scale Horizontal Axis Wind Turbine Blade with Humpback Whale Tubercles	Connectivity Preserving Multi-Spacecraft Formation Control for Trajectory Tracking with Obstacle Avoidance	0:15
		Amit Arora	Madhusudhanan U and Rajesh Kitey	Supreeth R, S K Maharana and Bhaskar K	Zhongyuan Chen, Shitao Wang and Wanchun Chen	
	13:00	**LUNCH BREAK**				1:00
	Venue	SL1				
	14:00	**Plenary Session -4: *Recent Status and Development of Korea Military Airworthiness System*** **Prof. Changduk Kong, Chosun University, South Korea** **Session Chair: Prof. B. N. Singh** **Mr. Pabitra Maji**				0:45
	Venue	SL1		SL3		
	14:45	**Plenary Session -5 : *Avionics Architecture Solutions and Analysis for Helicopters*** **Prof. Mahir Dursun, Gazi Universit, Turkey** **Session Chair: Prof. D. K. Maiti** **Mr. Umakant Meher**		**Plenary Session -6: *Shock-turbulence interaction: analysis and modelling for aerospace application*** **Prof. Krishnendu Sinha, IIT Bombay, India** **Session Chair: Prof. Somnath Ghosh** **Mr. Agneev Roy**		0:45
	Venue	SL1	SL2	SL3	SL4	
		Session Chair: Prof. Somnath Ghosh **Mr. Agneev Roy**	**Session Chair: Prof. B. N. Singh** **Mr. Umakant Meher**	**Session Chair: Prof. C. S. Mistry** **Mr. Ajey Singh**	**Session Chair: Prof. N. K. Peyada** **Mr. Harinarayana**	

	15:30	Shock wave effects on Chitosan bio-polymer for drug delivery applications	Comparative study of dampers on a G+26 storey building subjected to lateral loading	Research on Thrust Measurement System Design and Intelligent Thrust Prediction Method Applied to Micro-electric Propulsion	Optimization Design of Modified Stewart Platforms for Isotropic Force Output	0:15
		Pranav H A and B Sudarshan	Ritik Saxena, Divyansh Tewari, Akshit Gupta and Dr M Abdul Akbar	Haibo Wang, Guobiao Cai, Chencong Fu, Wei Liu and Weizong Wang	Zijian Liu, Weipeng Li, Hai Huang and Bin Ren	
	15:45	Effect of oblique shocks interaction on the inlet structure in a hypersonic flow	Effect of graphene nanoplatelets on the thermomechanical behaviour of smart polymer nanocomposites	PIC/MCC Simulation of Axial Ring-Cusp Hybrid Discharge in the Micro Ion Thruster Ionization Chamber	Performance Analysis of Autonomous Flight Models Based on Reinforcement Learning for Military UAV	0:15
		Sanjay A V and B Sudarshan	Nilesh Tiwari and A. A. Shaikh	Wei Liu, Weizong Wang, Guobiao Cai, Shuwen Xue, Yifei Li, Haibo Wang and Guangqing Xia	Hyoju Nam, Haejin Kwon, Keunho Yun, Jia Kim and Kyutae Cho	
	16:00	**Break**				0:15
		Session Chair: Prof. Arnab Roy Mr. Ramakrishnan	**Session Chair: Prof. D. K. Maiti Mr. Umakant Meher**	**Session Chair: Prof. C. S. Mistry Mr. Ajey Singh**	**Session Chair: Prof. N. K. Peyada Mr. Harinarayana**	
	16:15	Experimental study on two octave Indian flute acoustics	Effects of internal length scale parameter on damage initiation and evolution using gradient enhanced damage mechanics theory	Three-dimensional PIC-MCC Analysis of Ion Thruster Grid Misalignment	Agile Turn Guidance Law based on Deep Reinforcement Learning	0:15
		Praful K and Sudarshan B	Aditya Deshpande and Bhrigu Nath Singh	Yifei Li, Weizong Wang, Guobiao Cai, Chencong Fu, Wei Liu and Guangqing Xia	Xiaopeng Gong, Yizhong Fang, Wanchun Chen and Zhongyuan Chen	
	16:30	Performance assessment of five probe flow analyser suitable for wind tunnel calibration	Robust flutter analysis of a sweptback wing using μ method	Numerical investigation of discharge mechanism and plasma behavior in an external discharge plasma thruster	Capture Region of Realistic True Proportional Navigation Based on Closed-form Solutions	0:15
		Akhila Rupesh	A Arun Kumar and Amit Kumar Onkar	Shuwen Xue, Yuanyuan Gao, Wei Liu, Yifei Li, Guobiao Cai and Weizong Wang	Xiangxiang Li, Wanchun Chen, Zhongyuan Chen and Yizhong Fang	
	16:45	A Numerical Study on the Negative Lift and Point of Non-linearity in Lift Curve of NACA 0012 Airfoil at Low Reynolds Number	Numerical Study of Tilted Multi-Storied RCC Buildings on Shallow Foundations Considering Soil-Structure Interaction	Aerothermal Predictions of High-Pressure Turbine Flows Using RANS Methods	Understanding the Strapon Separation Dynamics in atmospheric phase	0:15
		Gangadhar Venkata Ramana Pinapatruni, Sunil Manohar Dash, Jit Sinha and Kalyan Prasad Sinhamahapatra	Devjit Acharjee, Srijani Bandyopadhyay and Debasish Bandyopadhyay	Pranjal Anand and Rajesh Ranjan	Ayush Raikwar, Vidya Gurumurthy and Devendra Ghate	
	17:00	Experimental Prediction of Wind Flow and Pressure Distributions Around a Low-Rise Building	A homogenized crystal plasticity model for lamellar transformed β colony of titanium alloys	RANS modeling for short and long separation bubbles in flow past low-pressure turbine cascades	Study of Stability Parameters for Multi-Rotor Aircraft using CFD Analysis and Validation with Theoretical Calculations	0:15
		Venugopal Mm, S K Maharana and Mahantayya K Hiremath	S. Mustafa Kazim, Kartik Prasad and Pritam Chakraborty	Shruti Rajpara and Rajesh Ranjan	Manoj S Naik, Sumedha Y D, Anish G P Nand, Yeshas M N	

					Bharadwaj and Promio Charles F	
	17:15	Three dimensional computational investigation of the geometric design of delta-type vortex generators deployed in finned tube arrays	Transient Low Velocity Impact Response of Functionally-Graded Rectangular Plates – A Finite Element Approach.	Mode Transition in Strut Based Parallel Fuel Injection in Scramjet Engine	A Review of Predictive Control for Autonomous Flight Systems	0:15
		Amit Arora	Ritwik Mandal, Tanmoy Bandyopadhyay and Amit Karmakar	Rajesh Kumar, Pruthvi Narne and Amardip Ghosh	Mahir Dursun	
	17:30					
21 December	Venue	SL1				
	09:00	**Plenary Session -7:** ***Numerical investigation of shock-turbulence interaction and shock-associated noise for supersonic jets*** **Prof. Zhenxun Gao, Beihang University, Beijing, China** **Session Chair: Prof. K. P. Sinhamahapatra** **Ms. Gargi Das**				0:45
	Venue	SL1		SL3		
	9:45	**Plenary Session -8:** ***New opportunities and challenges for future UAVs*** **Prof. Raktim Battacharya, TAMU, USA** **Session Chair: Prof. S. Saha** **Mr. Hitesh Sharma**		**Plenary Session -9:** ***Computational Determination of Detonation Characteristics of Condensed Explosives*** **Prof. A. Kushari, IIT Kanpur, India** **Session Chair: Prof. R. Joarder** **Mr. Shva Prasad**		0:45
	Venue	SL1	SL2	SL3	SL4	
		Session Chair: Prof. K. P. Sinhamahapatra **Ms. Gargi Das**	**Session Chair: Prof. M. R. Sunny** **Mr. Iqbal Ahmed**	**Session Chair: Prof. R. Joarder** **Mr. Shva Prasad**	**Session Chair: Prof. Anup Ghosh** **Mr. Raj Kumar**	
	10:30	Experimental study of inflight icing conditions on coefficient of pressure distribution around NACA0012 aerofoil	Quadratic Wachspress Shape Functions for Polygonal Finite Element Method	Mixing characteristics of circular and elliptical twin jets	An aircraft wing structural layout and cross-sectional size optimization design	0:15
		Ms. Swetha S, Dr. Sarat Kumar Maharana, Dr. Abdul Sharief and Ms. Steffi Thangachan	Shalvi Singh and Pritam Chakraborty	Ch Narendra Kumar and K P Sinhamahapatra	Hai Huang and Jiayi Fu	
	10:45	An Improved Homotopy Perturbation Method to Study Damped Oscillators.	Effect of carbon black content on quasi-static compression behaviour of filled rubber	A study on Applicability in Super Cavitation with SLBM	Analysis and control of Aeroelastic performance of delaminated composite plate using AFC	0:15
		C F Sagar Zephania and Tapas Sil	Spandan Bandyopadhyaya, Rajesh Kitey and C.S. Upadhyay	Kyungwon Oh and Changduk Kong	Jayant Prakash Varun and Prashanta K. Mahato	
	11:00	Influence of tab blockage on asymmetric under- expanded sonic free jet	Induction Heating of Thermoplastic using Fe3O4	AEROACOUSTIC STUDY ON HVLS FAN BLADE WITH SERRATIONS	Finite element analysis of biaxial cuboid voided slab under one way bending load	0:15
		Lavala Srinivasa Rao, Partha Mondal and Sudip Das	Inseok Baek and Seoksoon Lee	Shashank H K, Rohith J and B Sudarshan	N Nareshnayak and B N Rao	
	11:15	**Break**				0:15
		Session Chair: Prof. Arnab Roy **Mr. Narendra Kumar**	**Session Chair: Prof. M. R. Sunny** **Mr. Aditya Deshpande**	**Session Chair: Prof. Akshay Praksh** **Mr.Pranay Kumar**	**Session Chair: Prof. Anup Ghosh** **Mr. Raj Kumar**	
	11:30	Aerodynamics Analysis of Fighter Aircraft in Formation Flight	Drop Test of an Aircraft Landing Gear Equipped with MR Damper	Design of Propulsion System for Propeller-less UAV	Study on Multiscale Modelling Method for Investigation on Damage of Wind Turbine Composite Blade	0:15
		Jaemuk Kim and Cheolheui Han	Banghyun Jo, Jaihyuk Hwang and Daesung Jang	Rohith J, Shashank H K, Akshay S Prasad,	Haseung Lee, Younggyu Lee,	

				Dheeraj R and B Sudarshan	Changduk Kong and Hyunbum Park	
	11:45	Transverse-only VIV of a freely vibrating hybrid cylinder at low Reynolds number	Unsteady Aerodynamic Force Approximation for Flutter Prediction	DESIGN AND PERFORMANCE ANALYSIS OF AXIAL FLOW WIND TURBINE FOR HOUSEHOLD APPLICATIONS	Flutter Investigation of MW Sized Hybrid Composite Wind Turbine Blade	0:15
		Himalaya Sarkar, Pavan Kumar Yadav and Subhankar Sen	Promio Charles F and Vedavathi G A	Dr. Venkatesu Sadu, Dr. Pol Redy Kukutla, Dr. Syamsundar C and Dr. Sivaiah P	Praveen Shakya and Umakanta Meher	
	12:00	Aerodynamic Characterisation of a Re-entry Module in Supersonic Flow Regime	Parametric perturbation studies on the behaviour of bistable unsymmetrical laminates	ICETACM2021-EXPERIMENTAL STUDY OF FLOW BEHAVIOURS OF FLY ASH SLURRY WITH AND WITHOUT CHEMICAL ADDITIVES	Wake Dynamics of a Flexible Flapping Filament at Low Reynolds Number	0:15
		Devashish Bhalla, Vidya Gurumurthy and Manoj T. Nair	K. S. Suraj, P. M. Anilkumar, C. G. Krishnanunni and B. N. Rao	Priyanka Nimar, Kanwarpal Singh and Arvind Kumar	Chhote Lal Shah, Dipanjan Majumdar, Chandan Bose and Sunetra Sarkar	
	12:15	Insight into the mechanism of drag reduction for a spiked blunt body	Finite element modelling and Monte Carlo ray tracing for the solar parabolic trough collector with torque box	Mechanical and microstructural characterization of Incoloy 901 repair by DED for aerospace gas turbine engine parts	New Response Branch for Undamped 2-DOF VIV of a Diamond Oscillator	0:15
		Md Gulam Sarwar, Priyank Kumar and Sudip Das	Natraj H, B. Nageswara Rao and K. Srinivas Reddy	Jongkee Ahn, Dongyeop Lee, Bohee Kim, Chiwon Kim, Hyun-Uk Hong and Je-Hyun Lee	Kumar Sourav and Deepak Kumar	
	12:30	Turbulence model and grid Sensitivity analyses of T-shape tall building using Computational Fluid Dynamics technique	Prediction of Mechanical Properties for 3-D woven composite considering realistic features	Numerical Study on Transient Transverse Jet Effect of the Two-Dimensional Slot Under Supersonic Conditions	FOV-constrained 3D impact angle and impact time control guidance	0:15
		Ajay Pratap and Neelam Rani	Hiyeop Kim, Pyunghwa Kim, Yongun Jun and Jungsun Park	Song Xue, Tianyixing Han and Chongwen Jiang	Peng Wang, Wanchun Chen and Zhongyuan Chen	
	12:45	Numerical study of a square plan shape building with corner modification	Vibroacoustic analysis of simply supported and clamped functionally graded sandwich plates under transient loading	The Spray Characteristics Of Pintle Injector Using Homogeneous Mixture Model And Eulerian To Lagrangian Transformation	Experimental Verification of Stiffness behavior of Multilayer Metal bellows	0:15
		Geetam Saha, Dibya Jyoti Basu, Aritro Roy Mitra and Dipesh Majumdar	Avnish Pandey and K V Nagendra Gopal	Jeongseok Kang, Younglin Yoo, Hong-Gye Sung, Minchan Kwon and Junyoung Heo	Istiyak Khan, Nilesh Gohel, Samiran Sengupta and Sujay Bhattacharya	
	13:00	**LUNCH BREAK**				1:00
	Venue	SL1				
	14:00	**Plenary Session -10:** ***Compressive Failure Behaviors of Composites and Composite Sandwich Structures*** **Prof. Jia-Lin Tsai, National Yang Ming Chiao Tung University, Hsinchu, Taiwan** **Session Chair: Prof. P. Jana** **Mr. Nikhil Kumar**				0:45

	Venue	SL1		SL3		
	14:45	**Plenary Session -11:** ***Development Policy of Korea's Space Science & Technology*** **Dr. Chin-Young Hwang, KARI, South Korea Session Chair: Prof. Amardip Ghosh Mr. Saisantosh Iyer**		**Plenary Session -12:** ***Accurate measurement of laminar burning velocity of premixed fuel-air mixtures*** **Prof. Sudarshan Kumar, IIT Bombay, India Session Chair: Prof. R. Joarder Dr. Syam S**		0:45
	Venue	SL1	SL2	SL3	SL4	
		Session Chair: Prof. S. M. Dash Mr. Prabir Sikdar	**Session Chair: Prof. P. Jana Mr. Nikhil Kumar**	**Session Chair: Prof. R. Joarder Dr. Syam S**	**Session Chair: Prof. Anup Ghosh Mr. Kamal Kishor Prajapati**	
	15:30	A detailed analysis of improved mathematical models of secondary velocities along perpendicular and transverse directions for steady uniform turbulent flow	Structure analysis and optimization of SSS-1 microsatellite	Numerical Investigation of Cavity Flow Field in Presence of Store	Electro-mechanical Impedance response of delaminated glass-fibre composite beam	0:15
		Titas Chattopadhyay	Yipeng Zhang, Hai Huang and Shenyan Chen	Bhaskar K, Rakesh Kumar, Punit N. Gwalani, Anagha Mandayam Bhulokam, Gargi S. Pantoji and Aishvarya D. Joshi	Umakanta Meher, Praveen Shakya and Mohammed Rabius Sunny	
	15:45	Simulating the impact of ground vortex ingestion on inlet performance	Effect of Hygrothermal Environment on Dynamic Behavior of Folded Laminated Composite Plate	Numerical Analysis of Weapon Bay Cavities of Different Configurations	Numerical Study of the Effect of Shear Connectors in Insulated Sandwich Panel Building System	0:15
		Dr. Rajesh Kumar and Pramodkumar Vanam	Babu Ranjan Thakur, Surendra Verma, Bhrigu Nath Singh and Dipak Kumar Maiti	Bhaskar K., Rakesh Kumar, Arjun R. Prasad, Akshay M. M., Rahul Ithal H. L. and Siddalingana Gowda M. P.	Devjit Acharjee, Dibya Jyoti Basu and Debasish Bandyopadhyay	
	16:00	**Break**				0:15
		Session Chair: Prof. S. M. Dash Mr. Prabir Sikdar	**Session Chair: Prof. D. K. Maiti Mr. Aditya Deshpande**	**Session Chair: Prof. Amardip Ghosh Dr. Syam S**	**Session Chair: Prof. B. N. Singh Mr. Smruti Ranjan Sahoo**	
	16:15	NUMERICAL STUDY OF MULTIPLE-IMPINGEMENT JET ARRAYS ON ISO-THERMAL HORIZONTAL FLAT PLATE	Failure Mechanisms of SMA Reinforced Composites under Impact Loading	LES of shock-turbulence interaction in a Bell-shaped Convergent Divergent Nozzle.	Based on Natural Frequencies, Crack Analysis of Fixed Support Fibre Glass Composite Beam	0:15
		Dr. Pol Reddy Kukutla, Dr. Venkatesu Sadu, Dr. Syamsundar C, Dr. Maruthi Prasad Yadav G and Dr.Sekhar Babu P	Vagish Mishra, Ashish Mishra, Luv Verma and Anindya Roy	Agneev Roy and Somnath Ghosh	Vaibhav Suryawanshi, Shailesh Palekar, Prasad Patare, Prasad Bojage and Atul Joshi	
	16:30	LES of compressible round jet impinging on a flat isothermal plate	A comparative study of recent phase-field implementations for fracture prediction in solids	The Effect of Mole Weight Ratio of Reaction on the Propagation of Cellular Detonations	Probabilistic Mixed Mode Stress Intensity Factors of Single Edge Cracked Laminated Composite Plates Using Stochastic Extended Finite Element Method	0:15
		Swagatika Pradhan and Somnath Ghosh	Sidharth Pc and B.N Rao	Chun Wang	Shailesh Palekar, Achchhe Lal, Prasad Patare, Atul Joshi and Prasad Bojage	

	16:45	Experimental Investigation of Flow characteristics for Natural Circulation Valve	Third-Order Shear Deformation Theory for the Low-Velocity Impact Response of 3D Braided Composite Plates	Heat Treatment of AISI 1045 Specimens using High-Frequency and Simulation	Dynamic response control of adjacent structures connected by viscous damper using inerter-based isolation systems	0:15
		Nikhil Pandey, Samiran Sengupta, Vijay K. Veluri, Manoj Tilara and Sujay Bhattacharya	Pabitra Maji and Bhrigu Nath Singh	Jinkyu Choi and Seoksoon Lee	Sudip Chowdhury	
	17:00	Modelling and analysis of winglet morphing for aerial vehicles	Measuring deformation in lightweight structures with revamped DIC system: wind tunnel study	Numerical Analyses on Free-Play Nonlinear Aeroelasticity	Modeling damage evolution of laminated composites under high strain rate loading	0:15
		Nandni Sharma, Gaurav Chhabra and Abha Gupta	Vivek Khare and Sudhir Kamle	Guowei Yang, Chengde Huang and Guangnan Zheng	Bipin Kumar Chaurasia and Deepak Kumar	
	17:15	Study of evolving regular water-waves under steady wind forcing	Low-Velocity Oblique Impact Response of Pre-twisted Sandwich Conical Shell with CNTRC Facings		Effects of Column Orientation on Building Structure-Verified Through Pushover Analysis	0:15
		Santosh Kumar Singh	Tripuresh Deb Singha, Tanmoy Bandyopadhyay and Amit Karmakar		Suchintya Halder and Abhishek Hazra	
	17:30					
22 December	Venue	SL1				
	09:00	**Plenary Session -13: Prof. *Estimation of Aerodynamic Derivatives from Flight Data*** **A. K. Ghosh, IIT Kanpur, india** **Session Chair: Pro. N. K. Peyada** **Mr. Saumitra Barman**				0:45
	Venue	SL1				
	9:45	**Plenary Session 14: Dr. K. S. Parikh, ISRO SAC, Ahmedabad, India** **Session Chair: Prof. S. Bhattacharyya** **Ms. Reshma G**				0:45
	Venue	SL1	SL2	SL3	SL4	
		Session Chair: Prof. S. Saha **Mr. Hitesh Sharma**	**Session Chair: Prof. M. R. Sunny** **Mr. Iqbal Ahmed**	**Session Chair: Prof. K. P. sinhamahpatra** **Mr. Narendra Kumar**	**Session Chair: Prof. B. N. Singh** **Mr. Smruti Ranjan Sahoo**	
	10:30	A modified sharp interface immersed boundary method	Applicability of duffing oscillator on the dynamic analysis of bistable variable stiffness laminates	Comparison of Full-field Solution between Virtual and Experimental Digital Image Correlation for Model Verification.	Porous Scaffold by Additive Manufacturing for Bone Replacement in Biomedical Application	0:15
		Bo Yin, Guowei Yang and Zhanzhou Hao	K. S. Akhil, P. M. Anilkumar and B. N. Rao	Vipin Chandra and Pritam Chakraborty	Apurba Das, Arghya Mondal, Palash Mondal, Masud Rana, Amit Roy Chowdhury and Amit Karmakar	
	10:45	Effects of jet flow on wake of high-speed train	Numerical Analysis of Structural Design Result for UAV applied to Composite Structure considering on Self-Healing Method	Experimental Investigation of Siphon breaker for Small Pipe breaks	A Study on Vibration Characteristics of Cantilever Conical Shell Made of FG Sandwich Material with Porosity and Thermal Effect	0:15
		Guo Dilong, Liu Wen and Yang Guowei	Hyunbum Park and Yonggyu Lee	Samiran Sengupta, Vijay K. Veluri and Sujay Bhattacharya	Apurba Das, Subhendu Pal,	

					Korak Sarkar and Amit Karmakar	
	11:00	A robust fifth-order WENO-Z type scheme with improved accuracy at second-order critical point	Effects of vertical inclinations of square prism on the performance of piezoelectric energy harvester: An experimental study	Design and analysis of thermal control system for SSS-1 satellite	Application of finite element direct integration method in flutter analysis	0:15
		Yiqing Shen, Shiyao Li and Ke Zhang	Rakesha Chandra Dash, Dipak Kumar Maiti and Bhrigu Nath Singh	Shenyan Chen, Xingwang Yan and Shuchong Wang	Jie Huang, Guannan Zheng, Guowei Yang, Chengde Huang and Yingjie Yu	
	11:15	**Break**			First-ply failure load prediction of pre-twisted delaminated composite conical shells	0:15
		Session Chair: Prof. Akshay Praksh Mr. Sambhu Kumar	**Session Chair: Prof. P. Jana Mr. Kamal Kishor Prajapati**	**Session Chair: Prof. S. Saha Ms. Swagatika Pradhan**	Suman Karmakar, Tripuresh Deb Singha, Tanmoy Bandyopadhyay and Amit Karmakar	
	11:30	Study of influence of vortices on trailing airfoil	Stochastic finite element modelling of the graded cellular arches	A quasi-longitudinal study of the effect of hemodynamical parameters on the biomechanics of rupture in Abdominal Aortic Aneurysms		0:15
		Bhaskar K, Mithil K, Pushkar Chaudhary, Sacheet S Amblekar and Sachin Maruti Shet	Mohammad Amir, Mohammad Talha, Sang-Woo Kim and Changduk Kong	Samarth S Bhatt, Amritanshu Dixit, Ahmad Shaikh, Tejas Canchi and Rangavittal Hk		
	11:45	Numerical analyses of re-entry module - Apex cover separation aerodynamics at low subsonic Mach number for various angles of attack	Design and development of a piezoelectric XY micro-displacement scanning stage	Equilibration of Van der Waals liquid drop with vapour in smoothed particle hydrodynamics		0:15
		B Venkatshivaram Jadav, Babu C and Vidya G	Xiaoyan Zhang, Weipeng Li, Jie Liu and Shuo Yang	P. C. Harisankar, C. F. Sagar Zephania and Tapas Sil		
	12:00	Ensemble Machine Learning Methods for Unsteady Aerodynamics Modeling using Flight Test Data	Damage Analysis of Multi-layered Composite Structures	Design and verification of electrical power subsystem for a student small satellite "SSS-1"		0:15
		Ajit Kumar and Ajoy Kanti Ghosh	Kartikeswar Dwibedy and Anup Ghosh	Liu Bohan, Yu Xudong and Huang Hai		
	12:15	CFD Investigation of Geometrical Truncation effect of Typical Winged Re-entry Vehicle on Pressure Coefficient at FADS ports	Sensor/actuator position optimization for large size structure using multi-objective optimization	Wall effect on the Drucker Prager model parameters for pebble beds in nuclear fusion reactor		0:15
		Kunal Garg, Jathaveda M, G Vidya, Babu C, Dr Patil M M and Dr Ashok V	Jianhongyu Li, Hai Huang and Shenyan Chen	Deepak K Pawar, Maulik Panchal, Paritosh Chaudhuri, Ratna Kumar Annabatuala and Narasimhan Swaminathan		
	12:30	Risk assessment of cerebral aneurysms using FSI	Static and free vibration analysis of functionally graded shells using non-polynomial quasi 3D shear deformation theory	Modeling and design of hybrid reluctance actuator for fast steering mirror		0:15

		Shine S R, Shantanu Saha, Harshavardhan E and Jayanand Sudhir B	Sambhaji Lore, Aditya Deshpande and Bhrigu Nath Singh	Weipan Zhang, Weipeng Li and Bin Ren		
	12:45	Stably electrospraying Concentrated aqueous solution with outer ionic liquid	An analytical approach to sense the presence of damage through electro-mechanical impedance (EMI) response for a step-lap joint	Numerical simulation of wind-driven rain on gabled roof buildings		0:15
		Yufeng Cheng, Jinrui Zhang, Guobiao Cai and Weizong Wang	Umakanta Meher and Mohammed Rabius Sunny	Chenhao Xu, Chongwen Jiang, Siyuan Pi, Shuyao Hu and Zhenxun Gao		
	13:00	**LUNCH BREAK**				1:00
	Venue	SL1				
	14:00	**Joint Meeting Of Organisers**				1:00
	15:00	**Closing Session of ICTACEM2021**				1:00
	16:00					
Corresponding links for the technical sessions are embedded in the name of the sessions; namely SL1, SL2, SL3 and SL4.						

BOOK OF ABSTRACTS

INVITED TALKS

Compressive Failure Behaviors of Composites and Composite Sandwich Structures

Jia-Lin Tsai

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The compressive strength of unidirectional fiber composites is normally lower than the tensile strength. In this talk, the compressive failure behaviors of unidirectional composites are characterized based on the microbuckling model with the consideration of initial fiber misalignment. In addition, the compressive failure tests of fiber composites are performed in terms of different testing techniques. From the experimental data, it is indicated that the stress concentration occurring in the clamping area can significantly lower the compressive strength of fiber composites. A design of testing method is proposed to reduce the stress concentration resulting in the higher experimental data.

Composite sandwich structures are composed of highly stiff composite face sheets and a low density foam core. The foam core is sandwiched between two face sheets, and the entire laminate is bonded together by using an adhesive to form a sandwich structure. During the manufacturing process or engineering application, a debond defect between the face sheet and foam core might be generated, substantially deteriorating the performance of the sandwich structure. The second part of the talk will focus on the failure behaviors of debond sandwich structures subjected to compressive loading. Experiments and numerical simulations are conducted to understand the effects of the face sheet thickness and debond length on the compressive strength and failure mechanisms of the composite sandwich structures. It is revealed that, when the dominant failure mode is global buckling, failure occurs at the intermediate portion of the foam core and strength could be characterized using the maximum principal strain criterion. However, when the failure mode is local buckling, failure is initiated at the debond tip, and strength could be predicted using the damage zone method.

New opportunities and challenges for future UAVs

Raktim Bhattacharya

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Abstract:

Unmanned aerial vehicles are seeing an explosive growth in several domains, mostly in the commercial sector. Applications include real-estate, journalism, wild life conservation, precision agriculture, delivery, internet access, infrastructure assessment, etc. Each application has key requirements, which must be met in the design of these vehicles. A key design challenge is ensuring design flexibility, extensibility, and reconfigurability – while guaranteeing low cost, resource efficiency, reliability, and robustness. In this talk, some of the challenges in the air vehicle design for these applications will be presented, including aerodynamics, structures and flight control.

Spray-Swirl Interactions: Some Insights

Saptarshi Basu
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Coupling of spray with the coherent structures of a highly turbulent flow has been a long-standing problem especially in the context of liquid fuel delivery systems in gas turbine combustors. The atomizer in a gas turbine combustor usually has one or more (radial/axial entry) air swirlers with a fuel nozzle being mounted centrally along the longitudinal axis of swirler. It is well known that swirling flows are highly three dimensional in nature and often induce multiple aerodynamically unstable modes whose frequencies are several orders of magnitude. The basic understanding of flow dynamics in gas turbine swirl cup is critical to achieving clean and efficient combustion in modern-day gas turbine combustors. In this work, we analyze the evolution of the hydrodynamic topology and consequent spray-flow interactions in a coaxial swirl injector assembly.

The key results of the present work are discussed in four parts. In the first part, the global evolution and temporal dynamics of various vortex breakdown modes are discussed. Experiments are carried out for three sets of co annular flow Reynolds number. Furthermore, for each condition, swirl number is varied independently from. Three distinct forms of vortex breakdown namely, pre-vortex breakdown (PVB), central toroidal recirculation zone (CTRZ; axisymmetric toroidal bubble type breakdown) and sudden conical breakdown are explored in greater details. Energy ranked, and frequency resolved / ranked robust structure identification methods – POD, DMD respectively is implemented over instantaneous time resolved PIV data sets to extract the dynamics of coherent structures associated with each vortex breakdown modes. The dominant structures obtained from POD analysis suggest the dominance of KH instability (axial + azimuthal; accounts ~ 80 % of total TKE) for both PVB and CTRZ while the remaining energy is contributed by shedding modes. On the other hand, shedding modes contribute to the majority of the TKE in conical breakdown. The frequency signatures quantified from POD temporal modes and DMD analysis reveals the occurrence of multiple dominant frequencies in the range of ~ 10 – 400 Hz with conical breakdown. This phenomenon may be a manifestation of high energy contribution by shedding eddies in the shear layer. Contrarily, with PVB and CTRZ, the dominant frequencies are observed in the range of ~ 20 – 40 Hz only. In addition, the current work explores the hysteresis (path dependence) phenomena of conical breakdown as functions of Reynolds and Rossby numbers. It has been observed that the conical mode is not reversible and highly dependent on the initial conditions.

In the second part, we have reported how the liquid sheet behaves in such swirling flows. The air flow rate across the swirler is progressively varied to probe the two-phase flow interaction dynamics across weak, transition and strong momentum coupling regimes. The liquid sheet breakup and gas – liquid phase interaction dynamics suggests strong one way coupling at higher MR values. The POD analysis implemented over the shadow images clearly delineates the superimposing of gas phase instabilities with liquid sheet. The breakup length scale and liquid sheet oscillations are meticulously analyzed in time domain to reveal the breakup dynamics of liquid sheet. Furthermore, the large-scale coherent

structures of swirl flow exhibit different sheet breakup phenomena in spatial domain. For instance, flapping breakup is induced by counter rotating vortices in the flow field induced by vortex breakdown phenomenon. The breakup regime map is also constructed based to illustrate the various forms of breakup mechanism as a function of MR values. Finally, the ligament formation mechanism and its diameter, size of first-generation droplets are measured with phase Doppler interferometry (PDI). The measured sizes scale reasonably with KH waves.

In the third part, the fundamental mechanisms of vortex-droplet interactions leading to flow distortion, droplet dispersion and breakup in a complex swirling gas flow field are discussed. In particular, how the location of droplet injection determines the degree of inhomogeneous dispersion and breakup modes have been elucidated in detail. The droplets are injected as monodispersed streams at various spatial locations like the vortex breakdown bubble and shear layers (inner and outer) exhibited by the swirling flow. Time-resolved particle image velocimetry (3500 frames/s) and high-speedshadowgraphy measurements are employed to delineate the two-phase interaction dynamics. These measurements have been used to evaluate the fluctuations in instantaneous circulation strength caused by the flow field eddies and resultant angular dispersion in the droplet trajectories . The droplet-flow interactions show two-way coupling at low momentum ratios (MR) and strong one way coupling at high momentum ratios. The gas phase flow field is globally altered at low air flow rates (low MR) due to the impact of droplets with the vortex core. The flow perturbation is found to be minimal and mainly local at high air flow rates (high MR). Spectral coherence analysis is carried out to understand the correlation between eddy circulation strength and droplet dispersion . Droplet dispersion shows strong coherence with the flow at certain frequency bands. Subsequently, proper orthogonal decomposition (POD) is implemented to elucidate the governing instability mechanism and frequency signatures associated with turbulent coherent structures. POD results suggest the dominance of KH instability mode (axial and azimuthal shear). The frequency range pertaining to high coherence between dispersion and circulation shows good agreement with KH instability quantified from POD analysis. The droplets injected at inner (ISL) and outer shear layer (OSL) show different interaction dynamics. For instance, droplet dispersion at OSL exhibits secondary frequency (shedding mode) coupling in addition to KH mode, whereas, ISL injection couples only at a single narrow frequency band (i.e. KH mode).

Fundamental features of perturbation growth in high-speed compressible shear flows

Sharath S. Girimaji[1] & Bajrang Sharma[2]

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Abstract: High-speed shear flows are of much interest in a variety of engineering applications. The stability, transition and turbulence characteristics of these compressible shear flows exhibit some profound differences from those in incompressible flows. These differences arise from flow-thermodynamic interactions enabled by the change in the nature of pressure. Ultimately this change leads to the emergence of dilatational velocity fluctuations in high speed flows. In this talk, I will discuss the effect of dilatational fluctuations and internal-kinetic energy interactions on the development of perturbations in simple shear flows and canonical wall-bounded flows. The study clearly shows that the fundamental dilatational mechanisms are qualitatively identical in a range of shear flows. The findings are expected to aid in developing physics-based closure models and identify the appropriate features for data-driven turbulence models.

Status and Development of Korea Military Airworthiness

Changduk Kong

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1. INTRODUCTION & OBJECTIVES

Each country has enacted Airworthiness Certification based on the ICAO regulations established in 1944. (ICAO Annex 8 "Airworthiness of Aircraft") According to US civil regulation of 14 CFR Aeronautics and Space-Part 3, 'airworthy' means the aircraft conforms its type design and is in a condition for safe operation, while according to MILHDBK-516B Airworthiness Certification Criteria, 'airworthiness' means the property of particular system configuration to safely attain, sustain, and terminate flight in accordance with the approved usage and limits.. The civil aviation airworthiness authorities of each country are as follows; US has FAA(Federal Aviation Administration), Europe has EASA(European Aviation Safety Agency), and Korea has Airworthiness Division of MOLIT(Ministry of Land, Infrastructure and Transportation). While military airworthiness authorities are as follows; US has Air Force, Army and Navy, EU has European Defense Agency, and Korea has Airworthiness Planning Division of DAPA. Civil Airworthiness Standards of each country are KAS(Korea Airworthiness Standard) of MOLIT, CS(Certification Code of Specification) of EASA and FAR(or CFR) Part of FAA for airworthiness process, aircraft, engine, propeller, noise, fuel and exhaust gas. Because KAS and CS have been made based on FAR (or CFR), they are almost same as FAR. There are several types of certification such as TC(Type Certification), PC(Production Certification), AC(Airworthiness Certification), STC(Supplement TC), TSOA(Technical Standard Order Approval), and PMA (Parts Manufacturer Approval). In case of military airworthiness standards, Korea and US follow DoD MIL-HDBK_516C, and EU follows civil airworthiness standards, CS of EASA. This study is to make common application between Korea military airworthiness system and international military airworthiness system as well as to improve Korea military airworthiness system.

2. MILITARY AIRWORTHINESS SYSTEMS

Recently, more and more countries around the world require the airworthiness certification to ensure flight safety of military aircraft. Airworthiness certification regulation and process of military aircrafts differ from country to country. For instance, US is carrying out politics and regulations on airworthiness certification activities by Air Force, Army and Navy, and European Defense Agency is using the modified civil airworthiness process. In Korea, DAPA (Defense Acquisition Program Administration) is performing airworthiness certification as a military airworthiness authority by law. Korea military airworthiness system is composed of Act, Criteria, Organization and Process. The "Act on military aircraft flight safety certification (Act No.11690)" was legislated in 2009 for Korean military, police and other custom aircrafts including exporting A/Cs. The Korea military airworthiness authority is APD (Airworthiness Planning Division) of DAPB (Defense Industry Promotion Bureau), and Standard Airworthiness Certification Criteria was legislated based on US DoD MIL-HDBK_516B Change 1 "Airworthiness Certificate Criteria", later updated by MILHDBK_516C. Process Regulation on military airworthiness certification is stated at DAPA regulation No. 342 -4th revision. Since the licensed

production of military aircrafts such as F-5, MD-500, F-16, UH-60, F-15K, etc. and development of military aircrafts such as KT-1, T-50, KUH, KC-100, LAH and F-21, Korea aerospace industries including KAI, Hanwha Aerospace and KAL have got military aircraft development capability. These developed military aircrafts received type certificates and airworthiness certificates by Korea military airworthiness system and civil airworthiness system.

3. CONCLUSION

Recently, since the military airworthiness has been required in global military aircraft market, Korea enforced the "Act on Military Aircraft Flight Safety Certification (Act No.11690)'. Therefore the military airworthiness has taken charge of an important role not only for domestic delivery and sale of developed military aircrafts but also for export and purchase of military aircrafts. If continuous study on European and US advanced airworthiness systems and development of the effective military airworthiness system by application and improvement, it is expected the Korea military aircraft industry will be promoted more rapidly and effectively.

REFERENCES

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2. H. Youn et al, "Practice of Airworthiness Certification", pp. 21~68, Joendang, 2014.
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5. Act on military aircraft flight safety certification (Act No.11690), 2009

Development Policy of Korea’s Space Science & Technology

Dr. Chi-Young Hwang

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Abstract. Korea has began to participate in the space sector in the late 1980s. Initially, it began with the scientific interest and aspiration of researchers, but with the establishment of the Korea Aerospace Research Institute in 1989, and the establishment of a basic mid- to long-term space development plan in 1996, the government-level development began. Along with the progress of space development, legal and institutional systems were established. The Space Development Promotion Act was enacted in 2005 to establish the National Space Commission headed by the Minister of Science and Technology. Korea's space development has been developed around the demand of civil public sectors such as scientific experiments, earth observation, weather forecasting, environmental and ocean monitoring, and it is gradually expanding to astronaut projects, lunar probes, and national security. KSLV-2 was launched in 2021 following the KSLV-1 launch in 2013 as the national demand for increased domestic satellite launch. Along with the progress of space development programs, the investment of space development of national resources is increasing and the chairman of the National Space Commission upgraded to the prime minister this year. Currently, Korea is establishing the 4th Basic Plan for Space Development Promotion with the goal of 2022. In this presentation, I would like to introduce the main contents of the Korean space development system, the ongoing projects, and the basic plan for the promotion of national space development.

Thermal control system design and test for APSCO SSS-1 satellite

Chen Shenyan

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Asia-Pacific Space Cooperation Organization (APSCO) Student Small Satellite (SSS) project is aimed to train the students and faculties from Member States (MSs) of APSCO to study space technology and satellite engineering through practical design of satellites until its launch. SSS-1 is the main satellite with 36kg. According to the orbital environment, the external heat flow of SSS-1 was calculated by considering the direct sunlight, the earth reflection and the earth infrared radiation. The thermal control strategy was proposed by combining the passive and active thermal control techniques. The finite element model for thermal analysis was established according to the primal design. The extreme cold and hot conditions were applied as the typical load cases. The thermal analysis results showed that the temperature of most payloads satisfy the design requirements whether in the transient or steady state. In order to verify the thermal control effect of SSS-1, the ground vacuum thermal balance test of the satellite was carried out, and the satellite temperature distribution under various conditions was obtained. The test results showed that the temperature of most payloads can meet the design requirements, while the on-board power area is higher than expected. Finally, the test results are compared with the analysis results, and the thermal property parameters of the FE model were adjusted. And the thermal control design was updated according to the test and analysis results. The SSS-1 has been launched by CZ-2D rocket at Oct.14, 2021. The TT&C data showed that the temperature is kept at a proper region.

Computational Determination of Detonation Characteristics of Condensed Explosives

Abhijit Kushari

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Abstract. Defence research labs at present are working in the area of pressable polymer bonded explosives (PBX) compositions which have applications is strategic systems. In order to meet the requirement of strengthen blast waves for deep earth penetrator, concrete piercing warhead are being developed. The ingredients in these PBX compositions need to be tailored in such a way that the detonation products from these compositions react with air as well. This can be ensured by the addition of metal powders in the compounds. However, the addition of metal powder in these compositions make them non-ideal explosives for which the characteristics of the detonation waves are not available in literature. It is not possible to ascertain the impact and short-select the desired composition by repeated experimentation. Furthermore, the standard tools like NASA-CEA or ANSYS etc. do not have the desired properties for such explosives in their databases. Therefore, a theoretical model is developed in order to understand the thermochemical properties, CJ characteristics and equation of state for these metal infused explosives. The methods used for the development of this general-purpose computational method is discussed in the present talk and the results are compared with the literature data.

Numerical investigation of shock-turbulence interaction and shock-associated noise for supersonic jets

Zhenxun Gao

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Supersonic jet noise is a key component of the aerodynamic noise on aerospace vehicles. This paper focuses on the shock-associated noise for supersonic jets, and the numerical investigation is carried out to study the shock-turbulence interaction and the associated noise. Firstly, Direct Numerical Simulation (DNS) is applied to perform simulations for the turbulent mixing layer and shock/turbulent mixing layer. The results are compared to analyze the influence of shock/turbulent mixing layer interaction (STMLI) on the turbulence characteristics. Meanwhile, two mechanisms for generating shock-associated noise are identified by applying the shock-leakage theory and the turbulence scale analysis. Secondly, Large Eddy Simulation (LES) is used to simulate the axisymmetric non-ideally expanded supersonic jet, and the FW-H equation is applied to calculate the far-field noise. Based on the simulation data, the shock leakage presented earlier is discussed.

Accurate measurement of laminar burning velocity of premixed fuel-air mixtures

Sudarshan Kumar

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Abstract. In this talk, the importance of accurate measurement of laminar burning velocity of premixed fuel-air mixtures and its application for validating various detailed reaction models will be discussed. The development and application of externally heated diverging channel method will be presented for laminar burning velocity measurements at high pressure and high temperature conditions to understand and evaluate the combined effect of pressure and temperature on the propagation of premixed fuel-air flames. The experimental measurements of methane-air mixtures for different equivalence ratios are reported for a pressure range (1-5 atm), and elevated temperatures of 350 – 650 K. Predictions from three widely used detailed kinetic models (GRI-Mech 3.0, Aramco 2, FFCM-1) are employed to compare with present measurements. The variation of pressure exponent, β, follows a bell-shaped curve with maximum value for slightly rich mixtures (ϕ = 1.1) and a peculiar non-linear behaviour for very rich mixtures ($\phi \geq 1.3$). Based on the detailed analysis of experimental results, the temperature exponent (α) is proposed as a function of pressure, and pressure exponent (β) as a function of temperature at various equivalence ratios. A modified power law correlation considering the α and β variations is proposed as: ,

$$S_u = S_{u,o}\left(\frac{T_u}{T_{u,o}}\right)^{\alpha_o+\alpha_1\left(1-\frac{p_u}{p_{u,o}}\right)}\left(\frac{p_u}{p_{u,o}}\right)^{\beta_o+\beta_1\left(1-\frac{T_u}{T_{u,o}}\right)}$$

Analysis of the flame structure at high-pressure conditions indicates that the reaction layer thickness is reduced with an increase in pressure. A decrease in mixture thermal diffusivity with pressure contributes to a reduction in laminar burning velocity at elevated pressures.

Estimation of Aerodynamic Derivative from Flight Data

Prof. A.K. Ghosh

Department of Aerospace Engineering, I.I.T. Kanpur

Abstract. The estimation of aerodynamic derivative through flight data is of paramount importance in characterizing aerodynamic model for performance, stability and control analysis. The application of conventional and un-conventional method has been presented. The challenge of generating flight data using scaled model is also addressed and shared.

Shock-turbulence interaction: analysis and modelling for aerospace application

Krishnendu Sinha

Professor, Aerospace Engineering Department, IIT Bombay

Abstract. Shock waves and turbulence together make an interesting area of research. Shock waves can result in extremely high pressure and temperature in hypersonic flows. This translates to high aerodynamic and thermal loads on an aircraft. A shock wave can also enhance the mixing in turbulent flows, which is beneficial in combustion applications. The interaction of shock waves and turbulence in high-speed flows is thus a problem of fundamental interest, as well as practical importance.

The canonical problem of homogeneous isotropic turbulence passing through a normal shock wave is possibly the simplest and the most fundamental problem. It brings out many key aspects of shock-turbulence interaction, and is studied using direct numerical simulation and linear interaction analysis. Of particular interest are the amplification of turbulent kinetic energy and turbulent heat flux at a shock wave. Physical insights obtained from DNS and theoretical analysis are used to develop advanced turbulence models for CFD simulation. Application to shock-boundary layer interaction flows show marked improvement in predicting flow separation and peak surface heat transfer rates. The new turbulence models have also been applied to real-life configurations in aerospace vehicles.

CONTRIBUTED PAPERS

Effects of internal length scale parameter on damage initiation and evolution using gradient enhanced damage mechanics theory

Aditya Deshpande[1], Bhrigu Nath Singh[2]

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Abstract. Continuum based smeared crack and damage modelling methods have been proven advantageous in solving various damage problems. Due to evident strain localization and loss of well-posedness of the problem near failure loads, local continuum damage mechanics formulation shows high mesh sensitivity. To rectify these issues, gradient enhanced damage theory, incorporating internal length scale into the formulation as a method of regularization, is adopted. Present research work discusses the relative effects of internal length scale on the damage initiation and evolution response of the material. Gradient enhanced damage mechanics formulation is solved using non-linear finite element method. Effects of internal length scale on total dissipated damage energy and damage localization regions are presented. It is observed that, increasing length scale parameter tends to make the damage response of material less brittle as the damage localizes in larger region.

Mechanical and microstructural characterization of Incoloy 901 repair by DED for aerospace gas turbine engine parts

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Abstract. The additive manufacturing (AM) techniques is suitable for aerospace industry because of higher performance and flexible manufacturing. AM technique is used for producing new parts or repairing used parts. In this study, the performance of direct electron deposition (DED) repair part of Incoloy 901 applied to aerospace gas turbine engine parts have been examined. The Incoloy 901 coupons were prepared by DED, and the mechanical properties such as tensile and fatigue behavior were characterized. The measured properties were compared with that of the tungsten inert gas (TIG) welded coupons. Furthermore, the microstructure analyses were also conducted by Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). The DED coupons showed a higher mechanical properties compared to TIG coupons. The metallurgical properties such as volume fraction of γ' and area of heat affected zone were also analyzed. The results indicated that the microstructural properties could have contributed to the difference in mechanical properties between DED and TIG process.

Numerical Analysis of Weapon Bay Cavities of Different Configurations

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Abstract. Weapon bays play a crucial role in providing better aerodynamic performance and stealth of an aircraft. This can be analysed effectively by thorough understanding of the flow field within the cavity. The present study aims at analysing the effect of leading-edge profile on the cavity flow. A basic understanding of the effect of leading surface indicates that a straight leading surface leads to a stronger primary vortex, whereas a wavy leading surface profile can mitigate the effect due to complex interactions within the cavity. An attempt to quantify this effect is made by considering two variants of saw-toothed profile, provided at both leading and trailing edges. Two wavelengths for the saw-tooth, which is a function of width of the cavity, are considered, where the cavities have a length-to-depth ratio of 5 and a width-to-depth ratio of 1. They are subjected to a free stream velocity of 70m/s with variation in yaw angle from 0 - 6 degrees. Numerical approach is made to characterize the static pressure field through high fidelity simulations using ANSYS® Fluent. The results obtained for both the cavities are then compared with plain rectangular cavity to understand the effect of saw-tooth profiles on the flow field.

Aeroacoustic Study on Hvls Fan Blade with Serrations

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Abstract. Owls are able to fly noiselessly due to their wing feathers by alleviating the noise generated by the air flow effectively. The presence of serrations and fringes on its feathers plays a prime role in reducing the noise and also in improving the aerodynamic performance. However, implying such design is not abundant in the application arena applied to high-volume low-speed (HVLS) fan blades which generate a significant amount of noise due to the impeller rotation of. The current study is aimed at creating an array of serrations on the leading edge and trailing edge of the airfoil (NACA7415) similar to that of the owl's wing feather. The Aero-acoustic features are simulated using the ANSYS Fluent software and the effect is studied with reference to the baseline airfoil geometry. The preliminary results indicate that the serrations are effective in reducing the noise and improving overall aerodynamic performance.

Structure analysis and optimization of SSS-1 microsatellite

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Abstract. Abstract. SSS-1 is a 30kg micro-satellite mainly developed by Beihang University. In the present work, the structure of the SSS-1 microsatellite was analyzed and optimized. According to the overall requirements, the SSS-1 satellite adopts a frame-box-plate initial structure design scheme. To study the mechanical properties of the structure and judge the feasibility of the initial design, a finite element model of the SSS-1 satellite is established based on the geometry and mass characteristics of the on-board payloads. Static and dynamic analysis are carried out. The calculation results show that the second layer of the satellite has a local mode, and the first order frequency is low. Topology optimization and size optimization were implemented. Combining with the optimization results and the practical situation, the first and second layers of the satellite frame were reinforced. The structural analysis results show that the first-order frequency of the improved design is increased from 34.622Hz to 86.45Hz. Meanwhile, the weight of the entire satellite is reduced 1.13kg. And all the design requirements are still satisfied.

Characteristics Of Pintle Injector Using Homogeneous Mixture Model and Eulerian to Lagrangian Transformation

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Abstract. Numerical analysis is conducted to investigate the spray characteristics of a hydrogen peroxide/kerosene liquid pintle thruster. Three different rectangular shape injectors which are follow-directionally long, square, and flow-vertically long injectors, are considered. A homogeneous mixture model is applied to precisely compute the first breakup of liquid fuel column and then the Eulerian-To-Lagrangian transformation method simulates the second break up and tracks the droplet after the secondary breakup for computational efficiency.

Free Vibration Analysis of a Rotor-bearing System having Corrosion Defect

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Abstract. The corrosion, a common surface phenomenon, occurs due to harsh environmental conditions of the material resulting in the loss of material surface and change in the vibration behaviour and structural integrity of the material. In the present work, a Timoshenko beam theory based finite element formulation has been developed for the Jeffcott rotor-bearing system having corrosion defect to obtain the natural and whirl frequencies of the system. The length, depth and position of the corrosion defect have been varied to investigate the effect of corrosion defect on natural and whirl frequencies of the rotor-bearing system. It has been concluded from the analysis that the effect of reduction in stiffness due to corrosion defect is low near the bearings and high near the disk compared to the loss of mass. Hence, as the length and depth of corrosion defect increases, the natural and whirl frequencies increase due to the corrosion defect near the bearings and decrease as the position of the corrosion defect moves away from the bearings towards disk.

Numerical Analyses on Free-Play Nonlinear Aeroelasticity

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Abstract. This paper proposes a framework of computational fluid dynamics/computational structural dynamics (CFD/CSD) coupling approach that can deal with the three dimensional aeroelastic problems with both the free-play nonlinearity and the aerodynamic nonlinearity. The fictitious mass method is used to construct the reduced structural equations of motion and the switching point is detected using the bisection method. The adaptive time step obtained by the bisection method is returned to the CFD solver so that both the structural and the fluid equations are integrated using the same time step. An all-movable wing with free-play at the root is considered for numerical studies. Results demonstrate the CFD/CSD coupling method can predict the stable limit cycle oscillation (LCO) effectively. The initial condition shows that the LCO behavior is subcritical and the hysteresis response can be predicted in time domain effectively by the presented method. The viscous effect is shown to increase the LCO boundary and shift the LCO amplitude to a larger velocity in transonic regime.

Enhancement of Heat Transfer Cooling a Central Processing Unit (CPU) System with Nanofluids

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Abstract. Theoretical studies were performed to investigate the effect of nanofluids, which are different types of coolant fluids, being used in a CPU cooling system on heat transfer and fluid flow. The Reynolds number study encompasses a range of 5000 to 15,000. Twenty different types of base fluids with Al2O3 nanoparticle having a diameter of 20nm and concentration factor 4% have been used. Nusselt number increased as the Reynolds number increased in the presence of different base fluids as a coolant fluid. As the Reynolds number increased, skin friction increased with regard to the fluid used as a coolant. The SiO2 nanofluid has the highest Nusselt number value and skin friction coefficient. It was observed that the selected base liquid has the lowest Nusselt number and skin friction coefficient. The local Nusselt number considerably increased with increasing Reynolds number and local skin friction coefficient considerably increased with increasing Reynolds number.

Optimization Design of Modified Stewart Platforms for Isotropic Force Output

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Abstract. The output capabilities of the Stewart platforms rely on their configuration to a large extent. Compared with standard Stewart Platforms, modified Stewart platforms (MSPs) will be achieved a more balanced force output capability. The concept of isotropic force output of Stewart platforms is studied to get a uniform force output, and configuration optimization design of the MSP is carried out to realize the isotropic force output. Firstly, the configuration of the MSP is described and the parameters range of the MSP's configuration is deduced according to the definition of isotropic force output. Then, the optimization model of the MSP's configuration is established. The objective function that demonstrates the difference between the force output in different axes is presented. Four independent parameters of the MSP's configuration are taken as design variables. The Generalized Pattern Search method (GPSm) is applied in the optimization and an optimized MSP that achieves isotropic force output was obtained. Finally, the dynamic model of the optimized MSP was established, and dynamic simulation shows the maximum force output in different axes is uniform, which verifies the optimization result of the MSP.

Mixing characteristics of circular and elliptical twin jets

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Abstract. In this paper, the effects of orientation and spacing to distance (S/D) on mixing properties of twin circular and elliptical jets are investigated numerically. Here, D is the exit diameter of the circular nozzle that is kept constant, and S is the spacing distance provided between the twin jets. The elliptical twin free jet is studied in two orientations, either oriented along the major axis plane (Twin major) or oriented along the minor plane (Twin minor). The numerical simulations of twin jets are carried using the Reynold Averaged Navier Stokes (RANS) method of Shear Stress Transport (SST) K-ω turbulence model. The results show that near the nozzle exit, the twin jets are isolated to each other and act as a free jet, leading to a potential core length independent of spacing distance and similar to that of a free single round jet. The results also show that jet mixing is superior for twin minor elliptical configuration as compared to twin circle and twin major jets. In the radial direction as the jet progresses downstream the twin major and twin minor jets experience a shape transformation due to asymmetry in their geometrical shapes.

The Effect of Mole Weight Ratio of Reaction on the Propagation of Cellular Detonations

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Abstract. The effect of mole weight ratio of chemical reaction on the propagation of cellular detonation is concerned. The results of numerical investigation show that there is an important dependence of detonation cell size on the mole weight ratio of chemical reaction. Low mole weight ratio means that the gaseous reactant is dissociated to relatively smaller molecule product after chemical reaction, the cell size of detonation increases with the decrease of mole weight ratio, which can be widely observed in hydrocarbon fuel detonation. High mole weight ratio means that the gaseous reactant is recombined to relatively larger molecule product after chemical reaction., the cell size of detonation decreases with the increase of mole weight ratio.

Application of finite element direct integration method in flutter analysis

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Abstract. Flutter is a dynamic instability phenomenon caused by the interaction of aerodynamic force, elastic force and inertia force. Common analysis methods include K method, PK method, CFD/CSD coupling based on modal superposition method(M-S-M), etc. But these methods are not applicable when dealing with flutter problems (aerothermal, fuel consumption, etc.) in which structural vibration characteristics change with time. To solve those problems, this paper introduces the finite element direct integration method(D-I-M) into CFD/CSD coupling method. Compared with the M-S-M, all vibration characteristics of structure will be retained in D-I-M.

Assessing post impact mechanical characteristics of glass fiber laminates by using beam coupons: A simplistic approach

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Abstract. Compression after impact (CAI) test is often used to assess the residual strength of laminates, which are subjected to low velocity impact. While the test requires a complicated setup, it does not cover all load regime. Although not standardized yet, flexural after impact (FAI) test offers a simpler procedure, and has a potential to emerge as an alternative to CAI. In this investigation the beam specimens, machined from glass fiber reinforced polymer (GFRP) composites are subjected to impact energy up to 20J. The impacted specimens are subjected to symmetric four-point-bend tests to assess their post impact flexural properties. The extent of damage and dissipation energy are observed to increase with increase in incident energy. While the flexural strength decreases with increasing impact energy, the flexural modulus is decreased only beyond a threshold incident energy. The residual flexural characteristics are in good correlation with the impact induced damage in the laminates.

Influence of tab blockage on asymmetric under- expanded sonic free jet

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Abstract. Free jet facility to test various imperfectly/perfectly expanded sonic and supersonic jets have been established at Birla Institute of Technology Mesra, Ranchi. In the present investigation an underexpanded sonic jet with tabs having cylindrical cross sections have been adopted. The tab placements were made circumferentially 1200 apart thus making an asymmetric arrangement in terms of a plane bisecting the jet horizontally. The tab geometry has been selected as cylindrical in cross section for its fundamental wake characteristics. The sonic free jet diameter is 15 mm and tab diameter has been taken as 2mm. Three of these cylindrical tabs have been inserted and oriented circumferentially to have blockages of 3, 7, and 11% compared to the free jet exit. To have these blockages the tabs were either retracted away or inserted more towards the centre of the jet. All the tests were made with nozzle pressure ratio of 4, defined as ratio between settling chamber pressure to ambient pressure which makes the nozzle operate with underexpanded mode having ratio of exit pressure to ambient pressure as 2.11.

Flutter Investigation of MW Sized Hybrid Composite Wind Turbine Blade

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Abstract. Wind turbine blades of MW sized are generally made up of glass fibre or carbon fibre reinforced composite materials. These large blades are slender and flexible in structure which may lead to complex aeroelastic behaviour. In this work, a parametric study is conducted to determine the flutter instability of hybrid glass/fibre composite SNL 61.5 wind turbine blade. Flutter speed is determined using eigenvalue approach. Theodorsen's theory is used for aerodynamic model. Results obtained for different ratio of glass and carbon fibre hybrid composite are compared with original blade.

Scaling law for core length in supersonic free jets

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Abstract. The present work is motivated by the shortcoming to predict the length of supersonic core of free jet Lc*, especially the elliptic and circular jet exhausting into an ambient medium. Thus, we present here the experiments demonstrating the scaling law for supersonic core length in circular and elliptic free jets. Experimental conditions cover a wide range of nozzle design Mach number Md from 1.0 - 2.0, nozzle expansion ratio pe/pa from 0.51 - 3.17, aspect ratio of nozzle AR from 1 - 6 (where AR = 1 and > 1 correspond to circular and elliptic jets, respectively). In the present investigation, an empirical scaling analysis is performed for Lc* in order to find a scaling factor ζ.

Flow modifications & capacity augmentation due to streamwise deployment of longitudinal vortex generators in a finned tube bank

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Abstract. Intentional generation of three-dimensional longitudinal vortices is an effective way of promoting bulk mixing in the otherwise streamlined fluid flows. “Toe-out” type vortex generators are considered for the flow modifications, and the ensuing thermal augmentation in a plain finned tube bank. As the degree of augmentation is governed by the location of the vortex generators, three dimensional numerical investigation is conducted to analyse the effect of their streamwise translation. For that purpose two different cross-stream positions are chosen where vortex generators are deployed, and their streamwise position is varied in discrete steps. The study of velocity vectors makes it evident that the vortex generators produce secondary flow structures over a significant region in their downstream which promotes bulk mixing over a large fin area. Such flow modifications resulted in noticeable increase in the heat exchange capacity on account of higher heat transfer coefficients. The flow visualization study of the streamwise translation shows that the structure and the geometric extent of the vortices do not change much despite the position of the vortex generators.

A modified sharp interface immersed boundary method

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Abstract. The sharp interface immersed boundary (IB) method based on the ghost cell has high interface clarity at the boundary, compared with the diffused IB method. The physical quantity on the ghost cell can be calculated via interpolation to realize the influence of the immersed boundary on the flow field. However, the linear interpolation at the boundary reaches first-order accuracy at most. With the increase of grid density, the computational efficiency decreases greatly as well. In this study, after analyzing the causes of computational efficiency decrease, a modified sharp interface immersed boundary method is proposed. This method constructs a compound bilinear interpolation function and introduces a correction factor to improve the efficiency. This paper investigates the calculation results and time-cost of flow around a cylinder under different grid densities and Reynolds numbers. The effect of constant correction factor on the accuracy and efficiency is analyzed. It shows that when the correction factor is negative, the calculation efficiency of the algorithm can be greatly improved. The influence of the factor increases as the grid density increases, so that selected value of the correction factor is dependent on the grid size.

Aerodynamic Study on Airfoil With U-Shape Tubercle Geometry

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Abstract. Flow separation is a vital problem for the fluid flow over an airfoil and results in performance losses. Leading edge tubercles placed on turbine blades increases generation of energy and were found to be effective in generation of power by a marine tidal turbine and low flow speeds. Bio-inspired sinusoidal leading-edge protuberances are effective in flow control at higher angles of attack. The lacuna of literature in enhancing the lift performance by augmenting the vortices formation is observed. In the current study, the array of U-shape tubercles is investigated numerically and compared with sinusoidal tubercles and plain leading-edge configurations for NACA0020 at a Reynolds number of 200,000. The transient CFD simulation is performed ANSYS Fluent. The preliminary results demonstrated that the airfoil with sinusoidal tubercles is very effective in increasing the lift coefficient.

Boundary Layer Transition on Large Scale Models in JF-12 Hypersonic Shock Tunnel

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Abstract. Hypersonic boundary layer transition on large scale models were experimentally investigated in JF-12 hypersonic shock tunnel, including a flat plate with 3.2m in length and 1.2m, and a cone with 3.0m in length and half angle of 7 degrees. The effect of Mach number, unit Reynolds number of the incoming flow, and stagnation temperature were discussed in this paper, by measuring the wall heat flux, the location of transition zone, and the pressure fluctuation.

Shock wave effects on Chitosan bio-polymer for drug delivery applications

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Abstract. Biopolymers are natural polymers extracted from the cell wall of living organisms. Chitosan material is used to study its properties when subjected to shock wave loading. We modified the present manually operated shock tube to the semi-automatic where it produces a strong shockwave of order Mach 4, the useful test time was found to be 100μs.The pressure sensors at end of shock tube will sense exact pressure of de polymerized material under shockwave impact. The samples will be subjected to repeated loading, after using SEM the properties will be investigated.

Effect of carbon black content on quasi-static compression behaviour of filled rubber

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Abstract. Rigid particle-filled rubbers have several engineering applications. While the rubber matrix is an excellent shock absorber, the rigid fillers enhance the stiffness of the composite. Various mathematical models have been proposed to predict the stress vs. strain curves of filled rubbers, however, none of them could uniquely define the mechanical behaviour because of a complex deformation characteristic of the composites, especially under cyclic loading. In this investigation, vulcanized natural rubber, reinforced with carbon black fillers at different proportions, is subjected to monotonic and cyclic loading under quasi-static compression. Permanent deformation along with strain softening during successive loading-unloading cycles indicates the presence of Mullins effect, which increases with increasing filler content in the matrix. The experimental data exhibit that the elastic modulus and energy dissipation increase nearly exponentially as the filler content is increased, whereas the corresponding values appear to saturate with the loading cycle. While unique stress-strain curves are seen during initial cycles, successive loading-unloading conditions the material towards attaining superimposed curves.

Study of influence of vortices on trailing airfoil

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Abstract. Study of vortex induced vibrations forms an important area of research as the performance of most of the hydro and aerodynamic systems is influenced by them. The efforts in understanding the mechanism of vortices started in late 18th century with the commendable efforts of Strouhal (1878) and Von-Karman (1912). The most important dimensionless number which is used for obtaining the frequency of vortex shedding is the Strouhal Number (St). The vortices generated by the aircraft leads to wake turbulence, due to which smaller aircrafts flying in the vicinity experience a net downwash, which in turn lead to disasters. Though considerable research has been carried out in the field of vortex generation, study of effect of wake turbulence on the lift and drag coefficients of the aircraft in the turbulence region have not been studied. Therefore, the present study aims to study the performance parameters of airfoil in the turbulent region due to interaction with the vortices, by placing the airfoils in series. The vortices are generated by changing the angle of attack of the leading airfoil. The airfoils are placed at different relative distances as a function of chord lengths in order to analyse the effect of distance between the airfoils on the vortex interaction. The numerical simulations of the experiment have been conducted for various cases and the performance parameters like coefficient of lift, coefficient of drag, coefficient of moment and aerodynamic efficiency have been plotted for each case.

Parametric study of bio-inspired corrugated airfoil geometry in a forward flight at Reynolds number 80000

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Abstract. In this study, the effects of variations in the geometrical parameters on the aerodynamic performance and stability of a bio-inspired airfoil were assessed using the computational method at a Reynolds number of 80000. The investigation aims to recognize the influence of corrugations on aerodynamic forces and moments and compare the variations with a non-corrugated profile having similar geometry. Three different airfoils were chosen, the first is a corrugated airfoil inspired from the mid-section of a dragonfly wing, the second is a different form of the first airfoil which was then modified to match the maximum thickness of the first airfoil, and the third is a non-corrugated airfoil obtained by joining the peaks of the second airfoil. These three models were fabricated using an additive manufacturing process to undertake the experimental work in a low-speed wind tunnel to find aerodynamic characteristics. ANSYS FLUENT solver was used to solve the steady, laminar, incompressible, two-dimensional, RANS equations. The computational tests were performed for -4 to +20 degrees angle of attack at Re~80000. The results revealed that the non-corrugated airfoil showed comparatively better aerodynamic efficiency (up to 50% higher) whereas the corrugated airfoils generated smaller moment thereby decreasing the instability caused by the wing.

Design of a propellant grain with embedded metal wires

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Abstract. Embedding metal wires into propellant grain can enhance the burning rate by creating cone-shaped burning surfaces that amplify burning surface area. Applying a propellant grain with metal wires enables to provide a variety of performance design. In this study, the performance design of a small rocket motor using a propellant grain with embedded metal wires were conducted. Performance characteristics were analysed according to the location and number of metal wires. The results from internal ballistics design and experiment were compared.

Finite element modelling and Monte Carlo ray tracing for the solar parabolic trough collector with torque box

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Abstract. Parabolic trough collectors are the widely used concentrating solar technology. To be competitive among solar power technologies, structural optimization of the PTC components is essential. In this paper, a methodology is proposed to analyse the effect of self-weight and the wind loads on the optical efficiency of the collector caused due to structural displacements at the trough surface. Configuration of the parabolic trough collector having torque box similar to the design of LS-3 and Euro trough design is considered. Finite element analysis for the trough surface along with optical ray tracing reveals that the slope errors caused due to the wind loads have a substantial effect on the optical efficiency of the collector. A decrease of 36% in slope error is observed for a change of pitch angle from 0° to 90°. Under wind loads, the slope errors are as high as 4.074 mrad, causing a loss of optical efficiency of 9%. The slope errors for the wind loads of 15m/s and at 0° pitch angles reach the limit of shape quality of the mirror panels for the optimal performance. Hence the study highlights the need for optimization of the design of solar collectors for wind loads to improve the performance

Research on Thrust Measurement System Design and Intelligent Thrust Prediction Method Applied to Micro-electric Propulsion

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Abstract. To evaluate the performance of electric thrusters, we have designed and developed a micro-thrust measurement system, which is based on the torsion pendulum. Additionally, we designed a gravity adjustment and calibration mechanism. We also designed the drag-free gas and electricity bridge device to eliminate the drag force of the propellant supply pipeline and power supply cable of the electric thruster, which could affect the linearity and accuracy of the measurement results. The electrostatic comb pair is used to generate a standard weak force, and the thrust calibration and online measurement methods are studied. Finally, through isolating vibration, setting of damping system, filtering, and adding positive and negative bias forces for calibration, the measurement accuracy is improved as much as possible. The thrust range of the measurement system is 0-20mN, the resolution is less than 5μN, and the measurement error is less than 0.1%. To analyze the relationship between the power supply voltage, current, propellant flow, and the thrust of the electric thruster, we measured the thrust of a miniature ion thruster. Based on the measurement data under various working conditions, we try to build and train the PBF neural network model to predict the thrust of the miniature ion thruster.

Static and free vibration analysis of functionally graded shells using non-polynomial quasi 3D shear deformation theory

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Abstract. This paper deals with the bending and free vibration analysis of functionally graded cylindrical, spherical and hyperboloid shallow shell panels using tangential non polynomial quasi 3D shear deformation theory with eight degrees of freedoms (DOFs). The present theory assumes parabolic variation of out-of-plane stresses and satisfies traction-free boundary conditions on the top and bottom surfaces and does not require a shear correction factor. Power law is used to take into account the variation of properties of shell panels across the thickness. The accuracy and efficacy of the present theory and finite element model is validated with the results available in literature. For the analysis, various types of shell panels with different material properties, gradation, thickness ratios, aspect ratios, curvature ratios and boundary conditions are considered. The effects of these different geometric and material properties on transverse displacement and natural frequencies are examined in detail.

Connectivity Preserving Multi-Spacecraft Formation Control for Trajectory Tracking with Obstacle Avoidance

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Abstract. In order to make the multi-spacecraft formation flying safer, this paper designs a connectivity preserving multi-spacecraft formation tracking control algorithm with the ability of inter-collision avoidance and obstacle dodging. By combing the concept of consensus, a distributed control law for multi-spacecraft formation configuration and maintenance is designed. Then the proposed formation control law is expanded to trajectory tracking while achieving the safety requirements, including inter-collision avoidance, obstacle dodging, and connectivity preservation. Both formation control schemes are proved convergent by applying Barbalat's Lemma. The effectiveness of proposed control schemes is demonstrated through extensive simulations in the environment with multiple obstacles.

A numerical study of integrity of Z-pinned laminates

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Abstract. Many industries like aviation, automobile, rocketry, and missiles require structural materials with high specific strength, stiffness, and fatigue life. This has led to dramatic growth in the use of fibrous composite structures. However, in composite structures, joining two or more parts is not simple, like welding, clamping, or riveting of metallic parts. Metal fasteners can be used for joining parts, but drilling holes induce fatigue damages, structural failures and increased cost of drilling holes with high dimensional accuracy. Many methods like stitching, weaving, braiding, tufting, Z-pinning, etc., have been developed to fulfill this requirement. Z-pinning is a new technology that is better than metal fasteners as it results in uniform load distribution around the joints, less moisture ingress, improvements of delamination toughness, and prevention from fast (unstable) fractures. In this study, the effect of fillers' stiffness, Z-pin diameter, Z-pin density on stress distribution in plate, and load share of pins have been analyzed numerically. A square plate with 6% volume fraction of pins, made of different materials, has been considered. FEA analysis of stress distribution for three cases of loadings (tensile, shear, and transverse) is carried out. Subsequently, the filler diameter has been reduced, and filler density has been increased at a constant Z-pin volume fraction to understand its effect on load re-distribution mechanisms. An analogy of springs in series and parallel has been considered for a basic understanding of load shares of pin and ply.

Performance analysis of rough surface multi-recess porous hydro-static thrust bearing

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Abstract. This article presents numerical simulations of porous hydro-static thrust bearing considering surface roughness effect and shear thinning behavior of lubricant. Rabinowitsch fluid model is used to describe the shear-thinning of lubricant. An average film thickness model (Patir and cheng) has been used and surface roughness is described along with transverse, isotropic, and longitudinal orientation on the runner and thrust pad surface. The generalized form of the non-Newtonian Reynolds equation has been solved using the finite element approach. The effect of permeability of porous layer, flow coefficient of lubricant, and roughness orientation is analyzed on film pressure, load-supporting capacity, lubricant flow rate, stiffness, and damping parameters. It has been found that the use of porous layer and shear thinning of lubricant adversely affects the abovementioned performance indices. However, the presence of surface roughness tends to improve the load supporting capacity, stiffness, and damping parameters of bearing.

Transverse-only VIV of a freely vibrating hybrid cylinder at low Reynolds number

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Abstract. Vortex-induced vibration (VIV) of a rigid hybrid cylinder (i.e., amalgamated geometry of front of a half diamond cylinder and rare end of a circular cylinder) of finite length subject to uniform steady flow is investigated numerically. The vibrations of the cylinder are confined only in the transverse direction. Simulations are conducted for a constant mass ratio, $m*$ of 10, at a constant Reynolds number of 100 over a reduced speed, $U*$ range of 1 to 10. In the present work, observations focus on the response, aerodynamic coefficients and flow features.

A quasi-longitudinal study of the effect of hemodynamical parameters on the biomechanics of rupture in Abdominal Aortic Aneurysms

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Abstract. Maximum transverse diameter, routinely used as a clinical metric in Abdominal Aortic Aneurysm (AAA) management has been insufficient to accurately stratify rupture risk. In this study, a biomechanics-based approach is employed aiming to establish a relationship between maximum transverse diameter and hemodynamic parameters that are indicative of disease progression. A numerical methodology is used on six idealised, axisymmetric AAA models of increasing maximum transverse diameter representing disease progression. Additionally, a comparative hemodynamic analysis of the effect of four different inlet velocity profiles is performed. The results indicate a flow field with similar vortical structures forming in the aneurysmal sac, changing in intensity with increase in maximum transverse diameter. This is represented through elevated time-averaged wall shear stresses (TAWSS) in the distal neck region of the aorta in the largest aneurysm (3.16 Pa). However, the elevation of TAWSS in smaller aneurysms is observed to be sharper than those in large aneurysms indicating an elevated rupture risk for smaller aneurysms even below the clinical metric of 55 mm. The plug inlet velocity profile showed the highest (8.81 Pa) TAWSS indicating jet-like flows in the aneurysmal sac. Current clinical management of AAAs will greatly benefit by bringing in additional insights through biomechanical analysis.

Effect of oblique shocks interaction on the inlet structure in a hypersonic flow

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Abstract. Scramjet inlets is a vital component whose design has a significant impact on the engine's overall performance. The shock interaction in the inlet region influences the structure with pressure and temperature variations. In the present study, shock interaction effect on the structure in an scramjet engine kind of inlet is investigated. The inlet region with shock interaction condition is imitated with the like family oblique shocks using the opposite wedges. The hypersonic flow of free stream Mach number 5.5 to 7.5 is generated using the shock tunnel setup and the pressure variations are analyzed using fast-reacting pressure transducers. Shock interaction location is positioned in the inlet region by varying offset distance and wedge angles. The experimental testing model is designed and in parallel CFD simulation works are in progress.

A Numerical Study on the Negative Lift and Point of Non-linearity in Lift Curve of NACA 0012 Airfoil at Low Reynolds Number

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Abstract. In the present numerical study, incompressible flow around a NACA0012 airfoil is investigated to understand the negative lift and point of non-linearity as seen in its lift curve. Numerical simulations are performed using a finite volume-based CFD solver at a Reynolds number of 4.0×104. We found a higher-pressure gradient and a greater static pressure magnitude region on the upper airfoil surface, which creates a net negative circulation around the airfoil, resulting in a negative lift at a small positive angle of attacks. However, as the angle of attack increases, the pressure on the lower airfoil surface becomes more significant than the pressure on the upper surface along the entire chord, leading to recovery from the negative lift and eventually producing a positive lift. It is further noticed that at enhanced flow turbulence intensities, the pressure difference between the airfoil surfaces is suppressed, reducing the negative lift value. In addition, we observed a point of non-linearity on the lift curve at a moderate angle of attacks for which flow features around the airfoil are thoroughly analysed.

Performance Analysis of Autonomous Flight Models Based on Reinforcement Learning for Military UAV

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Abstract. In order for UAVs (Unmanned Aerial Vehicles) to perform their mission successfully without the control of human pilots, they must recognize the surrounding environment and fly autonomously while controlling the movement of airframe. The existing control methods for UAVs have been developed based on mathematical models. However, the mathematical models cannot control contently if the surrounding environment changes suddenly because the mathematical model has uncertainty. To solve this limitation, we conducted study on autonomous reconnaissance flight of the military UAVs based on deep reinforcement learning in which the UAVs can detect and avoid obstacles and fly to the destination successfully. In this paper, we propose the diverse 3D simulation environments such as cities and mountains generated using Unity for reinforcement learning, and the reward structure also. Moreover, the UAVs were trained under various hyper-parameter conditions using PPO and SAC, representative reinforcement learning algorithms. From the experimental results, we compared and analyzed the performance of PPO and SAC from the multiple perspectives. In conclusion, we confirm that using PPO in simple environments and SAC in more complex environments is more efficient in terms of mission success rate.

Aerodynamic Characterisation of a Re-entry Module in Supersonic Flow Regime

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Abstract. The estimation of aerodynamic characteristics is necessary for designing a re-entry vehicle. This is an essential input to study the static and dynamic stability of the configuration and also to provide inputs for structural, thermal and trajectory design/ analysis. Studies related to the flow field simulation based on CFD and the aerodynamic characteristics of a typical re-entry body, crew module, in supersonic flow regimes, are presented in this paper, along with the detailed analysis. CFD++, a commercial RANS solver with 2-equation realizable κ-ε turbulence model, is used for the 3D simulations, along with Pointwise, for structured grid generation. The effect of Mach number (ranging from 1.2 to 4) and angle of attack (ranging from 0◦ to -15◦) on CP, CL, CD, CL/CD and Cmcg, is thoroughly studied, after validation of the results at M=4.

Numerical Study of Tilted Multi-Storied RCC Buildings on Shallow Foundations Considering Soil-Structure Interaction

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Abstract. Tilt and settlement of mid-rise RCC buildings with shallow foundation in alluvial soil of greater Kolkata has become a common problem. It greatly affects the overall structural stability of these buildings and demands accurate investigation. Tilt & settlement monitoring to assess the verticality and non-destructive tests to assess strength & quality of concrete are practiced in real life situation, which cannot infer the overall building stability. Numerical modelling with fixed supports may address the stability issue to some extent but the soil-structure interaction seems to contribute to a great extent on the stability of the tilted building. Earthquakes have also shown that structures on softer soil are more vulnerable. Thus, stability analysis of various RCC buildings with different structural configuration with various tilt considering soil-structure interaction seems to be significantly important. Numerical study of building models on finite element platform considering different soil types, nature and extent of tilts, building configurations etc. have been made. It is found that the soil type, soil-structure interaction, building configuration have significant role on the stability of these tilted buildings. The present study may be explored for real life application of safety evaluation and retrofit of existing multi-storied tilted RCC buildings.

Numerical simulation of wind-driven rain on gabled roof buildings

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Abstract. Methods based on the Lagrangian particle tracking (LPT) model are commonly employed in the wind-driven rain numerical simulation. However, classical LPT methods require large number of raindrops to obtain accurate WDR intensity distribution on the facade. One of LPT methods named Finite Panel Method (FPM) proposed recently could reduce the require of the number of raindrops by panel division and WDR intensity reconstruction. Nevertheless, the trajectories ended on the corner of the panels are needed to be correctly acquired to ensure the accuracy. In this study, an efficient way to calculate the required trajectories that the terminates are given beforehand is established, and the WDR intensity on a gabled roof building is investigated by the present methods along with the FPM. Results indicate that the number of raindrops required in the present methods could be reduced by 1 to 2 orders compared with the shooting method, and the discrepancy of the maximum WDR intensity between the classical LPT method and the present method is 7.9% in the vertical windward façade and 0.7% in the gabled roof. It can be seen that the present method could accurately calculate the WDR intensity and need lower effort to compute the raindrop trajectories.

Research on Modeling Method of Complex Load Transmission

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Abstract. In this paper, the rocket body is regarded as a Euler-Bernoulli beam with variable cross-section and variable elastic modulus. a research on load modeling methods is carried out for a given complex force transmission model and is applied to developing related engineering analysis software. First of all, for a given load transfer model, a research on modeling method of statically indeterminate force transfer based on the McCauley singular function method is carried out, and a statically indeterminate force transfer load analysis engineering method is established. Secondly, on the basis of the first step, a statically indeterminate force transfer engineering analysis software is developed. Then the robustness and operability of the software are tested to ensure that the software has the ability to analyze engineering problems. Finally, the developed software is used to perform load transfer analysis on the given engineering model. The force transmission error between the developed software and large-scale commercial software is compared and analyzed, and the influence of uncertain factors in the model on the complex force transmission of the load is studied. This software has certain theoretical opinions and practical value for the load engineering analysis during the preliminary design of the rocket.

Numerical Simulation of flow over blunt body with Passive Control Technique

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Abstract. The aerodynamic design of hypersonic vehicles requires the accounting of complexities such as high-temperature effects, thin shock layer, and viscous interactions. These effects become more formidable with increasing altitudes and higher flight speeds. Hypersonic vehicles must be thereby able to withstand severe aerodynamic surface heating, as well as the mechanical loads acting on them and their reduction, plays an indispensable role in the design. The techniques being developed are broadly classified as active and passive flow control techniques. The former includes the use of a jet spike at the nose cone of the blunt-body, while the latter uses spikes and cavities or a combination of both. The use of a spike at the tip of the blunt-body happens to be the simplest and efficient technique in comparison to other passive methods. This study focuses on the method of reducing wave drag using aerospikes. The hemispherical structure is chosen as a basic model because it offers a good heat distribution. Through this work, the effect of aerospike, with different spike heads – pointed, flat, and hemispherical – has been investigated. It is observed that the presence of a spike generates a weaker tip shock, leading to the formation of a separation zone on the spike stem due to the adverse pressure gradient in the boundary layer region. Also, the formation of a shear layer separating the main flow and recirculation zone along with the reattachment shock on the main body, aids in reducing the drag.

LES of a Swirl-Stabilized Turbulent Kerosene Spray Flame in a Model Combustor

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Abstract. Kerosene is widely employed as aviation fuel of aeroengines. The combustion of kerosene spray is quite complex, which involves atomization of the fuel jet, breakup of spray droplets, and turbulent mixing between kerosene vapor and air. Large-eddy simulation (LES) is a useful high-fidelity numerical technique to study the complex multiphase turbulent combustion phenomena in kerosene flames. In the present study, flamelet generated manifold (FGM) chemistry tabulation approach is coupled with artificial thickened flame (ATF) model to describe the burning of kerosene under the LES framework. The FGM-ATF-LES approach take the complex chemical kinetic effects of kerosene combustion into account with a minor computational cost. A swirl-stabilized turbulent kerosene spray flame in a model combustor is investigated with the proposed FGM-ATF-LES approach and the overall partially premixed flame characteristics are well predicted by the LES simulation.

LES of compressible round jet impinging on a flat isothermal plate

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Abstract. Large eddy simulations(LES) of highly subsonic round jet impinging on a circular flat plate is carried out using high order compact finite difference scheme. An explicit filtering using approximate deconvolution method is applied. The Mach number of the jet is taken as 0.9 and Reynolds number is 50000 based on the jet diameter and center line velocity of the jet. The distance between the jet inlet and flat plate is taken as eight times jet radius. Isothermal, no slip wall boundary condition is used for flat plate. The complex flow phenomena of the impinging jet are studied. The mean flow variables obtained show similar behavior as reported earlier in the literature. From the instantaneous pressure field, it is observed that acoustic waves from the impingement region is travelling in the upstream direction towards the inlet inside the jet as well as outside the jet.

Robust flutter analysis of a sweptback wing using μ method

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Abstract. The present work deals with robust flutter analysis of a sweptback wing in the presence of structural and aerodynamic uncertainties. The methodology adopted is based on the concepts of linear fractional transformation and structured singular value (μ) method. Here, the uncertain aeroelastic system is constructed by introducing uncertainties in the modal stiffness matrix and unsteady pressure coefficients. Then, using linear fractional transformation, the uncertain aeroelastic system is transformed into a feedback loop consisting of nominal aeroelastic model and block-structured uncertainties. Finally, structured singular value (μ) analysis is conducted to find robust stability of the wing under the given set of uncertainties at various flow conditions. The robust flutter boundary obtained from the present approach is also compared with experimental data.

Risk assessment of cerebral aneurysms using FSI

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Abstract. The transient cerebral hemodynamics in weakened arterial sections is modeled using FSI to evaluate the risk of initiation of an aneurysm. Following the validation of the model, a qualitative analysis is done by simulating a sinusoidal pulse in the Circle of Willis. The results show that critical hemodynamic parameters at different locations are affected disproportionately due to wall weakening. The stresses are observed to be concentrated near the bifurcations. Though constrained by the idealistic assumptions in the geometry and boundary conditions, the study is able to capture the hemodynamic variations at critical regions.

Icetacm2021-Experimental Study of Flow Behaviours of Fly Ash Slurry with And Without Chemical Additives

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Abstract. In a thermal power plant, both fly ash and bottom ash cause a lot of damage to the environment. Keeping the environment in mind fly ash and BA (bottom ash) are transported through pipelines as slurry which is also economical than other transportation method. The aim is to investigate experimentally fly ash flow characteristics with and without chemical additions to coal ash concentrations ranging from 30 to 50% by mass. Cetyl Trimethyl Ammonium Bromide (CTAB) which is a cationic surface active agent and Sodium Salicylate (NaSaL) anionic surface active agent are used in equal proportions ranging from .01to 1% of total coal ash slurry. It is demonstrated that when the solid concentration is 30-50 percent by mass, all samples act non-Newtonian and match the Herschel-Bulkley model with shear thickening characteristics. It is noticed that the degression rate is slow over 200 s-1 shear rate for all chemical compounds tested. The experimental results reveal that as the percentage of chemical additives increases at the same shear rate, the degression in shear stress decreases. It is also discovered that shear stress is reduced when only CTAB is used. BA at 30% by mass with CTAB & NaSaL (1:1) doses demonstrates various tendencies. As the dosages of additive increase (0.5% & 1%) the shear stress increases with increase in shear rate. Viscosity drops rapidly at low shear rates up to 150 s-1, after which the degression rate slows.

Study on Multiscale Modelling Method for Investigation on Damage of Wind Turbine Composite Blade

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Abstract. In this work, 1 MW class horizontal axis wind turbine blade configuration is properly sized and analyzed using the newly proposed aerodynamic design procedure and the in-house code developed by authors, and its design results are verified through comparison with experimental results of the previously developed wind turbine blade. The wind turbine structural design is carried out using the Glass/Epoxy composite materials and the simplified deign methods by the netting rule and the rule of mixture. The structural safety of the designed blade structure is investigated through the various load case studies. Finally, multiscale modeming method for investigation on various damage of designed blade was performed.

Design and Numerical Study of Variable Geometry Scramjet Inlet for Mach 5 to Mach 7

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Abstract. A two-dimensional generic variable geometry scramjet inlet is devised to operate within a range of Mach number 5 to 7. For optimum performance of the scramjet inlet, the shock on lip condition is desirable. This paper focuses on achieving this condition through the displacement of the cowl backward at off-design Mach numbers. To validate the results, the numerical simulation platform of Fluent/MATLAB has been used. Specific performance parameters, i.e., pressure recovery factor, compression ratio, kinetic energy efficiency, and capture area, are analyzed using Reynolds average Navier stokes equation (RANS) and standard K- turbulence model. For discretizing the convective terms, QUICK (quadratic upwind interpolation for convective kinematics) is used. Examining the results, it is found that there is a marked improvement in the performance at off-design conditions when the variable design is implemented to the scramjet inlet compared to the fixed geometry.

Ensemble Machine Learning Methods for Unsteady Aerodynamics Modeling using Flight Test Data

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Abstract. Aerodynamic modeling from the flight data involves a process of identifying the aerodynamic model from the observed input and output data. It has an important contribution in the field of aerospace control and guidance design, performance characterization, aerodynamic database design, fault detection and diagnosis etc. In last few decades, several methods are reported in the literature to estimate these models. Apart from the conventional methods such as: equation error method, output error method, filter error method, data-driven based methods also have grabbed the attention. These methods use the principle of artificial intelligence and machine learning. In this work, two ensemble machine learning based methods namely Bagging and Boosting are proposed to model the unsteady aerodynamics of the aircraft from flight test data. Bagging creates a predictive model by combining multiple decision trees which are trained on different input-output datasets using the bootstrap. Boosting creates a predictive model where trees are grown sequentially based on previously grown trees and each decision tree fit on a modified version of the data. The efficacy of these two data-driven methods is examined and validated by estimating the force and moment coefficients of the standard research aircraft. Estimated results of the proposed methods are statistically analyzed and observed as vastly correlated with measured data and having significantly less root mean squared error (RMSE). Also, these estimated aerodynamic force and moment coefficients are compared with the estimated coefficient model from conventionally and most popularly used maximum likelihood estimation (MLE). Estimated results found to be on par with the MLE predicted aerodynamic models. Moreover, Bagging and Boosting based methods do not require to solve the equation of motion, and this advantage can be seen for generalized applications of nonlinear modeling such as load estimation, aeroelasticity, and fault diagnosis, detection and identification.

Robust Navigation with NavIC Software Receiver using Vector Delay Lock Loops

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Abstract. INTRODUCTION AND OBJECTIVES In harsh and challenging environments like urban canyons, the NavIC receiver experiences a sudden blockage of one or more satellites at any given time. In this scenario the positioning accuracy with the traditional scalar tracking loops of NavIC receiver gets severely degraded. The traditional GNSS receiver tracking architectures are vulnerable and not able to provide desired positional accuracy in these conditions. The Non-Line of Sight (NLOS) signals from the reflections of buildings or objects degrades the code and carrier frequency measurements, which results in the loss of lock of the code and carrier of the tracking loops. Consequently, the pseudo range and Doppler measurements are degraded. So, advanced methods like vector tracking architectures have been adopted recently to overcome the effects of temporary blockage of satellites or outages and interference especially in urban environments for autonomous navigation applications. The traditional scalar tracking loops in a GNSS receiver works independently for each channel. They don't take the advantage of available information like position, velocity and its errors for estimating the frequency and phase of the code and carrier. There is no exchange of information among the tracking channels, which can be derived from the user position. In a traditional GNSS receiver, the navigation solution is calculated using pseudorange and pseudorange rate observations i.e. code phases and carrier frequency observations, estimated only from the tracking loops. This inherently available information/advantage is exploited by the vector tracking loops, where aiding from the strong tracking channels to weak channels takes place. The performance of vector tracking loops is better than traditional tracking loops. In the Vector tracking loops, code phases and carrier frequency observations are calculated by projecting the relative position and velocity between the receiver and corresponding satellite in LOS direction. The aim of this paper is to implement and integrate vector tracking loops with Extended Kalman Filter (EKF) specifically VDLL (vector delay lock loop) into NavICSR, where NavICSR is a post-processing based time-synchronous software receiver implemented in MATLAB for the Indian Regional Navigation Satellite System (IRNSS/NavIC) at Research and Training Unit for navigational Electronics (NERTU) of Osmania University [1]. Initially it is developed from the open source GPS project of Dennis M Akos. At present, the proposed algorithms [2-5] for Vector Tracking Loops are verified with the IF data collected from RF front end. However, we are also expecting to get a GNSS simulator including NavIC signals, which will generate IF data for the given dynamics of the receiver. So, performance of NavIC Software Receiver (NavICSR) with vector tracking architectures will be compared with the traditional scalar tracking architectures and the results will be presented in this paper. The scalar and vector tracking loop architectures are implemented in this study. The experiment will be carried out with the IF data collected from an RF front end connected to antenna and software receiver or simulated IF data collected

in a file for static and dynamic conditions. This study enhances the NavICSR capability to deliver the PVT or navigation solution for dynamic IF data. This paves the way for NavIC research community to do further research and development using NavICSR in different challenging or signal degraded environments.

Development of drone-mounted mechanism for multiple fruit harvesting

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Abstract. The drones had been developed mainly for military purposes. Recently, the applications are expanding to various fields such as construction, geographic mapping, shipping, delivery, and agriculture. In particular, the use of drones in agriculture is rapidly expanding every year. In this article, we propose a drone-mounted mechanism for fruit harvesting to relieve labor shortage and improve safety of the farmer in the expanding smart agriculture market. The proposed mechanism is deployed with a telescopic method to approach the fruit and then harvest the fruit. By using only one motor, power consumption is minimized and more payload for harvested fruits is allocated. In addition, since telescopic method is realized by employing the rack and pinion gears, rigidity is secured. Therefore, multiple fruits can be harvested by pruning and grasping based on one time activation of the mechanism.

Wake Dynamics of a Flexible Flapping Filament at Low Reynolds Number

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Abstract. This study investigates the dynamical behaviour of the flapping filament subjected to a uniform inlet velocity at a low Reynolds number, considering the heaving amplitude as a bifurcation parameter. A discrete forcing immersed boundary method (IBM)-based inhouse fluid-structure interaction (FSI) solver is used for the present simulations. The flapping response transitions from periodic to aperiodic state as the bifurcation parameter is gradually increased. An interesting flow-field transition is observed in the corresponding trailing wake. At lower heaving amplitude, the flow field is periodic with a von-Kármán wake. As the heaving amplitude is increased, the von-Kármán wake transforms into a symmetric bifurcated wake, preceding a robust aperiodic state observed at a higher heaving amplitude.

Experimental study of inflight icing conditions on coefficient of pressure distribution around NACA0012 aerofoil

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Abstract. Since the beginning of civil aviation, ice accretion on aircraft has been a great matter of concern for flight operation and has posed a serious safety issue to its overall performance. The foundation of such weather-related and, sometimes, unpredictable occurrences lie with the changes in properties of air. The outcomes of earlier research activities in the field of ice accretion study have inspired scientists to go deeper into the phenomenon and unfold the mystery of ice accretion. A good amount of data collection, interpretation and visualization is necessary to derive the cause of ice accretion and the way to lessen it. Hence computational and experimental methods need to get complemented by the outcomes of other techniques. An attempt to study ice accretion for a clean and a rough NACA0012 aerofoil has been made. The complexity of the ice accretion situation over an airfoil needs to be thoroughly investigated as far as aerodynamic performance issue is concerned in the operation of aircraft. The impact of inflight icing conditions on the pressure coefficient variation around an aerofoil is significant. The pressure coefficient is one of the important aerodynamic characteristics that predicts the performance of the aerofoil. The icing conditions have been generated artificially around the aerofoil and experiments have been conducted for different conditions to note the impact of icing on the value of pressure coefficients. The experiments have been conducted using subsonic wind tunnel. Two grades of sand-papers (P120 and P220) have been used to emulate the roughness of ice. The arrangement for icing condition has been simplified to suit the need of the study. Numerical simulations have been done to verify the aerodynamic characteristics such as coefficients of lift and drag. Since ice accretion simulation needs to go through the fundamental steps such as the simulation of external flow, water droplet simulation and finally ice accretion, the FENSAP-ICE (Finite Element Navier-Stokes Analysis Package for Inflight icing) has been implementation to carry out all these simulations. The basic governing equations for the above-mentioned steps have been solved by the individual solver components like FENSAP (a finite element Navier-Stokes) for external flow, DROP3D for droplet solution and ICE3D for ice accretion.

Modelling and analysis of winglet morphing for aerial vehicles

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Abstract. This paper presents a study of the design of a wing-mounted with a morphing winglet, along with its aerodynamic and structural analysis. The concept of span-wise morphing of winglets is proposed as it is an effective technology for enhancing aerodynamic efficiency and has the potential to replace conventional control surfaces. Further, the main advantages of variable span morphing winglets are the drag reduction that leads to an increase in range and endurance of the flight. The design includes a honeycomb core placed in between the skin of the winglet where span-wise morphing occurs to increase the structural integrity. Two actuators are used which are fixed at the rib of the winglet to carry out the span-wise morphing of the winglet. For aerodynamic analysis, ANSYS Fluent solver is used to investigate a flow field in a three-dimensional wing structure and to obtain lift/drag variations. Static structural analysis has been performed on ANSYS Mechanical solver to obtain the deformation, stress, and strain variation. It was observed that a 25% extension in span leads to a 4% increase in overall L/D. This shows that morphing in winglets can be a profound way to increase the aerodynamic efficiency of aerial vehicles.

Effects of jet flow on wake of high-speed train

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Abstract. The wake region of high-speed trains usually consists of shear layers, shedding vortices, separation and reattachment regions, and a pair of large anti-symmetric rotating flow vortices, The rapid formation and shedding of vortexes not only increase the pressure resistance of the head-to-tail vehicles, but the periodical variation of vortex pair also affects the lift force and side force of rear vehicle seriously, which affects the stability of train operation and the comfort of passengers, as well as the passengers on the platform and workers along the railway line. In this paper, numerical analysis method is adopted to study the jet flow, starting from the wake vortex generation source, the jet flow is controlled by setting jet groove, and its mechanism and effectiveness are studied, Through comparative analysis, the effects of jet flow rate, jet direction on wake are obtained. Some results are shown as follows. 1. Jet control has an obvious influence on the aerodynamic lift force of the tail car, which changes from positive lift force of the tail car to negative lift force. The strength of the wake field is obviously weakened, which improves the safety and stability of train operation. 2. By comparing the effects of different jet flow rates, it is found that the negative lift of the rear vehicle increases with the increase of jet flow rate, and the wake vortex structure decreases with the increase of jet flow rate. The jet flow has a slight influence on the aerodynamic resistance of the train. When the jet Angle is 0, the low jet flow can reduce the drag, while the high jet flow can increase the drag. Therefore, the jet should be set up according to the actual situation. 3. By comparing the effects of different jet angles, it is found that the negative lift of the trailing vehicle increases first and then decreases with the increase of the jet Angle, the drag of the trailing vehicle increases with the increase of the jet Angle, and the trailing vortex structure increases rapidly with the increase of the jet Angle. Therefore, 0° Angle should be the best state for jet control.

Experimental Prediction of Wind Flow and Pressure Distributions Around a Low-Rise Building

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Abstract. The wind flow over low-rise buildings lying in close vicinity in urban areas generates flow interference effects. The wind-related issues are more complex to comprehend when there is a cluster of buildings and wind flow over each of these buildings gets affected due to the presence of another. One of the primary reasons for any physical phenomenon around an earth-fixed bluff body such as a building is the pressure and its distribution. To understand the significance of wind flow phenomena, it is necessary to study the pressure distribution around a building model. Experiments have been conducted in a subsonic wind tunnel to verify the numerically obtained pressure coefficients(Cp) over a single low-rise building with and without an opening shown in fig.1. Three different wind speeds such as 10 m/s, 15 m/s, and 20 m/s have been considered during the experimental study. For the numerical computation of Cp, the wind speed of 20 m/s was taken. The comparison between the experimental and numerical values of Cp has quite satisfactory. The effect of an opening through the walls at the bottom of the building and a cluster of prismatic buildings has also been considered for the study. The Cp distribution around a single building inside a cluster was also noted and compared with the Cp values for an isolated building.

LES of shock-turbulence interaction in a Bell-shaped Convergent Divergent Nozzle.

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Abstract. High-order accurate large-eddy simulation has been carried out for a compressible flow through a convergent-divergent nozzle with bell-shaped divergent portion. An explicit filtering using approximate deconvolution method is applied. The nozzle has isothermal walls and circular cross-section. The incoming flow is a turbulent, subsonic fully developed pipe flow at M=0.4 and friction Reynolds number 216. An adaptive filter is also used to stabilize the shocks. There is a smooth transition from subsonic flow to supersonic flow in the convergent section, reaching M=1 at the throat. However, with the exit to inlet pressure ratio of 0.6 a shock train develops in the bell-shaped divergent section of the CD nozzle.

A study on Applicability in Super Cavitation with SLBM

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Abstract. This study is about technical analysis in launching SLBM of North Korea. We expect that North Korea develop ICBM and SLBM by improving the technique called R-27. Also it is expected that they attempt to achievement in covertness and ambush by completing technique of cold launching. Recently, SLBM of North Korea rised 40 ~ 50 m on surface after launching in an underwater when they showed the scene of firing SLBM. We expect that they actively use not general technique but super cavitation technique. Also, they might improve the launching technique by doing SLBM launching test. This type is about that whole rocket is separated two parts and ignited with high velocity and we might think that 1st rocket is used in solid propellant to maneuver in high velocity in an underwater. After then, they might use liquid propellant for the long-range ballistic missile.

A Review of Predictive Control for Autonomous Flight Systems

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Abstract. In autonomous flight systems, the ability to make forecasts and cope with uncertain predictions is very important subject. There are some forecasts methods to compute real-time optimal control decisions. The objective is to find a control policy that minimizes a predicted time while satisfying operating constraintsand handled by optimizing over multiple uncertain forecasts. In this case, performance index and operating constraints take the form of functions defined over a probability space, and the resulting technique is called stochastic control technich. This research has focused on predictive control design methods that systematically handle uncertain forecasts in autonomous and semiautonomous systems flight over the past 10 years. In this article, we present an overview of the approach we use, its main advantages, and its challenges for autonomous flight systems. As a result it has been presented most recent results on predictive autonomous flight control systems. It has been show how to use efficiently formulate stochastic flight control problems and improve performance in repetitive tasks.

Comparison of Full-field Solution between Virtual and Experimental Digital Image Correlation for Model Verification.

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Abstract. Traditionally, an iterative procedure is used for the calibration of material model parameters using global response of experiments that develop homogeneous strain/stress fields. The calibrated model is then used in those applications where the response are heterogeneous in nature depending on the nature loading and /or structural geometry. Generally, experimental data is affiliated with its inherent noise, whereas simulation data is much clean. Hence, some discrepancies occur while comparing the simulation data with experimental data locally. In the present work, a novel proposed procedure of virtual speckling is developed and verified for von Mises elasto-plastic model on 6000 series aluminium alloy under uniaxial tension test. Virtual speckled images of random grey intensity are first produced based on simulation elements and their successive deformation fields, then the local strain field, as well as global behaviour obtained using Digital Image Correlation (DIC) post-processing algorithm. Finally, finite element method simulation response and virtual speckled DIC response are compared with uniaxial tensile test response, which is generated using the same DIC post-processing algorithm to check the effectiveness of the proposed procedure of virtual speckling.

Effect of viscosity gradient on sperm cell motion in micro-devices

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Abstract. Infertility is growing at rapid pace and affecting 8-10 % of couples worldwide. Males are found to be solely responsible for approximately 20-30 % of infertility cases due to abnormal sperm parameters. For successful fertilization, the important sperm parameters are progressive motility, sperm concentration, and morphology. The success rate of assisted reproductive technologies (ART) depends on the selection of high-quality sperms. Microfluidic devices or lab-on-a-chip (LOC) deviceInfertility is growing at rapid pace and affecting 8-10 % of couples worldwide. Males are found to be solely responsible for approximately 20-30 % of infertility cases due to abnormal sperm parameters. For successful fertilization, the important sperm parameters are progressive motility, sperm concentration, and morphology. The success rate of assisted reproductive technologies (ART) depends on the selection of high-quality sperms. Microfluidic devices or lab-on-a-chip (LOC) devices based on ART provides an excellent opportunity to study and separate high-quality sperms as they closely resemble the natural selection mechanism involved in the fertilization process. Herein, we experimentally examine and analyse the motion of sperm cells within microchannels subjected to different viscous environments. This work presents various results on swimming behaviour of sperm cells with viscosity gradients by examining their flagellar movement in confined microchannel geometries. The swimming speed of sperms in different viscous environments is characterized by various kinematic parameters like average velocity, straight line velocity, and curvilinear velocity. The results of varying viscosity, the influence on average velocity of sperm cells has also been presented. This study can further be used to sort high-quality sperm cells based on their swimming behaviour.s based on ART provides an excellent opportunity to study and separate high-quality sperms as they closely resemble the natural selection mechanism involved in the fertilization process. Herein, we experimentally examine and analyse the motion of sperm cells within microchannels subjected to different viscous environments. This work presents various results on swimming behaviour of sperm cells with viscosity gradients by examining their flagellar movement in confined microchannel geometries. The swimming speed of sperms in different viscous environments is characterized by various kinematic parameters like average velocity, straight line velocity, and curvilinear velocity. The results of varying viscosity, the influence on average velocity of sperm cells has also been presented. This study can further be used to sort high-quality sperm cells based on their swimming behaviour.

Measuring deformation in lightweight structures with revamped DIC system: wind tunnel study

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Abstract. Introduction Aerodynamic characteristics of lightweight structures are associated with their structural deformations and viceversa. These deformations play a vital role for maneuverability and agility in structures like inflatable space antennas, gossamer structures and flapping wing MAVs. Deformations in ultralight weight structures are due to flexibility attributes and involve multiple shape changes. Flexibility induced deformations improve aerodynamic performance and assist the structure to maintain dynamic stability in a wobbly wind environment. Scale-down aerospace structures are experimentally examined in wind tunnel to address the deformation characteristics. Challenge is to estimate these deformations which are inadequate to measure with conventional motion sensors or strain gauges. Digital image correlation based non-contact measurement techniques have been established but are effective for in-house experiments with small field of view. DIC setup would require precise calibration every time and can lead to measurement uncertainty. Out of plane structural deformations also include wind induced shape change such as camber development and trailing edge deformations along with flexural and torsional deformations. Wind tunnel experiments require far field imaging system with high depth of field and resolution to capture these deformations. Field of view should also be considered when the test structure is large and deformations are to be measured at multiple locations. Methods The aim of this study is to propose a stereovision based revamped DIC system and to evaluate its effectiveness with far field wind tunnel experiments. The DIC system is equipped with a dedicated mounting mechanism with two angle fixtures. First is the azimuth rotation disc for targeting along the length of the wind tunnel test section. The pitch rotation disc is introduced to focus along the height of the test structure. DIC system is calibrated for camera parameters, pixel resolution and magnification factor under variable focal length [F]. Based on calibration data, an expression shown in Equation [1] is derived for magnification factor which can be used to obtain actual structural deformation shown in Equation [2]. The calibrated setup was installed from outside of transparent test section walls of the wind tunnel. Precisely aligned stereovision system captures the deformation images during experiments. Image correlation is performed first with calibration parameters to obtain deformation fields. m=(20.254/F)*(X-0.081) (1) XPi=ui*m (2) Azimuth and pitch angle rotation are further used to determine spatial location of any point in the test structure using correlation theory based on Euler angle transformation. The theory is also used to verify the structural deformation obtained from existing DIC method. Displacements are first obtained in pixel coordinates (expressed as ui in Equation [2]) using the transformation matrices obtained for each camera. The coordinates are transformed into actual displacements (XPi) using the pixel resolution obtained from calibration. Results from existing DIC system are compared with those obtained from the correlation theory. The suitability of revamped DIC

system is investigated from the wind tunnel experiments on lightweight structures. A large inflated parachute model is tested for its maximum inflated diameter at variable wind speeds. The DIC system effectively predicted frontal diameter after full deployment. The results are verified by the measurement of known length of cross diagonals at parachute centre. Another study is based on an ultralight weight small flapping wing model for which the wing displacement fields are determined during flapping. The DIC system with appropriate azimuth and pitch rotations, effectively predicted the flapping wing displacements. The wing displacement fields are used to obtain sectional chord deformations along the wing span. These deformations obtained from DIC system can be further used to obtain the aerodynamic forces and moments produced in lightweight structures during wind tunnel experiments. The proposed DIC system can estimate structural deformations for both lightweight and large scale rigid structures without frequent calibration.

FOV-constrained 3D impact angle and impact time control guidance

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Abstract. For a stationary target, it is necessary for multiple missiles to attack at the same time from different directions to enhance the damage effectiveness. In this paper, a three-dimensional field-of-view-constrained guidance strategy is proposed for simultaneously attacking a stationary target, which can achieve desired impact angle

Parametric perturbation studies on the behaviour of bistable unsymmetrical laminates

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Abstract. Multistable composite laminates are ideal candidates for morphing applications due to their ability to switch between multiple stable states with proper actuation mechanisms. Even though extensive works have been reported on the analysis and design of the cured shape of unsymmetrical laminates for morphing application, the effect of small parametric perturbations (in design variables) on the bistable behaviour is not profoundly assessed in the literature. Based on the numerical model developed for the analysis of bistable structures, the influences of material properties on the deformation, and stability behaviour of cross-ply laminates are determined using a set of systematic parametric studies. The study thus provides a preliminary insight into the propagation of uncertainty through the system, where the effect of small parametric changes on the bistable behaviour has been investigated. In this work, design charts exploiting the change in characteristic parameters by altering the design variables are prepared from the numerical analysis using a commercially available finite element package, ABAQUS.

Insight into the mechanism of drag reduction for a spiked blunt body

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Abstract. Blunt body shapes are preferred for nose shape of high-speed aerospace application like reentry capsule, ballistic missile, planetary probes, etc. with large volumetric efficiency and low heat distribution on the surface of the body. But these shapes at high-speed flow generate a strong detached bow shock wave ahead of the body and results in high-pressure regions between body and shock. This corresponds to a high-pressure drag which requires high fuel consumption. There are many methods by which drag can be reduced but among them, the spike method is simple and effective for reducing drag and alleviating heating problems. When a blunt body uses a spike, it reduces drag and heating by the transformation of a strong bow shock wave into weaker conical shock waves. The spike establishes a recirculation region ahead of the blunt body helping to reduce its aerodynamic drag and heating which can subsequently increase the range of flight and reduce fuel consumption.

Understanding the Strapon Separation Dynamics and Aerodynamics in Atmospheric Phase

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Abstract. During the flight of a multistage launch vehicle, use of jettisoning systems has been made to carry away the spent stages once their active lives are over. For a launch vehicle with parallel staging (strap-on) boosters, these jettisoning systems ensure collision-free separation. For majority of launch vehicles, these systems are configured by specific springs' arrangement. The paper aims at deducing the necessity of a separation system for strap-on separation. The separation motion, with variation in dynamic pressure, system configurations was studied for two strap-on separation. Separation dynamics studies (with/without aeroeffects) for single spring force system and two spring force system applied at different locations were realised along with their influence in the system. The system configuration for single spring system was discussed and the advantages of having two spring separation system were presented. The optimum configuration of two spring force system for the considered two strap-on Launch vehicle was found out along with discussion on various other spring locations configurations. 3D CFD simulations were conducted using ANSYS FLUENT on a similar simplified two strap-on launch vehicle at a typical separation event to understand the interference aerodynamics of the separation system and study the effect of various parameters involved in the strap-on separation aerodynamics.

Probabilistic Mixed Mode Stress Intensity Factors of Single Edge Cracked Laminated Composite Plates Using Stochastic Extended Finite Element Method

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Abstract. The second order statistics of mixed (first and second) mode stress intensity factors (MMSIF) of single edge cracked orthotropic composite plates subjected to uni-axially applied tensile, shear and combined loading by using stochastic extended finite element method (SXFEM) is presented in this paper. A stochastic method based on the second order perturbation technique (SOPT) and direct Monte Carlo simulation (MCS) combined with the interaction integral (M-integral) in the framework of XFEM is used in the present analysis for computation of mean and coefficient of variance (COV) of MMSIFs. The randomness is considered in the system properties such as material properties, which are modelled as random input parameters.

A robust fifth-order WENO-Z type scheme with improved accuracy at second-order critical point

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Abstract. By introducing a global smoothness indicator, Borges et al. (J. Comp. Phys., 2008) proposed a weighting method for constructing a class of weighted essentially non-oscillatory schemes (WENO-Z schemes). The fifth-order WENO-Z scheme can enhance the order of convergence at the first-order critical point and has less dissipation at shocks. However, at the second-order critical point, the convergence order of the original fifth-order WENO-Z scheme is only second order. Many efforts have been devoted to improve the accuracy of the WENO-Z schemes at high-order critical points. However, some of them don't meet the physical requirement of dimension consistency and hence result in less robustness. This paper presents a novel weighting method for constructing WENO-Z type scheme. An adaptive function of local smoothness indicators of candidate sub-stencils is designed to replace the constant 1 used to calculate the un-normalized weights of the original WENO-Z scheme. The function can adaptively approach to a small value if the global stencil contains a discontinuity and approach to a large value if the global stencil is sufficiently smooth. The square of the approximation of the fourth-order derivative, which is the highest-order derivative can be approximated on a five-point stencil, is suggested as the global smoothness indicator. Numerical results show that the new WENO-Z type scheme can achieve fifth-order accuracy at first-order critical points and fourth-order accuracy at second-order critical points. The new scheme has low numerical dissipation and is robust for solving problems with shocks. This research work was supported by the National Natural Science Foundation of China under Grants 11872067, 91852203, and 11902326.

Three dimensional computational investigation of the geometric design of delta-type vortex generators deployed in finned tube arrays

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Abstract. Incorporating vortex generators in the finned tube arrays is an effective way of modifying the flow field, thereby improving the heat transfer coefficients. But the positioning of vortex generators in the aforementioned systems is not sacrosanct due to various constraints. Since there is a strong correlation between the geometric design of the vortex generators and the resulting flow modifications, the loss in performance due to locational shift may be compensated by varying the geometric design. This numerical investigation discusses the effect of geometric changes of delta-type generators on the flow modifications, and the resulting thermal augmentations. The vortex generators are erected at a preferred location, and four different aspect ratios (viz. 1.5, 1.0, 0.75, and 0.5) are considered for a detailed study. The changes in the flow structures are analyzed by studying the velocity vectors as well as contours, which manifest in the form of higher Nusselt numbers. The span averaged local Nusselt number is found to undergo a maximum augmentation of 133.9% whereas the maximum increase in the average Nusselt number equals 125.1%.

Failure Mechanisms of SMA Reinforced Composites under Impact Loading

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Abstract. In the past few years, pseudo-elastic shape memory alloy (PE-SMA) has surfaced as one of the potential secondary materials that can be embedded in composites to dissipate a higher amount of energy in comparison to plain composites. Therefore, the aim of this paper is to illustrate the damage modes in GFRP composites embedded with pseudo-elastic shape memory alloy (SMA) under two different types of loading, quasi-static indentation and high-velocity ballistic impact. In both the cases, impact loading was applied until complete material failure.

Numerical Analysis of Structural Design Result for UAV applied to Composite Structure considering on Self-Healing Method

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Abstract. In this work, structural design and numerical analysis for air intake of aircraft engine applied to composite materials. The investigation on structural design load and aerodynamic configuration of target structure was carried out. The distributed pressure load and acceleration condition was applied to structural design. In order to investigate the structural design result, finite element analysis was performed. The stress, deformation and buckling analysis for structural safety evaluation was carried out. Finally, it was confirmed that the air intake through structural design result is safety.

A homogenized crystal plasticity model for lamellar transformed β colony of titanium alloys

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Abstract. Titanium alloys are widely used in aero-engines because of their high specific properties, excellent corrosion resistance and strength retention at moderate to high temperatures. The thermo-mechanical route followed in design of these alloys results in a microstructure consisting of primary α grains having a Hexagonally Closed Packed (HCP) crystal structure and transformed β colonies having a lamellar microstructure with alternating laths of HCP and Body Centered Cubic (BCC) phases. CPFEM (Crystal Plasticity Finite Elements Method) simulations are widely used to obtain the macroscopic properties of polycrystals as well as design of microstructure. However, CPFEM simulations for α + β Ti-alloys becomes computationally intractable as the length scales of the lamellar microstructures within the transformed β colony are considerably smaller than that of the primary α grains. To mitigate this problem homogenization of the lamellar colonies is necessary and has been proposed in this work. The homogenized model ensures traction balance and strain compatibility at the lath interface. The semi-coherent nature of the lath interface and the interaction between the two phases is also included in the analysis for an accurate prediction. The results show a better prediction of the homogenized response for the transformed β colony than the existing models.

A comparative study of recent phase-field implementations for fracture prediction in solids

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Abstract. The computational modeling of failure mechanisms in solids due to fracture based on sharp crack discontinuities is found to suffer in situations involving complex crack topologies. This can be overcome by diffusive crack modeling based on the introduction of a crack phase field. Phase-field modeling of fracture is able to effectively model crack propagation with ease compared to numerical methods based on a discrete crack model, especially for complex crack patterns. Despite the versatility in modeling complex crack topologies, phase-field fracture models are usually implemented in in-house codes, greatly restricting their potential applications. Thus, it is of vital importance to implement the model in widely used commercial software packages like ABAQUS. In the present study, two of the recent implementations of the phase-field model are evaluated. The focus of the discussion is on the robustness of these models and on their performance compared with respect to several modeling choices such as length scale parameter and the finite element mesh.

Stably electrospraying Concentrated aqueous solution with outer ionic liquid

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Abstract. Concentrated aqueous solution has been proven difficult to be electrosprayed due to its low viscosity, high volatility and large surface tension, while ionic liquids have been widely used in electrospray. In this paper, we successfully electrospray concentrated sodium chloride aqueous(NaCl) solution thorough coating it with a thin layer of ionic liquid using coaxial capillary. In this approach, we not only extend the range of the flowrate and the applied voltage where cone-jet mode of NaCl solution occurs, but also increase the spray current of the ionic liquid. The thin layer of ionic liquid largely changed the surface characteristic and weaken the strong electric field inside the liquid surface, which avoids the discharge of the NaCl solution and facilitate the formation of the compound liquid cone. During the experiment, five possible modes, dripping mode, interceptive mode, intermittent mode, compound cone-jet mode and electro-discharge mode are observed as applied voltages increases. The spray current increased more rapidly with the flowrate of NaCl sulotion than that of ionic liquid. Besides, the underlying mechanism of how the compound liquid cone remain stable has been discussed and analysed thoroughly.

Based on Natural Frequencies, Crack Analysis of Fixed Support Fibre Glass Composite Beam

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Abstract. A Fibre reinforced composites (FRCs) are a type of composite material that consists of a plastic matrix reinforced by tiny thin fibres with high tensile strength and flexural modulus. Fibre reinforced polymer (FRP) or glass reinforced plastic are other names for it (GRP). FRCs are widely utilised in aircraft and space applications, marine, automotive, and construction sectors. The E-Glass epoxy resin composite beam was chosen for this study because of its high strength, rigidity, low cost, and ease of availability. The main goal of this research is to find out if a crack exists in a fibre glass composite beam. The crack analysis is required in order to assess the fracture prior to failure, which has an impact on the dynamic properties of the structure, such as natural frequencies and modes of vibration. To examine the free vibration response of composite beams, a numerical research utilising finite element is carried out in this paper. FFT analysis and FEA validation are required to comprehend the phenomenon of crack generation and its approximate placement.

Drag and flow analysis for a car model with different vortex generators

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Abstract. The fluid structure interaction on the rear side of the automobile vehicle induced flow separation leading to accentuate the drag force. The automobiles which are propelling from the velocity of 20 m/s experiences the drag force. Hence, most of the automobiles inevitably encounter the problem of flow separation and higher fuel consumption to encounter the drag force. To reduce the pressure change, induced by the flow separation, across the vehicle the vortex generators (VG) are used and well reported in the literature. There is a lacuna of material on optimization and physical mechanism of vortex generator geometries leading to effective reduction of induced drag. In the present study, using vane type, wedge type and hemispherical type of VGs, the flow mechanism, distinctive flow features and related operating mechanism affecting the drag parameters will be analysed computationally using CFD and validated experimentally using a wind tunnel facility. The preliminary CFD study is presented here.

Experimental Investigation of Siphon breaker for Small Pipe breaks

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Abstract. Siphoning application are quite useful to cause liquid to flow uphill against gravity without being pumped for emptying or transferring liquid from one tank to another. However, in some applications siphoning should be avoided. A typical application is found in Pool type nuclear research reactors where the reactor pool water should not get drained through siphoning in case of a break in the reactor system piping. Else the minimum reactor core submergence in the reactor pool required for cooling/ shielding of the core may not be ensured. The reactor core can no longer be cooled through natural circulation using the pool water which act as a large heat sink even during reactor shut down condition for decay heat removal. Therefore, siphon breakers are important to keep the reactor safe during LOCA scenario. Size of siphon breaker depends on the system piping size, elevation difference between reactor pool water level and break location, size of break, system resistance etc. Experiments were carried out to understand characteristics of siphon breaker for small size pipe breaks relevant to research reactors. A computer program has been developed to predict the undershooting height based on different empirical models of air-water flow through piping. The effect of the various break sizes on the undershooting height is presented in this paper.

Prediction and Prognosis of structural degradation by ML and DL algorithms

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Abstract. . Aircraft is the flying machine consisting of many structural components and assemblies. It's important to know the structural health as it's related to the airworthiness of an aircraft. So to determine the health status we have many tools which mechanically give us the life cycle prediction of the structure. The research is proposed to find the structural deterioration by the Ml and Dl algorithms. The research work is to Analyzing the structure with asuitable instrument to find the deterioration or damages and building data, storing data and training the system for the analysis. Structuring data and training the system with asuitable model. Using DL and ML algorithm, predicting health status. The scope of the research could be used in the following fields. • It could be new innovation in the structural health assessment by Dl and ML • It could reduce the millions of rupees on regular inspection, checks and repairs. Hence reduces the maintenance cost. • Could be a substitution for FEA and alternate for physical instrumentation on board. • Could be used to predict future of the structural life of an aircraft.

Numerical investigation of discharge mechanism and plasma behavior in an external discharge plasma thruster

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Abstract. External discharge plasma thrusters (XPTs) have been proved as efficient as conventional Hall thrusters. In that discharge channels are eliminated in XPTs, the ionization process occurs outside the thruster. Accordingly, they have the advantages of low wall erosion rate and long lifetime. Therefore, XPTs can meet the high precision orbit maneuver requirement of cube-satellites and micro-nano satellite networking systems. In this paper, a two-dimensional axisymmetric particle-in-cell/ Monte Carlo Collision (PIC/MCC) model for the discharge region is developed for an XPT, which adopt the real configuration of the literature reported XPT. The transient discharge process and the influence of operating conditions on the discharge process in the ionization chamber are presented for the first time. The influence of electron anomalous Bohm collision on the discharge process is studied to better understand the electron transport mechanism and the discharge process. Thruster performance indicators such as thrust, discharge current, the second electron emission rate, and mass utilization efficiencies are calculated. The calculation results are compared with literature experimental data under similar conditions and good agreements are reached. The simulations interpret the single-peak property obtained from experiment. These results lay a foundation for further optimization of low-power Hall thruster design in the future.

Performance Analysis of Circular and Lemon Bore Hydrodynamic Journal Bearing Considering Surface Roughness and Shear Thinning Effect

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Abstract. This article presents numerical simulations of rough surface circular and lemon bore journal bearing operating with non-Newtonian shear thinning lubricant, in turbulent regime. Numerical simulations of bearing have been performed by finite element solution of modified Reynolds equation for non-Newtonian lubricant. Rabinowitsch fluid model is used to define the shear-thinning nature of lubricant. Surface roughness has been modelled using the average film thickness model proposed by Patir and chang. The effects of orientation of surface roughness, turbulent flow (Reynolds number) and fluid flow coefficient are investigated on film pressure, minimum film thickness, frictional torque, stiffness and damping coefficients of bearing. It has been found that lemon bore bearing outperforms circular bearing in terms of above-mentioned performance indices. Turbulent flow condition is a notice to provide a higher value of minimum film thickness, stiffness and damping coefficients but at the expense of higher frictional torque. Roughness on the bearing surface tends to offer a high value of film thickness but also enhances frictional torque. It has been found that the transverse orientation of surface roughness is favourable for a higher value of stiffness coefficients, whereas the longitudinal orientation of surface roughness is favourable for better damping capabilities in the journal bearing system.

Transient Low Velocity Impact Response of Functionally-Graded Rectangular Plates – A Finite Element Approach.

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Abstract. This work presents the low-velocity impact response of functionally graded rectangular plates using finite element methods. Functionally-graded materials are advanced materials in which the material properties vary continuously along the thickness. Analyses are performed for an impact event that occurs between a spherical projectile and a cantilever functionally-graded plate for different FGM plates of varying constituents. First order shear deformation theory (FSDT) is implemented to derive the governing equations of motion. The modified Hertzian contact law is employed to calculate the contact force resulting from plastic indentation. The FGM properties are derived based on the established power-law accounting for the graded characterization of the material properties across the thickness direction. The time dependent equations are solved by the Newmark's time integration scheme. An eight noded iso-parametric shell element is employed to derive the stiffness matrices of the FGM plate. The transient response of FGM plates are obtained for different FGM constituents (Al/Al2O3, Al/ZrO2, SUS3O4/Si3N4, Ti-6Al-4V/Al2O3 and Ti–6Al–4V/Aluminium oxide) by varying parameters like power law index keeping plate-thickness ratio constant.

An aircraft wing structural layout and cross-sectional size optimization design

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Abstract. This work presents an aircraft wing structural optimization design, in which both the layout of wing rib and the cross-sectional sizes of components were considered as design variables. The wing structure consists of composite shells and beams, which can be taken as a typical complex structural system with a certain scale. This study could be understood as an engineering application of our former proposed method. Numerical results showed that the final design could obviously reduce the weight of the wing structure, which looks quite reasonable. The efficiency of the optimization is satisfied, and the required number of structural analysis even comparable with pure size optimization, which demonstrated the practical applicability of the method.

Damage Analysis of Multi-layered Composite Structures

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Abstract. This work proposes a mathematical model for analysis of damage in multi-layered composite structures in different service conditions. At first the growth of damage in the form of delamination and matrix crack can be predicted numerically. This study also includes propagation of damage with or without matrix crack under application of static uniformly distributed load on mathematical model of 16 layered square plate and spherical shell. It is an incorporation of two methods, Virtual crack closure technique and extended layerwise method for this simulation. The extended layerwise method is used for simulation of damage like delamination and matrix crack in multi-layered composite structures while Virtual crack closure technique is used for determination of strain energy release rates in different service conditions. An algorithm is also proposed for propagation of arbitrary and changing shape type damages.

Vibroacoustic analysis of simply supported and clamped functionally graded sandwich plates under transient loading

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Abstract. Sound radiation analysis of simply supported and clamped functionally graded sandwich plates under transient loading is reported in this work. Square sandwich plate configurations of different thickness ratios are modelled using the first-order shear deformation theory to incorporate the effects of transverse shear and rotary inertia. The structural system matrices of the functionally graded sandwich plate are computed using the finite element method. The radiated acoustic pressure in the far-field is determined using the time domain Rayleigh integral which is solved numerically by an elementary radiator approach. The time history of the structural response is obtained using the Newmark Beta time marching scheme. The effective material properties of the sandwich plate are derived by considering an approximate laminated model in MATLAB where the Poisson's ratio of the constituents of the sandwich is assumed to be constant. The influence of the volume fraction index and the thickness ratio on the transient vibroacoustic response of different sandwich configurations is investigated by a detailed parametric study.

Third-Order Shear Deformation Theory for the Low-Velocity Impact Response of 3D Braided Composite Plates

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Abstract. Advanced 3D braided composites are increasingly used in the assorted fields for their distinct characteristics. The equivalent Young's modulus of the 3D braided composite is predicted based on the volume average method (VAM) using Bridging theory. A third-order shear deformation theory (TSDT) with twelve degrees of freedom per node is implemented for the Low-Velocity Impact Response of the Three Dimensional Braided Composite Plate. In this theory, the transverse displacement is the function of the plate thickness coordinate, which can predict accurate results of thick plates. The present results are generated based on the finite element procedure. The modified Hertzian contact law is implemented to calculate the contact force of the impact phenomenon. The Newmark beta time integration is utilized to solve the time-dependent governing equations. Various comparison studies are carried out to judge the accuracy of the present models. numerous parametric studies are carried out on contact force, central displacement, impactor displacements, such as the effect of the initial velocity of the Impactor, braided volume fractions, braided angle, thickness ratio, and boundary conditions.

Design and analysis of thermal control system for SSS-1 satellite

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Abstract. According to the space environment and structure characteristics of SSS-1 microsatellite, the thermal control problem under limited thermal control resources was solved. Firstly, based on the outer space hea t flow in orbit, combined with the requirements of satellite missions and thermal control, the design idea of passive thermal control as the main and active thermal control as the auxiliary is determined. Then, according to the overall layout of the satellite and its own characteristics, the isothermal design of the whole and the local thermal design of the key parts are adopted, and the finite element thermal analysis model of the satellite is established to calculate the temperature distribution. Finally, outside the ground simulation including heat flow, black background in low temperature and vacuum environment, such as satellite space environment, design and carry out the whole vacuum thermal balance test, the test results show that: under the extremely cold and hot conditions, satellite components temperature can satisfy the requirements of design index, effectively solve the SSS - 1 satellite heat dispersion and heat preservation problem, achieve the effective control of the entire satellite temperature.

An analytical approach to sense the presence of damage through electro-mechanical impedance (EMI) response for a step-lap joint

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Abstract. The present work involves the development of an analytical model to sense structural damages using EMI response of the structure. The impedance responses of a PZT-host structure with single damage present have been obtained through the developed analytical model employing Euler-Bernoulli's beam theory. The analytical model is validated with ANSYS model for a pristine state aluminium step-lap joint with a PZT patch connected to it. Disbonds present inside the structure at different areas are considered as the damage here. The impedance responses of the step joint at the PZT transducer location have been obtained through the developed analytical model for different damage scenarios. The results obtained through the comparative assessment of the impedance responses provided some reliable information about the damage status of the structure which in turn describes the applicability of the analytical model to identify the structural damages employing EMI method.

Sensor/actuator position optimization for large size structure using multi-objective optimization

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Abstract. With the increasing size of spacecraft in orbit, or the increasing size of additional flexible structures (e.g., solar sails, antennas) due to increased performance targets, the impact on the spacecraft's attitude or pointing performance that may be caused by vibrations in space from flexible structures is coming to the fore. Adding intelligent units containing sensors and actuators into the flexible structure to form an intelligent structure is an effective way to control the vibration of the flexible structure. The number of smart structures needs to be strictly controlled due to the mass constraint of the spacecraft in orbit, the energy cost constraint, and the computational cost constraint of the on-board computer. To provide more effective vibration suppression, the position of sensor/actuator should be optimized. The objective function of the sensor/actuator position optimization should be the performance index of the control system, rather than the mechanical properties in a conventional structural optimization problem. Many scholars have proposed various objective functions. The structure optimized in this paper is a large size truss structure and there are several characteristics should be considered when building the optimization model and making the optimization calculation. First, the structure is complex, and the impact of sensor/actuator placement of the structure should be considered. During the optimization process, the structural finite elements need to be rebuilt and structural analysis needs to be performed each time the position of the sensor/actuator changes. Second, the number of sensor/actuator and the number of positions that can be placed sensor/actuator both are large. This leads to a huge number of options for sensor/actuator distribution. And at the same time, there exits the possibility that some different sensor/actuator distribution has the same or similar control effect. Finally, the control method also affects the final optimization results. In this paper, we have taken several steps to ensure that the optimization can be completed successfully. We build the linear system based on the eigenvalues and the eigenvectors generated by modal analysis. Modes are selected according to the frequency band to be considered. The method of modal reanalysis was introduced to obtain the new eigenvalues and eigenvectors after a small change in the structure by relatively much smaller calculations compared with rebuild the FEM and modal analysis. We choose multiple objective functions, which are divided into two classes. One class of objective functions is independent of the control method including control force input energy maximization and sensor output energy maximization. The other class is related to the control method including total system energy storage maximization. Two classical control methods, the collocated negative feedback and LQR, are chosen in building the objective function. Several constraint functions are considered such as controllability/observability, maximum control voltage, complex modal damping ratio. The multi-objective optimization problem can be established. Multi-objective genetic algorithm is chosen in this paper. Let the structure have n positions where sensor/actuator can be arranged and use a binary string of length n to create the design variables. 1

means the sensor/actuator is arranged while 0 means no sensor/actuator is arranged. The number of sensors/actuators constraint is a constraint that strictly cannot be violated. When the number of sensor/actuator selectable positions is large, the conventional crossover and variation functions in the genetic algorithm yield a low probability that the number constraint is satisfied by the offspring. This can lead to a large number of invalid calculations, and for large size structures, the computational cost of each optimization calculation is expensive. So, we also design a new crossover improved from uniform crossover, and mutation function. Let the two individuals of the parent generation have m codes that are different. There is 2^m species of individuals gained by consistent crossover and most of them do not satisfy the constraint. We randomly select m/2 of the m different codes and assign a value of 1 to them and assign 0 to the other m/2 positions. This ensures that the number of sensors satisfies the constraint and, at the same time, that the probability of the children's codes coming from the codes of the two parents is the same. We randomly exchange the coding information at two different positions in the individual code to achieve individual mutation. By using the crossover and the mutation can make all individuals satisfy the number of sensors constraint throughout the optimization process. A sensor/actuator position optimization work for a large flexible structure of 50-meter size, whose optional positions could reach more than 200 was done and a set of sensor/actuator layout solutions was obtained. And this is the basis for control system design in future.

Dynamic Modelling of a Porous Functionally Graded Rotor-bearing System for Different Temperature Distributions

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Abstract. In high-temperature environments, delamination of layers occurs in fibre reinforced composites due to the development of inter-laminar stresses between the layers. Therefore, the traditional composites are substituted by functionally graded materials (FGMs) to mitigate the problems of delamination, residual stresses and debonding for better structural performance. FGMs are non-homogeneous micromechanical composites that are generally made from using different phases of metal and ceramic. High mechanical strength of the metal and elevated thermal resistance of the ceramic influence the structural performance of the functionally graded (FG) rotors/structures. Modelling of a porous functionally graded rotor-bearing system has been developed for various radial temperature distributions such as linear, non-linear, and sinusoidal to compute the natural frequencies. An FG rotor-bearing system, consisting of an FG shaft, uniform steel disc and linear isotropic bearings shown in Fig. 1, is considered in the present work. Power-law is used to assign the material properties along the radial direction of the porous FG rotor. Material properties and temperature are varied only across the cross-section of the porous FG shaft. By considering the effects of translational inertia, rotational inertia, and transverse shear deformations, a two-nodded porous FG shaft element with four degrees of freedom on each node (two translational and two rotational) has been developed using the finite element method (FEM) based on Timoshenko beam theory (TBT). An FEM code has been developed to compute the elemental mass and stiffness matrices of porous FG shaft. Fig.1. An FG rotor-bearing system A metal-ceramic FG shaft, whose inner core is composed of Stainless Steel whereas the outer layer is made of Zirconia, is considered to analyse the porous FG rotor system's natural frequencies for different temperature distributions to validate the modelling. An FE code is developed in Python to calculate the natural frequencies of the porous FG rotor-bearing system. The code validation has been carried out to check the correctness of the code. The natural frequencies of porous FG rotor-bearing system are computed at $\Delta T = 600$ for different power-law indices, volume fractions of porosity and temperature distributions. Since the material properties of the FG rotor decrease with an increase in the power-law index and volume fraction of the porosity, the stiffness of the porous FG shaft is decreased. Consequently, the natural frequency of the porous FG rotor-bearing system is also decreased. For $0 \leq k < 1$, the natural frequency of the system is higher compared to other temperature distribution types when the temperature is distributed using sinusoidal temperature distribution (STD). However, for $k \geq 1$, the natural frequency is the highest when the temperature is distributed using the non-linear temperature distribution law.

Vibration of a damped Euler-Bernoulli cantilever beam with a tip mass

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Abstract. We study vibrations of a hysteretically damped Euler-Bernoulli cantilever beam with lumped mass at the free end. The damping is modelled with a scalar rate-independent hysteresis. We derive Lagrange's equations for the modal coordinates. Equations include discrete hysteretic states. When a single mode dominates, the free vibrations decay exponentially, and when multiple modes are active, higher modes decay relatively faster. With harmonically forced, lightly damped responses of the beam are studied using a frequency sweep and a shooting method.

Design and Performance Analysis of Axial Flow Wind Turbine for Household Applications

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Abstract. The rural territories are confronting inconvenience because of absence of power from years. To defeat this trouble and give power through wind vitality is the best option source to deliver the power. The primary goal of present research is to plan and advancement of axial flow wind turbine with 3-blades rotor (120̊ apart each) with gearing system to produce power. The kinetic energy of wind strikes the blades of rotor tends to rotate and this wind energy converts into mechanical energy by gearing system and the mechanical energy further converts into electrical energy with help of dynamo and stores in the battery and it will be useful for the household applications. In this paper the plan, improvement and execution examination analysis of the wind turbine with 3-blades rotor system has been explained briefly and the experimental results have been compared with analytical results

Performance assessment of five probe flow analyser suitable for wind tunnel calibration

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Abstract. In the field of inviscid fluid flow studies, theoretical concept has to be developed even more. In order to make it possible, it is very important to supplement the concepts with strong experimental results. While performing experimentation, various accepts of design can be determined with factors influencing the and also required modification can be recommended in a more systematic and economic manner. Also, the aim objective of experiment is to extend the underlying theory and to produce new designs with improvements that can be great support to the advancement in technology. In experimental analysis, wind tunnels are used for the flow analysis over a flying object to be tested. Analyzing the flow plays a predominant role in aerodynamics study. The flow in the test section has to be uniformly streamlined and has to be parallel to the axis of the wind tunnel. The change in flow properties inside the tunnel with respect to the time should be negligible. So, before conducting a test process, calibration of wind tunnel has to be done. Normally, calibration of subsonic wind tunnel is done by the Pitot static tube. It has the limitations of deprived accuracy and misalignment of probe with the flow direction. Therefore, new calibrating instruments are proposed by overcoming the limitations of Pitot static tube. In this paper, experimentation using wind tunnel has been discussed and the truth flow analysis of a low-speed open circuit wind tunnel has been recorded using a five probe flow analyser respectively. Also, the results obtained have been compared with the data obtained using a pitot static probe.

Study of evolving regular water-waves under steady wind forcing

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Abstract. Numerical simulations of wavemaker-generated waves evolving under steady wind forcing are presented. The computational model accounts for effects of nonlinearity, wind input, and dissipation, as well as for the stochastic nature of wind-waves. The accuracy of simulations is assessed for a range of wavemaker forcing frequencies and amplitude by comparison of the numerical results with detailed measurements performed in a wind-wave tank

Equilibration of Van der Waals liquid drop with vapour in smoothed particle hydrodynamics

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Abstract. Smoothed particle hydrodynamics (SPH) is a Lagrangian based mesh free method, which is useful to model high deformation dynamic problems. This article presents a liquid-vapour static equilibrium model in SPH considering Van der Waals equation of state. A hyperbolic shaped kernel function and variable smoothing length is considered along with a periodic boundary condition to model liquid drop-vapour coexistence for different vapour densities. Effect of the existence of the vapour on the coefficient of surface tension is studied.

Design and development of a piezoelectric XY micro-displacement scanning stage

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Abstract. This paper presents the design, analysis, and testing of a piezoelectric XY micro-displacement scanning stage (MDSS). The stage is composed of piezoelectric actuation mechanisms (PAMs), compliant restraint mechanism, and moving frame. Due to the limited displacement of stack-type piezoelectric actuator, diamond shaped amplification mechanism (DSAM) is applied in PAM to increase displacement. Since the coupling problem in two-dimensional motion, elliptical compliant restraint mechanism (ECRM) is applied to constrain in-plane parasitic rotation and coupling error between the two motion axes of moving frame. Finite element models of DSAM, ECRM, and XY MDSS are established and structural analysis is carried out. Analysis results show that: 1) the displacement amplification ratio of DSAM is 2.08; 2) compared with the stage without ECRM, the in-plane parasitic rotation and the coupling error between the two motion axes of moving frame are decreased about 96.1%, 61.5%; 3) the first resonant frequency of XY MDSS is 586.90Hz. Moreover, a prototype of XY MDSS is manufactured, a testing system is established, and a preliminary test is carried out. Testing results show that the displacements of piezoelectric actuators are 23.17μm, 18.82μm. It follows that the displacements after magnification by DSAM are 48.19μm, 39.15μm.

Comparative study of dampers on a G+26 storey building subjected to lateral loading

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Abstract. Due to increase in urbanization, popularity of high-rise buildings has increased which are vulnerable to the effect of wind and seismic loads. In the design of these structures, dampers are proven to be effective in resisting the effect of lateral loads. In this paper, a realistic G+26 story RCC building is modelled and analysed. Structure under observation is unsymmetrical which induces torsional moments, in order to avoid that shear walls are added along with dampers. The structural response of the building is compared using pall friction damper (PFD), lead rubber bearing (LRB) base isolators, and fluid viscous dampers (FVD) as a viable energy dissipating system. PFD and FVD are provided on the corners of the structure and LRB is provided at the base. The overall performance of the aforementioned structure is simulated by performing response spectrum analysis in the different seismic zone, using ETABS. Further stability of the structure is studied for Kobe and El Centro earthquakes by performing time history analysis. Base Shear calculated by the analytical formula is 2512.7 kN which is in acceptance with the simulated model i.e. 2538.84 kN. It is observed that design parameters of FVD and PFD varies with ground motion frequency and variation of inter storey drift is least for LRB. In addition, the structural response of the PFD for the Kobe earthquake is lower than that of the others in terms of displacement and stiffness.

A Study on Vibration Characteristics of Cantilever Conical Shell Made of FG Sandwich Material with Porosity and Thermal Effect

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Abstract. Free vibration behavior of a cantilever conical shell made of functionally graded sandwich is studied using finite element method. The effect of porosity due to manufacturing defects and the effect of operating temperature are analyzed. The finite element formulation consists of an eight-noded isoparametric shell element with five degrees of freedom at each node. Lagrange's equation is employed to derive the governing equation for free vibration analysis at moderate rotational speeds where Coriolis effect is not considered. Mesh convergence study and validation of the present solutions are performed to confirm the accuracy. Isotropic metallic core and two FGM face-sheet (top and bottom) of sandwich conical shells are considered. Two type's porosity function namely even and uneven configurations are considered to model the void/defects in the FGM configuration. The material properties of FGM are varied with a simple power-law distribution of the volume fractions of their constituents through FGM face sheet thickness. First four natural frequencies are determined and Campbell diagrams are plotted for resonance study. Influences of operating temperature and porosities on the free vibration behavior are evaluated. Parametric studies in terms of twist angle, thickness ratio of core to face-sheets, rotational speed on the natural frequency are evaluated and analyzed.

Numerical study of a square plan shape building with corner modification

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Abstract. Generally, aerodynamic boundary conditions are overlooked for the design of the external shape and orientations of buildings. These designs are normally made in accordance with architectural and functional requirements. Under such circumstances, the structures are more susceptible to wind-structure interaction induced loads. The present study focuses on investigating the wind pressure developed on different faces of a square plan shape tall building. Developments in hardware, software technology along with reliable turbulence models had made the use of CFD possible for prediction of wind effects in the atmospheric boundary layer. A numerical study was performed to evaluate the performance of a square plan building with corner modifications. The study was performed using commercial code CFX with k-ε turbulence model. The faces of modified square plan model demonstrated different pressure distribution as compared to the typical square plan shape model with major differences observed in case of side faces. A square plans shape building was also investigated for compassion of results and validation of the CFD package with IS 875:2015 (Part III). For better understanding of different phenomenon occurring around the building, the flow pattern around the model was also studied in detail.

Induction Heating of Thermoplastic using Fe3O4

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Abstract. Thermosetting composites are commonly used, but these composites are increasingly being replaced by thermoplastic counterparts because thermoplastics offer an equivalent performance and can be recycled via heating. Induction welding is a fast, clean, non-contact process that uses a metal-mesh susceptor to facilitate localized controlled heating, but the metal mesh presents various problems. In this study, the induction heating behavior of a 450-μm-thick thin-film susceptor, fabricated by mixing magnetite (Fe3O4) nanoparticles (NPs) and polyamide 6/CF (30%) thermoplastic resin, was examined with respect to the weight ratio of Fe3O4 (50, 67, 75, and 80 wt%). The high induction heating behavior of the 75-wt% Fe3O4 susceptor was selected for additional heat-treatment experiments carried out at 3.4 kW at a frequency of 100 kHz. The resulting welded joints had lap shear strength values of 44, 30, and 36 MPa under tensile test loads of 1.1, 0.75, and 850 kN, respectively. Scanning electron microscopy images confirmed a uniform weld quality. Thus, the proposed manufacturing method involving the incorporation of Fe3O4 NPs into thermoplastic resin should help expand the application range of thermoplastic composites

Experimental Verification of Stiffness behavior of Multilayer Metal bellows

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Abstract. Metal bellows are used in wide spread industrial applications. One of the application of multilayer bellows is in design of pneumatic loading system wherein the imposed load is governed by bellows internal pressure and its stiffness. Multilayer bellows have important characteristics of large pressure retaining capability and less stiffness compared to single layer of equivalent thickness. For designing the precision loading system, it becomes necessary to know accurate stiffness of bellows. Design standard like EJMA does not consider the interlayer behavior including friction between the layers. Therefore, need arises to determine the stiffness using detailed numerical simulations as well as experimental verifications. The aim of the present work focuses on estimation of stiffness of small diameter the multilayer (3 layers/ plies) metal bellows at different temperature using numerical simulations and theoretical calculations. Experimental verification was carried out to predict the deviations from estimated results. Consequently, the sensitivity analysis considering the effect of friction between the different layers of bellows was performed to understand the stiffness behavior.

New Response Branch for Undamped 2-DOF VIV of a Diamond Oscillator

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Abstract. Undamped simultaneous in-line and transverse oscillations of a rigid diamond cylinder is investigated numerically at a Reynolds number of 100. A stabilized space-time finite-element method has been used to discretize the governing incompressible fluid flow equations in two dimensions. The non-dimensional displacement and oscillation frequency of the diamond oscillator is compared with the corresponding response and frequency data of the same oscillator executing undamped transverse-only vibrations. From the frequency and response plots, it is established that the response curve of the present study consists of the following response branches: first and second desynchronization regimes (DS I & DS II), initial branch (IB) and lower branch (LB). A novel and previously unreported response branch, ELB connecting LB and DS II branches has been obtained for a vibrating diamond cylinder. The identification of the response branches are done on the basis of the slope change in the variation of oscillation frequency with reduced speed.

Drop Test of an Aircraft Landing Gear Equipped with MR Damper

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Abstract. The commercial landing gear equips an oleo-pneumatic passive damper which has a limitation to achieve optimal landing performance in specific landing cases. A landing gear system equipped with a magnetorheological(MR) damper receives attention to replace that passive damper. This paper adopts the simulation of a single landing gear equipped with an MR damper. A drop test experiment of a scale prototype of the landing gear equipped with an MR damper is set up to verify the simulation results. The main result shows that there is a small gap between simulation results and experimental data.

Dynamic response control of adjacent structures connected by viscous damper using inerter-based isolation systems

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Abstract. In the present study, the seismic performance of two adjacent SDOF systems connected by viscous dampers has enhanced by inerter-based isolation systems. Two hybrid passive control schemes have proposed and analytical solutions have derived to evaluate the seismic responses of both adjacent structures under harmonic ground motion. The responses of uncontrolled adjacent structures have compared with responses of the controlled structures. It is observed that the responses of the controlled adjacent structures are significantly less than the responses of the uncontrolled structures. It has also observed that the vibration reduction capacity of hybrid passive control two is 52.24% superior to the hybrid passive control one.

Capture Region of Realistic True Proportional Navigation Based on Closed-form Solutions

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Abstract. In this paper, a new method to obtain the exact closed-form solutions of realistic true proportional navigation (RTPN) is proposed without any linearization of equations of motion. During the relevant derivation of closed-form solutions, state equations of missile-target system and the hyperbolic property of relative velocity are employed. A geometric scheme of high efficiency to determine the orientation of missile velocity is suggested. Based on the closed-form-solution, some relevant important characteristics, such as the commanded acceleration and time-to-go, are also discussed.

Experimental Investigation of Flow characteristics for Natural Circulation Valve

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Abstract. Experimental investigation was carried out to establish flow characteristics of a Natural Circulation Valve for Pool type Research Reactor. Normally these valves are kept closed by the pump pressure and are opened by the spring action when core cooling using natural circulation needs to be established. When the valve needs to be closed by small pressure differential, the spring design is not feasible. Hence a special type of Natural Circulation Valve is developed which actuates due to difference between buoyancy force and self weight of NCV. The aim of the design of the NCV is that it can be kept closed with very low system pressure and it will open once system pressure falls below this. The flow characteristics for this valve have been established experimentally which have been reported in the paper. Computational simulations have been done and compared with experimental results.

Aerothermal Predictions of High-Pressure Turbine Flows Using RANS Methods

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Abstract. In this study, the flow around an uncooled high-pressure turbine guide vane cascade is simulated using RANS methods. A well-experimented VKI cascade at Re(exit)= 10^6 and isentropic Mach no. at exit = 0.84 is investigated using the SST k-ω, Realizable k-ε, Spalart- Allmaras and Transitional SST models. The results show a good match for aerodynamic parameters against experiments for classical turbulence models, however, predictions for heat transfer coefficients fail miserably. Inclusion of transitional formulation in the SST model dramatically improves these predictions. This is likely attributable to the largely laminar and transitional nature of flow which is not predicted well by purely turbulent models.

Numerical Study of the Effect of Shear Connectors in Insulated Sandwich Panel Building System

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Abstract. A low cost energy efficient earthquake resistant building system seems to be an alternative solution for the much needed affordable housing in India. Insulating Building Panel is one of the advanced building system consists of panel of expanded polystyrene (EPS) insulation confined with galvanized welded steel reinforcement mesh and shear connector, which are subsequently applied with pressurized concrete at site. A layer of mesh on either side of EPS welded together by shear connector steel, penetrating through the polystyrene. However, the structural stability of these buildings greatly depends on the performance of these shear connectors. The proposed paper studied the effect of the spacing and different scenarios of shear connector failures in addition to the reduction of bond between concrete and polystyrene core. Parametric study on the thickness of the wall panel, reinforcement spacing, and grade of steel is also attempted. The effect of through-thickness shear behavior is also studied. Various static as well as dynamic responses are compared. It is observed that the structural stability of these composite sandwich panel depends on the spacing, diameter and adequacies of the shear connectors. It may be concluded that these insulated precast building panel structural system has a great potential for practical implementation and it is able to achieve the goal of efficient affordable housing.

Near - Wake Flow Structures of a Rectangular Wing at the Onset of Stall

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Abstract. Flow field surveys f the near-wake behind a rectangular wing, Aspect Ratio,6.4, NACA4415 as section have been carried out around stall. The velocity fields are measured using single component Laser Doppler Velocimetry at different span-wise and chord-wise locations. The detailed results include mean, and root mean square velocity components with fluctuations, wake half-width variations, and detailed higher moment turbulent statistics. The profile drag coefficient is calculated from the distribution of stream-wise velocity profiles, and an attempt is made to compare with the total drag values measured from the force balance data with the addition of induced drag computed from a numerical method.

Effects of Column Orientation on Building Structure- Verified Through Pushover Analysis

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Abstract. Recognizing the capability of destruction for the last few decades many research works have been directed towards the safety of the RCC structure through the development of earthquake-resistant structures. From the past research and different codal provisions available worldwide it can be found out that moment-resisting capability greatly affects the overall seismic stability of the structures. In this regard, it can be observed that the column orientation is one of the prominent factors of seismic stability. Generally, the distribution of column orientation has been done according to the span lengths and aesthetic values of the structures. In this backdrop, the present study aims to provide an overview of the effect of column orientations for asymmetric structures.

An Improved Unsteady CFD analysis of combined pitching and plunging airfoil using Open Foam

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Abstract. There is a need to improve the propulsive efficiency of flapping airfoil by combining pitching and plunging kinematics. Unsteady Aerodynamics study of combined pitching and plunging airfoil at various Strouhal numbers and at low Reynolds Numbers of the order of Insect/Birds flight is of importance to design and fly Micro Aerial Vehicle to meet the requirement of Para-military forces, Border Security forces and other homeland service forces. A new methodology including customized solver has been developed for the analysis of combined pitching and plunging airfoil based on CFD tool 'OpenFoam'. Since experimental data available for NACA 0012 Airfoil in combined pitching and plunging motion, conditions relevant to the experiment are chosen for the analysis. As Strouhal number increases there is an increase in mean thrust coefficient as well as mean propulsive efficiency. Similar trends are observed from experiment. However, OpenFoam agreement with experiment is reasonably good at all Strouhal numbers. Combined pitching and plunging motion produces higher propulsive efficiency when compared to pure plunging motion

Study of Stability Parameters for Multi-Rotor Aircraft using CFD Analysis and Validation with Theoretical Calculations

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Abstract. The quick development of Unmanned Aerial Vehicles has led to development in different designs of the UAV to counter the challenges faced by conventional aircraft and helicopters. One such solution is using tilting multi-rotor aircraft, the rotors offer thrust for VTOL, and the fixed wings provides lifting force due to the motion of the complete aircraft. Since the rotors can be configured to be more efficient for propulsion (e.g., with variation of root-tip twist), it avoids a helicopter's issues of retreating blade stall. The tilt-rotor can also improve the cruising speeds and take-off weights as compared to helicopters. With a population of 4.2 billion, Asia Pacific is the largest market in the world by people and will soon have a clear future growth in some of its economies like India, Vietnam, etc. It is on track to become the most important economic region in the world. The biggest problem in this part of the world is infrastructure and the social capital is relatively low, in other words, there is a shortage of runways and thus poor connectivity. The tilt-rotor aircraft market is therefore very large in this region as these do not require a fully-fledged runway that is difficult to operate in mountainous regions and also because of low cost. This demands a high-fidelity model with accurate knowledge about the stability parameters for the different modes of flight. In this project, a study on the stability is done using Computational Fluid Dynamics analysis for the full aircraft model. The stability parameters evaluated are in the Longitudinal, Lateral and Directional planes for different conditions of angles and centre of gravity positions. This requires a Preliminary aerodynamic study on the full aircraft model to understand the lift and drag characteristics of the aircraft design. A MATLAB code is developed using the theoretical equations for aerodynamic and stability analysis. The values obtained from this code is considered to be the theoretical base values. The values from CFD and from MATLAB are compared to obtain a validation study. This study gives us an understanding about the variation of stability parameters according to the changing conditions, and will be useful for determining the placement of rotors and other parts in the fuselage. These comparisons are also helpful in determining the efficiency of the aircraft design and the flight dynamics model to obtain few significant conclusions, that are beneficial for the future design of the tilt rotor vehicle.

An Improved Homotopy Perturbation Method to Study Damped Oscillators

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Abstract. This article introduces a new approach for finding out the approximate analytical solutions for damped oscillators. In this approach (LHTT) the two-timing method (TT) is coupled with the improved homotopy perturbation method (LH) [1]. Results obtained from LHTT for the van der Pol's oscillator are compared with the numerical solutions (RK4). Variation of displacement with time and the limit cycle computed by LHTT mimics those from the RK4 method.

Satellite topology and continuous size optimization based on Two-level multi-point approximation method

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Abstract. In view of the in-plane stiffening characteristics of the initial structure layout of a box-plate satellite, optimal design of a certain satellite structure is carried out under several working conditions based on the Two-level multi-point approximation method. Firstly, the finite element model of a satellite structure and the mathematical model of the optimization problem are established. Secondly, the two-order sequence problem is established by using the multi-point approximation method. The approximate problem is solved by the genetic algorithm and the dual method to approach the original problem. Finally, the method is used to carry out the integrated optimization design from the topological configuration/layout of the satellite to the detailed size of the section, in which the in-plane reinforced beam is the topological variable, and the section size of the beam and the thickness of the plate are the continuous variables. The results show that the satellite weight can be reduced effectively under the requirements of frequency and static force, and the optimization results can provide reference for the design of other satellite structures.

CFD Investigation of Geometrical Truncation effect of Typical Winged Re-entry Vehicle on Pressure Coefficient at FADS ports

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Abstract. FADS system allows for determination of Air-data state using non-intrusive surface pressure measurements. Current system employs nine port configuration all being placed on spherical nose cap region. The algorithm determines the flight conditions based on the local surface pressure measurement. The wind tunnel size and pressure probe spacing constraints in nose cap region restricts the scaling of the model and subsequently requires model truncation for data generation for algorithm calibration. CFD studies are carried out over full body and truncated body to bring the effect of truncation on flow field near nose cap region and quantify the same. CFD Simulations are carried out at Mach 0.2 & 0.85, $\alpha = 0^{o}$ to 10^{o}. The pressure coefficient at ports are compared. The cp distribution at nose cap region is minimally effected by the geometrical truncation. Simulation at other Mach–α-β will be undertaken to establish the same for full flight spectrum.

Turbulence Model Selection for Low Reynolds Number flight

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Abstract. While Reynolds number aerodynamics is important to natural and manufactured flyers, low Reynolds number aerodynamics is critical for a variety of nature and man-made fly operations. For years, people have wanted to know more about birds, bats, and insects, and recently, research in the aerospace engineering community has become extremely active. Compatible turbulence model must be chosen for the exact predictions of low Reynolds number aerodynamic characteristics. In this report, numerical analyses of low Reynolds number flight 2D airfoil are done to compare the outputs of different types of turbulence models for the prediction of aerodynamic characteristics for various flight conditions i.e., 0° to 20° at chord based Reynolds number 2× 〖10〗 ^5. The turbulence models tested were: one equation Spalart Allmaras (S-A), two equation k-ε, two equation k-ω, three equation transition k-kl-omega, four equation transition SST. However, the variation in flow physics differs between these turbulence models. Procedure to establish the accuracy of the simulation, in accord with previous experimental results, has been discussed in detail.

First-ply failure load prediction of pre-twisted delaminated composite conical shells

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Abstract. In this research work, a finite element method based computational procedure is developed to predict first-ply failure (FPF) load of thin pre-twisted delaminated composite conical shell subjected to uniformly distributed load. An eight-node isoparametric shell element is chosen in the formulation which considers the effect of transverse shear deformation based on Mindlin's theory. The delamination crack front is modeled employing multi-point constraint algorithm. Different failure criteria such as maximum strain, maximum stress, Hoffman, Tsai-Hill, and Tsai-Wu are considered to estimate the FPF loads. The accuracy of the present method is established by validating with the benchmark results available in the published literature. The numerical results are obtained to analyze the influence of some important parameters such as stacking sequence, pre-twist angle and delamination on the FPF loads are analyzed.

Design and Analysis of Active Phased Array Antenna for 80 kg-Class Micro-Satellite SAR

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Abstract. In this paper, an active phased array antenna with high gain characteristic for micro-satellite SAR was designed and analysed. This active phased array antenna consists of array antenna with 1×16 sub-arrays and semiconductor transceiver modules, which are operating at X-band. The antenna element based on radiating patch, spacers, slotted ground, and cavities. By applying a honeycomb-structured spacer and a perforated PCB on the antenna elements, lightweight characteristic is achieved. Also, the semiconductor transceiver module is designed to control the amplitude and phase of the each exited signal on the radiating elements. Based on the designed this active phased array, beamforming performance were confirmed (in case that beam steering angle is 10°). Also, the mechanical analysis results show the compliance with the structural stiffness and thermal stability.

Agile Turn Guidance Law based on Deep Reinforcement Learning

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Abstract. In this paper, a deep reinforcement learning (DRL) based agile turn guidance law for air-to-air missiles is proposed. Facing the complex aerodynamic environment with large angle of attack, the proposed data-driven guidance law can effectively address the problem of modeling difficulties caused by inaccurate aerodynamic parameters. By utilizing the DRL-based guidance law, the missile can track the maneuvering target during the turn phase, providing advantageous initial conditions for the terminal guidance. Experimental results indicate that the DRL-based guidance law is suboptimal compared with the optimal solution given by a direct method and robust to aerodynamic disturbances. Furthermore, the executing time is short enough for online guidance effectively.

Study of effect of rotational rate of a cylinder on the volume fraction of vapor formed during nucleate boiling phenomenon of water

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Abstract. The problems of fluid flow and heat transfer phenomena over an array of cylinders gives rise to some of the important aspects in fluid dynamics theory such as fluid flow interaction, interferences in flow, vortex dynamics and a variety of engineering applications such as compact heat exchangers, cooling of electronic equipment, nuclear reactor fuel rods, hot-wire anemometry and flow control. These structures are subjected to air or water flows and therefore, experience flow induced forces which can lead to their failure over a long period of time. Basically, with respect to the free stream direction, the configuration of two cylinders can be classified as tandem, side-by-side and staggered arrangements. In the present study, two heated cylinders in tandem are immersed in water and are involved in the phase change phenomenon due to nucleate boiling process. Different study situations have been created by making both or one of the cylinders rotating or stationary and the volume fraction (VF) of vapor is noted when the simulation of phase change is completed. The Eulerian multiphase mixture model has been used along with the RANS (Reynolds-averaged Navier-Stokes) equations to simulate the two-phase (water and vapor). At a specific location of one cylinder, the VF values over a time period are observed and compared with that of the other cylinder. The rotational rate of the cylinder versus VF of vapor produced during the nucleate boiling process has been reported. A significant rise (about 85%) of VF of vapor around a rotating cylinder against the value obtained for a stationary cylinder confirms that there is an impact of rotational rate on the production of water vapor. Fig.1 shows the contours of volume fractions of water vapor when the saturation temperature water is 100 oC and the surface temperature is 120 oC. The maximum value of VF recorded is 0.99 (maximum achievable value is 1= volume fraction of water + volume fraction of vapor). In the Fig.2 is shown the variation of VF of vapor with respect to the rotational rates. It is noted that VF has accelerated from a value of 0.5 when the cylinder was at rest to 0.90 when the rpm is 1000 and afterwards, for each 500 rpm increase in the rotational speed, the VF has remained in a stable range from 0.93 to 0.98. The objective of this part of the study is achieved because it is confirmed that there is a significant impact of rotation on the overall phase change phenomenon and, in particular, on the volume fraction of vapor.

Modelling method of 3-Dimensional woven composite considering realistic features

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Abstract. The yarns forming 3-Dimensional woven composites are bent and contracted in cross-sections due to interference between them. Therefore, it is necessary to calculate the mechanical properties of the composite in consideration of these geometric shapes to obtain a more accurate prediction of results. In this article, cross-sections of the 3D woven composite are obtained using an optical microscope to observe the bend and contracted shapes of yarns. The properties of the composite are predicted using the modeled RUC and the weighted average model. The proposed method is validated by comparing test and prediction results using the idealized model. We conclude that the present method is useful for the design of structures to which the 3D woven composite is applied.

Organic Dye based sensitized solar cells: A performance study

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Abstract. Dye-sensitized solar cell (DSSC) which is a alternative to the conventional p-n junction devices The key difference of the DSSC over traditional single junction solar cells is the use of a organic dye, which enhance the absorption rate of the wide band gap semiconductor and thereby increase the efficiency of the working electrode. The natural dyes as sensitizers are the emerging sources due to their availability, low cost and environmentally safe. Moreover, absorption field of the dye and their adherence to the surface of the nanostructured TiO2 are important parameters related to the efficiency of the cell. To have uniformity of layers and precision, the cells are manufactured inhouse using fully automatic special purpose machine. Ferreira et al, 2020 explains fresh daisy flowers namely Yellow Daisy, Purple Daisy and Wine Daisy based organic dye were utilized attained efficiency of 0.88% . Najm et al, 2019 were utilized pinang fruit crusts crushed in a grinder, 400 mL of ethanol based dssc were tested and attained 0.118% efficiency. Chaudhari et al, 2020 manufactured the DSSC using automated special purpose machine and evaluated performance of glass based synthetic dye solar cell. This study examined the performance of DSSC by using organic dyes with organic and synthetic electrolyte. For testing, natural dyes were extracted from dried black currant, java plum as both this fruit contains large amount of Anthocyanin which is responsible for absorption of light. Parsley extract was also added to both the fruits as it has excellent amount of Chlorophyll which helps in absorption of sunlight as in natural photosynthesis. The concentration level of black java, Black currant and parsley were added in the ratio of 2:2:1. The counter electrode used was graphite and the electrolytes used were concentrated Vinegar as organic electrolyte and ethylene glycol-potassium iodide as synthetic electrolyte. The performance characteristic of both DSSCs being observed throughout the day of the cell. The performance parameters such as power output and maximum efficiency and corresponding fill factor are plotted and analysed.

APSCO SSS-1 Communication System Design and Implementation

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Abstract. Students Small Satellites (SSS) project was initiated by Asia-Pacific Space Cooperation Organization (APSCO). This project is aimed to train students from member states to study space technology and satellite engineering through practical design of satellites. SSS-1 microsatellite is the principal satellite in the SSS constellation with other two nanosatellites. SSS-1 communication system needs to transmit payload data and serve as an international space education platform. In this paper, it presents the design of this system including the onboard part and the ground station. The onboard part includes a UV transceiver and an S-band transceiver. Low-speed and high-speed transmission complement. For data receiving, analysis and sharing, Beihang ground station has been built with a 3.3m parabolic antenna and a UHF/VHF Yagi antenna. Cost-effective SDR solution is used for signal demodulation and decoding. Ground station network scheme will be adopted for APSCO member states to sharing telemetry data and control satellite's payload with a tracking and control center built in Beihang. At present, SSS-1 satellite's communication system has passed the test and the satellite will be launched in October 2021.

Numerical Investigation for Selection of Airfoil with Regard to Flying Wing Applications

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Abstract. Future airfields will become increasingly intrigued with UAVs due to their versatility. These robots can conduct a multitude of tasks, including carrying out strategic reconnaissance, offering telecommunications links, and aiding in metrological research, as well as finding and mapping resources, detecting forest fires, monitoring natural disasters, and defending borders, to name a few. When UAVs fly at low altitudes, they usually have multiple abilities, such as on-site information gathering, target classification, photogrammetric survey, or audio broadcasting. They may be better equipped to help with emergency management or disaster relief. In the case of low Reynolds number flights, the airfoil plays a crucial role in generating lift. This paper presents an approach using open source/free software and commercial software ANSYS to evaluate and choose the airfoil for low Reynolds number flight designs and suggests a set of criteria used to evaluate the airfoils. The numerical simulations of the flow around obtained/selected (Eppler-326, Eppler333, and Marske7) 2D airfoil were carried out by using the computational fluid dynamics (CFD) software, Analysis system (ANSYS) at Reynolds number 2×〖10〗^5. From the results, the recorded maximum coefficient of lift for Eppler-326, Eppler333, and Marske7 airfoils are 1.1584, 1.3468, and 1.0391 at stall angle of attack (12°). Applications of this philosophy were demonstrated through the successful selection of a suitable airfoil (Eppler-333) for the design and development of a flying wing that achieved a maximum coefficient of lift of 1.34. The Eppler-333 airfoil is strongly recommended for the design and development of flying wings applications.

Evolution of heat transfer at the stagnation point during the detached bow shock establishment

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Abstract. The diffraction of a shock wave by a stationary body is a problem of interest associated with the starting of shock tubes and expansion tubes which are well suited to the study of hypersonic flows. However, these facilities come at the expense of test time. The transient parameters during the establishment of the detached bow shock in such short impulsive facilities are important for both data processing and experimental design. In the present study, numerical simulations are conducted to investigate the diffraction of a normal shock wave by a sphere and the subsequent transient phenomena in a viscid, perfect-gas flow field. The incident shock Mach number ranges from 3 to 5 with a specific heat ratio of 1.4. Based on the theoretical description of the reflected shock position during bow shock formation, approximate solutions for the time histories of the stagnation point heat flux are also derived. Analytical and numerical results match well. The results also show that the stagnation point pressure and heat flux approach the steady value much more rapidly than the shock detachment distance.

Design and fabrication of biocompatible quadcopter board

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Abstract. The role of hybrid composites in aerospace structures has widely increased due to enhanced mechanical properties, low cost of production and ease of manufacturing. The fibers used being raw untreated silk and jute, both biodegradable and natural fibers. Manufacturing of composite in combination of these two fibers prove to have superior mechanical properties. The manufacture of hybrid composite has been carried out and the obtained laminate is used as a quadcopter board, capable of carrying payload of 1-1.5 kilogram and natural fibers used being 100% biodegradable.

Numerical Study of Multiple-Impingement Jet Arrays on Iso-Thermal Horizontal Flat Plate

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Abstract. The numerical investigations were performed with CFD commercial code of COMSOLE 5.2 In the present paper, both the modeling and computational analysis was carried by the COMSOLE. The grid independence test was obtained with the fine and coarse meshes. The fine meshes exhibit higher effectiveness and coolant distribution with reduced mesh size. The study was performed for coolant air with constant Prandtl's number and isothermal wall. The Reynolds number was c varied between 25 and 100 in laminar flow conditions.The obtained numerical results exhibit good agreement with experimental data.

Linearized control of an axisymmetric spinning top to a regular precession trajectory

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Abstract. In this work, we consider the problem of controlling a pivoted axisymmetric spinning top to a steady precession trajectory with a constant nutation angle. In the 3-1-3 Euler angle convention, we show that the linearization of the equations of motion about nutation-free trajectories leads to a time-independent Jacobian matrix. A control system with two actuators, providing input to the base in two globally fixed directions, is developed using eigenvalue placement techniques on the linear time-invariant system and assuming full state feedback. A numerical example is presented to demonstrate the effectiveness of the developed control system.

Theoretical & experimental study on a miniature jet pump with low area ratio

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Abstract. Jet pump is used for many conventional applications. For some special applications like in experimental device in a nuclear reactor, miniature size jet pump with low area ratio is to be used for achieving comparatively high flow amplification with lower primary flow rate. Since sufficient data are unavailable in the open literature for miniature size jet pump with low area ratio, theoretical investigation with complementary experimental study are carried out. Results obtained using an axisymmetric CFD models are compared with those of the analytical model. Effect of flow ratio on internal pressure & velocity profile is presented. The computed results are then compared with the experimental results. It was observed that results obtained from the CFD model is in very good agreement with the experimental results for flow ratios up to 2.

Heat Treatment of AISI 1045 Specimens using High-Frequency and Simulation

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Abstract. AISI 1045 specimen was compared through a high-frequency heat treatment simulation and experiment considering metal phase transformation. Hardening zone predictions were confirmed through cooling and metal phase transformation simulations after obtaining the results from electromagnetic heat transfer simulations. The cooling process was modeled by applying the cooling coefficient of the cooling water in the same way as the actual heat-treatment process. Experimental and simulated results of the heating temperature and curing depth of an AISI 1045 specimen with a carbon content of 0.45% were compared; the comparison indicated good agreement between the two. We established a method for obtaining the high-frequency thermal treatment simulation method considering metal phase transformation.

Investigations in Flapping Wing Ornithopters Modelled as Nonlinear Compliant Mechanisms

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Abstract. Nature's flapping wing systems are a precious source of inspiration for efficient propulsion and lift generation devices used in micro air vehicles. The use of flapping wing devices is very attractive, because they are able to operate in different regimes of motion, combine the function of control device, stabilizer, and provide high maneuverability. The potential application of Flapping Wing MAVs mainly focuses on sensing, information gathering, relevant for disaster monitoring and security surveillance, which plays a major role in civil and military sectors. Deficiencies of conventional fixed-wing or rotary-wing approaches in terms of aerodynamic performance and achieving the necessary specifications for small-scale MAV designs have directed attention to the biologically inspired flapping-wing approach. Stanley S. Baek et al[1] experimentally demonstrated that the average power and the peak torque can be reduced by resonant excitation with a constant voltage for motor-driven oscillating systems. Avadhanula et al[2] analysed the kinematics of the mechanism which converts piezoelectric actuation into complex wing motion. A complete non-linear modelling of the system based on the Lagrangian energy technique is also presented. Three piezoelectrically actuated flexure-based mechanisms are described by A. Cox et al[3] that transforms the linear output of piezoelectric unimorph actuators into single degree of freedom flapping motion. Fernando and Ronald [4] conducted experimental studies using a simple biomimetic optical flow algorithm which extracted net motion direction by averaging the flow field across the whole sensor, demonstrating the significance of pitch oscillations due to wing flapping on the optical flow direction estimates. Bor-Jang Tsai and Yu-Chun Fu's[5] analysed the aerodynamic performance of a planar membrane wing as shape aerofoil for the micro aerial vehicle. They employed the concept of four-bar linkage to design a flapping mechanism which simulates the flapping motion of a bird. In this work a DC motor driven flapping robot modelled as a nonlinear motor driven crank arm mechanism coupled to spring mass system (Compliant Mechanism) is considered. The nonlinearities in the system includes nonlinearity in the damping, modelled by Coulomb friction model and the cubic nonlinearity in the spring. Non dimensional analysis is carried out to demonstrate a relation between the resonant frequency of the mechanism and the ideal motor input voltage to achieve maximum input power reduction. The main focus of this study investigate the effect of nonlinearities on the system performance by conducting a numerical study using MATLAB.

RANS modeling for short and long separation bubbles in flow past low-pressure turbine cascades

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Abstract. The flow within low-pressure turbines (LPTs) at high altitudes is essentially complex, involving separation-induced transition, leading to the formation of a separation bubble. These bubbles can be classified as short or long, based on their influence on aerodynamic parameters of interest. In this work, we study the transitional flow in a high-lift LPT cascade T106C using low-cost turbulence and transitional models. The study is performed for Reynolds numbers (Re): 80,000, 120,000, and 160,000, each of which exhibits a different kind of separation bubble. None of the classical turbulence models show the ability to correctly predict the separation and hence transition. However, modern transitional models, Transitional SST (TSST) and Laminar Kinetic Energy (LKE), show reasonable predictions of separation regions. While the TSST model is superior in high Re flows, where closed separation bubbles are found, the LKE model better predicts the long open bubble in the low Re case. Lastly, the effect of variation of pitch-to-chord ratio is examined on the separation bubble as well as blade-load distribution. This can serve as an initial step for potential blade shape optimization.

Porous Scaffold by Additive Manufacturing for Bone Replacement in Biomedical Application

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Abstract. Porous Scaffold structures are widely used in biomedical application for bone replacement. In the present study, porous Ti–6-Al-4V alloy scaffolds with different structures are successfully fabricated by a selective laser melting (SLM) method. The fabrication of porous scaffold by conventional techniques mostly offer control in varying composition and hardly offer control in varying structural design. The flexibility of structural design provided by additive manufacturing such as selective laser melting (SLM) makes it an outstanding technique to fabricate scaffold. In this work, an overview of porous scaffold fabrication techniques is presented using additive manufacturing techniques. On the other hand, fabrication of a porous scaffold with varying structural design is demonstrated using SLM technique and titanium alloy as material. The structural design fabricated by SLM was periodic cellular structures with 15 mm cubic unit. To obtain porous scaffold, the structure was varied by change in strut thickness continuously and linearly in single direction. Results showed that the complex design is successfully fabricated by SLM and achieved nearly bone properties of the fabricated scaffold to use in bone replacement.

Al/epoxy adhesion strength by a modified butt joint test configuration

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Abstract. Al/epoxy adhesively bonded joints are quite common in aerospace applications. The reliability of such joints highly depends upon their interfacial properties. Often pull tests are conducted to evaluate the interface strength of bonded joints. Unless the effect of stress concentration is taken into account, a reliable interface strength data cannot be obtained from the experiments. In this investigation, the interface strength between Al 6063-T6 alloy and epoxy is evaluated under quasi-static loading conditions. Test specimen is designed by performing a systematic computational analysis. The effect of stress concentration on the interface stress is subdued by opting for an Al/epoxy/Al configuration with 300 tapered aluminum cylinders. The modified axisymmetric butt joint specimen is prepared by naturally bonding the epoxy layer with the aluminum. Pull tests conducted on the specimens with tapered and untapered edged specimens showed that the interface strength is enhanced by nearly 2.3 times in the absence of stress concentration.

Numerical Study on Transient Transverse Jet Effect of the Two-Dimensional Slot Under Supersonic Conditions

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Abstract. Reaction control system (RCS) has the advantages of high response speed, wide adaptability and small shape interference. In practical engineering applications, in order to achieve high-precision control under high-speed conditions, the jet usually runs only a few milliseconds. During this time, the complex wave system and vortex structure in the jet flow field have not been fully established. Therefore, it is especially significant to study the transient process of lateral jet flow under supersonic conditions for the realization of RCS. However, there is a lack of research on the transient process of transverse jet. In this paper, the transient developing and fading process of the jet through the two-dimensional slot is studied. Based on this, more researches are carried out, including the effects of jet pressure ratio and freestream Mach number on the transient process of two-dimensional slot jet.

Mode Transition in Strut Based Parallel Fuel Injection in Scramjet Engine

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Abstract. This study focuses on numerical investigation of strut-based parallel fuel injection in supersonic reacting flows. A Two dimensional, density-based solver has been used with the k-ε turbulence model. Reacting flow has been simulated using the Species transport model to better estimate the species concentration and reaction rates. Short residence time in conjunction with compressibility effects in supersonic reacting flow regimes leads to problems like inadequate mixing, flame blowout, and incomplete combustion. High-speed propulsive systems exploit the presence of shock to increase the efficiency of combustion as well as mixing. This study focuses on the dynamic switching between ram and scram mode of operation for a dual-mode scramjet engine and quantifies the effect of fuel injection to air pressure ratio on combustion, shock cell pattern, thermal chocking, and ram-scram transition. Observations were made regarding changes in the flow field and combustions zones during the mode transition.

Simulating the impact of ground vortex ingestion on inlet performance

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Abstract. Abstract. Simulating the aerodynamic impact of ground vortex ingestion on aero-engine inlet performance, close to the ground under crosswind conditions. There can be notable interaction between the intake aerodynamic and the surface. This interaction results in a concentrated vortex originating at the ground plan and terminating inside the engine. The rotational flow field induced by the ground vortex is the cause for ingestion. This is the major source of engine performance deterioration and reduced service life. This interaction is primarily dependent on the intake ground clearance and the stream tube contraction ratio of the intake. Computational fluid dynamics (CFD) analysis have been performed to predict the ground vortex, its strength and characteristics of the flow-field. Simulation using Simcenter STAR-CCM+ have been executed to provide insight into this important phenomenon. The characteristics of the ingestion location have been studied for range of crosswind conditions and simulation results have been compared with experimental data to assess the numerical prediction capability.

Modeling damage evolution of laminated composites under high strain rate loading

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Abstract. Carbon fiber laminates are widely used in defense and aerospace applications. These types of components are subjected to dynamic loads, such as ballistic impacts and high velocity impacts, which cause high strain rate deformation. The high strain rate deformation results in localized damage and the impact energy is dissipated near the contact area. In this paper, using the modified Matzenmiller-Lubliner-Taylor (MLT) method, the behavior of a nonlinear rate-dependent constitutive composite model is investigated. The composite model consists of carbon fibers with balanced stacking sequences [0/45/90/-45]3s. In the model, the modified method considers six types of damage, axial (d11), normal (d22,d33) and shear (d12,d23,and d31) on seven damage envelopment criteria of material criteria. The method introduces three levels of shear damage that provide fiber and matrix shear and improves damage prediction. These damage equations are based on the micromechanical strain energy method to predict the nonlinear deformation of the composite as a function of strain rate. The failure criteria of the composite model depend on the stiffness, strain rate as well as the progression of damage. Thus, the model based on the modified method predicts the strength and damage behavior of the carbon fiber composite more accurately than the MLT method.

Wall effect on the Drucker Prager model parameters for pebble beds in nuclear fusion reactor

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Abstract. Lithium ceramics in the form of pebble beds are used as tritium breeder materials for future fusion reactors. Drucker Prager (DP) model has been found to be an appropriate model for predicting the macroscopic thermomechanical behaviour of these granular pebbles. Discrete element method can be used to simulate triaxial compression tests to extract DP model parameters which can then be used to describe the constitutive relationship of a homogenized finite element model of a pebble bed. In the present work, the effect of nearby wall on DP parameters is studied by considering the various bed geometries.

Stochastic finite element modelling of the graded cellular arches

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Abstract. In the present work, an efficient stochastic finite element model based on the three-nodded element has been utilized for the stochastic vibration analysis of graded cellular arches. The present formulation is based on the higher-order shear deformation theory and orthogonal curvilinear coordinate axes. The internal pores in the graded cellular arches follow the two distinct types of distributions. The material properties of the graded cellular arches vary in the thickness direction as a function in terms of porosity coefficient and mass density. In the present study, a stochastic finite model in conjunction with the first-order perturbation technique (FOPT) has been used to analyze these kinds of structures with material stochasticity.

Unsteady Aerodynamic Force Approximation for Flutter Prediction

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Abstract. Abstract. The existing aerospace industries are mostly dependent on finite element-based software, for extracting the air loads at the discrete frequency and velocity conditions. Further, the unsteady air loads can be used to predict flutter. In the present work, unsteady aerodynamic forces are used to compute flutter in time domain, using Matric Polynomial Approach (MPA). The flutter analysis input parameters, namely, frequency and mode shapes are obtained from normal mode analysis. Then discrete unsteady aerodynamic forces are obtained from the frequency-based flutter analysis performed in MSC PATRAN. Then Matrix Polynomial Approach is used to transform the three-dimensional discrete aerodynamic parameters into continuous function, thus facilitating to build a Linear Time-Invariant (LTI) state-space system. The state-space model built is a Multi Input Multi Output (MIMO) system that can be easily solved as an Eigen value problem. From the characteristic (Eigen value) value problem, the dynamic instability conditions are determined for predicting the onset of flutter in time domain. This approach is bench marked by validating the flutter results obtained from the simulation using CFD, in comparison with the NASTRAN flutter result. In the proposed work, it is directed to validate the procedure by using a simple aluminum cantilever plate, and thereby studying the novelty in dealing with the aeroelastic studies more efficiently and practically. Introduction The present aerospace industries are very keen in identifying the problems associated with aeroelasticity, and it paves wide opportunities for practicing researchers all around the globe. Among the different aeroelastic problems identified, flutter appears to be more dangerous and may sometimes lead to catastrophic failure, if it is not controlled. Hence, aeroelastic studies are very much essential in qualifying the aircraft to fly safely at different flight conditions. Air load approximation techniques are the algorithms used for computing unsteady aerodynamic forces that are required to transform the discrete values to a continuous function. The importance of air load approximation technique is that it transforms the discrete frequency domain data into a continuous time domain function, so that it can be used for aeroservoelastic studies. The aeroservoelastic equations of motion must be translated into a first-order, time-domain (state-space) form in order to use various current control design approaches, simulations, and optimization procedures. The order of the resulting state-space model is a function of the number of selected modes, the number of aerodynamic approximation roots, and the approximation formula, while this transformation requires the aerodynamic matrices to be approximated by rational functions (ratio of polynomials) in the Laplace domain. Methodology Structural modelling and meshing is done to carry out flutter analysis in frequency domain. Then unsteady aerodynamics forces is extracted in modal domain. By implementing Matrix Polynomial Approach, the three dimensional discrete aerodynamic parameters is transformed into continuous function, thus facilitating to build a Linear Time-Invariant (LTI) state-space system. The state-space model built is a Multiple Input Multiple Output (MIMO) system that can be easily solved as an Eigen value problem. From the characteristic (Eigen value) value

problem, the dynamic instability conditions are determined for predicting the onset of flutter in time domain. This approach is bench marked by validating the flutter results obtained from the simulation in comparison with the NASTRAN flutter result. In the proposed work, it is directed to validate the procedure by using a simple aluminum cantilever plate, and thereby studying the novelty in dealing with the aeroelastic studies more efficiently and practically.

Analysis and control of Aeroelastic performance of delaminated composite plate using AFC

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Abstract. Aeroelastic analysis of a delaminated composite plate with integrated active fiber composite (AFC) as actuator/sensor is considered for the present study. A region-wise approach is adopted to incorporate delamination defects at the mid-plane of eight layered laminate. Firstly, first-order shear deformation theory based finite element code is written in MATLAB to perform modal analysis of smart delaminated composite plate followed by flutter analysis in MSC/NASTRAN. Flutter velocity and frequency are calculated for a laminate with square delamination. The effect of different locations of delamination on flutter performance is also investigated. The delaminated plate performance is compared with a healthy laminated plate and voltage-imposed actuators are used to enhance the flutter properties which were degraded due to the presence of delamination defect. It has been found that the presence of delamination in composite degenerates the aeroelastic performance which was later improved by a voltage-imposed AFC actuator.

Effect of graphene nanoplatelets on the thermomechanical behaviour of smart polymer nanocomposites

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Abstract. Smart polymers have been in significant utilization for the various structural, aerospace, flexible electronics and biomedical engineering applications. These polymer could be sensitive to heat, electricity, moisture, pH or magnetic. Shape memory polymer (SMP) are one of these smart material which are temperature sensitive. SMP have capability to deform into the programming orientation and to regain its original state under the influence of heat above the glass transition temperature (T_g) of SMP. In the present study, thermomechanical and morphological characterization of graphene nanoplatelets (GNP) reinforced shape memory nanocomposites. Incorporation of 0.4 an 0.6% GNP in the epoxy matrix considerably enhanced the elastic modulus of the nanocomposite prior to the glass transition region. The improvement in the interfacial bonding between the nanofillers and matrix was the primary cause of improvement which was depicted in the FESEM morphology. However, the decline in the properties were observed at 0.8% GNP because of the initiation of agglomeration of nanoparticles in the matrix. The simulation of the dynamic mechanical analysis was performed through the phenomenological approach based on the theory of superposition. The comparison indicated appreciable congruence which could be used as a reference for the future numerical investigations.

Effects of vertical inclinations of square prism on the performance of piezoelectric energy harvester: An experimental study

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Abstract. This paper experimentally investigates the effects of various orientations of a square prism (about the vertical axis) on the performance of a galloping based piezoelectric energy harvester (GPEH). Regulation of galloping amplitude at constant wind speed is the prime objective. Again, it is found that 5 degree rotation of the square prism about the vertical axis produces more power compared to conventionally used upright square cylinder. This research can be utilized to design a GPEH with a movable bluff body that can produce specific power output in a natural fluctuating flow field without any structural damage.

Electro-mechanical Impedance response of delaminated glass-fibre composite beam

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Abstract. The Electro-mechanical Impedance (EMI) technique has been gaining wide acceptance in various engineering applications for structural health monitoring purpose since last two decades due to its ease of implementation. In this work, the EM response of a delaminated composite beam is studied for some possible delamination scenarios. At first, glass-fibre composite was fabricated by standard vacuum resin infusion process. The surface bonded PZT patch and the host structure interaction was obtained by an E4990A impedance analyzer in terms of impedance responses experimentally. The impedance response of the pristine state composite beam was obtained through ANSYS and validated with the experimental results. Various delamination scenarios between different layers of the composite were incorporated in the ANSYS model to obtain the impedance signatures. The changes in EM response of the structure due to occurrence of damage are observed to investigate the delamination here.

Low-Velocity Oblique Impact Response of Pre-twisted Sandwich Conical Shell with CNTRC Facings

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Abstract. A finite element approach coupled with higher-order shear deformation theory (HSDT) is employed to investigate the dynamic responses of cantilever pre-twisted sandwich conical shells with carbon nanotube-reinforced composite (CNTRC) facings and homogeneous core under low-velocity oblique impact. The carbon nanotubes reinforcement in the facings follows either uniform or functionally graded distribution along its thickness direction. A refined rule of mixture is utilized to evaluate the effective elastic properties of the nanocomposite facings. The derived dynamic equilibrium equations are based on Hamilton's principle, while the contact force between the spherical impactor and the target sandwich shell is formulated using the modified Hertzian contact law. The solution of the resulting equations in the time domain is obtained using Newmark time integration method. After accomplishing the validity of the present model, some numerical examples are furnished to analyze the influences of important parameters on the impact responses of the nanocomposite sandwich conical shell.

Development of a Flight Simulator for Low-End Computers

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Abstract. Commercially available flight simulators are computationally heavy software and thus this makes them inaccessible to people who have low-end compatible office laptops. This project aimed to develop a flight simulator that is computationally less intensive and has a near-real world and optimized physics model. We decided to use the Unity game engine since it's user friendly and develops applications to have a wide compatibility range. We kept physics and motion modelling as the highest priority and graphics at the lowest priority. To make the flight mechanics model of our simulator accurate and simultaneously less CPU intensive, certain non-iterative methods (as opposed to iteratively solving NavierStokes Equation) are used for the computation of aerodynamic coefficients and were further modified to account for change in parameters like Mach number and Reynolds number. Different models and empirical data have been considered along with a custom wind and gust model to simulate the environmental effects on the aircraft. Minimum graphics elements were added to minimize the rendering requirements. The comparison with other available simulators shows that the present model gives better performance on low-end computers, mainly because it has low CPU and GPU requirements.

Numerical analyses of re-entry module - Apex cover separation aerodynamics at low subsonic Mach number for various angles of attack

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Abstract. Aerodynamics of re-entry bodies is one of the most critical aspects of design for any space missions. The velocity of a re-entry body varies from hypersonic Mach number in outer-inner atmosphere to supersonic, transonic and finally subsonic Mach numbers till it touches down on earth. Generally, a bluff body is chosen for re-entry missions. Flow over multiple bluff bodies (two or more) in proximity is a very interesting topic and it has wide variety of applications in the area of aerospace engineering. An attempt has been made to study the aerodynamics of pair of separating bodies in tandem at low subsonic Mach number. This separation event occurs when apex cover is separated from re-entry module before the deployment of drogue chutes. In this study re-entry module is considered as fore body and apex cover as aft-body. CFD studies have been carried out to estimate drag coefficient of the aft-body using CFD software FLUENT. The effect of gap (axial distance) on axial force coefficient of aft body placed at various axial distances (ΔX/D), at subsonic Mach number and different angles of attack, is the subject of this paper. D is the maximum diameter of the fore body.

Finite element analysis of biaxial cuboid voided slab under one way bending load

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Abstract. This article presents a nonlinear finite element approach on the one-way flexural strength determination of biaxial hollow slabs (voided slab). Voided slab appears as traditional solid slab. Primary advantage of voided slab is lighter than conventional solid slab, as a result of it, studies have done on capacity analysis of voided slabs. In the paper, eight node brick finite element slab model was analysed. Nonlinearities of concrete and reinforcement bars was incorporated in the numerical programme using stress-strain relationship of each material. Numerical load-deflection plot was compared with experimental plot. Experimental and numerical results are matched appropriately in terms of ultimate load and deflection. A parametric study was performed to study the impact of cuboid voids on the deflection and ultimate load. Numerical findings were shown. Results obtained from the numerical analysis showed that presence of voids will significantly affect the initial stiffness and not the ultimate load.

A detailed analysis of improved mathematical models of secondary velocities along perpendicular and transverse directions for steady uniform turbulent flow

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Abstract. Cellular secondary flows are generally present in turbulent flows through natural or artificial streams / chennels and significantly modify the characteristics of turbulence and primary flow. In this study, the proper mathematical models of secondary velocities along vertical and transverse directions are derived for steady turbulent flows. Till now most of the studies regarding secondary currents reported in the literature assume the models numerically or empirically using boundary conditions. Starting from the continuity and Reynolds averaged Navier-Stokes equation, first the equation is derived and then using appropriate boundary conditions the analytical models for cellular secondary currents are developed using the separation of variable method and Fourier sine series approximation. These models include the effects of viscosity of the fluid and the eddy viscosity model of turbulence. Models are validated with existing experimental flume data for the rectangular open channel, open compound channels, and duct flows, and satisfactory results are obtained. Further, models are also compared with empirical models from literature to show the effectiveness of the proposed models. Apart from these, the obtained results in this study are used to investigate the effect of secondary current on settling velocity and stream-wise Reynolds shear stress. Effective alternate models for the settling velocity vector and the Reynolds shear stress distribution in a cross-sectional plane are proposed. Both these models are also validated with experimental data as well as previous models. To get quantitative idea about the prediction accuracy of experimental data of the proposed models, error analysis has been carried out and results show that present models are more effective then all previous models. Finally, all results are justified from a physical viewpoint. This study proposes effective mathematical models of vertical and transverse secondary velocities in steady uniform turbulent flows through open rectangular channels, compound rectangular channels and closed ducts. The work has represented the consideration of viscous effect in the model, the new solution methodology, and the broad applicability of the proposed model. This study is further applied to investigate the effects of secondary currents on the hindered settling velocity vectors and stream-wise Reynolds shear stress distributions in a cross-sectional yz plane. New effective alternative models for settling velocity vector and cross-sectional Reynolds shear stress distribution are proposed.

Unsteady Simulation of Frontal Cavity in Supersonic Flows

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Abstract. This study is motivated to develop the understanding of bow-shock instability observed around a frontal hemispherical shell in supersonic flow through numerical simulations. This kind of unsteadiness is generally observed in the supersonic parachute decelerators adopted in many space missions as well as during wind tunnel testing of rigid hemispherical shell in supersonic and hypersonic flows. In very few previous numerical studies, initiation of rapid large amplitude fluctuation in bow shock in front of hemispherical shell leads to failure in simulation. Hence, the principal objective and novelty of the study is to capture and analyse the experimentally observed “large amplitude” shock unsteadiness in front of hemispherical shell in a supersonic flow of Mach 4 using the recently emerging numerical concept of Detached Eddy Simulations (DES) in two dimensional axisymmetric domain.

Turbulence model and grid Sensitivity analyses of T-shape tall building using Computational Fluid Dynamics technique

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Abstract. This paper represents the numerical study carried out on wind effects on T-shaped tall building using computational fluid dynamics (CFD) technique. The boundary layer wind tunnel experiment on the scaled model of T-shape building were conducted at Indian Institute of Technology Roorkee, India. The numerical simulation is carried out in the ANSYS FLUENT in which the wind flow parameters i.e., velocity and turbulence intensity profile obtained from experiment are validated numerically. Sensitivity analyses for turbulence model and mesh convergence are conducted on T-shaped tall building at a wind incidence angle of 0°. Three-dimensional Reynolds -average Navier-Stokes (RANS) equation is used to conduct the sensitivity analyses in which four different turbulence model are taken: Standard k-ε model, Renormalization Group (RNG) k-ε model, Realizable k-ε model and k-ω shear stress transport (SST) model. The main aim of this study is to compare the wind pressure coefficient obtained from sensitivity and mesh convergence analyses with the wind tunnel experiment on the various faces of T-shape building at a wind incidence angle of 0° and identifying which turbulence model and grid size is best fitted for the proper wind flow around T- Shaped buildings.

Experimental study on two octave Indian flute acoustics

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Abstract. The Indian classical flute called ‘Bansuri’ is a side blown flute originating from the Indian subcontinent. The air blow makes the oscillation of the air column in the flute passage and sounds differently as the exit volume changes. Accordingly, the different notes are configured with an octave and currently two octaves are in practice. In the direction of exploring the third octave nodes, the standard two octave nodes are analyzed in the present study using the analytical correlations and experimental data by frequency analysis performing the Fourier Transformation considering an ‘E’ base flute. Technical parameters affecting the acoustics of flute such as note frequency, wavelength and sound pressure levels are studied in detail using various diagnostic tools like sound pressure level meter and MATLAB programming tool. The variation in such technical parameters corresponding to each note of two octaves is described in detail with graphical results. It is observed that the frequency of the middle octave notes is nearly two times of the lower octave nodes thereby octave shift forms.

Applicability of duffing oscillator on the dynamic analysis of bistable variable stiffness laminates

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Abstract. Bistable composites provide an alternative to traditional designs in shape-adaptable structural systems due to their multiple stable equilibrium configurations. In this study, the response of a square curved bistable plate has been analyzed by focusing on the snap-through mechanism. An appropriate finite element model has been used to predict the load-deflection characteristics of the bistable plate. Nonlinear dynamic analysis of bistable plates with large degrees of freedom can be computationally expensive. The load-deflection response has been approximated using polynomial expansions, where it has been included as the restoring force in the dynamic equations of motion. A single degree of freedom (SDOF) model from literature is chosen for the present analysis. Single well and double-well potential systems associated with the dynamic behavior of bistable variable stiffness (VS) plates are explored in the analysis.

Modeling and design of hybrid reluctance actuator for fast steering mirror

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Abstract. As the key component of the fast steering mirror (FSM), the actuator's quality directly determines the performance of FSM. To achieve high compactness, high efficiency, large output torque and good linearity, a new hybrid reluctance actuator for FSM (NHRA) is designed. In order to get high-force density and small flux leakage, four permanent magnets (PM) are designed on the side near the lens, which also make the NHRA has essentially linear characteristics by generating bias flux. Meanwhile, to obtain maximum output torque in a limited size, the structural model of NHRA is established in ANSYS Maxwell, and all structural dimensions are optimized. In addition, an analytical model of NHRA is established via the equivalent magnetic circuit method. In order to improve the modeling accuracy, both PM flux and coil flux leakages are taken into consideration. The theoretical and simulation results are in good agreement, and both show that under the same volume, the output force of NHRA is almost twice that of a state-of-the-art actuator HPHRA, while the linear characteristic of the output is also improved.

Quadratic Wachspress Shape Functions for Polygonal Finite Element Method

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Abstract. Voronoi tessellation can alleviate issues of discretization and skewed elements arising from inappropriate meshing of complex domains. Significant reduction in computational cost can also be achieved due to decrease in the number of degrees of freedom in the polygonal mesh. Polygonal Finite Element Method (P-FEM) can also be effectively used to simulate crack propagation and fracture problems. In P-FEM, the linear Wachspress rational polynomial shape functions are widely used since they are comparatively easy to develop and fulfill all requisites of node-based shape functions such as positivity, interpolation, and the partition of unity[1]. A plethora of examples in the context of elasticity, linear elastic fracture mechanics and elastic plasticity using P-FEM can be found in the literature. The higher order Wachspress shape functions are less popular. However, the higher order functions in the same domain when compared to linear element can lead to less error and fulfil the C^1 continuity. The higher order approximation can assist in capturing gradients in response more effectively with lesser number of elements. Due to these inherent advantages, quadratic Wachspress shape functions have been developed in this work for small strain elasticity and elasto-plasticity.

Numerical Analysis of Aerodynamic Characteristic of Aircraft Wing Using Cant-Angle and Taper Ratio

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Abstract. Aerodynamic performance of an Aircraft is highly affected by the friction drag over the surface and the induced drag due to wingtip vortices. To obtain an efficient wing configuration which produces maximum lift these drag forces have to be reduced. A Numerical Analysis of Three dimensional fluid flow over an aircraft wing is conducted to study the variation in lift-to-drag ratio by varying cant-angle of the winglet and taper ratio of the wing. The simulation is performed with fixed wing and air as a flowing fluid with static inlet temperature of 275k, constant density through control volume and negligible heat transfer using CFX solver in ANSYS. The static outlet pressure was kept as 0.7846 atm. Twelve different configuration designed by varying taper ratio (0.6, 0.8, 1) and cant-angle (0 , 30 , 60 , 90)degrees to evaluate the effect on drag and lift force by comparing the lift-to-drag ratio. The Spalart-Allmaras turbulence model used to study the effect of eddy-viscosity. Results shows that with the use of winglet, the size of the wingtip vortices reduces and by reducing cant-angle the lift-to-drag increases. On reducing the taper ratio the drag force decreases and hence the lift-to-drag ratio increases.

Numerical Performance Studies of a Small Scale Horizontal Axis Wind Turbine Blade with Humpback Whale Tubercles

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Abstract. Attributing to the idea of portable power generation, small scale wind turbines are aggressively expanding across rural areas disconnected from the power grid. However, due to their small size and low operating altitudes, the performance of the small wind turbines are severely affected resulting in low power outputs. In the study, efforts are made to passively improve the performance of a 2kW wind turbine baseline blade by implementing humpback whale tubercles. Tubercle geometry with amplitude A(LEP) =5% and wavelength λ(LEP) =7% of the local chord ci is interspersed to the leading edge of the baseline blade. Numerical evaluation of the blade performances at various flow conditions proved the modified blade to outperform the baseline blade. From the outcomes, the tubercled blade manifested a total power output P of 26% and coefficient of power CP of 7% greater than the baseline blade at design conditions

Numerical Investigation of Cavity Flow Field in Presence of Store

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Abstract. Weapon bays are the internal store carriage of the aircraft and provide better aerodynamic performance and stealth over external store carriage systems. However, the flow field within a cavity results in numerous challenges for the carriage and release of weapons. This study aims to computationally obtain the quantified effect of the interaction of a flow field with a store mounted in two different cavity configurations. The cavity configurations selected are rectangular and oblong hexagonal cavities with a length-to-depth ratio of 5 and width-to-depth ratio of 1, to simulate an open cavity flow condition. Additionally, the geometries are differentiated by offset-to-depth ratios of 0 and 0.25 for rectangular and oblong cavities respectively. The store considered for the study is the B-57 model. The flow field is numerically calculated using ANSYS® Fluent, with a constant input free stream velocity of 70m/s ($M\infty=0.2$) at yaw angles = 0°-6°. The static-pressure distribution is studied for various sections in the cavity in the presence of the store. Finally, the results obtained for both the cavities with store in it are compared to understand the effect of change in cavity configuration on the flow field. Moreover, the results of empty cavities are also studied and compared with the store-mounted cavities.

Experimental and Numerical Simulation for Residence Time Distribution of Deactivation Tank

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Abstract. Deactivation tank is sometimes used in nuclear reactors to increase the delay time for the radioactive fluid to decay its radioactivity level. Short lived but hard gamma emitters radioisotopes like N-16 and O-19 are produced during nuclear fission reactions and lead to increase in radiation field in working areas of process & equipment rooms. To reduce the radiation level, the fluid containing the short-lived radioisotopes are passed through a deactivation tank. Time spent by fluid particle inside the deactivation tank is important parameter to consider in design of the same. Experiments were carried out to estimate the residence time distribution by injecting in pulse mode, aqueous NaOH solution at the inlet of the tank with the fluid and by measuring conductivity of fluid at outlet of deactivation tank using online electrical conductivity meter. CFD studies were also carried out using species transport method and results are compared with experimental measurements to validate the model. The validated CFD model can be used for predicting the delay time of larger deactivation tanks of similar geometry where experiment may not be feasible.

Design and verification of electrical power subsystem for a student small satellite "SSS-1"

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Abstract. As advances in space technology, much effort has been devoted to the field of microsatellite, due to its cost-effectiveness for conducting various space mission. The present article investigates design and verification of electrical power subsystem (EPS) for the SSS-1 platform, which is a student small satellite proposed by Beihang University, Beijing, China. EPS consists of three units, including solar array (SA), battery pack unit (BPU), and power control and distribution unit (PCDU). Their main design index and the initial design results are first briefed. Due to the energy shortage arose from energy balance analysis, an iterative design of the EPS has been adopted, involving optimization of the SA layouts, over-discharging protection for BPU, as well as adjustment of payload strategy. To achieve this, the EPS is modelled via MATLAB®/Simulink® combined with Satellite Tool Kit (STK) simulation, in which sunlight conditions, photovoltaic cell equations and the characteristics of Li-con battery are considered. The verification modelling results manifest that ultimate design of EPS is capable of sustaining the energy consumption of SSS-1, and thus associated energy balance can be attained.

Effect of Hygrothermal Environment on Dynamic Behavior of Folded Laminated Composite Plate

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Abstract. In this paper, the effects of hygrothermal environment on the free vibration and transient response of one-fold and two-fold folded laminated composite plates are analyzed. A nine-noded C0 continuity finite element approach utilizing a non-polynomial shear deformation theory is employed for the analysis. To model the induced stress due to thermal loading, the Green-Lagrange non-linearity has been employed. Newmark's method is employed to integrate the spatial-temporal partial differential governing equations. The effect of the thermal environment on the natural frequency and transient response of folded composite plates has been illustrated through various examples. The obtained solution has been validated with the available solution in the literature. The effect of fiber orientation, crank angle, and boundary condition is assessed extensively and some insightful solutions and interpretations have been presented.

PIC/MCC Simulation of Axial Ring-Cusp Hybrid Discharge in the Micro Ion Thruster Ionization Chamber

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Abstract. Micro DC ion thrusters have broad application prospects as the propulsion system of micro spacecrafts due to their advantages of high discharge reliability and efficiency. The experiments in the literature show that the plasma discharge under axial ring-cusp hybrid (ARCH) magnetic field has higher discharge efficiency in the ionization chamber of micro DC ion thruster. In this paper, a 2D axisymmetric particle in cell/ Monte Carlo (PIC-MCC) numerical model is developed for plasma discharge under ARCH magnetic field. This model takes the thermal electron emission including the Schottky effect, various collision processes and the uneven background gas density distribution in the cathode-anode gap into account. The formation and transport process of DC discharge plasma are presented and the spatiotemporal dynamic characteristics of plasma are investigated. The plasma characteristics under the ARCH magnetic field and the traditional 3 ring-cusp field are compared and the sensitivity of the thruster performance to the magnetic field intensity at the cusp point are explored. The above results provide a further support for the design optimization of the micro DC ion thruster ionization chamber.

Aerodynamics Analysis of Fighter Aircraft in Formation Flight

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Abstract. Formation flight is one of typical methods that migrating birds use for a long distance flight. It has been known that aircraft in formation flight have the advantage that their aerodynamic efficiencies increase with a optimal combination of axial and lateral distance between the aircraft. The disadvantage is that the slight change of the relative distance can result in the unstable operating conditions. In the present study, a potential based panel method is utilized in order to compute the aerodynamics of the aircraft in formation flight. In the conference, the effect of the changes in the relative distances(axial, lateral, and vertical) on the aerodynamic performance will be addressed.

Three-dimensional PIC-MCC Analysis of Ion Thruster Grid Misalignment

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Abstract. The assembly deviation between screen and accelerator grid apertures is one of the critical reasons for the erosion failure of optic systems of ion thruster, which can also cause an unexpected roll torque about the ion beam axis. A three-dimensional computer model of ion optics is developed to analyze the focusing properties and erosion characteristics of ion thrusters. In this model, the movement of particles is conducted by the particle-in-cell (PIC) method, while the collision between different species is conducted by the Monte Carlo collision (MCC) method. The influences of the non-uniformity of neutral density and the charge exchange (CEX) collision are considered. In the present study, variation of beam deflection angle with misalignment of apertures, acceleration voltage and current density are investigated. The calculated space charge distribution is consistent with the results in the literature. The results show that the upstream sheath of the grid is the main factor affecting the beam deflection. The influence of sheath on deflection increases with the decrease of current density. In addition, the erosion of accelerator grid caused by misalignment of apertures and CEX is also studied.

Design of Propulsion System for Propeller-less UAV

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Abstract. Unmanned Aerial Vehicles (UAVs) are extensively used in many applications, including drug delivery, agricultural applications, fire monitoring, civil survey, etc. These uses make the UAV industry have a positive growth trajectory in the future. The current generation UAVs consist of a propeller-based mechanism that develops the thrust to propel the vehicle. The exposed blades of the propeller lead to safety and efficiency issues. To overcome this, UAVs reported in the literature were depending on combustion-based systems like micro gas turbine engines and internal combustion (IC) engines. In the current study, we are attempting to design a novel battery-powered propeller-less propulsion system for UAVs without any exposed blades. The preliminary CFD results have shown the enhancement in the performance and efficiency of the propulsor.

SCHEDULED LIST OF PAPERS

NAME OF THE AUTHORS	PAPER TITLE
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Sudip Chowdhury	Dynamic response control of adjacent structures connected by viscous damper using inerter-based isolation systems
Arun Kumar Perumal and Ethirajan Rathakrishnan	Scaling law for core length in supersonic free jets
Dr. Rajesh Kumar and Pramodkumar Vanam	Simulating the impact of ground vortex ingestion on inlet performance
Aneesh Batchu, Bharath Obalareddy and Prabhakar Sathujoda	Dynamic Modelling of a Porous Functionally Graded Rotor-bearing System for Different Temperature Distributions
Bharath Obalareddy, Aneesh Batchu and Prabhakar Sathujoda	Free Vibration Analysis of a Rotor-bearing System having Corrosion Defect
Yagya Dutta Dwivedi, N Lakshmi Narasimhan, Jayendra Rajanala and Kameswara Sridhar Vepa	Parametric study of bio-inspired corrugated airfoil geometry in a forward flight at Reynolds number 80000
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Pushpendra K Kushwaha, Vivek Kumar, Vinay Vakharia and Satish C. Sharma	Performance analysis of rough surface multi-recess porous hydro-static thrust bearing
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Rohith J, Shashank H K, Akshay S Prasad, Dheeraj R and B Sudarshan	Design of Propulsion System for Propeller-less UAV
Madhusudhanan U and Rajesh Kitey	Al/epoxy adhesion strength by a modified butt joint test configuration
Ritik Saxena, Divyansh Tewari, Akshit Gupta and Dr M Abdul Akbar	Comparative study of dampers on a G+26 storey building subjected to lateral loading
Aritras Roy and Rinku Mukherjee	Near - Wake Flow Structures of a Rectangular Wing at the Onset of Stall
Amit Arora	Flow modifications & capacity augmentation due to streamwise deployment of longitudinal vortex generators in a finned tube bank
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Pranav H A and B Sudarshan	Shock wave effects on Chitosan bio-polymer for drug delivery applications

Aditya Deshpande and Bhrigu Nath Singh	Effects of internal length scale parameter on damage initiation and evolution using gradient enhanced damage mechanics theory
A Arun Kumar and Amit Kumar Onkar	Robust flutter analysis of a sweptback wing using μ method
Sanjay A V and B Sudarshan	Effect of oblique shocks interaction on the inlet structure in a hypersonic flow
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