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Guest Editorial

Selected Papers from 4th National Aerospace Propulsion Conference (NAPC-2022)

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The National Aerospace Propulsion Conference (NAPC) is a national conference dedicated to aerospace propulsion technologies. Two erstwhile popular conference series, the National Propulsion Conference (NPC) and the National Conference on Air-Breathing Engines (NCABE) were merged to result in NAPC. This biennial conference is intended to bring together the entire propulsion community spanning the industry, academia and the research labs nationwide. The aerospace propulsion-centred conference is considered an ideal opportunity to showcase one's research activities with peers and foster future collaborations through networking. The 4th edition of the conference, NAPC-2022, comprised a keynote lecture, several topical invited lectures and presentations of contributed papers in parallel sessions. This special issue contains eight manuscripts selected based on peer-reviews of selected papers presented during the conference. The manuscripts broadly cover several aspects pertaining to aerospace propulsion that includes airbreathing engine components such as intakes, compressors, combustors and nozzles. From the rocket propulsion (non-airbreathing), there are papers that investigate the rocket motor grain port alignment and another paper on the heat transfer characteristics of a supersonic rocket nozzle.

Pathak, *et al.* investigate the utilization of a movable flap as a throttling device to explore scramjet inlet unstart numerically. The flap serves as a means to simulate the increase in combustor pressure in the scramjet. Computational analyses are conducted for a freestream Mach number of 6.0 using a 2D compressible CFD in-house solver designed for perfect gas. Of particular interest in these simulations is the implementation of the Immersed Boundary Method (IBM) along the wall boundaries, allowing for the use of structured grids for complex geometries. The results delineate the starting condition of the inlet based on the throttling values of the flap. Comparative results, depicted in the form of Mach number and pressure contours, are presented for various flap positions. The successful demonstration of the IBM is highlighted through the simulation of a movable flap.

Kumar, *et al.* discuss the intricate flow physics associated with an axial flow rotor. A transonic axial compressor rotor is characterised by the presence of a set of shock waves, especially near its tip (or shroud). The performance of a compressor rotor is very sensitive to the shock structure. This manuscript explores the flow features and their interaction with the shock structure. The investigation primarily focuses on examining the flow dynamics from choke to near-stall conditions, encompassing the study of shock formation within the blade passage, its behaviour under different back-pressure conditions, interactions with the boundary layer, tip leakage flow patterns, and the resultant losses. The work explores the compressor performance from 60 % to 100 % of the design speed, employing both steady and unsteady Reynolds-Averaged Navier-Stokes (RANS) simulations. The aerodynamic performance of the rotor is assessed in terms of total pressure ratio, efficiency, and flow patterns. Unsteady analysis reveals that the primary and secondary tip leakage vortices, coupled with suction side tip corner separation, are the principal instabilities near the stall region.

Mahto and Chakravarthy present a workflow aimed at automating the exploration of the design space for gas turbine combustors using response surface methodology. Utilizing CFD investigations, coupled with central composite design for experiments and genetic aggregation for generating response surfaces, the performance of the combustor within the design space is quantified. A comparison among three distinct design methodologies is conducted to illustrate how the selection of a particular methodology alters the available design space, consequently constraining or broadening combustor performance. Additionally, this study presents candidate optimal designs and their associated trade-offs derived from the optimization process. The insights gleaned from this research can assist combustor design engineers in selecting the most appropriate preliminary design methodology tailored to their specific requirements.

Srinivasarao and Reddy report results from their numerical simulations for Moderate and Intense Low Oxygen Dilution (MILD) combustion. To address complexities associated with detailed flow physics and computational time, various advanced combustion modelling techniques have been recently developed to investigate MILD combustion characteristics. However, each combustion model encounters specific challenges in accurately predicting the temperature and emissions of MILD combustion flames. Recognizing the diffusive nature of MILD flames, this study explores Lewis numbers' effects on a non-premixed flame. The investigation spans from stoichiometric to ultra-rich mixtures in non-premixed flames, exploring individual Lewis numbers for methane and hydrogen. Multiple numerical simulations are conducted within the OpenFOAM9 framework, employing a modified EDC model with adjusted turbulence and combustion model constants. The study further examines various combustion parameters with diverse CH_4

and H_2 Lewis number combinations, including a comparison with the unity Lewis number case.

Singh, *et al.* report their study involving a chemical kinetic investigation to explore the characteristics of Intense Low Oxygen Dilution (MILD) or Moderate combustion in ammonia (NH_3)/air flames. The work focuses on examining the combustion attributes of MILD through dilution with H_2O and N_2. As the inlet temperature of the premixed reactant increases, the flame's peak temperature also rises. Notably, flames diluted with H_2O exhibit lower peak temperatures compared to those diluted with N_2. H_2O-diluted flames result in reduced NOx emissions compared to N_2-diluted flames. Additionally, for N_2-diluted flames, exit NOx emissions increase with rising oxygen concentration. In contrast to N_2, H_2O-diluted flames exhibit a wider range of no-ignition. The increase in peak temperature in H_2O-diluted flames is less pronounced than in N_2-diluted flames, corresponding to broader MILD combustion ranges. Furthermore, achieving MILD combustion in H_2O-diluted flames at a specific O_2 concentration requires a higher reactant temperature compared to N_2-diluted flames.

Chitimada and Sinhamahapatra, in their study, investigate the influence of elliptical, square, and triangular shaped orifices on the mixing characteristics of a free jet with a Mach number of 0.8. Numerical simulations were conducted, and parameters such as mean velocity, decay rate, half-velocity width, spread rate, and turbulence intensity of the jet were scrutinized. The findings revealed that the triangular orifice yielded the most efficient mixing, accompanied by a shorter jet core length. The decay rate was observed to be lowest for the square jet and highest for the triangular jet, consistent with prior research. Asymmetric jets exhibited two axis-switching points, while the square jet underwent a 45° rotation of its axes without axis-switching. Turbulence levels were lower in the core region, while the shear layer exhibited the highest turbulence levels.

Rocket nozzles commonly employ the method of passing liquid propellants through channels within the nozzle walls to facilitate cooling. Accurately estimating the heat transfer from the hot gases within the nozzle to the wall is crucial for determining the requisite coolant flow rates. Makhija, *et al.* investigate the computational prediction of convection heat transfer to the nozzle walls under compressible turbulent flows. Utilising the rhoSimpleFoam solver within OpenFOAM®, computations are conducted employing two distinct turbulence models. The supersonic flow over a flat plate is simulated to validate the methodology for calculating heat flux and to assess the characteristics of the turbulence model. Results indicate that the realizable k-epsilon turbulence model yields satisfactory results in estimating the heat transfer coefficient.

A hybrid rocket motor (HRM) represents a form of chemical rocket propulsion wherein the propellants are stored in distinct physical states. To address the inherent challenges of low regression rates associated with HRMs, various grain configurations with innovative port techniques have evolved over time. Gyandeep and Kumar, in their present study, adopt a similar approach. The study employs a solid grain composed of polyvinyl chloride and di-butyl phthalate in a 50:50 ratio, paired with gaseous oxygen as the oxidizer. This paper conducts analyses to evaluate the performance of a hybrid rocket motor by manipulating the axial alignment of the grain port at different locations along its length. By offsetting the fuel port at various positions, recirculation zones are generated, subsequently augmenting pressure within the combustion chamber by approximately 1-2 bar. Consequently, the thrust generated was observed to increase. Furthermore, the utilization of these port alignment techniques leads to observed enhancements in regression rate and efficiency.

The above set of manuscripts offers a glimpse of propulsion-related research activities undertaken at various academic institutes and research laboratories across the country. It is hoped that conferences such as these will motivate researchers to use this as a platform to network and share their knowledge with others in this very interesting and important area of research.

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