INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:

EXPERIMENTAL AND COMPUTATIONAL INVESTIGATIONS OF FORCE PREDICTION METHODOLOGY FROM FORCE BALANCES FOR SHORT DURATION APPLICATIONS

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Force measurement is one of the vital areas of research, which is essential in the design of any mechanical or electromechanical systems. Due to lack of sophisticated testing and force prediction on the scaled models in the design phase, a lot of failures are encountered over the decades for various vehicles such as ships, rockets, airplanes, internal combustion engines etc. However in recent years, rate of failures of such kind were reduced due to the development in force measurement facilities and force measurement techniques. Force measurement in impulse facilities such as shock tunnel is one of the specialized area useful for the design of hypersonic vehicles. These measurements are sophisticated due to their short test duration. Computational techniques like Finite Element Method (FEM) and Computational Fluid Dynamics (CFD) are generally used before actual design of the system. Recently evolved fluid structure interaction (FSI) is one of the emerging computational tools for the analysis of fluid and solid domains simultaneously. Here, the surface forces obtained from the fluid simulations are transferred to the fluid solid interface for obtaining the response from the structural simulation. Since increasing mission complexities and advanced technologies demand more accurate assessments, the experimental force prediction strategies are preferred since they provide golden mean between the accuracy and the cost effectiveness. Therefore, ground based

facilities are essential for the purpose of proper understanding of the physics of the flow and the associated aerodynamic parameters. Encouraging developments in the short duration facilities like conventional shock tunnel free piston shock tunnel etc. has posed challenges in measuring forces and moments during the experiments.

Two different techniques viz., accelerometer and stress wave based force balances are generally used for measurement of forces and moments in the high speed impulse (short duration) facilities. Therefore in the present work initial investigations deal with establishment of a non-intrusive force measurement technique using laser and development of the associated experimental set-up. This technique is then assessed with the well-established contemporary techniques for the step and impulse loading.

Accelerometer force balance has been used by various researchers for force measurement in shock tunnel testing with the assumption of free-flying condition. Finite element modeling is carried out for one of the literature reported test model to evaluate the resistance offered by the rubber during the experimental test time. These studies show that the effective test time decreases with increase in the angle of attack due to increase in resistance of the rubber. These studies are also found useful to demonstrate the use of computational techniques in developing the force balance for a given test model.

Accelerometer based force balances are seen to be directly used for force measurement as seen in the literatures. At the same time stress wave force balances are involved with detailed calibration procedure based on de-convolution technique. Therefore, present investigations are carried out to assess the use of soft computing techniques viz. Neural Network (NN) and Artificial Neuro-Fuzzy Inference System (ANFIS). An ANFIS based methodology is found to be more precise to predict the forces and moments in comparison with the NN based methodology. In view of this parametric studies are initiated to explore the use of best algorithm in ANFIS for prediction of forces and moments.

Shock tunnel tests are then performed on a hemispherical test model for force measurement using accelerometer balance. These experiments are carried out in the Shock Tunnel at Indian Institute of Technology, Bombay, India (IITB-ST) in order to justify the use of soft computing techniques for actual experiments in impulse facilities. In view of this calibration tests are carried out to train the ANFIS based algorithm using known impulse force and accelerations signals. Acceleration signals obtained from the shock tunnel tests are then used to recover the force. It has been observed that the ANFIS based prediction of aerodynamic

coefficients has encouraging match with the prediction of same using accelerometer force balance theory.

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