INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:
FORCE RECOVERY TECHNIQUE FOR MULTI COMPONENT BALANCES UNDER IMPULSIVE LOADING IN HIGH SPEED FLOW EXPERIMENTS

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SHORT ABSTRACT

Accurate force measurement is a major concern in the design phase of any high speed vehicle in order to assess its stability and to estimate the fuel requirement. Evolution of new strategy for force prediction has to be authenticated by implementing the same in various impulse facilities like shock tube, shock tunnel, expansion tunnel etc. Force measurement experiments in such facilities are necessarily sophisticated due to the short duration. Further, inclusion of the whole system dynamics during force measurement studies is also a challenging task. Since stiffness based balance represents the system more accurately, present investigations mainly focus on the stiffness based force balances.

To monitor the strain variation, usually strain gauge and pizofilm are opted as dynamic sensors in case of stress wave balance systems. Present study has been initiated to explore the types of configurations by which strain gauge can be connected in a Wheatstone bridge circuit. During dynamic calibration of the instrumented model and stress bar assembly, strain responses are captured and analyzed in temporal as well as frequency domain. This investigation reveals that half bridge circuit is more suitable for application in impulsive facilities. Further, piezofilm is also mounted on the model assembly and in order to assess the capabilities of both the sensors, the model is subjected to low supersonic flow environment in shock tube to measure the drag force. Drag force acting on the model during the experiment is predicted through de-convolution technique and Adaptive Neuro-Fuzzy Inference System (ANFIS) using the system response function derived from the dynamic calibration responses. Keeping in view of the good agreement between force obtained though experiments and numerical method, it is further planned to extend the application of ANFIS to multi component systems.

Usually during evaluation of system response function for multi component systems, single point dynamic calibration is performed. This seems to be the prime factor for deviation in force magnitude estimation, since recovery of aerodynamic coefficients depends upon the choice of calibration point. In this regard, a new multi-point calibration method is proposed for accurate measurement of aerodynamic coefficients. This methodology is developed using genetic algorithm, with an intention to calculate the responses upon application of forces in orthogonal directions. Thereafter, this methodology in conjunction with ANFIS is assessed through comparative analysis of the force recovery method reported in the literature. Internal accelerometer and piezofilm based force balance systems have been developed and employed for the verification of the proposed strategy. In this regard, a blunt bi-cone shaped model is employed to test in the IITB-Shock Tunnel at two angles of inclination. Encouraging match has been observed between theory and ANFIS based prediction methodology, at all angle of attack conditions, for both accelerometer and piezofilm balances. Thereafter, this method has been extended for drag reduction studies using hemispherical and sharp spikes where sensitivity of force measurement and prediction techniques has been monitored.