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DESIGN AND DEVELOPMENT OF FIBER OPTIC BASED FORCE BALANCE FOR SUPERSONIC WIND TUNNEL

Abstract

Great strides have been made in the application of fiber-optic measurement technology to measure material strain, and thereby loads. This project aimed to employ existing fiber-optic technologies developed by Cranfield University to design, construct and test a simple sting, instrumented to measure drag force of fore bodies in a Supersonic or Hypersonic wind tunnel. Existing force balance designs were reviewed and feasible design was made in collaboration with Prof. Ralf Tatum's Photonics group who have developed the fiber-optic instrumentation, and a prototype was constructed. FEA Stress analysis was performed using MSC NASTRAN by simulating expected working loads acting in the wind tunnel, the results of which were used to determine the Fiber optic sensors position to measure the strain. 4 FBG sensors were attached on the designed sting which measure strain in normal, axial and side force components. The constructed prototype was then static calibrated to determine the range and usability for wind tunnel measurements. Calibration test results reveal that the designed prototype measures 3-component forces (normal, axial and side) accurately up to 8 N and can sustain loads of up to 20 N. Error Analysis results revealed the standard mean error in output readings for FBG Channels 1, 2, 3 and 4 as 0.019 nm, 0.021 nm, 0.016 nm and 0.018 nm respectively with a precision of 0.002