Shear Stress-based Air Speed Indication System

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The conventional air speed indication (ASI) systems rely on Pitot-static pressure differentials, which remain vulnerable to blockages from contaminants and icing, compromising measurement reliability, necessitating robust sensing alternatives. We present a novel shear stress-based airspeed indication system, designed for aircraft applications. The proposed airspeed indicator employs a cantilever type slender, T- beam, rigidly anchored at its base, free at the opposite end [1]. The floating head of T-beam translates in response to velocity-induced wall shear stress (illustrated in Fig. 1), bending the slender beam. Strain gauges positioned near the base of the cantilever beam capture the bending-induced strain. A transient structural analysis was carried out using the *ANSYS 2022 R2 Transient Structural module* to evaluate the strain response for different air speeds. The wall shear stress is subsequently determined from the strain obtained through simulation studies on the cantilever beam.

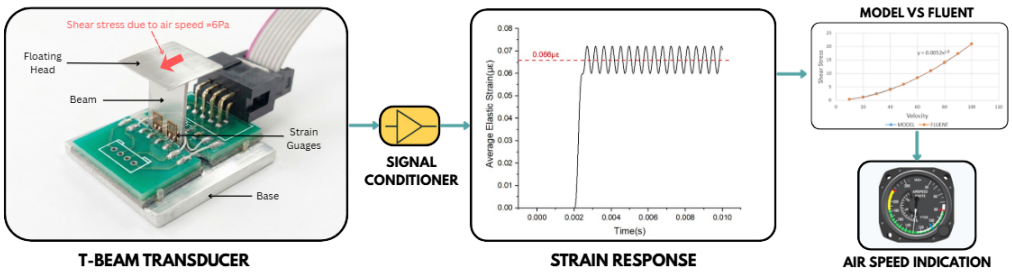

Figure 1. Shear stress-based air speed indicator (ASI) Model

The free-stream velocity is correlated to wall shear stress through a mathematical model given by Eq. (1).

$$u = k_c \tau_w^{5/9} \quad (1),$$

where, turbulence effect is taken into account through k_c (k_c = 18.4747), which is an empirical constant; u is the freestream velocity and τ_w is the wall shear stress.

The mathematical model was validated through numerical simulations carried out using *ANSYS 2022 R2 FLUENT*. The results obtained from the mathematical model are in good agreement with the numerical simulations (*ref. Fig. 1, inset Model vs Fluent*). The results demonstrate the feasibility of shear stress-based airspeed indication, offering a simple, cost-effective alternative to conventional Pitot-static probe-based systems, with improved robustness and reduced susceptibility to blockage.

[1] S. Pathan, M. Kshetrimayum, V. Menezes, C.S. Yerramalli, Sādhanā 50, Article 128, 2025. https://doi.org/10.1007/s12046-025-02767-1