Student Project/Master Thesis

Design of a Miniature Traverse Mechanism for Boundary Layer Measurements Application Using Hot-Wire Anemometer in Low-Speed Wind Tunnel

Motivation

In hybrid laminar flow control (HLFC) application the capability to investigate the boundary layer (BL) characteristics on a flat-plate or an airfoil surface is essential. One efficient way to do so is by using the Constant Temperature Anemometry (CTA) technique. Constant Temperature Anemometry (CTA), also known as Thermal Anemometry, is a technique for the measurement of turbulence in gas and liquid flows using hot-wire or hot-film probes inserted into the flow. CTA is particularly suitable for the measurement of flows with very fast fluctuations at a given point. CTA can resolve small flow eddies down to the order of tenths of a millimeter [1].

The working principle of a hot-wire (hot-film) anemometry is based on the cooling effect of a flow on a heated body. In hot-wire anemometers, very fine wires of about one micron, in diameter, are heated up to temperatures above ambient and the airflow past the wire has a cooling effect. The wire is connected to one arm of a Wheatstone bridge and heated by electrical current. The bridge voltage, E, represents the heat transfer and is thus a direct measure of the velocity, which can be processed into amplitude and time-domain statistics. Using this technique, flow features such as mean velocity, turbulence intensity, auto-correlations, and power spectra. There is a wide range of hot-wire probes with a wide spectrum of prices [2].

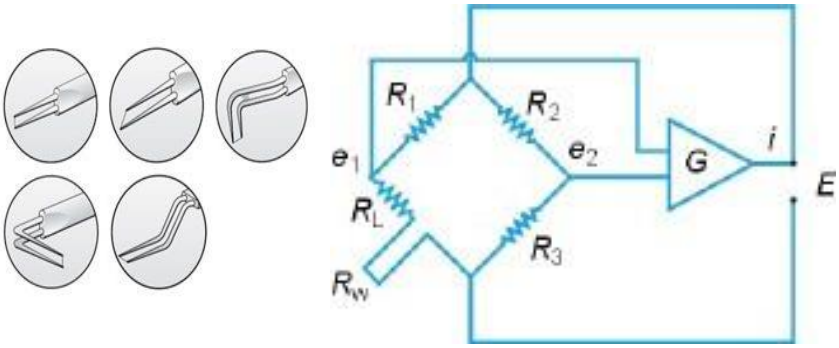

Figure 1. Examples of hot-wire probes, and a Wheatstone bridge diagram, Ref.[2]

To map and measure the BL at different point locations (i.e.: in chordwise, spanwise and normal direction) on an airfoil or/and flat plate, a **miniature traverse mechanism** with small dimensions and displacements is required. The traverse system supports the hot wire probe and it should be mounted in the wind tunnel facility.

Research objective

The main study objective of this project is to ***design and build a miniature travers model system, with 2 or 3 degrees of freedom, that support a miniature hot-wire anemometry probe***. The system will be used for measuring the BL profile on a flat plate and 2d airfoil model (up to 50 cm chord) in low-speed wind tunnel. The traverse unit will be aligned parallel to the boundary layer plate to within ±0.5mm over an area of 500 x 500mm.

Figure 2. Traverse mechanism example Ref. [3], and the wind tunnel facility at TU Braunschweig

Some of the key points to consider in the traverse system design:

1. The dimensions and the tools are relatively small w.r.t conventional traverse mechanism
2. The probe holder should be designed such that the probe can be re-attachable to the traverse
3. The head of the probe must be far away from any other physical entities to prevent the effects of the other bodies on the result of experimentation
4. The rigidity and the robustness should be the prime goals to structure the design of the transverse mechanism.
5. To be designed to withstand the wind force and manipulate the probe robustly and repeatedly against this wind force. Max wind velocity 60 m/s
6. Can be mounted efficiently in the wind-tunnel and on the testing model

Required

For this project, a Master student from Mechanical or Aerospace Engineering department with sufficient knowledge in mechanical systems design, CAD design and FEA (optional). This proposal is suited for a ***student project*** as well ***Master thesis (Studien-or Masterarbeit)***.

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References

[1] Low-speed wind tunnel testing, J. B. Barlow, W. H. Rae, JR. and A. Pope, Third Edition, Wiley
[2] https://www.dantecdynamics.com/solutions-applications/solutions/fluid-mechanics/constant-temperature-anemometry-cta/
[3] https://www.aerolab.com/products/traverse-systems/