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A FLYING HOT-WIRE PROBE SYSTEM FOR MEASUREMENTS IN SEPARATED FLOW

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ABSTRACT

This paper contains a description of the principles of a flying hot-wire system, and outlines the advantages and disadvantages of using a hot-wire probe system based on either a circular, linear or 'bean shaped' curve path. The system developed at Bradford University is based on the 'bean shaped' curve path first utilized at Imperial College. A brief description is given of its operation. The validity of the system was demonstrated by a calibration test in which a single normal hot-wire probe was moved in still air. Finally, results are presented for measurements with such a probe behind a backward-facing step with a height H = 120 mm. The results obtained show many of the features observed in similar investigations with Laser-Doppler anemometry, but some new bi-modal phenomena are noticed in the pdf curves in parts of the separated flow region. It is demonstrated that this bi-modal phenomena is consistent with the existence of a flip-flop stability situation in the shear layer, which bounds the separated flow region.

1. INTRODUCTION

Hot-wire anemometry is a useful and practical tool for the study of many turbulent flows. A single normal hot-wire probe is easy to use and can provide information on the longitudinal velocity component in low/moderate turbulence intensity flows. However with a single stationary hot-wire probe one is not able to detect reversals in the flow direction. To measure the lateral velocity components a variety of probe configurations are commercially available with one, two or three wire sensors, the output from which can be manipulated to obtain the desired quantities. Tutu and Chevray [1] carried out an extensive study of the effects of large velocity fluctuations on the output of an X hot-wire probe including errors caused by flow reversals. In practice it has been found that to obtain reliable results the (U,V) velocity vector must lie within the approach quadrant of the X-probe.

For these reasons it has, until recently, proved difficult to obtain reliable quantitative experimental information on the velocity field in regions of separated flow. However, due to the development of more complex techniques such as the flying hot-wire technique, the pulsed hot-wire anemometer and Laser-Doppler anemometer, detailed flow measurements in separated flow regions are now possible. This paper is concerned with the flying hot-wire technique. Basically, a hot-wire probe responds to the velocity vector relative to a wire-fixed co-ordinate system. This principle is used in all flying hot-wire techniques. To avoid the signal rectification associated with stationary probes in reversing flows, the probe is moved through the region of interest with a known velocity, higher than any instantaneous negative velocity. Various implementations of this technique are considered in this paper, and the advantages and disadvantages, of systems utilizing a circular, a linear and a 'bean shaped' probe path are discussed. The 'bean shaped' path was selected in the flying hot-wire probe system developed at Bradford University, and this paper gives a brief description of its implementation. Initially the system was tested using a single normal hot-wire probe. A calibration test was first carried out in still air to demonstrate the accuracy of the system. This was followed by a test involving measurements behind a backward-facing step.

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2. THE FLYING HOT-WIRE TECHNIQUE

The basic principle of the flying hot-wire technique can be explained with reference to figure 1. It is assumed that we have a surface with a separated flow region. A space-fixed co-ordinate system (X, Y) is introduced, in which the flow velocity vector $\vec{V}$ and the related velocity components (U, V) are to be evaluated. (In this discussion only a two dimensional flow field is considered.) For a given

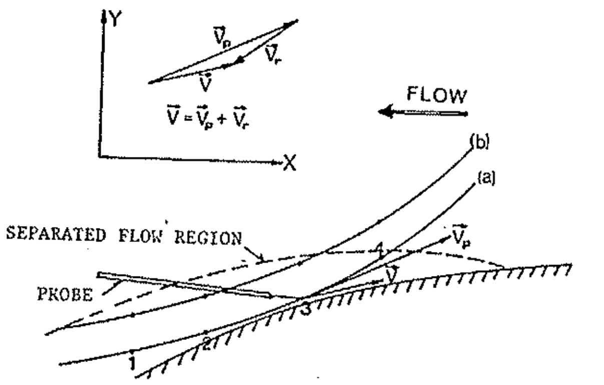

Fig 1 Principle of measurement with a flying hot-wire probe.

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