TIME-OF-FLIGHT ANEMOMETER FOR HOT SECTION APPLICATIONS

Robert V. Edwards
Chemical Engineering Department
Case Western Reserve University

The purpose of this section of the project is to design, construct, and test laser anemometer configurations for Hot Section velocity measurements. Optimizing the laser anemometer system necessarily included the data processing algorithms used. It is felt that the requirements here are too demanding for standard laser anemometer systems.

Relevant Hot Section Properties

1) High temperature with possibility of large background radiation
2) Difficult optical access
3) Large flow velocity variation - especially in the rotating sections
4) Presence of solid surfaces that generate spurious reflections
5) Low seed particle density

In the past few years, the laser scattering group at Risø, Denmark, under the direction of Lars Lading, and the laser scattering group at Case Western Reserve University under Robert V. Edwards, have worked together to develop procedures for the optimal design of laser anemometry systems. The principles derived are being used to design the system for Hot Section measurements.

The system decided on is a so-called time-of-flight anemometer with elliptical spots. The version of the time-of-flight designed for this project contains two new features: 1) Elliptical spots - this gives the wide flow angle acceptance characteristics of a "fringe" anemometer combined with the superior spatial resolution of a time-of-flight anemometer. 2) The prototype for the Hot Section measurements uses a unique optical coding to transform the pulse into the optimal form for pulse position sensing. Heretofore, this required rather complex and inflexible electronic circuitry. This optical processor is intrinsically free from some of the errors to which the electronic circuits were prone.

Figure 1 is a photograph of the prototype optical system. The system is presently undergoing tests for accuracy and spatial resolution. The preliminary indications are that the system is capable of measurement within 300 μm of a surface. A better estimate of the spatial resolution will be possible only after we mechanically stiffen the system. It requires very tight tolerances on the optics.

A prototype has been built of an electronic signal processor for the anemometer. Figure 2 shows the signals generated to detect the pulse position. The zero crossing of the s-shaped pulses are used. A velocity histogram obtained using this system on a seeded flow in a small wind tunnel is shown in Figure 3.

The prototype system is being evaluated in terms of scale-up to a system capable of the desired hot stage measurements. In particular, the mechanical and optical requirements of the system are being evaluated.

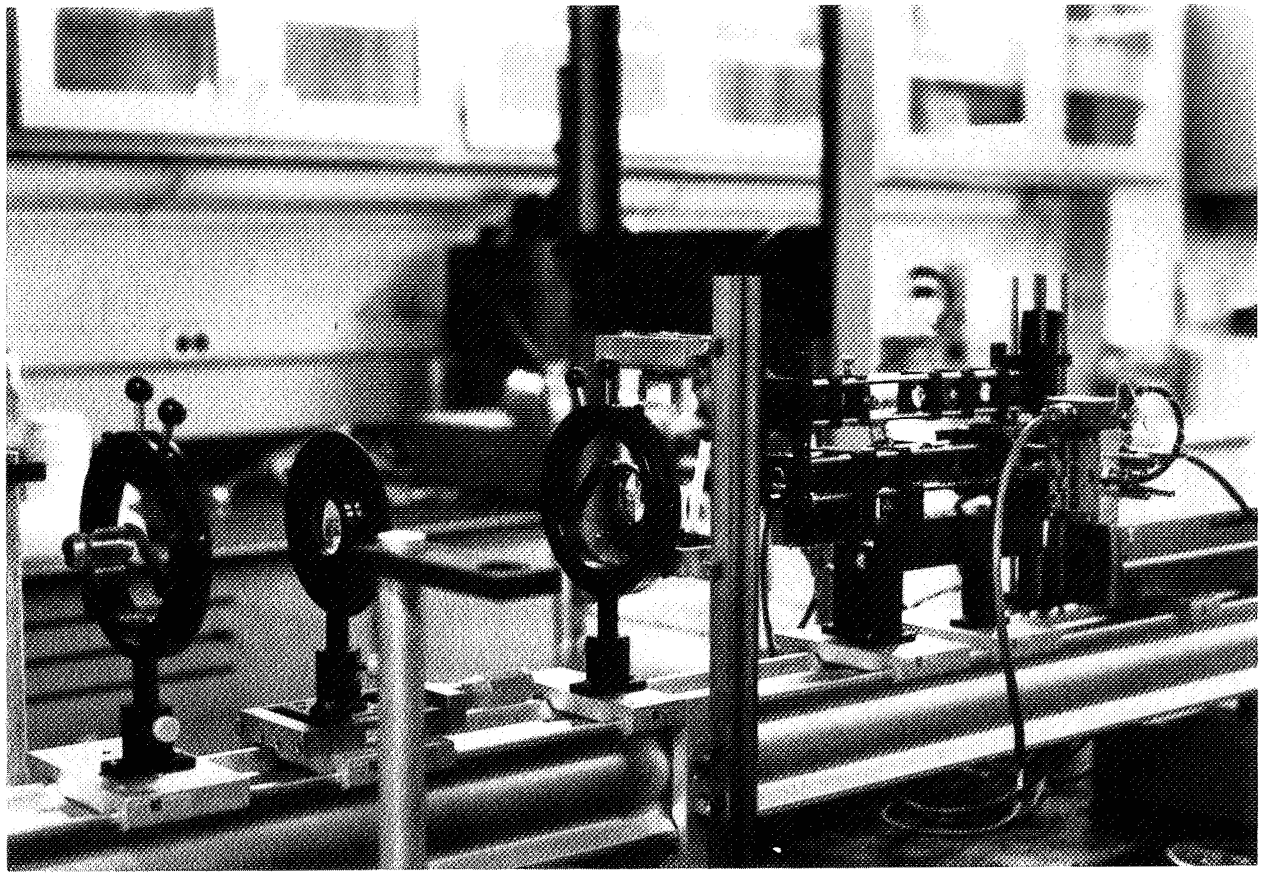

Figure 1: Prototype of Time-of-Flight Anemometer. It is constructed of commercial optical "breadboard" components.

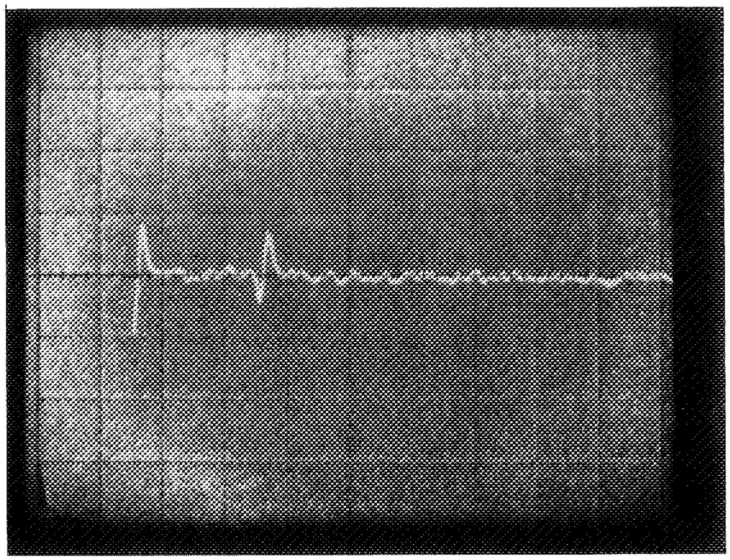

Figure 2: Oscilloscope trace of difference signal from the two photo-detectors.

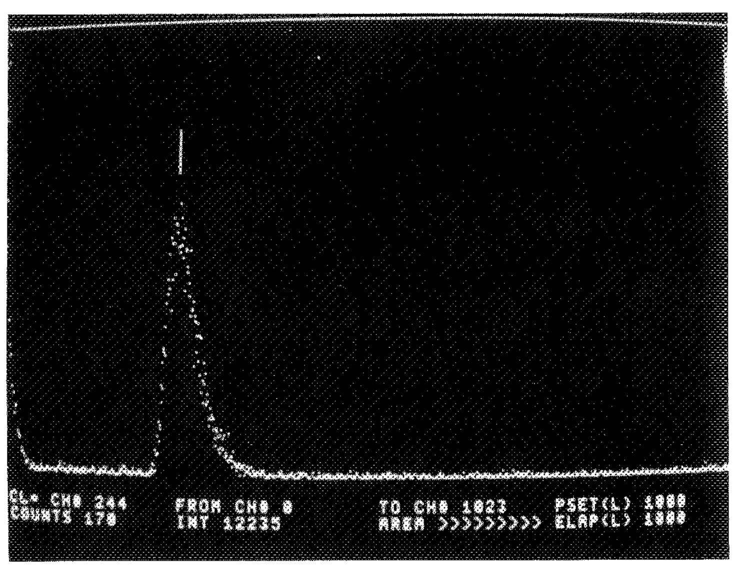

Figure 3: Velocity histogram obtained using new anemometer on air flow in a small wind tunnel. The pulse separation is converted to a pulse height and then stored on a pulse height analyzer.