SELECTING THE COINCIDENCE WINDOW FOR A MULTICHANNEL LDV SYSTEM

LDV SYSTEMS

Measurements of multiple velocity components are of interest in many practical flows. Simultaneous measurement of the velocity components provides information essential to understanding the flow dynamics. Velocity component values, at the same instant, are needed to obtain Reynolds stress values, instantaneous flow direction, etc. In the case of a three-component system using a non-orthogonal arrangement, simultaneous measurements are essential to obtain the statistical properties of the orthogonal components of velocity.(1) In addition, in areas such as mass transfer, combustion, and energy transfer, the interdependence of the fluctuation of properties such as temperature, concentration, and velocity is of importance. This is obtained from correlations of the instantaneous values of the flow properties. Correlation measurement implies the need to obtain the quantities to be correlated at the same instant in time.

In laser Doppler velocimetry, the source of the signal is the scatterer (particle). Velocity measurements using LDV are obtained only when particles pass through the measuring volume. As pointed out earlier, the need to obtain measurements at the same instant in time (coincidence) exists in the use of LDV. The simpleminded approach to achieve this would be to sample all signals at equal intervals in time. However, since particle arrival is random, even time sampling will not provide true samples of signal evolution and hence, the desired correlation. Instead, what is needed will be to sample the signals, at the same instant, when they occur. In the case of two- or three-component LDV measurements, the coincidence condition would imply that the passage of a particle through the measuring region generates Doppler signals in all channels and that the signal processors provide valid measurements.

Coincidence Measurements

In LDV, measurement of velocity components at the same instant in time translates into multichannel measurements obtained through the passage of a scattering particle. The duration of the Doppler signal corresponds to the transit time of the particle. Ideally, a particle passing through the measuring region of a three-component LDV system will simultaneously generate three signals which, when processed by three signal processors will provide three velocity values. In this case, the signal processors will also provide three data-ready signals indicating the availability of the velocity measurements. Thus, coincidence can be easily checked using the data-ready signal from the processors. Simultaneous measurements of velocity components are obtained by ensuring that the data-ready signals become available within a time window called the "coincidence window" (Figure 1).

Coincidence Window

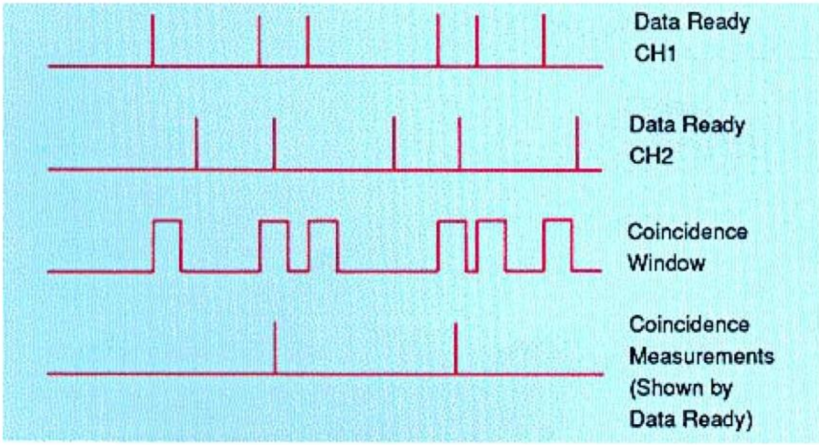

Figure 1. Schematic on coincidence detection.

In order to ensure that the measurements are simultaneous, the coincidence window has to be selected properly. Usually, the selection of window width (Figure 1) and the check for coincidence is done in the multichannel interface. In the coincidence mode of operation, the first signal processor to provide a measurement (data-ready signal) initiates the coincidence window, and the other signal processors should complete the measurement (provide data-ready signals) within the selected time window. Hence, the selection of coincidence window width is to be done carefully.

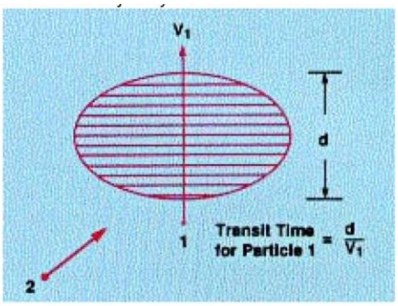

Figure 2. Particle trajectory

Doppler signals exist for the time taken by the particle to cross the measuring volume (Figure 2). Consider the example of an LDV system having a measuring region diameter of 0.22 mm and length of 4.6 mm. For a flow with a maximum velocity of 10 m/sec, a scattering particle will take at least 22 microseconds to cross the measuring region. If the flow is at an angle (particle 2) to the optical axis, then the particle transit time and hence, the duration of the Doppler signal will be greater (Figure 2). Hence, it is possible to have data-ready pulses occurring within a larger time window (based on system setup). The transit time based estimates, therefore, give an estimate of the coincidence window width which are toward the lower end of the suitable window width (coincidence window > transit time).

On the other hand, the maximum value of the coincidence window should be such that the measurements from one particle and the next are not mistakenly taken to be from the same scatterer and hence satisfying the coincidence criterion. In other words, the time of arrival (at the measuring volume) between two "consecutive" particles should be greater than the coincidence window selected, thus, the necessary condition for the coincidence window width should be that it is less than the time [t(2)] between two successive measurements (coincidence window <t(2)). Generally, the data rate could be used to estimate the average time elapsed between measurements (t(1), Figure 3). Because of random arrival of particles, the time between successive measurements can be significantly different from estimates obtained from an average data rate. A simple estimate of the appropriate window width would be to use a value an order of magnitude less than the time between data, obtained as the inverse of the data rate.

Multichannel Interfaces (MI-990 and MI-550)

The selected value of the coincidence window is set on the multichannel interface. Multichannel interfaces are available for both intelligent flow analyzers (MI-550) and counter-type processors (MI-990). One multichannel interface enables data transfer from several signal processors into computer memory via direct memory access. These interfaces can operate in random or coincidence mode. In coincidence mode, data transmission occurs only when each channel generates a data-ready pulse within the selected coincidence window. The coincidence window width is selected and set using the computer through the RS232C control. Velocity data transferred into the computer can be used to obtain Reynolds stress values, instantaneous flow vector, the on-axis component statistics, etc. This concept of coincidence data-taking can be extended to collecting other properties such as pressure, temperature, and species concentration along with velocity. This would provide cross-correlations that would show the interdependence of various flow properties.

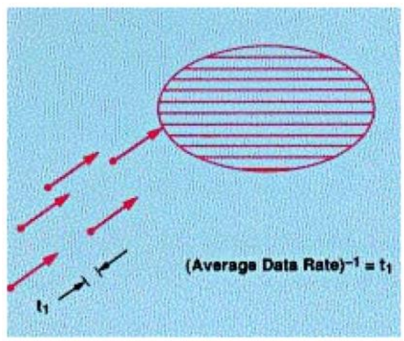

Figure 3. Trans. time < coinc. window < t2.

References

1. Menon, R.K., "Three-component Velocity Measurements in the Interblade Region of a Fan," ASME Paper no. 87-GT-207, Gas Turbine Conference, Anaheim, California, May 1987.