ADVANTAGES TO THE LOOK-UP TABLE APPROACH OF VOLTAGE-VELOCITY CONVERSION IN THERMAL ANEMOMETRY

TECHNICAL NOTE

A look-up table is a matrix of anemometer voltages, and the corresponding velocities are based on a velocity calibration of a hot-wire/hot-film sensor. The use of a look-up table in computer data acquisition and analysis greatly enhances the speed of acquisition and accuracy of experimental data.

When digital data acquisition and analysis were not as popular and inexpensive as they are today, anemometry users relied on analog linearizers and mean/rms meters to interpret the voltage output in terms of velocity. However, analog linearizers were restricted to a specific functional relationship (such as a fourth-order polynomial). If the calibration data could not be fitted accurately to that predetermined relationship over the entire range of the data, accurate linearization was not possible. With the advent of inexpensive computers, analog instruments have become less attractive.

In any experiment where look-up tables are used, the digitized voltages, prior to statistical analysis, are routed through the look-up table in the computer for voltage-velocity conversion.

Procedure to Generate a Look-Up Table

Initially, calibration data (typically 15 to 20 voltage-velocity pairs) is fit to a mathematical curve shape using the method of least squares. This curve could be any empirical heat-transfer relationship (such as King's Law, Collis-Williams' Law, etc.) or a fourth-order polynomial such as

$$V = K + A*E + B*E^2 + C*E^3 + D*E4$$

Where: V = velocity; E = voltage; K, A, B, C, and D are constants determined for the best curve fit or any empirical heat-transfer relationship such as King's Law, Collis-Williams' Law, etc.

Once the best fit to the calibration data is obtained, an entire matrix of voltage-velocity pairs can be generated simply by calculating velocities for assumed voltage values across the range of calibration data. Though the number of voltage-velocity pairs is not limited in a look-up table, the maximum can be determined by available computer memory and the resolution of the analog-to-digital converter. For example, for an A/D converter with 12 bits of resolution, the number of pairs in the lookup table need not exceed 4,096.

Advantages of a Look-Up Table

Speed of Data Analysis

Since the look-up table is generated in the computer prior to an experiment, velocity for any digital voltage point is readily available. This greatly enhances the speed of on-line statistical data analysis. For example, if the polynomial in above equation should be employed for voltage-velocity conversion instead of a look-up table, all of the arithmetic operations involved in that polynomial reduce the speed of on-line analysis.

Accuracy of Voltage-Velocity Conversion

For the entire velocity range of an experiment, use of a single polynomial may not give the best fit. But the look-up table need not be restricted to one functional relationship. The velocity range may be divided into several "subranges." Segmental fits can be made to obtain "best" fits in these subranges, and then a look-up table can be generated covering all of the subranges. This enhances the accuracy of voltage-velocity conversion.

Ability to Handle Different Probes

Probes with different sensor geometries (cylindrical, noncylindrical, etc.), probes with multiple inclined sensors (X-probes and triple-sensor probes), probes with different types of sensors (hot wires, hot films, etc.), and probes for different fluids, may have different functional relationships between voltage and velocity. AR of these can be handled effectively with the appropriate look-up table.

Versatility

The look-up table approach can be readily extended for other related measurements in an experiment such as temperature, pressure, and wall shear.