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NASA TECH BRIEF

Marshall Space Flight Center

Three-Dimensional Gas Turbulence Measurement With a Laser-Doppler Velocimeter System

The problem:

Conventional gas-velocity measurement devices, such as a Pitot tube or a hot-wire anemometer, are limited in dynamic range and sensitivity to velocity direction. In addition, they require a physical probe which in many cases disturbs the flow field.

The solution:

A laser-Doppler system records gas-velocity data over a wide dynamic range in three-dimensional space without a physical probe.

How it's done:

The system detects the Doppler-frequency shift in a laser beam scattered by flowing particles and uses this frequency to calculate the particle velocities. The technique is based on the principle that a laser beam scattered by flowing particles is shifted in frequency by an amount proportional to the laser frequency. The velocities of the particles cause this shift and form the geometrical angle at which the scattered light is observed.

In use, a focused laser beam is directed into a flow field containing submicron particles. A laser-Doppler velocimeter (LDV), placed on the opposite side of the flow field, collects the forward-scattered laser light from three different directions and homodynes this light with reference, or unscattered laser light, to produce a Doppler-frequency output on three photodetectors. The three Doppler frequencies are then fed into a frequency-tracking unit which locks onto and tracks the Doppler signal. The frequency trackers provide a dc voltage output, corresponding to the mean Doppler frequency or flow velocity, and an ac voltage output, corresponding to the fluctuating Doppler frequency or flow turbulence. The three dc components are then passed through an analog network which transforms the components into three outputs, corresponding to a Cartesian coordinate system.

With a knowledge of the frequency-tracker calibration curves and the geometry of the LDV relative to the flow field, the three-dimensional levels of the particles causing the shift can be computed.

Note:

Requests for further information may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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