D I A L
Diagnostic Instrumentation & Analysis Laboratory
Mississippi State, MS 39762-5932

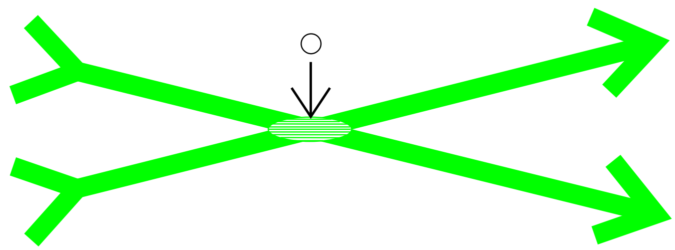
Laser Doppler Velocimetry (LDV)

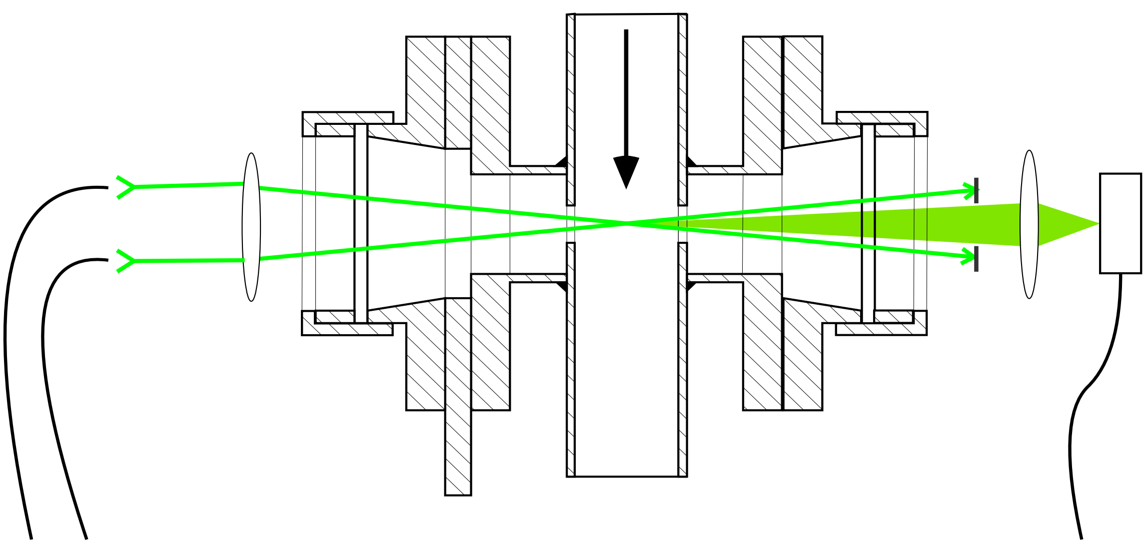
Laser Doppler velocimetry (LDV) is a modern, laser-based, nonintrusive technology for measuring spatially and time resolved velocities in gas and liquid flows. The measurement is made with laser beams, without the need to insert a probe or sensor into the flow. This is important for two reasons: first, because a probe can disturb the flow; and second, because the technique can be used under extreme conditions that would destroy any probe inserted into the flow.

DESCRIPTION

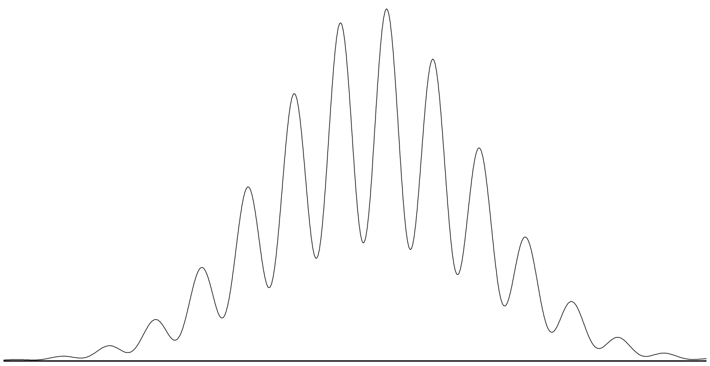
The basic operation of the Laser Doppler Velocimeter (LDV) is shown in the diagram. Coherent light from a laser (not shown) is split into two parallel beams. These two beams are then focused with a lens so that they cross where the velocity measurement is desired. The velocity measurement occurs when a particle in the flow passes through the region where the two laser beams cross. This crossing region is an ellipsoid of revolution which is typically a few hundreds of microns across and a few millimeters long. Within this crossing region, the two beams interfere with each other to form alternating bright and dark fringes. When a particle in the flow passes through these fringes, it scatters a portion of the incident light onto a photodetector. The resulting light signal is a burst with a modulated frequency proportional to the particle's velocity component perpendicular to the plane of the fringes.

Detail of Beam Crossing





Optical Fibers from Laser...to Signal Processor



The method has excellent spatial resolution because of the small size of the beam crossing region. The time resolution is dependent on the particle loading, since a velocity measurement occurs whenever a particle passes through the beam crossing region. It is possible to acquire velocity data at a rate sufficient to explore the frequency spectrum of the flow turbulence, or to measure the oscillations in an unsteady flow. If the system does not contain sufficient particles, then additional particles can be injected upstream to obtain the desired data acquisition rate.

ON-SITE APPLICATIONS

The LDV system has been used by DIAL to make velocity measurements in prototype magnetohydrodynamic (MHD) test facilities in facilities at the University of Tennessee Space Institute, near Tullahoma, TN, and at the CDIF facility in Butte, MT. The MHD test program involved burning coal at high temperatures--and the resulting gas stream was very hot (>2500 K) and laden with coal slag particles. In certain sections of the flow stream, where the flow was supersonic, the combination of high temperature, high velocity, and particle loading meant that even water-cooled stainless steel probes were rapidly destroyed. Under these conditions, intrusive measurements would not be possible. However, LDV velocity measurements have been successfully made by DIAL under these extreme conditions.

DIAL has made LDV measurements in radiant boiler sections 48 inches across. We have measured velocities in excess of 1500 m/s. Using our optical fibers for remote access, we have made measurements from platforms 50 feet above ground level.

Currently, we are working on waste remediation technology for EM-50 of the US DOE. Under this contract, we have measured flow velocities in the plume of plasma from a plasma torch. DIAL has also measured the flow velocities in offgas handling systems from waste vitrification systems in Butte, MT and Clemson, SC.

Additional information about this technique or any other research being conducted at DIAL can be obtained by contacting:

DIAL
Post Office Box MM
Mississippi State, MS 39762-5932
Telephone 662-325-2105
FAX 662-325-8465
dial@dial.msstate.edu