Lasers in Medicine

Presented by

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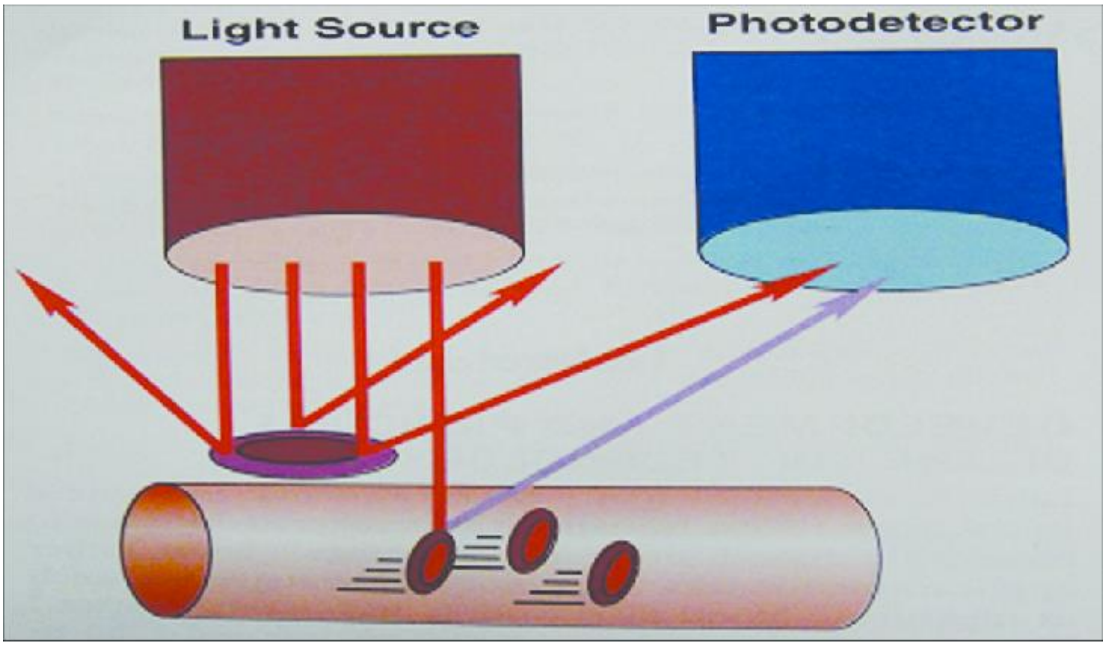
Laser Dopplerography principles

Principle of laser Doppler flowmetry: red light is emitted from a light source; if the light beam is scattered-off of stationary tissue or cells, there is no shift in the light spectrum. If, however, the light hits a moving cell in a blood vessel there is a shift in the light spectrum of the scattered light according to the Doppler flowmetry



MEASUREMENT TECHNIQUE

The forward-scattering Laser Doppler Anemometer (LDA) was used to measure the instantaneous velocities of the gas and particles in the two-phase flow.

The LDA consists of two channels, each channel for the respective phase of the dispersed flow.

The transmitting unit of the LDA channels with a 26 mW and 10 mW laser formed two different measurement volumes in order to distinguish between the velocities of the two groups of particles, the TiO_2 seeding particles and the glass particles with an averaged diameter about 700 μm.

The channels were organized by the module principle. Hence, it was possible to easily get access to the system depending on the peculiarities of the problem to be solved.

The tuning of each LDA channel for registration of its own particles was based on an amplitude discrimination of the Doppler signals by means of changing the parameters characterizing the measurement volume and the geometrical conditions of the receiving optics, and by varying the sensitivity of the photomultiplier.

Measurement techniques

The measurements are performed by means of a two-component laser Doppler anemometer (LDA) and using pressure transducers.

The LDA technique is a non intrusive method used here to measure the mean radial velocity V_r and tangential velocity V_θ and the associated Reynolds stress tensor components $R11^*=vr'2^{-}/\Omega r2$, $R12^*=vr'v\theta'^{-}/\Omega r2$, $R22^*=v\theta'2^{-}/\Omega r2$ in a vertical plane (r,z) at a given azimuthal angle.

This method is based on the measurement of the Doppler shift of laser light scattered by small particles (30 μm) carried along with the fluid.

The main defect of this method is to provide an integrated value on a probe volume, whose size in the axial direction (0.8 mm) is large compared to the interdisk space (9 mm).

Pressure is measured using 6 piezoresistive transducers, which are highly accurate (0.05% in the range 10 to 40 °C) and, which combine both pressure sensors and temperature electronic compensations.

They are fixed to the stator at the radial positions: 0.093, 0.11, 0.14, 0.17, 0.2 and 0.23 and located along two radii.

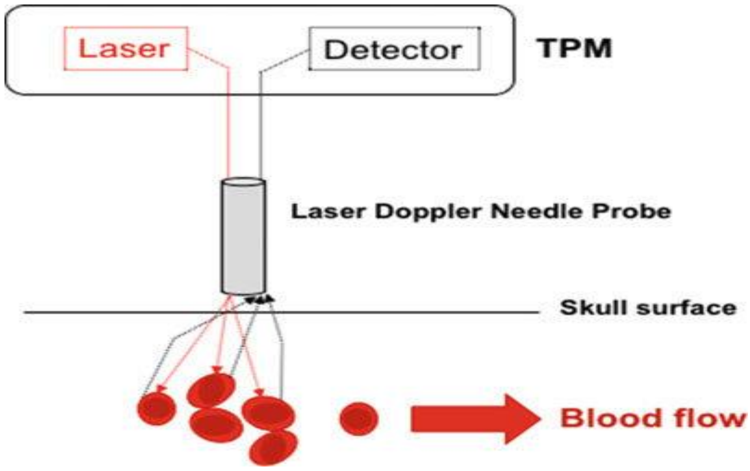
Previous pressure measurements by embarked pressure gauges performed by Gassiat (2000) showed that the pressure on the rotor side and the one on the stator side are almost the same within 2.5%.This is in fact a direct consequence of the Taylor-Proudman theorem, which forbids axial gradients in rapidly rotating flows.

Laser Doppler principles

A single-frequency light, emitted from the laser diode of a tissue perfusion monitor (TPM), travels via a probe's fiber optic light guide and illuminates a tissue sample.

As laser is scattered by moving red blood cells within the tissue, a portion of light is reflected back into the probe's light guide and onto the photodetector of the TPM.

By processing the frequency distribution of the backscattered light, an estimate of the blood flow can be achieved



LDV - Laser Doppler Velocimetry

Laser Doppler Velocimetery (LDV) is a technique used to measure the instantaneous velocity of a flow field. This technique, like PIV is non-intrusive and can measure all the three velocity components. The laser Doppler velocimeter sends a monochromatic laser beam toward the target and collects the reflected radiation. According to the Doppler effect, the change in wavelength of the reflected radiation is a function of the targeted object's relative velocity. Thus, the velocity of the object can be obtained by measuring the change in wavelength of the reflected laser light, which is done by forming an interference fringe pattern (i.e. superimpose the original and reflected signals).This is the basis for LDV. A flow is seeded with small, neutrally buoyant particles that scatter light. The particles are illuminated by a known frequency of laser light. The scattered light is detected by a photomultiplie tube (PMT), an instrument that generates a current in proportion to absorbed photon energy, and then amplifies that current. The difference between the incident and scattered light frequencies is called the Doppler shift.

By analyzing the Doppler-equivalent frequency of the laser light scattered (intensity modulations within the crossed-beam probe volume) by the seeded particles within the flow, the local velocity of the fluid can be determined.