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INTERFEROMETRY : A POWERFUL TECHNIQUE IN PRECISION MEASUREMENTS

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INTRODUCTION

Noninvasive techniques are being extensively used in engineering measurements. These techniques employ different radiation sources as probes. All radiation-based measurements share a common feature in that they generate images of a cross-section of the physical domain. This is to be contrasted with mechanical probes which are concerned with measurements at a point in space and can accomplish this task only after the field to be studied has been physically disturbed. Radiation methods are also non-invasive, contact less & inertia-free. Hence, the scanning of a cross-section of the physical region using radiation-based probes results in a large volume of information with instantaneously.

OPTICAL METHODS

When the wavelength of the radiation used is in the visible range, the measurement procedure classifies as an optical technique and the region being scanned appears on a screen as an image that is visible to the naked eye. In thermal sciences, a revival has taken place in use of optical techniques for temperature and velocity measurements in fluids. This is due to commercially available cost-effective lasers having a high degree of coherence (both spatial and temporal) which are easily accessible.

Optical images can be recorded conveniently with the help of computers and can be processed speedily. The implications are that coherence generates stable image patterns, which truly reflect the flow behaviour.The image formation can be related to the patterns formed by solid particles suspended in the fluid, attenuation of radiation, scattering or the dependence of reflectivity and refractive index on temperature. Optical methods that utilize the dependence of refractive index of light on quantities such as density, concentration and temperature can also be configured in many different ways.

APPLICATIONS

Most of the advances have been due to the advent and development of the laser. Laser-based optical techniques have reached such a high degree of maturity that, optical methods such as laser Doppler velocimetry have replaced traditional methods such as pilot tubes and hot-wire anemometry. Flow visualization methods of the past have evolved to a point where it is now possible to gain qualitative understanding of the flow and transport phenomena. Sophisticated measurement techniques such as Rayleigh and Mie scattering for temperature and concentration measurement and Raman spectroscopy for detection of chemical species in reacting flows are routinely employed in engineering research.

Using satellite radar interferometry, orbiting instruments hundreds of kilometres away in space, can detect subtle deformation of the earth's crust and thus detect minerals and oil& predict volcanic eruptions. Integrating techniques of photography and video recording, digital image processing, optics and colour measurement, it is now possible to map the fluid surface slopes of oceans, rivers and lakes optically into colour space.

APPLICATIONS

Using reconstruction techniques, the surface elevations can then be accurately obtained. If the surface is relatively flat, the spectrum of the reflected light contains rich information about the temperature variation over it. Radiation-based measurements form the backbone of satellite instrumentation, weather prediction programs and defense weaponry.

Studying convection patterns is also of importance in nuclear power plants. Specific examples include passive heat removal in advance reactor systems, stratification phenomena in steam vessels in which hot and cold water streams mix, and thermal pollution in reservoirs. The liquid metal pools in fast breeder reactors are also subjected to stratification. Measurements of the shape of the fluid surface and temperature distribution over it using interferometric optical methods are critical for studies of near surface dynamics.

A special application where laser optics is profitably utilised is in growth of a crystal from its supersaturated aqueous solution. Crystals with a high degree of perfection are required for important and sensitive high-technology applications. Examples are the semiconductor industry for making computer chips and optically transparent materials for making high-power lasers.

Measurements of the temperature and concentration fields around a crystal growing from an aqueous solution, the surface morphology, and the kinetics of major faces of the crystal is a critical engineering application. The crystal is grown in a specially-designed growth cell under controlled temperature conditions. The solution around the crystal can be optically mapped to generate the full three-dimensional information of the scalar fields. They can be controlled online with the objective of enhancing the in situ quality of the growing crystal.

Optical applications utilising interferometry in many precision measurements have become extremely important. The above mentioned are just a few to illustrate the powerful nature of such measurements in science & technology.

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