Fizeau and Twyman Green Interferometers

PRECISION-OPTICAL ENGINEERING

IF 005

Application Note

Interferometry involves measuring the distortions in a wavefront from a coherent beam of light interacting with the test piece compared to a reference beam. The interference patterns which result from differences between the test beam and the reference beam appear as a set of black and white fringes which yield information which can be related to surface form errors or optical waveform distortion errors. In this way, geometrical aberrations in optical systems, badly manufactured optical components and inhomogeneities in materials can all be readily identified. The two most commonly used designs for commercial interferometers are the Fizeau and Twyman-Green geometries.

Laser Fizeau Interferometers

The Laser Fizeau arrangement is shown schematically in Figure 1.

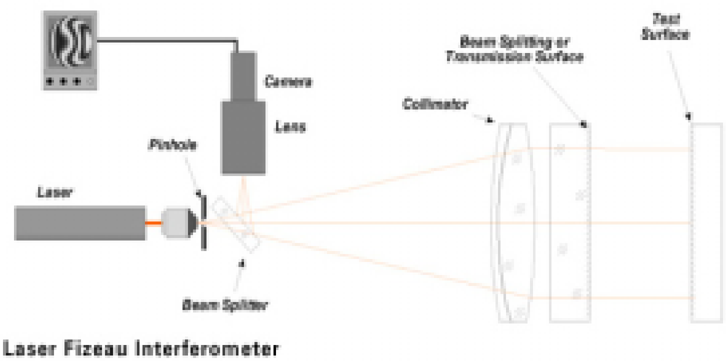

Figure 1:

Here, the entire optical system of the interferometer is used identically by both the test beam and the reference beam except for the surface that splits the beam. This means that aberrations in the optical system only have a very low order effect on the shape of the fringe pattern ultimately observed. However the beam splitting surface needs to be of very high quality to avoid having a major effect on fringe shape. The use of lasers does have a disadvantage in that the long coherence length enables interference to take place between any of the many beams which are reflected around an optical system due to imperfections in coatings etc. For this reason it is necessary to be very careful regarding antireflection coatings on all optical components after the pinhole. The pinhole itself acts as a spatial filter for all optics which precede it and thus removes all coherent noise from focusing optics such as microscope objectives used in visible or near infra-red systems.

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Twyman-Green Interferometers

The Twyman-Green configuration , shown schematically in Figure 2, is generally used in infrared interferometers such as the INTERFIRE 10.6, INTERFIRE 3-5 and INTERFIRE 2.

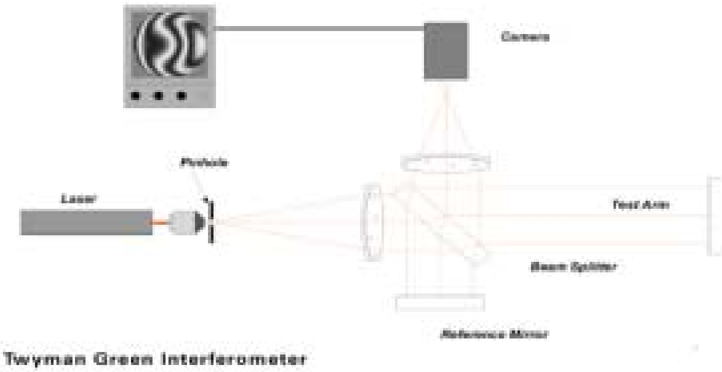

Figure 2:

This system has a greater need for high accuracy components since both sides of the beam splitter together with the reference mirror and any window need to be very flat. However, the optics for collimating the laser beam and for projecting the combined beams to the camera do not need the same level of accuracy. In the infra-red it is usually necessary to employ large aperture fast optical systems in front of sensors because of the long wavelength and the need for high resolution and efficient energy collection. Most optical systems can be tested through a smaller aperture by focusing the laser radiation down to the focal point of the lens under test using a transmission sphere of equal or lower f/number. However, particularly for looking at material blanks for homogeneity assessment, it is often essential to have large aperture interferometers.

Applications

The Fizeau configuration is widely used in interferometers operating in the visible region of the spectrum. These instruments tend to be less expensive than Twyman-Green. However because of their susceptibility to multiple reflections, they are less well suited to evaluation of highly reflective optics. The beam splitting surface normally has a reflectivity of ~4% which then has to be approximately matched by the return mirror at the end of the test arm. This means that the majority of the light is lost. This however does not present a problem in the visible waveband because of the availability of sensitive cameras. Fizeau interferometers are widely used in optical polishing workshops, where measurements are made on uncoated glass samples of low reflectivity.

The Twyman Green interferometer is ideally suited to high reflectivity reference and return mirrors. The geometrical arrangement means that multiple reflections are not possible. More of the radiation is available to the camera (~25%). This is very important in the infra-red region of the spectrum where cameras are less sensitive and laser sources less widespread, especially in the 3-5micron waveband. Additionally, for general use, it is necessary to ensure that the interferometer has the lowest possible Laser Safety Classification, therefore efficient use of available radiation is essential.

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