A novel method for a multiphase flow measurement in turbo machinery

M Menacer, A Aroussi, S Kucukgokoglan
School of Mechanical, Materials, Manufacturing Engineering and Management
University of Nottingham, Nottingham, NG7 2RD, UK.

To understand and optimise the lubrification process and the heat to oil transfer in the bearing chamber of an aero-engine, the scrutiny of the prevailing two-phase fluid flow is essential. This fluid behaviour is difficult to monitor due to the hostile environment for transducers and due to the lack of access for probes.
The presence of air and oil in the chambers with walls rotating at high speed can result in oil fires as well as the deterioration of the lubrication function of the oil. Further, the rotating oil film and droplets it generates through shearing or through the impingement of the lubricating jets on it, interact with the windage and provide continuous interchange of mass, momentum and heat between the oil, the air and the solid surfaces. This dynamic and hostile environment is conventionally inaccessible for present instrumentation. Consequently, a non-intrusive instrument has been developed that allows optical access with minimal flow disturbance.

The device being developed is based on Particle Image Velocimetry (PIV). This technique has good accuracy, resolution and reliability for the instantaneous qualitative and quantitative measurements of a whole flow field. The principle of the PIV method is to determine the flow velocity from the motion of tracer particles. A plane sheet of laser light illuminates the flow area of interest and the light scattered from the tracer particles is recorded by means of a camera. The velocity information is then extracted from images exposed to single, double or multiple laser pulses. Further processing can be carried out for flow visualisation and particle analysis [1]. Its unique ability to extract quantitative information on steady or unsteady flow structure, made the technique useful and feasible in a wide range of applications, such as turbo machinery, aerodynamics, biology, and medicine [2].

The development of the instrument consists of the design of miniature probes capable of generating a laser sheet from a pulsed beam and introducing it into the volume of space, under scrutiny, within the bearing chamber. The second component is a mean of recording the area within the chamber illuminated by the light sheet. This is achieved through the use of an endoscope attached to a camera.

Several tests have been performed successfully on a small scale annular rig which was designed to provide generic data and validation. Figure 1 shows a sample image, with the resulting velocity vectors map (figure 2), obtained using the transmitting and receiving probes.

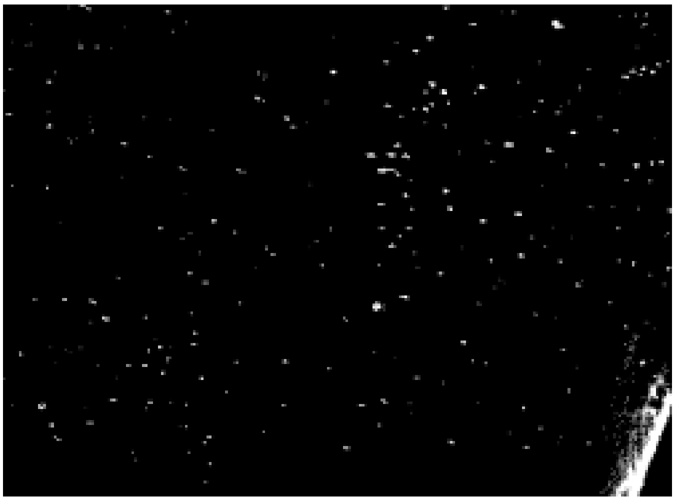

Figure 1: Sample image from a rotating shaft test rig.

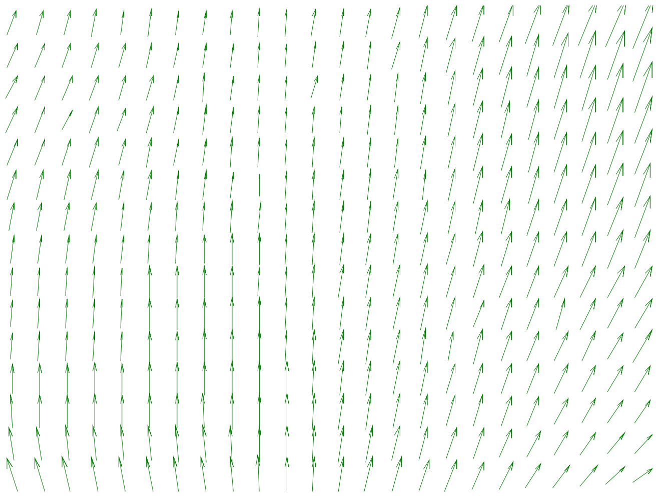

Figure 2: Velocity vectors obtained from figure 1.

References

1. Willert C.E, Gharib M, Digital particle Image Velocimetry, Experiments in Fluids, Volume 10, 1991.
2. Meynart R, Lourenco V.K, Digital image processing in fluid mechanics, Von Karman for Fluid Dynamics. Lectures series, 1984.