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Experimental analysis of the flow dynamics in the suction chamber of an external gear pump

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ABSTRACT

Time-Resolved Particle Image Velocimetry (TRPIV) has been used to investigate the flow inside the suction chamber of an external gear pump where the movement of the fluid through the pump is maintained by the rotation of the gears. The main purpose of this paper is to study the characteristics of the complex flow pattern of this pump system in order to help in improving its total performance. The applied experimental techniques establish a method that allows visualising the flow inside the gear pump with a high rotational velocity system. Small micro air bubbles have been used as flow seeding. The images have been processed using domestic PIV software that uses specific aspects of the TRPIV technique. Instantaneous and phase-locked ensemble average fluid motions have been obtained for different gear pump rotational velocities to investigate the turbulence effect of rotating gears to the system.

1. Introduction

A great number of industrial machineries contains rotating elements interacting with fluid flow. Most of this machinery is responsible for the fluid movement through the flow system. This is the case of a large number of pump types. Knowledge of the interactions between the mechanical elements and the fluid flow can provide improvements in the pump design. A variety of measurement techniques have been applied to several industrial machines in the struggle for accurate quantitative flow descriptions [1]. This paper is focused on the analysis of fluid flow through an external gear pump. This type of pump is used for transferring and metering high viscosity fluids and power transfer in industrial processes usually at high pressure rates. An external gear pump is a positive displacement pump that has two cogwheels rotating against each other. It transfers the fluid from a suction chamber to an impulse chamber increasing the fluid pressure as well. The fluid in the suction chamber is trapped between the teeth of the gears and the body of the pump. As the gears rotate, the fluid is transported to the impulse chamber under pressure. The flow rate depends on the rotational velocity of the gears. Recently there is a trend to increase the pump performance by reducing its size and increasing the pressure as well as the rotational velocity [2,3]. Thus, the pumps are designed to be smaller and provide more power to the fluid. With the current design of the suction and impulse chambers the volumetric efficiency of the pump decreases when rotational velocity increases [4,5]. This means that the real flow rate could substantially decrease due to backflow through the gaps between the gear and the compensating plates or the pump body. Consequently, it is necessary to increase the knowledge of the flow characteristics on the suction and impulse chambers to improve their design. Furthermore, gear pumps can produce high frequency pressure pulsations, increasing the fluctuations of the delivered flow, which tends to damage pressure gauges. To reduce the fluctuations, geometric design of the gear tooth profile and the body of the pump are needed to be improved. As the gear tooth profiles are mainly comprised of complicated curves, significant parameters have to be determined in their design. Houzeaux and Codina [6] developed a numerical strategy for the simulation of rotary positive displacement pumps that can help in the understanding of the flow phenomena occurring in the suction and impulse chambers. Manring and Kasaragadda [7] have analysed the flow pulsation that is produced by external gear pumps with different number of teeth on the driving and driven gears from a theoretical point of view. Huang and Lian [8] have investigated numerically how several gear parameters (including teeth number and pressure angle) help in reducing the flow rate fluctuation. Iyoi and Ishimura [9] have shown that it is not possible to get external gear pumps with no delivery fluctuation but it can be minimised. The efficiency of the pump is directly related with the relationship between the moving parts and clearance factors. Moreover, the

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