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Experimental analysis of pressure distribution in a twin screw compressor for multiphase duties

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ABSTRACT

This paper presents the results of an experimental investigation of pressure distribution inside working chamber of a twin screw compressor for multiphase duties. A mathematical model for describing the pressure distribution inside working chamber is proposed. By means of a small pressure transducer embedded into the groove at the root of the rotor, the pressure distributions of a multiphase compressor under various running conditions have been recorded successfully to verify the model. It is found that the pressure curve during the discharge process has a higher level under the conditions of the lower gas void fraction, higher discharge pressure, higher rotational speed and higher inlet pressure. The pressure distribution calculated by model in this paper shows good agreement with the data recorded by a small pressure sensor in a prototype multiphase compressor at the high gas void fractions under different operating conditions.

1. Introduction

Multiphase production system (MPS) is a relatively new technology which is seeing increased industrial application in recent years [1–3]. Multiphase transportation technology enables the transport the mixture of oil, water and gas, occasionally sand, natural gas hydrates and waxes from wells via a single flow line to the processing facilities. MPS can reduce the cost of exploring and conveying about 70% that of a conventional facility [4–6]. Especially designed for application in multiphase transportation are a rotor dynamic pump of the helicon-axial type and a positive displacement pump of twin screw type [7,8]. The twin-screw pump works on the principles of enclosing a defined volume on the suction side and moving it to the discharge end by adding energy. It is used for liquids ranging in viscosity from water-like consistency to polymers with a viscosity of millions of centipoise, and it does a creditable job over a fairly wide range of gas void fractions (GVFs) including 100% gas for short periods.

A number of papers have been presented in recent years on development and preliminary tests of twin-screw multiphase pumps. Dolan et al. [9] presented a reason for wishing to develop a twin-screw pump capable of pumping gas–liquid mixtures and a preliminary test leading to the design of a full specification pump. Internal backflow is divided into four groups by Egashira et al. [10], a preliminary physically based model was also proposed to describe it but not detailed. Peng et al. [12] present the results of an experimental investigation of the thermodynamic processes in an oil-flooded screw compressor which provide the essential reference points for investigation for twin-screw multiphase pump. Feng et al. [11] present the mathematical models to predict the backflow within twin-screw multiphase pumps. A theory and computational program for the performance of rotary positive displacement pure liquid and multiphase double-entry twin-screw pump is developed by Prang and Cooper [13]. Rausch et al. [14] investigate the function of multiphase twin-screw pumps by theoretical and experimental work. Within the pipe system the operation of two multiphase pumps in single, serial or parallel mode is investigated. Nakashima et al. [15] presents a model of the heat transfer processes in the casing and rotors of a twin-screw multiphase pump. Räbiger et al. [16] perform the theoretical and experimental analyses of the pumping behaviors of multiphase screw pumps, handling gas–liquid mixtures with very high gas volume fractions.

Pressure distribution is showing large influences on the multiphase pumping behavior especially during the boosting of two phase mixture. The pressure build-up has a very important contribution to the fluid backflow recirculated through the internal clearance back to the inlet of screws, which leads to the varieties of pump's delivered volume flow rate, volumetric efficiencies and the power consumption. On the other side, the inlet/outlet pressure, rotational speed and gas volume fraction (GVF) have a direct influence on the pressure distribution inside the working chamber. Nevertheless, the prediction of pressure distribution of twin-screw pump on multiphase mixture presents a challenge. Since the

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