Geometrical Comparison of Conventional and Gerotor-Type Positive Displacement Screw Machines

IOP Conf. Series: Materials Science and Engineering **604** (2019) 011011 doi:10.1088/1757-899X/604/1/011011

Geometrical Comparison of Conventional and Gerotor-Type Positive Displacement Screw Machines

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1. Introduction

Cylindrical gearing profiles can allow an externally lobed inner gear to rotate inside an internally lobed outer gear while maintaining continuous lines of contact between the gears. With co-rotation about fixed parallel axes, this creates working chambers between the rotors whose volume changes with rotation. This gerotor configuration is commonly used as a pump but can also be used to compress or expand gas by changing the port shapes. Furthermore, adding helical twist to these rotors produces internally-geared screw machines, which have the advantage of potentially lower rotor contact forces and larger port flow areas.

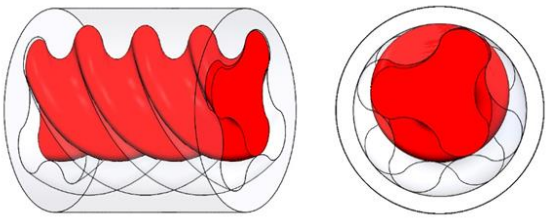

Figure 1: Illustration of rotors for internally geared machine

2. Influence of geometry on machine performance

This study considers how key geometrical parameters such as volume, leakage path areas and port areas vary with the shape and dimensions of the rotors. Simple rotor profiles consisting of epi and hypocycloid curves have been used in this investigation, as illustrated in Figure 1. It is important to investigate the axial port areas that can be achieved with the different configurations as they will have a strong influence on the pressure losses that occur during filling and discharge of the working chamber, and hence the efficiency of the machine. This has been investigated by defining representative rotor profiles and investigating the effect of different wrap angles and built-in volume ratios on the flow area into and out of the working chamber during filling and discharge operation respectively.

Another important factor in understanding the performance of these machines is the leakage areas, and these have been found by considering different machine geometries that are scaled to achieve the same swept volume.

3. Key findings

The results of the geometrical analysis of internally geared machines has been compared with conventional twin-screw machines in order to identify possible advantages and disadvantages for compression and expansion processes.

The main conclusions from the current study are that the internally geared configuration can achieve higher swept volume per unit of enclosed volume than conventional machines, although this decreases with increasing wrap angle due to the continuous variation of working chamber cross-sectional area with angular position. This is in contrast to conventional machines, where the working chamber area remains constant through a large range of angular positions, resulting in a constant swept volume until the wrap angle approaches around 270ºC.

For the particular case considered, when sized for constant swept volume per revolution of the driven rotor the internally geared configuration with outer rotor lobe number N1 = 4 and cycloid shape factor $\lambda = 0.8$ is found to result in a significantly higher maximum rate of change of volume with rotor position. When compared to a conventional machine with equivalent swept volume, the maximum axial port flow areas are found to be higher for the suction port when the normalized wrap angle, $0 < \bar{\Phi}_1 < 1$, and higher for the discharge port when $\bar{\Phi}_1 > 0.4$. The total tip sealing line lengths are found to be lower than in the conventional machines when $V_{wc} > 0.25V_{wc,max}$, with the maximum value increasing with wrap angle.

Future work will focus on using the port and sealing line geometry described in this paper in a detailed thermodynamic chamber model. This will allow a thorough investigation of the effect of the key geometrical parameters including rotor profiles, lobe number, wrap angle, and rotor lengths, on the volumetric and isentropic efficiency of the internally geared configuration.