

NUMERICAL AND EXPERIMENTAL STUDY OF WATER LUBRICATED SPIRAL GROOVE FACE SEALS

M. Rouillon ^a, N. Brunetière ^{a*}

*noel.brunetiere@univ-poitiers.fr

^a Institut Pprime, UPR 3346, CNRS, Université de Poitiers, Ensm
86962 Futuroscope, France

KEYWORDS

Spiral groove, face seal, hydrodynamic lubrication, two-phase flow, non-laminar flow

ABSTRACT

The sealing of rotating machines such as pumps is usually ensured by mechanical face seals. They are basically composed of two flat annular rings in relative motion and their contacting interface is the sealing dam. To avoid friction and wear spiral grooves can be machined on one face to enhance hydrodynamic lubrication. Figure 1 presents an example of spiral groove face seal with a cross-sectional view of the seal rings. Spiral groove seals were initially proposed to seal gas in turbomachinery but they can also be used with liquid when face contact is an issue [1]. However, there is a lack of experimental data as well as simulation results for this type of component in the literature. The objective of this work is to present experimental results and comparison to numerical results for a wide range of operating conditions.

The numerical model solves the Reynolds equation and the energy equation in the fluid film. It allows calculating the fluid pressure and enthalpy in liquid or two-phase flow configurations. The thermal and mechanical coupling between the fluid film and the seal rings is moreover considered. An example of simulation result is given in Fig. 1. The hydrodynamic pressure generation can be clearly seen at the inner edge of the grooves. Because of the viscous friction, temperature rise is observed in the seal rings.

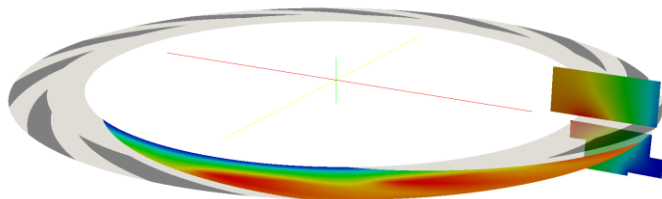


Fig.1 Pressure in the fluid film and temperature in the seal rings
(Operating conditions: 40°C, 50 bars, 4000 rpm)

Some experiments have been performed on a test rig working with water. Several spiral groove seals have been tested on wide range of operating conditions which are given in

table 1 while measuring the friction torque, leakage and temperature in the seal rings.

Table 1 Operating conditions

| Parameter | Value |
|-------------------|-----------------|
| Water temperature | 40 – 95°C |
| Water pressure | 10 – 50 bars |
| Rotating speed | 2000 – 6000 rpm |

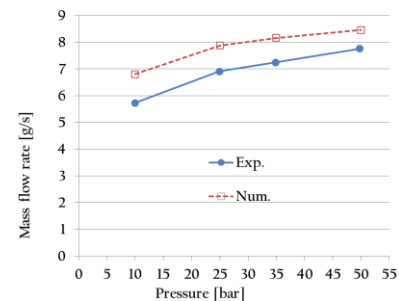


Fig.2 Comparison of the measured and calculated mass flow rate (Operating conditions: water at 40°C, 4000 rpm)

The variation of the mass flow rate with pressure is given in Fig. 2. As expected, the flow rate increases with the pressure but not in a linear way. The evolution is well captured by the model. The experimental results highlight some particular operating regimes: non-laminar flow, two-phase flow. The model is used to analyze the conditions of occurrence of these regimes.

ACKNOWLEDGMENTS

The CNES and ASL are due particular thanks for supporting this PhD part work

REFERENCES

- [1] Lai, T., "Development of non-contacting, non-leaking spiral groove liquid face seals," *Lubrication Engineering*, 1994, 50, 625-631