A model of watertight based on fluid movement percolation on 3D rough surfaces

Raphael Deltombe [1*], Maxence Bigerelle [1,2] and Abdeljalil Jourani [3]

[1)] Laboratoire d'Automatique, de Mécanique et d'Informatique Industrielle et Humaine
LAMIH, UMR CNRS 8201, Valenciennes, France.
[2)] Laboratoire de Thermique, des Ecoulements, de Mécanique et Matériaux en Mise en Forme et Production,
TEMPO, EA 4542, Valenciennes. France.
[3)] Université de Technologie de Compiègne, Laboratoire Roberval, UMR 7337, Compiègne, France.
[*]Corresponding author for tribo-lyon2013@sciencesconf.org

1. Introduction

The control of sealing in mechanical systems like rod is provided by machined surfaces (Fig.1a). These industrial processes introduce roughness anisotropy on the surface often orthotropic. Thus, the direction of leakage is closely related to this orthotropic structure inducing an anisotropic flow. Often, superfinishing processes are added to conventional processes in order to minimize leakage but without knowing precisely its physical origin. This paper focuses on the role of enhanced surfaces on leakage.

2. Experimental procedure

Two stainless steel rods (plunger of the pump) are tooled machined (**TM**) and one of them is super finished by abrasive machining.(**TMA**). Then a PVD treatment is performed to increase wear resistance. The seat is based on stainless. The fluid pressure is 97.5 bars and the air one is 6.5 bar. The fluid volume per cycle is 25 cm^3 (40 cycles/liter). The **TM/Seat** presents fluid leaks and **TMA/Seat** is fluid proof.

3. Topographical surface analysis

3D Conventional topographical analysis shows no difference between **TM** and **TMA** rods. However autocorrelation function of **TMA** rod surface shows a weak periodical wave with a spatial period of 0.2mm (fig.1b). This wave corresponds to the cutting tool's feeding and was hidden by macroscopic topography and could not be underlined by conventional analysis. This perpendicular micro waviness to rod movement create micro fence and prevent leakage. At the opposite, TM rod presents this micro waviness but is too sparsely spaced to prevent leakage. Only the regularity roughness parameter allows characterizing the leaks due to roughness. The plunger with low regularities presents some leaks (fig.2),

To validate our hypothesis, an elastoplastic 3D model is applied to determine the contact areas under load [1]. Thus, for an equivalent macroscopic force applied on the surface, the **TMA** surface possesses many fences perpendicular to the direction of the rod movement (also fluid movement) leading it fluid proof (Fig.1c). A detailed analysis clearly shows that fences introduced by conventional machining are worn by polishing (sluggish peaks erosion) and then generates topographical barriers of contact preventing leakage.

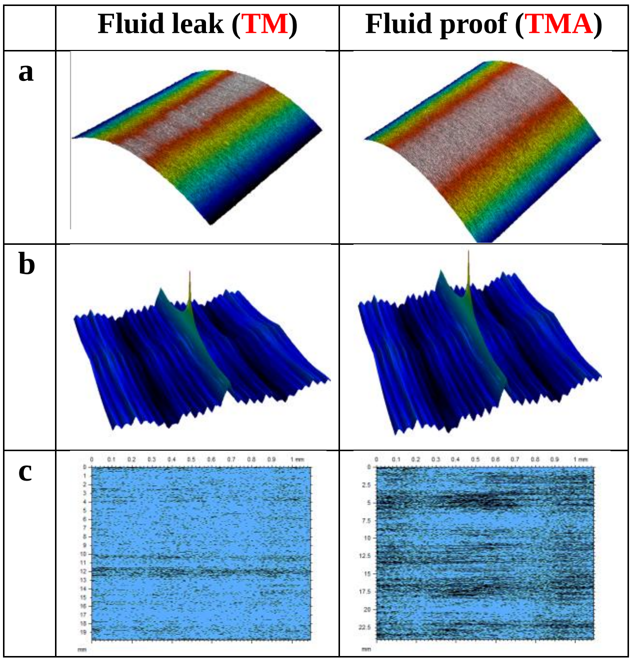

Figure 1: Original rod topographies (a), auto correlation plot (b) and contact area (c, black=contact).

4. Conclusion

The structure of the micro-roughness must be controlled in order to prevent leakage. Surface micro texturing allows creating regular topographical leakage barriers. These barriers can be tooled by conventional machining followed by superfinishing process ensuring a appropriate morphological regularity.

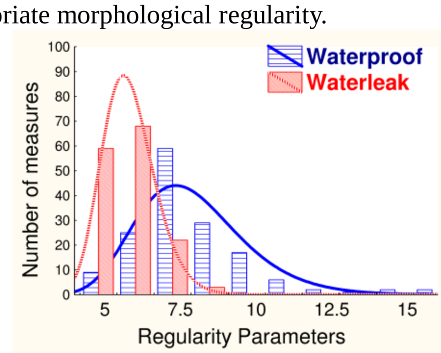

Figure 2: Regularity roughness parameter histograms

5. References

[1] A. Jourani, B. Hagège, S. Bouvier, M. Bigerelle, Tribology international, 59, 30-37, 2013.