EXPERIMENTAL TESTING OF CARBON BRUSH SEALS

FOR AERO-ENGINE BEARING CHAMBERS

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Recent developments in the aeronautic domain focus strongly on the reduction of aero-engine specific oil consumption thanks to the optimization of the lubrication oil system for civil aircraft gas turbine engines. Specifically, as brush seals have shown tremendous leakage performance in sealing secondary flows compared to classic labyrinth seals over the last few decades in other industrial applications, an increasing idea is to extent their utilization to oil bearing chamber applications [1].

The brush seal is a clearance seal used in turbomachinery since the 80's [2]. It is an annular seal composed of bristles arranged on its internal diameter with a high density and usually canted in the direction of the shaft rotation. During utilisation, it is tightly clamped between a front and a backing plate. The distance between shaft surface and backing plate, referred as fence height, requires a design taking into account, a trade-off between the bristles radial stiffness and the pressure loading (Figures 1 and 2) [3].

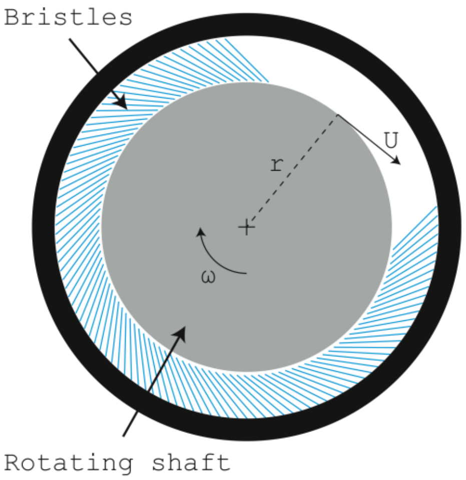

Figure 1 - Schematic front view of a brush seal

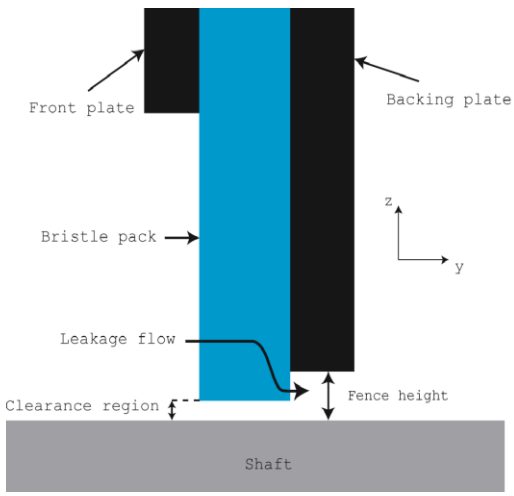

Figure 2 - Schematic side view of a brush seal

Submitting the brush seal to these new working conditions evocated in first paragraph arises new interrogations related to the oil behaviour in contact with the bristles, such as the impact of oil coking and shear heating [1] on the brush seal performance, in function of various operating conditions that can be controlled in a test bench specifically designed for seal testing, and more particularly endurance testing in realistic working conditions.

In the frame of the European FP7 E-Break project, the Aero-Thermo-Mechanics department of ULB collaborates with the French aircraft engine manufacturer SNECMA in order to investigate experimentally the brush seal behaviour in an environment simulating the bearing chamber working conditions. The aim is to deepen the brush seal behaviour knowledge by identifying the most influential geometric parameters acting on its wear, and by evaluating the leakage performance on both sides of the seal (oil and air leakage).

The paper will first describe the new test bench developed at ULB to perform this study (Figure 3). Although the bench can theoretically work for any type of seals, this work is focused on the carbon bristles brush ones. The theoretical advantage of the carbon fibres compared to the Kevlar® ones, the most recent brush seal technology successfully tested [4-5], is their lower heat generation, due to the friction between the bristles and the shaft, while maintaining at least, the same leakage performance (lower than with metallic brush seals).

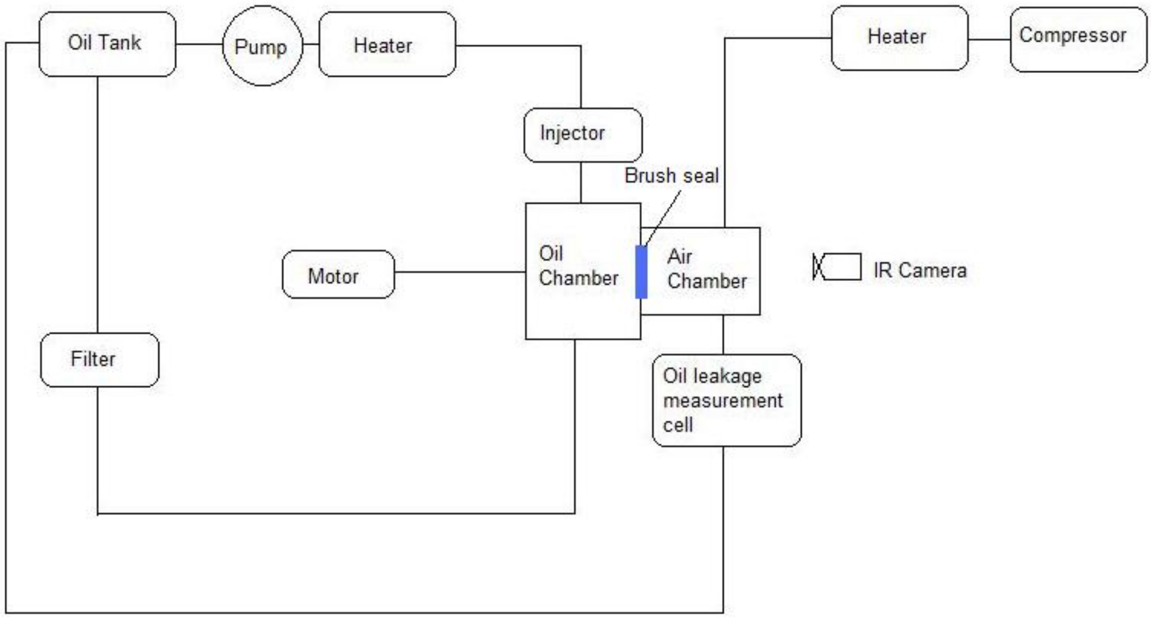

Figure 3 : ULB brush seal test rig principle

After the test bench has been described, several results will be shown with experiments determining the performance of the carbon brush seals. The experiments are divided into three steps. The first one ensures that the same results are obtained for a standard test repeated at least three times. The second is an endurance test after which the brush seal wear will be characterized by high precision dimensional measurements. Finally, the third and most important one will deliver several results helping us to determine the ability of the seal to prevent or reduce oil and air leakage. The influence of the shaft rotation speed, the temperature of the fluids, the oil flow, the pressure difference between the chambers, and the interference/clearance will all be highlighted, with the idea of mainly determining the worst operating conditions the seal can withstand to ensure proper sealing. A correlation in function of the pressure difference between oil and air flows can then be developed. In addition, an IR camera will provide thermal imaging of the rotor and seal temperature distributions, and a torque sensor will deliver the torque friction due to the contact between the rotor and the bristles. The experiments will also provide data to develop a computational model in addition of a theoretical model, in the continuity of the work described in [6].

Keywords: brush seal, carbon fibers, bearing chamber, performance investigation, endurance testing.

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