Comparison of PEEK and Babbitt lined bearings

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EXTENDED ABSTRACT

Oil-film bearings are widely used in industry to support rotating shafts. The operating limits of these bearings are mainly represented by the maximum operating temperature of the materials used and by the minimum thickness of the oil-film under which mixed lubrication can occur, with possible friction phenomena.
One current trend in bearing development concerns the adoption of innovative materials in the production of bearing. In recent years there has been a strong use of polymer lined pads [1] in tilting-pad journal bearings (TPJBs) and to a lesser extent the use of aluminum-tin lined pads [2]. In general, these advanced coatings allow a bearing size reduction and, therefore, a reduction in power loss. Standard pads for TPJBs are typically steel backed with a Babbitt lining (white metal). The search for new pad coating materials is still linked to the maximum operating temperature of the bearing. Generally, when the working temperature of material reaches above 30–50% of the melting point, the material will be likely to creep [3], that is the surface movement of the lining due to a combination of high local pressure and high local temperature which exceeds the local yield strength of the material. Babbitt is a tin-antimony-copper alloy, has high load capacity and wear resistance but has a low melting point. Aluminum-tin lined pads provide higher load capacity than Babbitt pads due to higher temperature capability and greater fatigue resistance [4]. Polyetheretherketone (PEEK) materials have higher operating temperature capabilities and have a very low coefficient of friction that allows to reduce torque and wear at start-up [5]. During stops and starts, the combination of high loads and low speeds makes the oil film unable to completely separate the sliding surfaces or shafts from the bearing surfaces, and the beginning of wear is unavoidable. The durability of bearings depends above all on their ability to resist wear under these operating conditions. Conversely, PEEK material has a poor thermal conductivity, that is, behaving as a thermal insulator towards the base steel of the pad which remains colder than in the case of the white metal coating. This leads to a problem of misinterpreting the temperature value measured by the temperature probes [6].
At first, the tribological properties of fiber reinforced PEEK (15% and 20% carbon fiber) and metallic Babbitt material will be investigated in terms of coefficient of friction (CoF) by means of ball-on-disc (BoD) tests at room temperature in dry conditions. Dry tests are significant because they give an estimate of how well the material can withstand the load without lubrication. For both PEEK samples, the dry tests ended with an average CoF of about half that of the white metal. As shown in Figure 1 the Babbitt test failed after a few meters. The PEEK samples exhibited two different behaviors: PEEKcf20 had a flat trend throughout the test, while PEEKcf15 grew linearly about halfway through the test and then stabilized at a higher value.

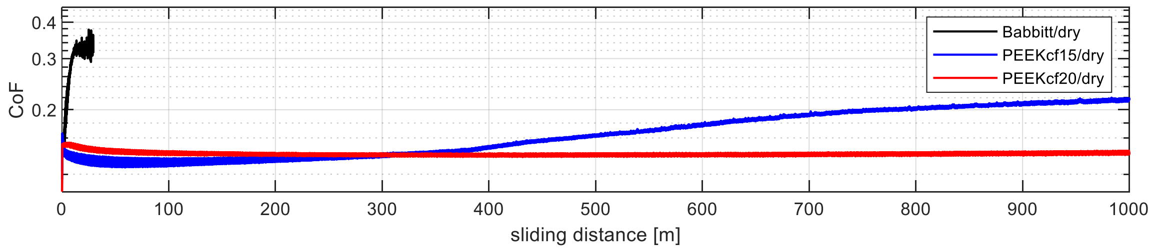

Figure 1. Ball-on-disc tests in dry condition with 10 N load applied and linear speed of 0.3 m/s.

Secondly the dynamic behavior of a TPJB lined with Babbitt and PEEK material will be investigated and compared, highlighting the effectiveness of PEEK material. The temperature distribution in the bearing will be evaluated by means of a full 3D thermal model and the stress coefficient defined as the ratio between the maximum von Mises stresses and the 0.2% offset yield strength in the lining, will be estimated.
At the end, the permissible operating range in terms of load and speed will be defined for each material by considering the limits on the permissible mechanical stress.
The maps of the stress coefficient, are shown in Figure 2, where three regions with limits on the stress coefficient at 50% and 100% can be assumed for the definition of the operating range of the bearing. In the red region plastic deformation occurred whereas the green region represents the safe region with a stress coefficient lower than 50%.
From the comparison of the stress coefficient maps, it results that the PEEK lining allows the operating range of the bearing to be extended.

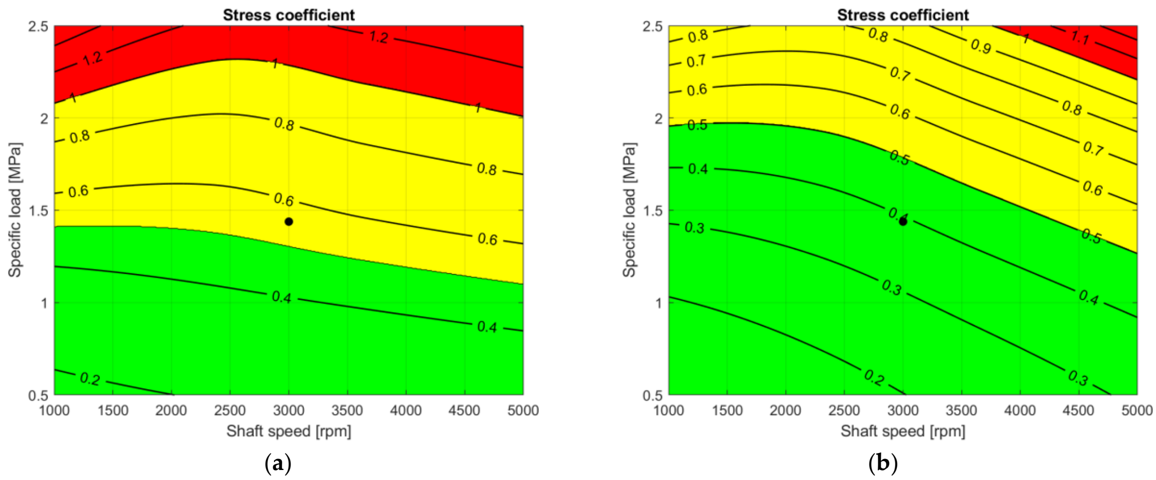

Figure 2. Operating range: (**a**) Babbitt and (**b**) PEEK.

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