New Research Proposal

Performance Measurement of ATSP Coating and Bulk PEEK Faced Tilting-Pad Thrust Bearings

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Subject Categories: 4 (performance), 8 (tribology), 9 (bearings & coupling)

Objective: Evaluate the static performance of tilting-pad bearings coated/faced with (a) thin ATSP-based coatings (thickness of 0.03 mm), and (b) PEEK pad, lubricated with water and a water/ sand mixture. Fig.1 shows the type of tilting pad thrust bearing to be coated and measured using a specialized test rig.

Fig.1 Tilting pad thrust bearing [1] to be coated with ATSP coating

Background: Under severe operating conditions, such as lubricant contamination, elevated temperatures and high unit loads, the hydrodynamic (HD) lubrication condition in a HD bearing may degrade and be reduced to mixed and boundary lubrication conditions, which traditional pad bearing materials (Babbitt metal) are not able to sustain. For example, Electrical Submersible Pump (ESP) systems are rated up to 220˚C, which is based on the last 80 years' experience in oil wells, geothermal and steam assisted gravity drain applications [2]. Polymeric materials are good candidates for bearing systems due to their good resistance to temperature, corrosion, galling and seizure, tolerance to small misalignments, low friction during contact, moderate wear resistance, self-lubricating properties, low noise emission and low production cost [3-5]. PTFE and PEEK-based polymers in bulk format (thickness 1.4-5.0 mm) are widely tested as plain bearing materials [6], due to their aforementioned advantages. However, bulk polymers cannot be applied for precision conditions because they are subjected to large deformation with temperature change due to high thermal expansion. In addition, polymers have low thermal conductivity that is combined with high thickness of the bulk polymer which will result in high surface temperature [7].

These disadvantages can be overcome by applying thin polymer coatings, in which appropriate dimensions and thermal stability can be retained [8]. Dr. Polycarpou's previous research showed

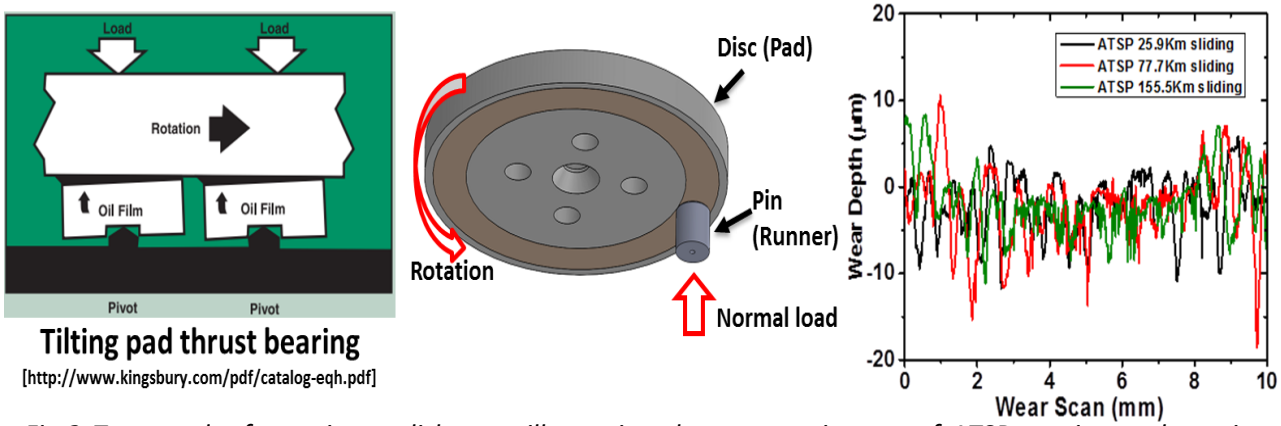

Fig.2 Test results from pin-on–disk tests illustrating the wear resistance of ATSP coating under unit loads and surface speeds similar to those experienced by tilting pad bearings in downhole applications.

ATSP coatings exhibiting extremely low wear rates ($4.15x10^{-8}$ mm^3/Nm) in boundary lubrication regime, simulating tilting pad bearings in harsh conditions [7], as shown in Fig. 2 of the wear track after different sliding distances. This ATSP coating also showed excellent abrasive wear resistance in silica sand [9] and temperature capability up to 260°C [10].

In this work, it is proposed to test two different polymers ATSP (0.03 mm) and PEEK, which is the standard material used in thrust bearings for downhole applications. We will also attempt for the polymer surfaces to also be micro-textured by using a technique developed in-house that has been proven to effectively improve film thickness and load capability, and also reduce the friction coefficient and pad temperature [11].

Test Equipment: Texas A&M University Turbomachinery Laboratory is building a tilting-pad thrust bearing test rig shown in Fig.3, which is capable of measuring bearing film temperature, bearing load and film thickness, power loss, inlet and outlet temperatures.

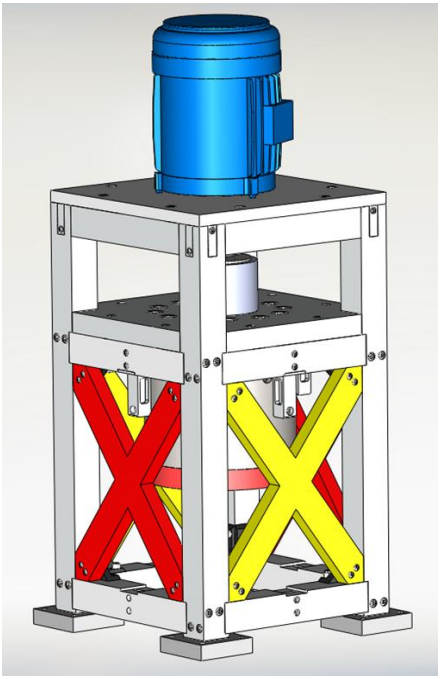

Fig.3 Thrust bearing test rig

Proposed work 2017-2018: Two tilting-pad thrust bearings will be procured either from a TRC member or from a bearing OEM. One of the bearings will have standard PEEK pads and be ready for testing; the other bearing will have only substrate metal pads and it will be sent to our collaborator (ATSP Innovations) for ATSP coating deposition. Subcomponent tests (pin-on-disk) will be performed to evaluate best coating candidates. The following measurements under three loads (300-700 psi range) and two speeds (1800, 3600 RPM) will be performed for each bearing (PEEK, ATPS coated) lubricated with water:

- Bearing film temperature
- Bearing film thickness, power loss and load
- Inlet and outlet lubricant temperatures

The ATPS coated bearing will be subsequently tested with a water/ sand mix to evaluate pad wear.

Budget: Salary for 1 PhD student $26,400; tuition and fees $9,600; machining parts and materials $3,000; consumables, coatings and supplies $6,000; **total: $45,000.**

References:

[1] https://grabcad.com/library/tilting-pad-high-load-thrust-bearing
[2]. J. Vandevier. GRC Transactions 33, 649-652 (2009)
[3] K. Holmberg, A. Mathews, Thin Solid Films, 253(1994), 173-178
[4] M.W. Akram, J.L. Meyer, A.A. Polycarpou, Tribology International, 97(2016), 200-211
[5] C.M. Ettles, R.T. Knox, J.H. Ferguson, D. Horner. Journal of tribology, 125(2003), 814-823
[6] Wodtke, M., and M. Wasilczuk. Tribology International 97 (2016): 244-252.
[7] P. Lan, A.A. Polycarpou, et al., Wear 354(2016), 10-20
[8] M. Fillon, S.B. Glavatskih. Tribology International, 41(2008), 1219-1225
[9] P. Lan, A.A. Polycarpou, et al. Wear, 382–383(2017), 40-50
[10] P. Lan, A.A. Polycarpou, et al. Tribol Lett (2016) 61: 10.
[11] V.G. Marian, Gabriel, D., Knoll, G. and Filippone, S., *Tribology Letters*,*44*(3), pp.335-343, 2011.