Developments in PTFE faced thrust bearings for use in vertical pump applications

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ABSTRACT

This paper outlines recent work undertaken to determine if PTFE technology, normally employed for large thrust pads, can be successfully used for small pad sizes operating across typical vertical pump speed ranges. Two sets of 80 mm thrust pads, one with offset pivots and the other centrally pivoted, were tested at sliding speeds between 2.5 metres/sec and 21.2 metres/sec with specific loads up to 7MPa. Results demonstrate that small PTFE faced thrust pads can sustain significantly higher thrust loads than the equivalent sized whitemetal pads. The potential advantages of using PTFE faced thrust pads in pump applications are discussed.

1. INTRODUCTION

Polytetrafluoroethylene (PTFE) is now well established in the hydro industry where it has been used as a thrust bearing lining material since the 1970's (1). PTFE thrust bearing technology was originally used in the former Soviet Union to overcome persistent hydrogenerator bearing failures. By 1990 the vast majority of hydro-electric power stations in Russia had been fitted with PTFE faced thrust bearings (2). Since then much work has been undertaken (3, 4, 5, 6, 7) to understand the performance of PTFE thrust pads.

Typically the advantages of PTFE in large thrust pad applications are one or more of the following:

- Higher load carrying capability: Specific loads in excess of 10MPa are cited (6, 7) and certainly Michell Bearings has thrust pads operating in service at 6.3 MPa
- Reduced thermal crowning: This is an advantage in large thrust pads for hydro applications which need careful design to keep pad distortion to a minimum. PTFE is an insulator, so the thermal gradient through the thickness of the pad is lower, resulting in a flatter operating surface (6, 7).
- Higher starting load capability: Michell Bearings has tested the breakaway capability of PTFE thrust pads under specific loads of 7MPa (8) and supplied bearings for Pelton turbine application with starting loads of up to 6.2 MPa.
- Durability: PTFE faced thrust pads have proven successful in highly misaligned conditions where whitemetal faced pads have previously failed

(5). In addition, service life of more than 20 years for a single set of pads is reported (8), with the pads undergoing 12-13 start/stops per day.

- Reduced coefficient of friction: PTFE has a much reduced coefficient of friction compared to whitemetal. Tests have shown that PTFE has a breakout coefficient as low as 0.06 compared to 0.18 for whitemetal (8)
- Reduced power loss: Due to the ability of PTFE to sustain higher loads than whitemetal, Michell Bearings has been able reduce the thrust surface allowing air cooled bearings to be used that would otherwise have had to be water cooled. Typically power loss savings in the order of 20-30% are cited (9).

Today, the current performance and reliability of PTFE technology is such that many large machines have been designed and built with PTFE faced pads as the first choice.

Figure 1 shows an example of one such case, supplied by Michell Bearings to Andritz Hydro Canada Inc. for Caojie power station on the Jialing River in China. Four machine sets were supplied with the first machine set being commissioned in 2010. The thrust pad had an outside diameter of 3.85 metres, a radial width of 665 mm and supported a thrust load of 26,000 KN. The principal reason for the use of PTFE was to reduce thermal distortion of the pad during operation.

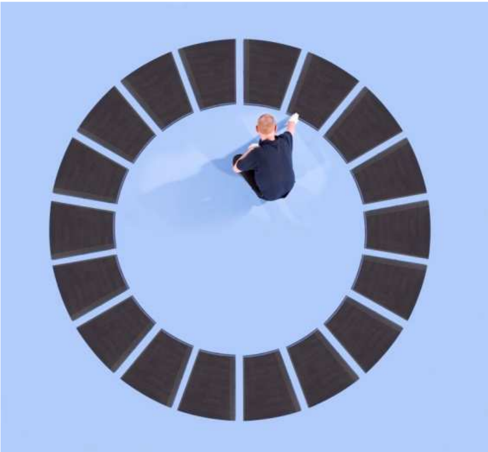

Figure 1. Caojie thrust bearing

In comparison to large hydro applications, the thrust pads fitted in the majority of vertical pump applications are much smaller, normally in the size range between 50 mm and 150 mm. Even though Michell Bearings has supplied such sizes of PTFE faced pads for pump applications in the last 13 years, the use of PTFE facings on small thrust pads has received much less publicity. All of the afore mentioned advantages for large thrust pads, with the exception of reduced thermal crowning, are potential advantages for small pads also.

The vast majority of hydro-generator applications are uni-directional meaning offset pivoted thrust pads are normally fitted. In pump applications, there is usually a requirement for the bearings to sustain common rotation reversals unless an anti-rotational backstop is fitted. Hence, unlike the majority of hydro-generators, the bearing thrust pads must be capable of accepting such rotation reversals and, in many cases it is specified that the bearing must be capable of accepting full load during reverse rotation (10). Whilst it is well established that whitemetal faced thrust pads are able to tolerate rotation reversals with either offset or centrally positioned pivots, this is not the case for PTFE thrust pads, even though some results have been published (5, 8).

This paper reports the results of a test programme in which both offset and centre pivoted 80 mm sized PTFE thrust pads were tested in forward and reverse rotations. The thrust pads were tested in a mid-range frame size of vertical bearing popularly used in pump and pump motor applications. The performance of offset and centre pivot pads are compared with each other and also, where possible, to that of the equivalent sized whitemetal pads tested at a previous date. The PTFE faced pads were tested across a speed range typically experienced in pump applications but at specific loads significantly higher than those established for whitemetal thrust pads.

2. TEST BEARING & EQUIPMENT

The test bearing and loading arrangement is shown in Figure 2 below. Oil is supplied to the test bearing from an external source and is drawn through the working elements via the pumping action of the rotating thrust collar, which is attached to the shaft. The oil then flows to drain over a weir, which ensures that the test pads are fully submerged with oil. The loading module uses hydraulic pistons to force the shaft downwards against the test thrust pads, which are situated beneath the thrust collar.

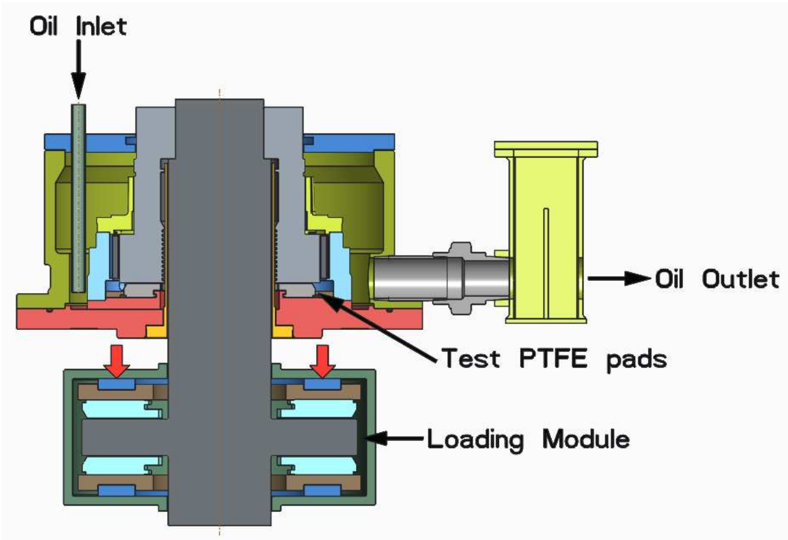

Figure 2. Test bearing and loading arrangement

The thrust pads were faced with a 15% carbon 2% graphite filled grade of PTFE fixed to the steel backing using a copper interlayer as previously described (4). Thrust pad temperatures were measured using miniature thermocouples embedded into the steel backing of the thrust pads. The thermocouples were situated in the trailing outer quadrant of the thrust pad and a small hole was drilled through the PTFE surface to meet up with the tip of the thermocouple, hence ensuring that the thermocouple was measuring the oil temperature in the oil film itself. Four of the eight thrust pads contained thermocouples. The position of the thermocouple for forward rotation is shown in Figure 3 and the dimensions of the test pads are shown in Table 1. In addition to the thermocouples fitted into the thrust pads, thermocouples were also positioned to measure oil inlet, oil outlet and oil bath temperatures.

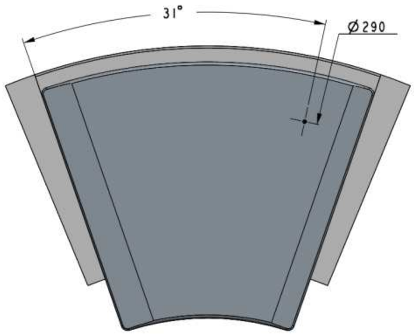

Figure 3. PTFE faced pad showing thermocouple position

Number of thrust pads	8
Outside diameter (mm)	321
Inside diameter (mm)	161
Mean pressure diameter (mm)	254
Thrust pad radial width (mm)	80
Pad angle (degrees)	38
Pivot position (% of pad angle)	50% and 60%
PTFE layer thickness (mm)	1-2