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SOLID LUBRICANTS FOR OIL-FREE TURBOMACHINERY

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Introduction

Recent breakthroughs in gas foil bearing performance coupled with improved high temperature solid lubricants and computer based modeling has enabled the development of revolutionary Oil-Free turbomachinery systems [1]. These innovative new systems rely on gas lubricated foil bearings at high speeds and solid lubricants at low speeds (start-up and shut down). Foil bearings are hydrodynamic, self acting fluid film bearings made from thin, flexible sheet metal foils. These thin foils trap a hydrodynamic lubricating air film between their surfaces and moving shaft surface. For low temperature applications, like aircraft air cycle machines (ACM's), polymer coatings provide important solid lubrication during start-up and shut down prior to the development of the lubricating fluid film. The successful development of Oil-Free gas turbine engines requires bearings which can operate at much higher temperatures (>300 °C). To address this extreme solid lubrication need, NASA has invented a new family of composite solid lubricant coatings, NASA PS300 [2].

PS300 is a family of plasma-spray deposited, high temperature, solid lubricant coatings specifically developed to lubricate high temperature sliding contacts like foil air bearings. PS304 is a specific composition. made from a nickel-chromium binder (60 wt%) and chromium oxide hardener (20 wt%) with the solid lubricants silver (10 wt%) and barium/calcium fluoride eutectic (10 wt%). PS304 is deposited onto shaft or runner surfaces which then operate against foil bearings which may also be coated for added wear protection. PS304 has been demonstrated in foil air bearings from 25 to 650 °C over a wide range of loads and has provided wear lives in excess of 100,000 start/stop cycles [3]. Figure 1 shows a coating cross section photomicrograph.

Recent research has shown that PS304 lubricated foil air bearings require a break-in period before maximum bearing load capacity is realized. During this period surface polishing occurs, making for a more favorable air bearing [4]. In addition, solid lubricants in the PS304 coating form a lubricating glaze on both the coating and foil surface finish, further improving bearing load capacity. Figure 2 shows an x-ray analysis of a PS304 surface after break-in confirming the presence of these lubricants namely Ag, Ca, and Ba. Newly developed treatments involving the application of thin sacrificial solid lubricant overlays of graphite have obviated this break-in challenge and resulted in no initial de-rating of foil bearing load capacity [5].

The combination of a suitable high temperature solid lubricant system, like PS304, and advanced high load capacity foil air bearings are key technology enablers for Oil-Free turbomachinery systems.

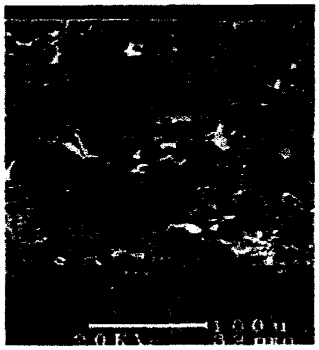

Fig. 1 Cross section photomicrograph of PS300 showing multi-phase composite nature.

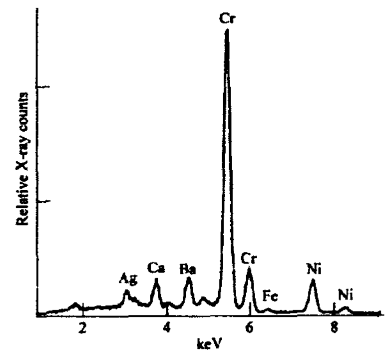

Fig. 2 X-ray analysis of journal surface after break-in.

References

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