

Modification of Bushing Test Rig and Research of Variable Inlet Guide Vane Bushings For Further Development of PM304 Bushings

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PS304 is a high temperature solid lubricant coating comprised of a nickel-chrome binder, chrome oxide hardener, barium-calcium fluoride high temperature lubricant, and silver as the low temperature lubricant. This coating is used to lubricate Oil-Free Foil Air Bearings as they experience friction and wear during start up and shut down. The coating deposition process begins with undercutting the shaft. This area is then sandblasted to provide a rough surface for the coating to adhere to. The coating powder is then sent through the plasma spray gun and a reasonably thick layer is applied to the undercut area of the shaft. The coating is then ground down even with the surface of the shaft and gets a nice polished finish.

The foil air bearings use the solid lubricant, as mentioned above, during start up and shut down. During normal operating conditions, generally above 2000RPM, the bearings utilize air as their lubricant. Foil air bearings are comprised of a thin top foil and a corrugated bump foil. They have an interference fit with the shaft before operation. As the air gets "trapped" between the top foil and the shaft, it presses the top foil against the bump foil, in turn compressing the bumps. As the bumps compress, it allows for the air to separate the top foil from the shaft, therefore, utilizing the trapped air as its lubricant.

The coating has proven to sustain over 100,000 start/stop cycles at temperatures ranging from ambient to 650°C.

Since PS304 comes initially in powder form, we are able to use it for other applications as well. For example, PM304 bushings can be made from the material through conventional powder metallurgy methods. The powder is fed into the die, and is then cold pressed. Finally, the pressed piece is hydrogen sintered at 1100°C for 20 minutes.

A test rig has been developed to determine the sliding characteristics of the PM304 bushings, such as friction and wear. During the preliminary testing, it was discovered that the bushings require a break in period at high temperatures to obtain a lubricating glaze on the surface of the shaft. Without this break in period, the bushings would disintegrate not far into the test. After the break in period, the PM304 bushings, just like the PS304 coating, not only are able to withstand temperatures up to 540°C but also perform better with increasing temperature.

These bushings are currently being used in industrial furnace conveyors, and they have been working very well compared to the previously used bronze bushings. Another application the bushings should perform well in is variable inlet guide vanes (IGVs) and variable stator blades. The bushing test rig is under modification to simulate the appropriate operating conditions of variable IGVs and variable stator blades to begin testing and analysis. This will ensure the bushings are in fact capable of operating in such conditions.

The maximum temperature for the furnace being used is 1000°C, which will allow very high temperature testing to be done, potentially opening the door for use of these bushings in the hotter areas of the engine. With the modifications, the tests performed can include full rotation of the shaft at speeds up to 400RPM or an oscillatory motion up to 45°, which could be easily modified for a larger angle of rotation, if desired.

The PM304 bushing test rig modifications and the resulting data will be the focal point of my master's thesis. I will be studying the bushings under conditions similar to current variable IGV and variable stator blade conditions. My goal is to determine if the PM304 bushings are an alternative to the bushings currently in use and have the data to backup my conclusion.