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ABSTRACT

It has recently been shown that high-speed grinding can be applied to the finishing of ceramics with considerable improvements in throughput and quality. This will require new high-speed high-power centerless grinding spindles (7,000 RPM, 50 HP), with high-stiffness of three hundred and fifty million Newtons/meter (2 million lb/in). To meet these requirements a novel inside-out, three-pad, pivoting-pad oil-fed hydrodynamic journal bearing has been devised, built and tested. One of the three pad’s pivot point is supported by a hydraulically-actuated radial-motion loading piston. This provides real-time controllable preload to all three bearing pads, thereby controlling bearing stiffness, providing less-stiff spindle bearings for initial rough grinding and very high stiffness spindle bearings for precision finish grinding. Extensive bearing test data compare favorably with theoretically predicted bearing performance.

INTRODUCTION

The generic configuration of a centerless grinder is illustrated in Figure 1. The regulating and grinding wheels are set up with their respective rotational centerlines mutually out-of-parallel by a small angle (e.g., 6°). This provides the means for the regulating wheel to pull the work piece axially through the three converging contact lines. As the work piece exits, its finished ground diameter is set by the circle defined by the three work-piece points of contact (G, R and S in Figure 1).

Figure 1. Centerless grinder generic configuration

Clearly, the two wheels/spindles and work rest must have quite high structural stiffness when producing high precision finished ground diameters (e.g., IC engine hydraulic valve lifters). Figure 2 shows the layout of the bearing configuration developed in this research. Two such bearings are employed to support the grinder spindle, each with a single-acting axial thrust bearing preloaded against the other. Detailed FEA analyses were performed [1] to assess the influence of forces and high rotational speeds on stresses and deflections. Figure 3 shows a photo of the prototype bearing manufactured for laboratory testing. The development of this bearing was guided by extensive analyses for all the important operating parameters, including lubricant type and flow requirements, minimum film thickness, operating temperatures, power dissipation, all as functions of spindle speed up to 7,000 RPM and bearing preload. Laboratory test results compare favorably with design analysis predictions, with fluid-film stiffness results summarized in Table 1, [1].

In the novel design here presented, the preload is real-time adjustable by supporting one of the pad’s pivot points on a hydraulically actuated radial motion loading piston (illustrated in Figure 4). The inside-out aspect of this bearing design is dictated by the overall design configuration of the new centerless grinder spindle with an integrated internal advanced motor design (shown in Figure 5). Since three pivot points define a circle, employing the 3-pivoting-pad configuration allows the bearing preload to be set by the radial adjustment of only one pad’s pivot point relative to the bearing housing. Bearing stiffness is thereby real-time adjustable using hydraulically actuated preload adjustments.

REFERENCE

Table 1. Measurement-prediction comparisons

<table>
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<tr>
<th>Speed (RPM)</th>
<th>Actuator Force (N)</th>
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<th>Error</th>
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Figure 2. Layout of bearing configuration

Figure 3. Test bearing with 3 copper pads

Figure 4. Hydraulically actuated pivot point

Figure 5. Integrated-motor centerless grinder spindle