Production of Near-Mirror Surface Quality by Precision Grinding

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Introduction

Mechanical components such as gears and bearings operate with the working surfaces in intimate contact with a mating part. The performance of such components will be influenced by the quality of the working surface. In general, a smoother surface will perform better than a rougher surface since the lubrication conditions are improved. For example, surfaces with a special near-mirror quality finish of low roughness performed better than ground surfaces when tested using a block-on-ring arrangement (Ref. [1]). Bearings with near-mirror quality have been tested and analyzed; lower running torques were measured and improved fatigue life was anticipated (Ref. [2]). Experiments have been done to evaluate the performance of gears with improved, low roughness surface finishing. The measured performance improvements include an increased scuffing (scoring) load capacity by a factor of 1.6 (Ref. [3]), a 30-percent reduction of gear tooth running friction (Ref. [4]), and longer fatigue lives by a factor of about four (Ref. [5]). One can also anticipate that near-mirror quality surface finishing could improve the performance of other mechanical components such as mechanical seals and heavily loaded journal bearings. Given these demonstrated benefits, capable and economical methods for the production of mechanical components with near-mirror quality surfaces are desired.

One could propose the production of near-mirror quality surfaces by several methods such as abrasive polishing, chemical assisted polishing, or grinding. Production of the surfaces by grinding offers the possibility to control the macro-geometry (form), waviness, and surface texture with one process. The present study was carried out to investigate the possibility of producing near-mirror quality surfaces by grinding. The present study makes use of a specially designed grinding machine spindle to improve the surface quality relative to the quality produced when using a spindle of conventional design.

Experimental Procedure and Results

Experiments were conducted to compare the surface quality of ground surfaces produced using two grinding machine spindles of different designs. One spindle used was of conventional design and in new condition. The second spindle used was of a special design using technology aimed to improve the surface quality. The grinding experiments were conducted using a universal grinding machine at the NASA Glenn Research Center.

To compare the capability of the grinding machine equipped with each of the two spindles, hardened rings were ground and the resulting surface qualities were evaluated. The rings used were hardened rolling-element bearing rings. The rings had an internal diameter of 62 mm. The machine was operated using the same grinding regime (same grinding wheel, speed, feed rate, and coolant) for both spindles. The grinding regime was chosen to optimize the surface quality when using the spindle of conventional design. The ground surfaces were inspected and analyzed using a mapping interferometric microscope. Figure 1 shows the surfaces resulting from these tests. On the left hand side of Figure 1 is a surface ground using a spindle of conventional design. Tracks of contacts between the grinding wheel and the working part can be seen on the surface. The measured surface roughness average (Ra) was 0.041 micrometers (1.6 micro-inches). On the right hand side of Figure 1 is a surface ground with the spindle of the new design. The roughness of this surface (Ra) is 0.019 micrometers (0.75 micro-inches). The quality of the surface, as quantified by roughness average, is improved by a factor of two by making use of the specially designed spindle rather than the spindle of conventional design.

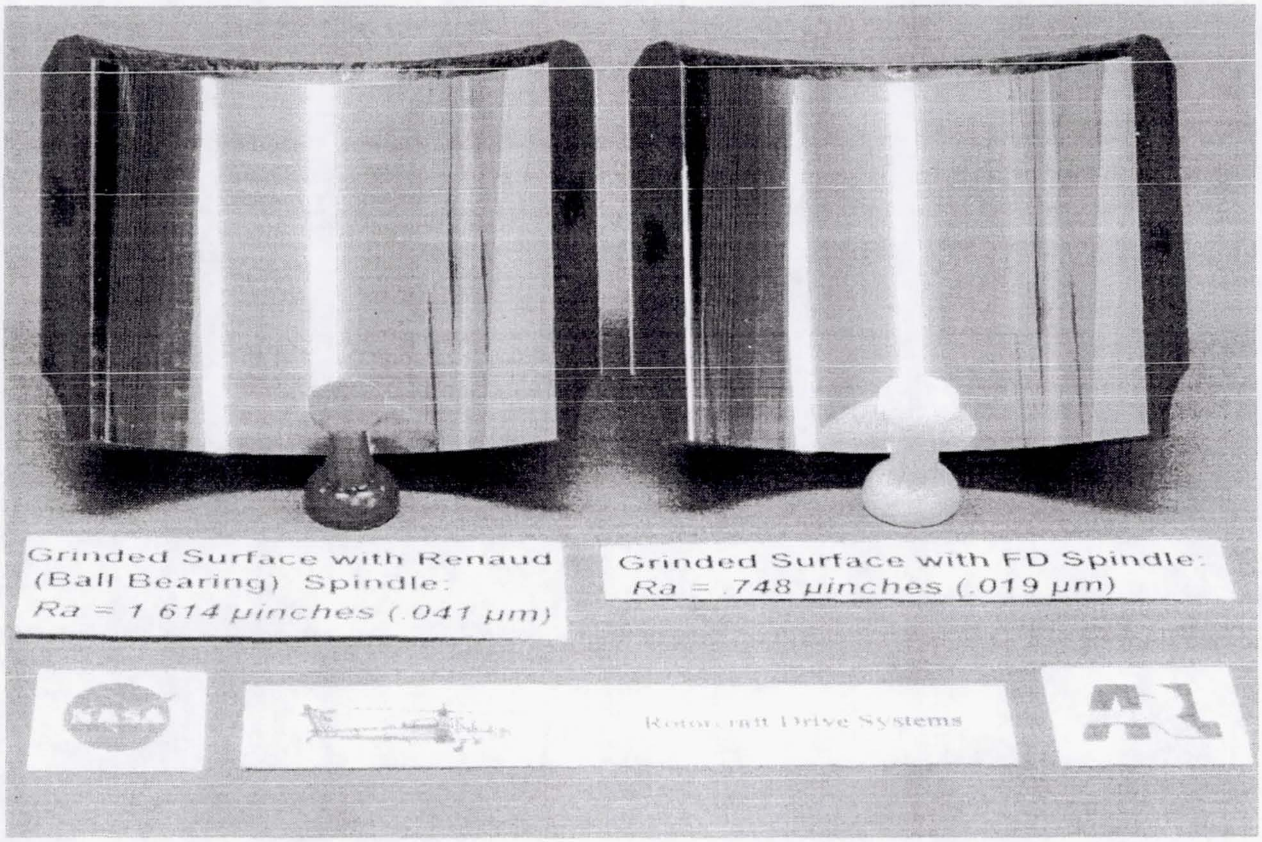
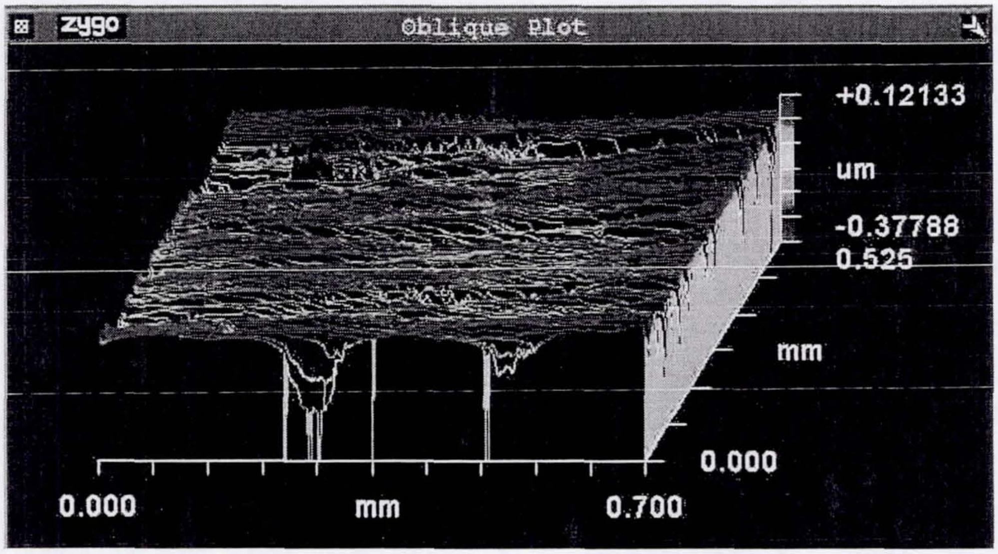
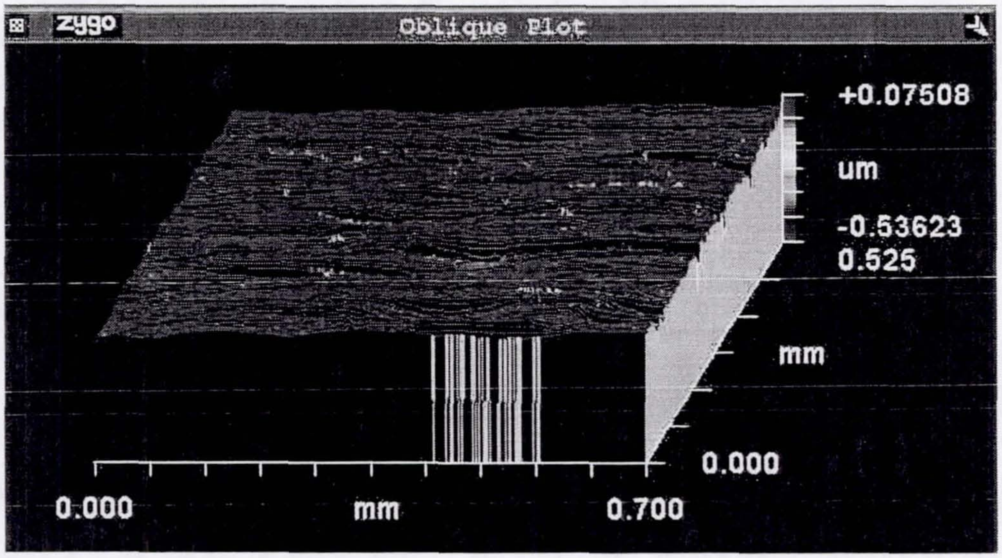


Figure 1: Quality of ground surfaces produced using a spindle of conventional design (left side) and a spindle of a special design (right side).

Surface topographies of the ground surfaces are provided in Figure 2. The images are plots of the inspection data with the form removed to highlight the surface roughness. The improved surface quality due to the use of the specially designed spindle is evident



(a)



(b)

Figure 2. Comparison of surface topographies of ground surface as measured using mapping interferometric microscope. (a) Surface produced using a spindle of conventional design. (b) Surface produced using a spindle of special design.

Discussion

Production of near-mirror quality surfaces by grinding was demonstrated. The demonstration was done using a universal grinding machine to finish the internal surfaces of sample bearing rings. Using a spindle of a special design produced a superior quality. A typical example of the resulting surface is provided in Figure 3. The technology employed in this demonstration project can be employed on many types of grinding machines, including gear-grinding machines.

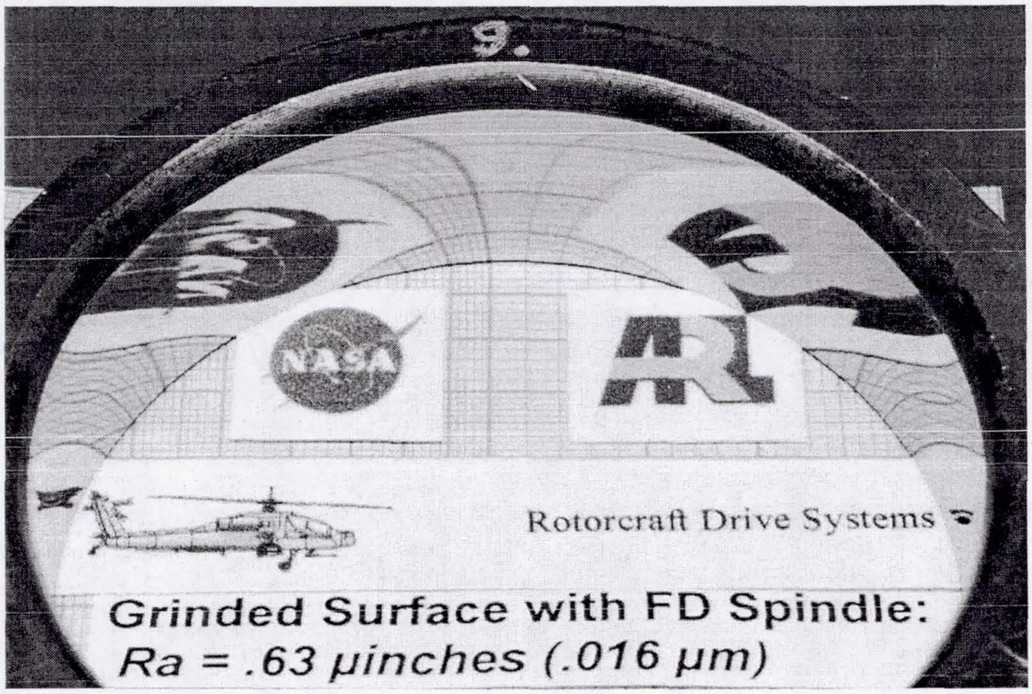


Figure 3: Typical ground surface quality produced using the specially designed spindle.

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