Manufacturing of Dimpled Surfaces in Hard Turning and subsequent Honing operation

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Abstract

A new method for manufacturing of dimpled surfaces has been developed and patented by SKF. The method comprises Hard Turning with an oscillating tool and a subsequent Honing operation. A precision actuator is used for generating high-frequency oscillation (up to 8 kHz) with amplitude within 1 to 15 microns. A tool holder with CBN or Ceramic insert is attached to the actuator and subject to oscillation at the same time as the tool is cutting a chip. Due to the oscillation the depth of cut will vary giving a wavy track shape on the produced surface.

After the Hard Turning operation with an oscillating tool the surface is relatively rough, with peaks and valleys. The final surface topography is achieved after a honing operation where the peaks are removed. Depending on honing depth and method, different proportions between plateaus and dimples can be achieved to attain best tribological conditions for a specific application.

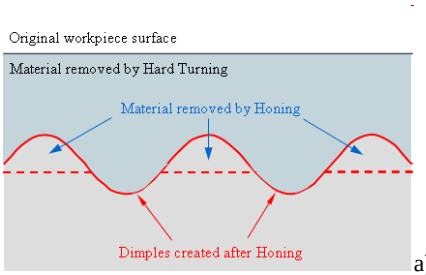
1 Background

Surface topography is one of the most important parameters that have significant impact on performance of functional surfaces subject to rolling and/or sliding working conditions. The life of functional surfaces exposed to extreme working conditions like high loads and low speeds is strongly depending on the tribological effects in the contact zone between the rings and the rolling elements. It is known that in applications with starved lubrication, the surface topography has a dominant role in keeping a proper thickness of lubricant film creating the lift-off distance between the bodies in motion. Different methods can be used for creating both deterministic and stochastic surface topographies and patterns. The most common method is stone honing that gives a crosshatch pattern e.g. as on cylinder liners or bearing raceways.

Other methods that can create desired surface topography and specifically dimples are laser patterning, etching and shot peening. It should be mentioned that the last mentioned methods are both time consuming and costly.

2 Method description

As mentioned the developed method consists of two manufacturing operations. In the first operations a surface is generated by Hard Turning Process where the tool tip is oscillating giving a sinus formed wavy surface. This is performed by using a precision actuator where both the amplitude and frequency are precisely controlled.



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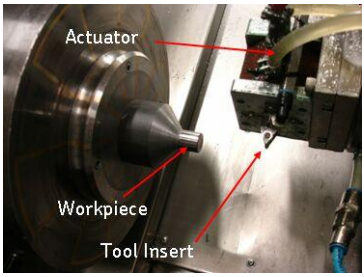
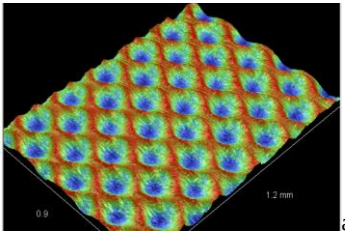


b)

Figure 1: Schematic description of method b) Actuator with a cutting tool and work piece mounted in the chuck

The depth and the distance between dimples is carefully controlled by the correct selection of several parameters like feed rate, cutting speed, oscillation frequency, oscillation amplitude, nose radius and geometry of the cutting tool as well as by the honing parameters. Figure 2a shows a typical surface topography after Hard Turning with the oscillating tool. Depending on the mentioned parameters a density of dimples up to 80 dimples /mm^2 could be achieved.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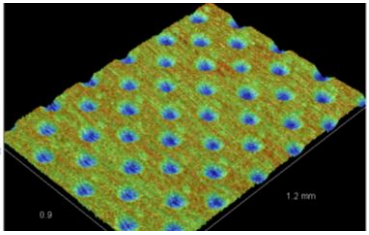
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Figure 2: a) Surface shape after Hard Turning process, b) Surface shape after HaT and Honing process.

The Hard Turned surface as shown in Figure 2a is not suitable for rolling or sliding applications since the peaks will give high stress concentration and failure of the surface. After additional super-finishing operation like Honing, the peaks are removed and plateaus with dimples are obtained, see figure 2b.

3 Surface patterning

Different surface patterns can be obtained by proper synchronization of the oscillation frequency and the angular position of the work piece. Example of different surface created with the method is shown in Figure 3. Here is can be seen that there is high flexibility in what pattern can be created.

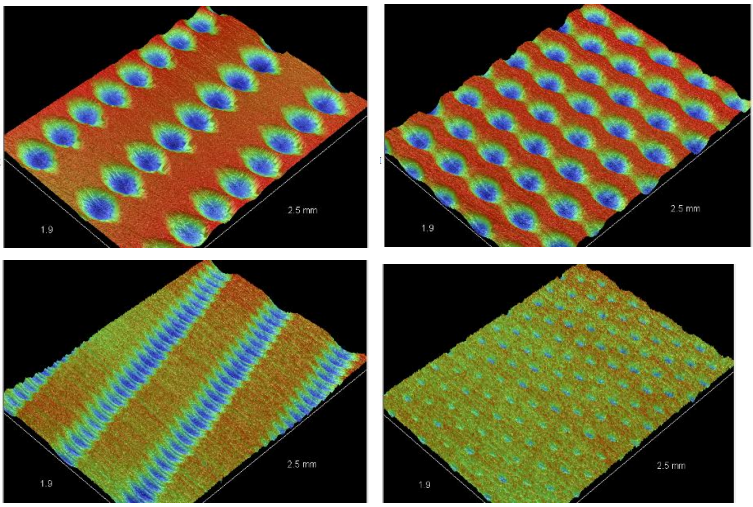

Figure 3: Different surface patterns generated by the Hard Turning and Honing processes.

This requires equipment with high precision in rotational speed and movement of the slides, as well as high resolution in the control of the frequency of the actuator.

4 Application test

The dimpled surfaces have been tested in bearing applications and compared with standard surfaces. Figure 4 shows the relation between friction torque and rotational speed in one tested application. Here it can be seen that the dimpled surface not only has lower starting friction torque (40% lower) but also has lower frictional torque at speeds lower than 45 rpm.

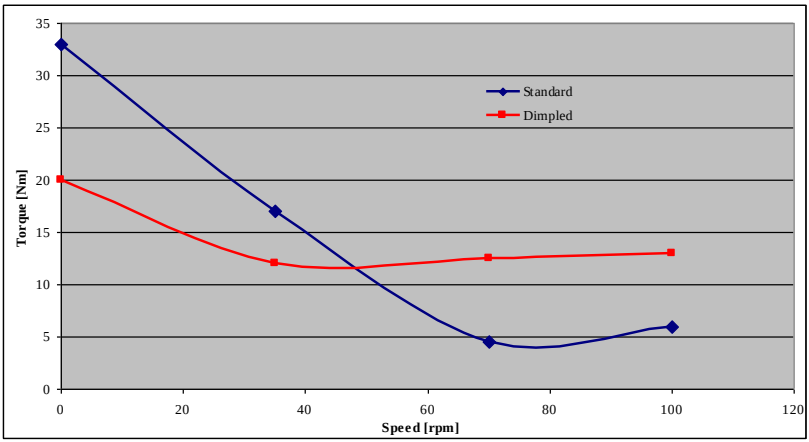

Figure 4: Friction torque measurement with standard solution (blue) and solution with dimpled surfaces (red)

5 Conclusion

High precision control of cutting parameter in Hard turning operations along with controlled oscillation of the tool tip give possibilities to create controlled surface patterns. With additional super finishing operations, dimpled surfaces with plateaus between the dimples are be created.

It has been shown that these dimpled surfaces can lower the friction in rolling or sliding working conditions.

The method developed by SKF gives opportunities to make tailor made surfaces with best tribological conditions for specific applications.