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Investigation of Tooling for Anisotropic Optical Functional Surfaces

D. Li[1], F. Regi[1], Y. Zhang[1], M. H. Madsen[2], J. B. Nielsen[3], G. Tosello[1]
[1]Technical University of Denmark, Department of Mechanical Engineering,
[2]Danish National Metrology Institute, [3]Technical University of Denmark, Department of Applied Mathematics and Computer Sciences

E-mail: dongyli@mek.dtu.dk

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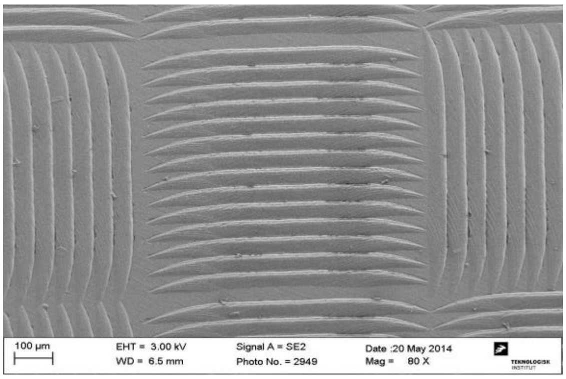
Abstract This paper studied steel inserts with anisotropic surfaces for injection moulding. The inserts surfaces were machined by a five-axis micro-milling machine and the surface structures will be replicated by injection moulding. The aim of the surface structuring is to maximize visible contrast between horizontally orthogonal textured surfaces from a certain viewing angle, of both the insert and the polymer replicas. The contrast is defined by the difference of the reflectance between two areas with horizontally orthogonal textures under a certainly fixed light source. The brightness of the surface is assessed by processing the images obtained from a digital microscope Hirox RH-2000 [1]. Figure 1**Error! Reference source not found.** illustrates the studied surface structure and the microscope. The optical axis of microscope can be tilted within 90 degrees from the horizontal level, which simulates the viewing angle; the analysed surface texture can be rotated horizontally by the adjusting the stage so only one surface was used to achieve orthogonal textures and images at different rotation angle can be captured. Via image processing tool, the reflectance (brightness of the obtained images) will be analysed and therefore the contrast can be calculated.

A full factorial 2-level design of experiment (DOE) with 5 factors was used to evaluate the influence of milling parameters including: spindle speed, feed speed, cooling condition, tool diameters and orientation of textures [2]. The orientation of textures was considered as the accuracy of the milling machine along x and y axis might result in different finish of the anisotropic featured surface. **Figure 1.** Left: The surface microstructure investigated in the paper; Right: The Hirox RH-2000 digital microscope.

Table 1 lists the setup for each parameters. The roughness and the dimension of the surface were measured by a laser confocal 3D scanner. The measurement uncertainty is calculated. The roughness of the surface and the contrast obtained by rotating the surface were used as the response of the DOE. Eventually, the micro-milling process was optimized.

Moreover, based on the optimal milling process parameters, the tool wear was investigated by inspection to the geometry and the achieved contrast of the obtained surface structures. Areas of 0.8mm x 0.8mm with the studied structures will be milled by the optimized process parameters. Every 100th area were measured. The obtained dimensions of the structures and the contrast were plotted against the area number so that the influence of the tool wear on the geometry and the function was revealed.



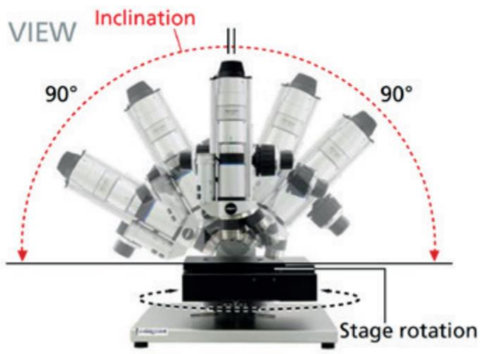


Figure 1. Left: The surface microstructure investigated in the paper; Right: The Hirox RH-2000 digital microscope.

Table 1. The investigated milling parameters and levels in the DOE.

Factor	**Cutter**	**Spindle speed**	**Cooling**	**Feed speed**	**Orientation**
Low	*Φ3mm*	*8500rpm*	*oil+air*	*700mm/min*	*Horizontal*
High	*Φ4mm*	*9600rpm*	*oil+water*	*1000mm/min*	*Vertical*

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