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Publication date:
2017

Document Version
Peer reviewed version

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Citation (APA):

Li, D., Zhang, Y., Regi, F., Tosello, G., & Nielsen, J. B. (2017). The impact of tool wear on the functionality of replicated polymer surface with micro structures. Abstract from Polymer Replication on Nanoscale: 4th International Conference, Aachen, Germany.

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The impact of tool wear on the functionality of replicated polymer surface with micro structures

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Wear happened frequently in the tooling process of mold for polymer production. The scope of this paper is to understand how the wear of the milling tool affected the function of the replicated polymer surface. This study is part of the process chain of fabrication of optical functional surfaces on polymer components. The aiming function of the surfaces is to maximize the reflectance from a certain viewing angle and direction, and minimize from its horizontally orthogonal position, i.e. to maximize the contrast between two horizontally orthogonal view positions at the same inclination. A five-axis micro milling machine was employed to pattern the surface of a steel insert for subsequent polymer replication.

In order to conduct the study, 1200 pixels (0.8 x 0.8 mm²) was machined on the surface of a steel insert using the same mill tool (Φ 0.5 mm, ARNO®); each of the pixels contains 16 ridges which is illustrated in figure 1 (a). The obtained surface structures were replicated using liquid silicon rubber (LSR).

The mill tool was inspected by scanning electron microscope (SEM) before and after the machining. Noticeable wear was observed. The weight of the studied tool was measured before and after machining for comparison. The obtained surface features on the insert and the LSR replica were measured using a confocal 3D laser scanner. The reflectance of the surfaces on the LSR replica was evaluated using a gonioreflectometer[1]. The gonioreflectometer captured the images of every 100th pixel from all the viewing angles by rotating the sample holder and tilting the objective lens. The reflectance for each configuration were obtained via image processing tools.

Results in this study include: 1. Tool wear was visualized by SEM images, which is shown in figure 1 (b). 2. However, the weight decrease could not be detected due to lack of precision in the measurement. 3. The number of defects on the obtained surface structures increased significantly along with the process. 4. The reflectance of these pixels on the LSR replica decreased from the first machined one to the last one.

As a conclusion, the tool (Φ 0.5mm, ARNO®) used in this study worn after machining for approximately 100 pixels, considering the function loss of replica surface. Future work will be dedicated to the methods that can prolong the tool life.

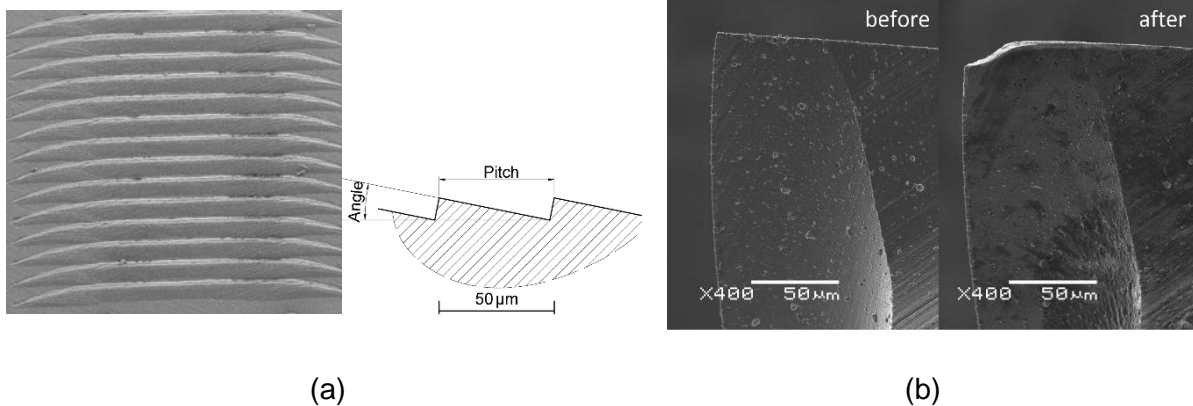


Figure 1: (a). Structures on the surface; (b). Wear on the tip of the tool was observed after machining

References

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