Manufacturing and Quality Assurance of Micro Structured Crankshaft Bearings

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Abstract
This paper focuses on the manufacturing of microstructures for the enhancement of friction loaded surfaces of a crankshaft. The studied structures are presented and an approach for the quality assurance of the microstructures is explained. This approach is based on the assessment of the neighbourhood distances between the single measurement points within a measurement point cloud and the application of edge detection to classify the detected form deviations.

1 Introduction
Individual mobility is one of the general achievements of modern societies, but it is also one of the biggest challenges regarding the rising emission of carbon dioxide globally. The intention to reduce the emissions of carbon dioxide through the integration of new technologies in vehicles for private transportation has lead to new requirements for power train components. Some examples for these technologies can be seen in the use of fuel-efficient engine oil, the implementation of an automatic start-stop system for engine management and even in the downsizing of the combustion engine. The application of these technologies, especially the automatic start-stop system, has lead to an increased attention on the friction partners within the engine. To increase the lifespan of the power train, the friction partners need to be improved to cope with the higher stresses. To improve the continuous functionality of friction surfaces, friction losses in the system should be minimized.

2 Production of micro structured surfaces
The reduction of the friction losses can be achieved by applying a microstructure to the surfaces of the parts. This friction reduction works for both, oscillating and
continuous sliding contacts [1] [2]. A suitable microstructure can be applied by laser ablation. The choice of ablated microstructures is made with consideration to the high pressures during the operation of the power train. This structuring creates an increased hydrodynamical pressure gain and thus leads to an improved tribological behaviour since the friction partners are separated earlier. For the preliminary survey, a pulsed Nd:YAG laser with a wavelength of 1064 nm and a pulse length of 6 picoseconds was used in order to produce the test structures for tribological testing. The structures shown in Figure 1 were produced and finally tested on a Pin-On-Disk Tribometer.

Figure 1: Exemplary microstructures on the test samples

3 Quality assurance of micro structured friction bearing surfaces

Aside from the challenges concerning the manufacturing of microstructured workpieces, the quality assurance of the produced structures also faces challenges when it comes to the influence of form deviations on essential product properties. One main complexity is the fact that even small production errors can result in severe changes of the behaviour of the produced surface. Therefore this paper provides an approach for an assessment of three dimensional shape deviations on the microstructured surface of a crankshaft bearing. This assessment is based on the analysis of the position of single measurement points by analyzing the distances between the points [3]. In the case of the crankshaft bearing, the measurement data is sampled in a regular grid within the x-y-plane obtained by measurement with an optical sensor with a fixed lateral resolution via confocal microscopy. The different values of the measurement points within the z-direction can be analyzed and visualized by using the distances between the single points.
As shown in Figure 2, the single points are evaluated by the calculation of a quality value for each point, depending on the distance to its direct neighbours. Based on the mean distances between the points of the entire measurement point cloud, all points are weighted with a score between 0 and 100 by an adaptable weighting function and finally visualized by plotting the whole point cloud according to a corresponding colour scale. The result of this calculation performed by the single-point-analysis algorithm can be seen in Figure 3 on the left side. The black points within the figure are points with a quality score of zero and the white points obtained the maximum quality score of 100. The corresponding colour scale on the right side of the figure represents the Quality Weight. The measurement range of this example point cloud of a crankshaft bearing surface was set to 1.6 x 1.6 mm with a lateral resolution of 3.1 µm, which results in a grid of 512 x 512 coplanar points. The detected form deviations on the bearing surface were caused during a grinding process. After detecting form deviations on the bearing surface, they have to be described mathematically. For this essential step within the part evaluation, edge detection was used in order to visualize the real shape of the deviation. The edge detection is performed by the application of the sobel-algorithm, which uses the variations of the brightness values within the picture, generated by the single-point-analysis algorithm (Figure 3 a). The white area in the middle of Figure 3 b shows a form deviation (grinding groove) caused by the production process in a higher resolution marked by edge detection.
4 Summary
With the microstructures presented, the friction losses within a tribological system can be reduced. Furthermore a fast, automated and adaptive assessment of the part surface using a point cloud analysis with edge detection leads to a conclusion about how to improve the production parameters for micro structuring the bearing surface.

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