40th Leeds-Lyon Symposium on Tribology & Tribochemistry Forum 2013
September 4-6, 2013, Lyon, France

Influence of machining-induced 3D surface roughness on component’s performance

Q. Zeng[1, 2], G. Liu[2], L. Liu[2], Y. Qin[1*]

[1)] Departmetn of Desgin, Manufacture and Engineering Management, University of Strathclyde, G1 1XQ, Glasgow, UK.
[2)] School of Mechanical Engineering, Northwestern Polytechnical University, 710072, Xi’an, China

[*]Corresponding author for qin.yi@strath.ac.uk

1. Introduction

Machined surfaces are never as smooth as a mirror; they are full of peaks, valleys, fluctuations, crevices, etc from the view of the micro scale. The complex surface topography directly affects component’s functional performance like load bearing, friction, wear and fluid retention properties. Although many works studied the correlation between 2D characterization parameters and surface tribological properties, there is a consensus that standard 2D roughness parameters are inadequate for describing tribological properties since the contact areas are of a 3D nature[1, 2]. This paper investigates the effect of machining processes and the resulting 3D surface topography on contact, friction and wear properties of machined components. The grinding and turning induced 3D surface topographical parameters[1](S_a, S_q, S_{sk}, S_{ku} S_{dr}) as well as the surface amplitude distribution function(ADF) and bearing area curve(BAC) are analyzed and compared to differentiate their specific functional performances.

2. Experiment and Procedure

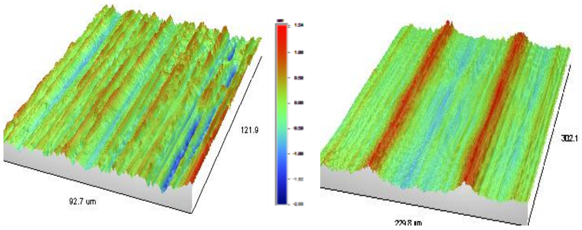
A hard-to-machine Ni-base superalloy, GH4169, which is widely used in aero engine and sensitive to machined surface behaviors, is employed for the processing experiment and measurement analysis. External grinding and turning are carried out with different processing parameters but producing identical surface mean roughness values (S_a=0.29μm). The contact and tribological properties of machined surfaces are also calculated and analyzed by using 3D surface parameters and functional curves.

3. Results and Discussion

With 3D optical interferometer, the ground and turned surfaces texture are measured as Fig.1. Although the S_a and S_q values of two machined surfaces are the same, their textures and corresponding ADFs and BACs in Fig.2 look apparently distinct. The 3D characterization parameters for ground and turned surfaces are shown and compared in Table 1. The ADF of the ground surface are closer to a Gaussian distribution of random surface than the turned surface. It means stronger texture direction of the turned surface. The BAC of ground surface indicates quicker running-in and longer steady wear-resistant stage if contact or friction loading is applied on the surface. 3D skewness S_{sk}=-0.44<0 shows the predominance of valley structures for the ground surface. The developed interfacial area ratio S_{dr}=11.29 for ground surface means it has much more complex micro structures and better oil retention capacity than those of turned surface.

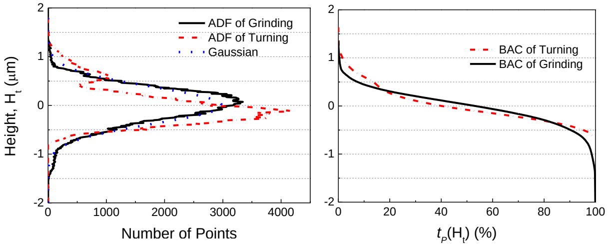
Table 1 3D statistics characterizing machined surface

	Ground	Turned		Ground	Turned
S_a (μm)	0.29	0.29	S_{sk}	-0.44	0.91
S_q (μm)	0.38	0.38	S_{ku}	3.76	3.46
S_{sc}(1/μm)	1.8	0.26	S_{dr}	11.29	1.13



(a) ground surface (b) turned surface

Fig.1 3D machined surface topography



(a) ADF (b) BAC

Fig.2 ADF and BAC curves of machined surfaces

4. Conclusion

For the material and machining processes that have been investigated, the influence of machined surface behavior on the load bearing, friction and wear resistance could be ascribed to the predominant effect of 3D surface parameters. For characterization and differentiation, the measured 3D surface statistics and functional curves accurately describe and analyze the corresponding contact and tribological prosperities of ground and turned surfaces. This kind of research overcomes the inability of the conventional 2D surface parameters comprehensively characterizing the practical 3D machined surface and evaluating its functional performance.

5. References

[1] Griffiths, B., “Manufacturing Surface Technology – Surface integrity and functional performance,” London: Penton Press; 2001.

[2] Mathia, T.G., Pawlus, P., Wieczorowski, M., “Recent trends in surface metrology,” Wear, 271, 2011, 494-508.