Experimental Study on Surface Texture and Coefficient of Friction in Sliding Friction Test

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Abstract

This paper describes the experimental results of relationship between topological indices of surface texture and coefficient of friction in machined surface. Firstly the definitions of topological indices based on the linear material ratio curve are explained. Secondly the experimental results in the reciprocating sliding friction test are mentioned. The following remarks were obtained. 1) The coefficient of friction in a surface texture with wide dimple area trends to be smaller than that with small dimple area. 2) The coefficient of friction seems not to be affected by the relative moving direction of reciprocating sliding friction test.

1 Introduction

For the control of coefficient of friction, there were many studies reported on the assessment index of surface texture [1], on Stribeck curve [2] and on machining manners [3]. Recently a machined surface texture can be arbitrarily designed and realized in ball end milling by using multiaxial CAM and machine tools. In this study, the research objective is to investigate the relationship between the coefficient of friction and the newly presented geometric feature indices.

2 Surface texture and geometric indices

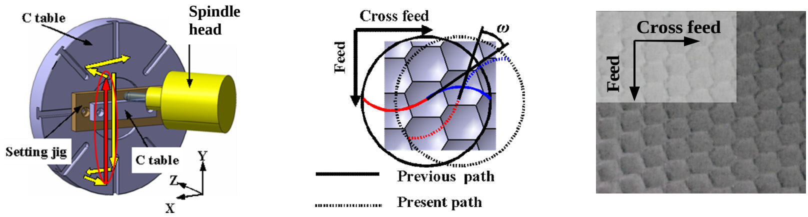
2.1 Generation of surface textures

Fig. 1 shows a tool path to generate a dimple aligned surface by adjusting path length of air cur in ball end milling and a photo of machined surface with dimples.

2.2 Geometric feature indices

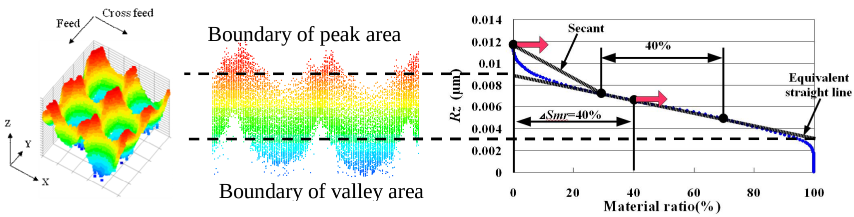
Fig. 2 indicates the determination manner of mountain and valley area of surface texture based on the linear material ratio curve [4]. Fig. 3 also indicates the definitions of 3D feature indices of *Lp*, *Lv*, θ, *Vv* and *Vm*. In each bottom section of mountains, a directional angle θ of principal axis of inertia was detected and its average angle Sfd defined in Equ. 1 was calculated.

$$Sfd = (1/m) \sum_{k=1}^{m} \Theta_k \,. \tag{1}$$



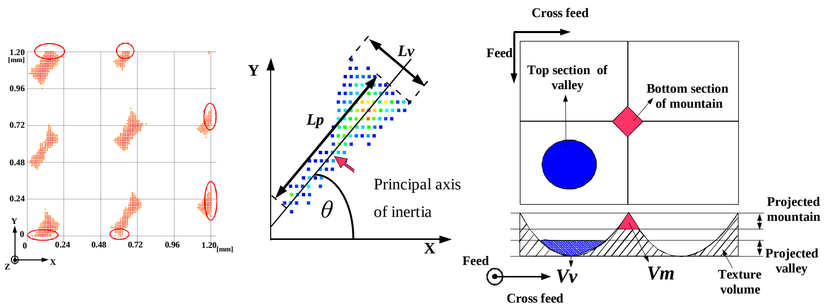
(a) Tool path for dimple (b) Phase angle ω of cutting edge (c) Aligned cutter marks

Figure 1: Ball end milling for generation of dimple aligned surface texture.



(a) 3D image of dimple (b) Coloured height image (c) Linear material ratio curve

Figure 2: Determination of mountain and valley based on linear material ratio curve.



(a) Projected mountain area (b) Feature indices: Lp, Lv (c) Feature indices: Vv, Vm

Figure 3: Definitions of 3D feature indices of Lp, Lv, θ, Vv and Vm [1].

3 Experiment

3.1 Experiment apparatus and conditions

Fig. 4 illustrates a manner of reciprocating sliding friction test with use of the 5-axis controlled machine tool and a 3D dynamometer as a force sensor. Table 1 indicates the experiment conditions of reciprocating sliding friction test.

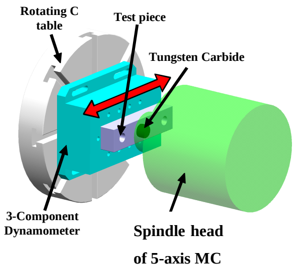


Figure 4: Experiment apparatus of reciprocating sliding friction test.

Table 1: Experiment conditions of reciprocating sliding friction test.

Specimen of friction test	Alloy tool steel: SKD11 (H_{Rc}58)
Cutter	Ball end mill, 2 flute, Φ6, Φ10 and Φ14
Phase difference angle of machined surface: ω (°)	0, 30, 60, 90
Direction of sliding friction test	The same as ***Sfd***
Sliding speed : $\boldsymbol{V}$ (mm/min)	600
Contact insert	Disk of Tungsten carbide with Φ 20 (Hv1680, Rz 0.3 μm)
Load (N)	200
Lubrication	Oil used

3.2 Experimental results of coefficient of friction

Fig. 5 shows the coefficient of friction classified by the ratios of *Vv/Vm* and *Lv/Lp* and Fig. 6 shows them classified by *Sfd* and the sliding directions. Each result in Fig. 5 and 6 suggests the first and second remark of conclusions respectively.

4 Conclusion

1) The coefficient of friction seems to become small according to the increase of 3D

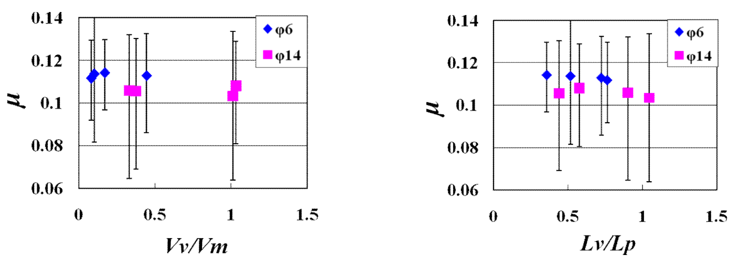
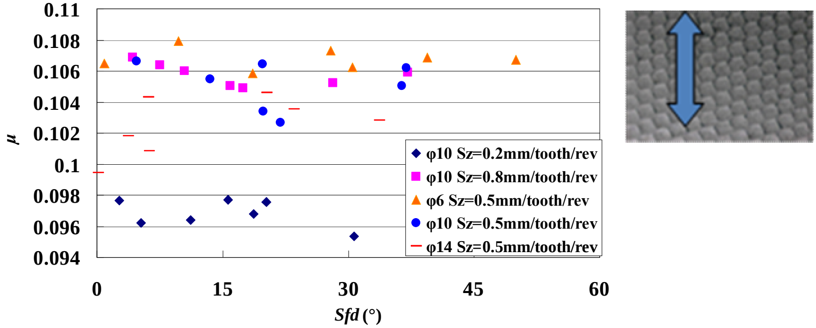


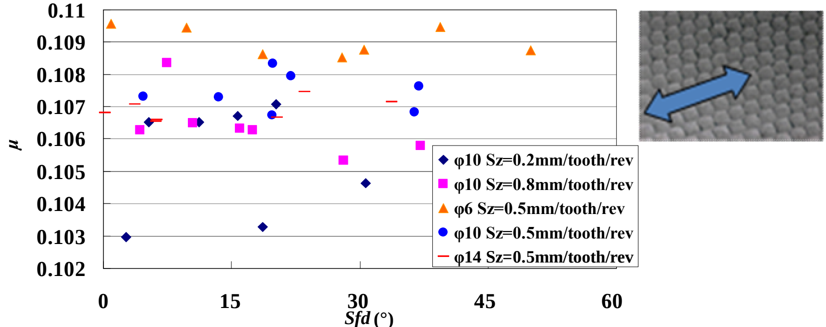
Figure 5: Experimental results of coefficient of friction.

feature indices. A large dimple brings a small coefficient of friction.

2) A small feed rate of 0.2 [mm/tooth/rev] brings smaller coefficient of friction than that with a large feed rate. The coefficient of friction seems to be insensitive to the sliding direction of friction test because its change is similar.



(a) Coefficient of friction along the feed direction



(b) Coefficient of friction along the direction of *Sfd*

Figure 6: Coefficient of friction along the sliding direction of friction test.

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[4] ISO 1356502: 1996 Geometrical Product Specifications (GPS) – Surface texture; Profile method; Surfaces having stratified functional properties – Part 2: Height characterization using the linear material ratio curve.