Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/acme

Original Research Article

The effect of surface topography on dry fretting in the gross slip regime

Agnieszka Lenart [a], Paweł Pawlus [b,*], Andrzej Dzierwa [b], Jarosław Sęp [b], Kazimiera Dudek [c]

[a] Heli-One, 36-102, Jasionka 947, Poland
[b] Rzeszow University of Technology, Powstancow Warszawy 8 Street, 35-959 Rzeszow, Poland
[c] University of Rzeszow, Tadeusza Rejtana 16C Street, 35-959 Rzeszow, Poland

ARTICLE INFO

Article history:
Received 18 September 2016
Accepted 29 March 2017
Available online

Keywords:
Fretting
Friction force
Surface topography
Wear resistance

ABSTRACT

This paper describes the tribological influence of surface topography on friction and wear under dry fretting gross slip regime in a point contact. Experiments were made using ball-on-disc tribotester in oscillatory motion. 100Cr6 sphere co-acted with a disc made of 42CrMo4 steel. During tests, the friction force was monitored as a function of time. Wear of discs and balls was measured after the tests using white light interferometer. Disc surfaces were prepared by various techniques, including milling, vapour blasting, polishing, lapping and grinding. Initial surface roughness height of discs, determined by the Sq parameter was in the range: 0.01–9 μm. During tests, normal load was kept constant at 45 N within the contact with frequency of 20 Hz. Tests were carried out with different displacement amplitudes: 0.02, 0.05 and 0.075 mm. It was found that initial surface roughness height had a significant influence on friction and wear.

1. Introduction

Fretting is defined as a cyclic relative motion between two surfaces in contact at a small displacement amplitude. Partial slip or gross slip conditions can be observed in the fretting contact. In the first case there are parts of contact where no slip displacement occurs, but in the second case there is slip displacement across the whole contact [1]. The fretting regimes can be characterised as functions of displacements and normal load [2]. The type of damage, either fatigue or wear is related to the sliding condition, i.e. gross slip or partial slip. Under higher loads and smaller amplitude of motion, the contact is within partial slip regime, resulting in fretting fatigue. Wear is dominant in the gross slip regime [3]. In this condition the generated particles are of huge importance. The role of the third body formed by wear debris is substantial. Oxidised debris can increase the wear or can separate the sliding surfaces, thus having a positive role [4]. There is opinion that on a rough surface debris can escape from areas of contact into neighbouring valleys, minimising fretting wear. However this belief was not confirmed in work [5]. Varenberg et al. [6] found that the role of oxidised debris depended on kind of wear. For dominant adhesive wear particles can reduce the damage acting as a solid lubricant but for abrasion particles facilitate wear. Difference between hardness of the

* Corresponding author.
E-mail address: ppawlus@prz.edu.pl (P. Pawlus).
http://dx.doi.org/10.1016/j.acme.2017.03.008

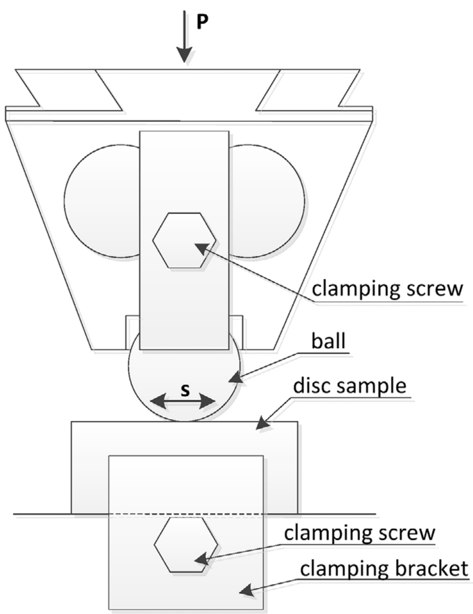

Fig. 1 – Scheme of tribotester.

tested materials under fretting conditions is important. Budinski [7] found that a hard/soft damage produced higher wear compared to hard/hard pair. The authors of paper [8] observed that for larger difference between hardness of both steel samples the oxidised particles were retained on the softer material; this resulted in small wear of the softer specimen and substantial wear of the harder sample. In calculation of the total wear volume of sliding pairs under gross fretting condition not only a negative volume (material loss) but also positive volume (build-up or transferred materials) should be taken into consideration [1,8].

The displacement amplitude has strong effect on the coefficient of friction and wear under fretting conditions. Li and Lu [9] found that with increasing the fretting amplitude, wear and coefficient of friction increased.

The effect of surface topography on fretting is often neglected. However the surface preparations and finishing processes are essential to monitor and reduce damage caused by fretting [5,10–12]. But the results of research are sometimes contradictory. Kubiak et al. [10,11] obtained lower coefficient of friction for rougher disc surfaces. However Pawlus et al. [5] found that for rougher disc surfaces, the coefficient of friction and wear of the system were higher. Surface texture affected coefficient of friction at the transition between partial slip and gross slip; for smaller roughness height this coefficient was larger [12]. The influence of surface texture on fretting was also analysed in works [13–16]. However it is difficult to find one research analysing the effect of various surface properties (spatial height and others) on fretting under dry gross slip regime.

Two-process texture, formed by two processes, seems to be more important from functional point of view than one-process surface. Plateau honed cylinder liner surface is the typical example of two-process topography. It consists of smooth peaks with intersecting deep valleys and combines good sliding properties of a smooth surface and great ability to maintain oil of a porous topography. Such surfaces have been machined to simulate those resulting from normal running-in. Two-process textures have advantage over one-process surfaces [17–20]. However it is difficult to find research works analysing the effects of two-process textures on the fretting (except for Ref. [13]).

2. Experimental details

Experiments were made using a ball-on-disc tribotester Optimol SRV in oscillatory motion. A steel ball from 100Cr6

Table 1 – Parameters of one-process disc surfaces: root mean square height Sq, skewness Ssk, kurtosis Sku, correlation length Sal, texture parameter Str and root mean square slope Sdq.

Surface	Sq, μm	Ssk	Sku	Sal, mm	Str	Sdq	Method of preparation
PL1	0.022	−0.01	3.2	0.13	0.194	0.0036	polishing
PL2	0.018	−0.19	2.73	0.18	0.211	0.0033	polishing
PL3	0.045	−0.08	3.9	0.0061	0.139	0.0162	lapping
PL4	0.069	−0.09	4.2	0.0047	0.266	0.0261	lapping
G1	1.19	−0.84	4.4	0.064	0.032	0.183	grinding
G3	0.3	−0.61	3.8	0.034	0.255	0.066	grinding
G3	0.43	−0.38	3.3	0.032	0.018	0.087	grinding
G4	0.34	−0.22	3.4	0.023	0.023	0.077	grinding
G5	0.27	−0.57	3.6	0.014	0.038	0.083	grinding
M1	0.3	−0.31	2.7	0.104	0.06	0.028	milling
M2	0.32	−0.11	2.7	0.101	0.07	0.03	milling
M3	0.28	−0.54	3.7	0.07	0.11	0.04	milling
M4	0.59	0.18	2.28	0.05	0.02	0.089	milling
M5	0.4	−0.1	4.9	0.06	0.03	0.06	milling
M6	0.37	0.28	3.5	0.05	0.02	0.084	milling
M7	9.4	−0.8	3.6	0.11	0.15	0.36	milling
M8	8.1	−0.27	3.28	0.13	0.26	0.39	milling
VB1	1.22	−0.6	5.7	0.009	0.77	0.35	vapour blasting
VB2	1.9	−0.6	4.1	0.013	0.8	0.46	vapour blasting
VB3	3.75	−0.39	3.97	0.02	0.85	0.62	vapour blasting