STATISTICAL ANALYSIS OF TRIBOLOGY FRICTION DATA IN A LONG REPEATED SLIDING SYSTEM

prof. KanaoFukuda,
Malaysia-Japan International Institute of Technology, UTM Kuala Lumpur
ass. O.Qurbonov,
ass. H.Axralov,
Tashkent State Technical University
ass. Z.Muminov,
National University of Uzbekistan

Though understanding fundamental mechanisms of phenomena is of decisive importance for the contribution of tribology to society, those mechanisms have not yet been clarified sufficiently.

As the requirements on the quality of tribological components continue to rise, the need for understanding the factors that govern their properties also rise.

A tribological phenomenon, especially siding, is widely recognized as a time-dependent phenomenon and a running-in processand a severe-mild wear transition are typical examples(Lancaster, 1963).

Some of the efforts made to understand adhesive wear phenomena were headed to atomic to nano-level approaches such as experimental analysis using SPM (scanning probe microscopy) (Sato et.al, 2016)and numerical simulations e.g. molecular dynamics simulations on interactions of atoms etc. (Shimizu, Zhou & Yamamoto, 2013).

Novel analysis method was devised to studyrepeated sliding phenomena and the method enabled the visualmapping of dynamic information e.g. friction force and pin-displacement on a plane which employs two axes normal to each other ofsliding position and the number of repeated sliding (Fukuda,2004).

Necessary additional parameters should include shape and size of a transfer unit and shear strength at interface of sliding with theoretical background. It is necessary to define those parameters theoretically based on scientific knowledge to comprehend the sliding phenomena.One of the current authors further devised the data collection and analysis method using a computer to compile data and enabled a correlative analysis on different kinds of dynamic information based on the sliding position (Fukuda, 2008).

The devised method is effective to avoid mistakes of researchers such as wrong correlational analysis between plural kinds of information obtained at different sliding positions.

In the current research, adhesive wear phenomena of metallic materials were studied using quantitative information obtained by pin-on-disk apparatus (Figure 1) in the long stage of sliding. Pin-on-disk tests collecting quantitative information related to friction force and pin displacement (micron) were conducted under relative humidity (80 RH).

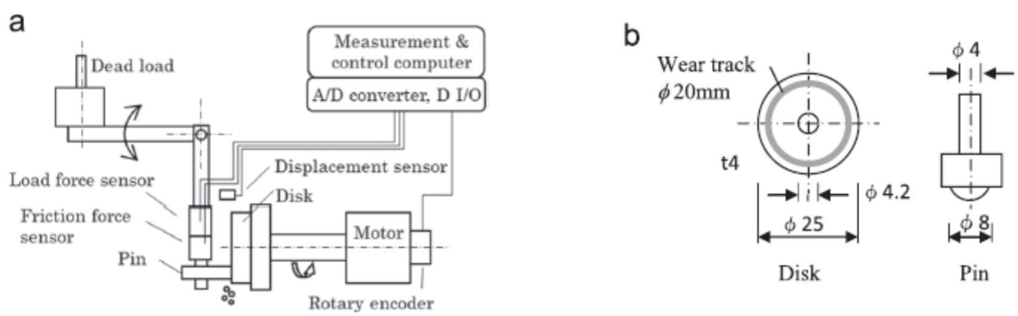

Figure 1. Schematic drawing of (a) pin-on-disk apparatus and (b) shape and dimensions of disk and pin specimens.

Quantitative analysis was carried friction and pin displacement data.Pin-on-disk apparatus used to obtain friction force data and pin displacement data.

Figure1 (a) shows a schematic drawing of a pin-on-disk apparatus and (b) the shapes and dimensions of the specimens used in this study. Both disk and pin specimens were made of austenitic stainlesssteel (JIS:SUS316).

A study was conducted on the stable humidity in the long early stage of sliding for austenitic stainless steel and ball shape pin-displacement, and this study clarified the existence of several elemental processes of adhesive mechanism with quantitative parameters such as growth of rate and the size of adhesive substances achieved at the interface of sliding members.

Table 1. Experimental conditions

Sliding speed (mm/s)	62.8	Sliding Speed (m/s)	0.063
Load (N)	27	Sliding distance (m)	64.m
Contact voltage (V)	150	Number of Rotations	1-1455
Humidity (RH)	80	Rotation Counts	1455
Size of Ball	8mm diameter	Counts of the Disk	720
Materials of Ball and Disk	Austenitic stainless steel (JIS SUS316)	Number of the Data	4*720*1455= 4190400

Introducing the concept called slopes in the term of discrete forward difference, the distribution matrix was constructed in the coordinate plane with axes including rotation counts and 720 collected counts of the disk (Table 1).

For each rotation, the histogram of the slopes gave a bell shape. Since distributions were stabilized in this study since skewness of data for each rotation would have been greater than 2 the stable distribution is most suited for modeling data distributions more prone to outliers than the normal distribution.

The stable distribution is a four-parameter family of distributions and is (usually) denoted by $S(\alpha, \beta, \gamma, \delta)$. The first parameter $\alpha \in (0,2]$ is called the characteristic exponent, and describes the tail of the distribution. The second, $\beta \in [1,1]$ is the skewness, and as the name implies, specifies if the distribution is right- ($\beta > 0$) or left- (β<0) skewed.

The last two parameters are the scale, $\gamma > 0$, and the location $\delta \in \mathbb{R}$.

The density function of an alpha-stable random variable cannot be given in closed form. However, the characteristic function can always be given.

$$\phi(t) = \begin{cases} \exp\left(-\gamma^{\alpha}|t|^{\alpha}\left[1 - i\beta sign(t) tan\left(\frac{\pi\alpha}{2}\right)\right] + i\delta t\right) \\ \qquad for\ \alpha \neq 1 \\ \exp(-\gamma|t|\left[1 - i\beta sign(t)\frac{2}{\pi}log(t)\right] + i\delta t\ , \\ \qquad for\ \alpha = 1 \end{cases}$$

Stability parameter, skewness parameter, scale parameter and location parameter of the stable distribution for different sliding rotation were compared, and moreover, the relations between corresponding parameters of the data were analyzed.

References

1. Fukuda, K. (2004) J. Jpn. Soc.Tribologists, 49, 738–745.
2. Fukuda, K. (2008) Wear, 264, 499–504.
3. Hase, A & Mishina, H. (2016) Tribology Online, 11 (2), 114–120.
4. Lancaster, J.K. (1963) Proceedings of Royal Society, Series A, 273 (1355), 466-483. Available from: DOI: 10.1098/rspa.1963.0103.
5. Sato, T., Hirai, Y., Fukui, T.& Usami, H. (2016). Tribology Online, 11 (2), 195–202.
6. Shimizu, J., Zhou, L.& Yamamoto T. (2013) Tribology Online, 8 (1) 38–43.