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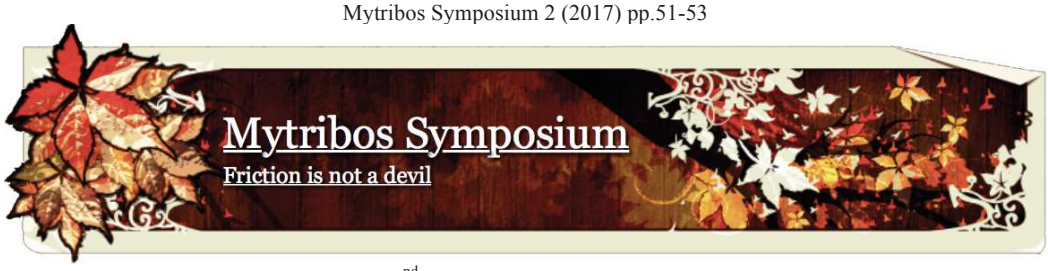

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Pin-on-disk tribo-tester with spatiotemporal mapping analysis

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ABSTRACT
In this paper, innovative analysis method on sliding phenomena is introduced. Dynamic data such as friction force collected as the function of the number of repeated sliding and sliding position are mapped on a spatiotemporal plane to grasp the phenomena intuitively. Further utilization of collected data for advanced analysis is also discussed.

1. Introduction

One of the biggest obstacles to elucidate sliding phenomena has been a difficulty in observation. Sliding phenomena are dynamic, originated at small real contact area, complex and taking place in interface between 2 sliding objects. These disadvantageous conditions have disallowed the direct observation on sliding phenomena utilizing light sources, electron and other probes except for some special cases. In early 1990's, innovative technique to visualize sliding phenomena [1-3] was proposed. The technique uses dynamic data such as friction force, specimen displacement, electro-conductivity between specimens, etc. A spatiotemporal mapping analysis of the obtained data, which is also known as "tribo-scopy" [2], enables direct observation and intuitive understanding of the the phenomena and their temporal changes. In this article, principles, effectiveness and evolution of the spatiotemporal mapping analysis applied for a pin-on-disk tribo-tester are introduced.

2. Spatiotemporal mapping

Figure 1 shows the schematic drawing of a pin-on-disk tribo-tester which is designed to realize the spatiotemporal mapping analysis of tribological data. "TriboMaster", which is a software developed originally in our laboratory, collects the dynamic data synchronously with clock signals from a rotary encoder which is equipped on the rotating shaft for driving disk specimen. With this mechanism, the dynamic data can be collected as the functions of the number of repeated sliding and sliding position, and then mapped on the spatiotemporal plane, which has 2 axes; vertical one for the number of repeated sliding and, horizontal one for the position on the disk as shown in Figure 2. The spatiotemporal map shows distribution of friction force on the sliding track of the disk and changes of the distribution due to repeated sliding. A researcher can observe how friction force increased in the initial period of sliding

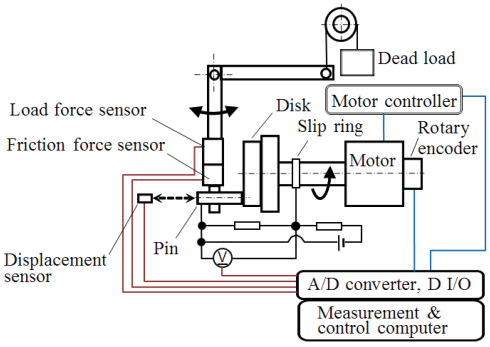

Figure 1: Advanced pin-on-disk tribo-tester

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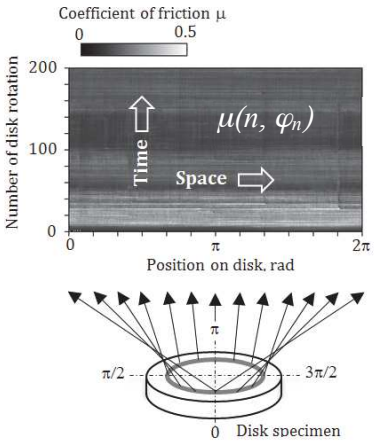

Figure 2: Spatiotemporal map of friction force and where and when the friction force reduced suddenly. The information provided by the spatiotemporal mapping is effective to establish a physical model which can explain complex adhesive wear mechanisms [4].

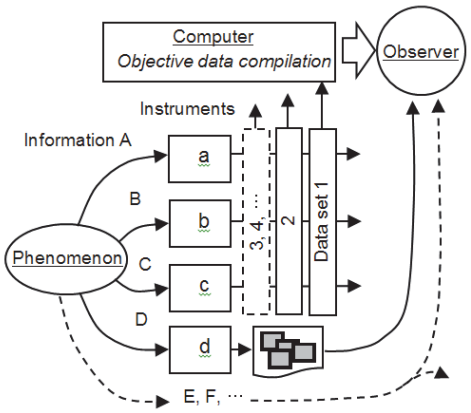

Figure 3: Synchronized multiple kinds of data collection [5]

3. Combinational analysis of multiple kinds of dynamic data

The merit to collect dynamic data as the function of the number of repeated sliding and sliding position is not limited to the mapping analysis of the data but extended to combinational cross statistical analysis of multiple kinds of data [5]. The concept of synchronized data collection for multiple kinds of data is shown in Figure 3. Dynamic data *A*, *B* and *C* are collected synchronously and recorded by the TriboMaster successively as the data set, which includes data $A(n, \varphi_n)$, $B(n, \varphi_n)$ and $C(n, \varphi_n)$ collected at an identical number of repeated sliding n, and a sliding position φ_n. The collected data sets are provided for objective compilation and combinational cross statistical analysis between multiple kinds of data. Figure 4 shows the example of the combinational analysis between friction force converted into coefficient of friction and pin displacement differential. In Figure 4, slope effect, which is equivalent to $tan(\theta)$, on the coefficient of friction as one of components which consist friction force is clearly shown for the typical abrasive wear. As shown in this example, data for the cross statistical analysis needs not to be original data and differential and integrated data are able to be employed for the analysis. The combinational cross statistical analysis is effective to analyze time dependent phenomena represented by a severe-mild wear transition which is frequently observed in dry sliding [6].

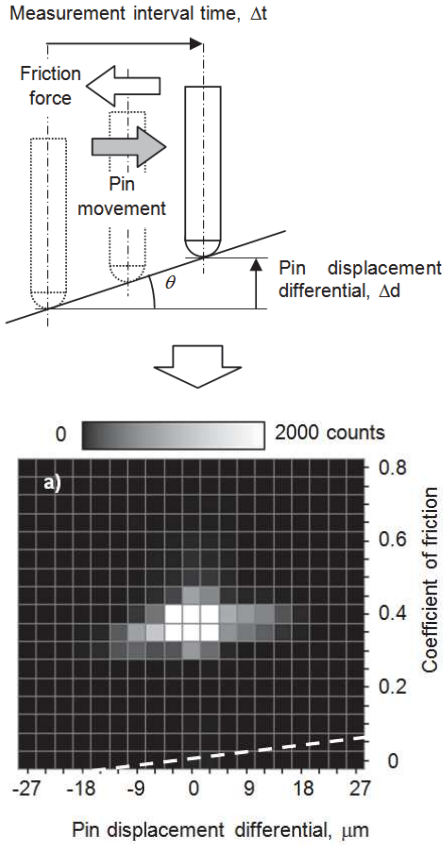

Figure 4: Combinational cross statistical analysis of coefficient of friction and pin displacement differential [5]

4. Conclusion

Spatiotemporal mapping analysis and its application for combinational cross statistical analysis are introduced. It is expected for the analyses technique to be widely used in various tribological problem solving.

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