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The novel active friction control method using machine learning for realizing long-life of solid lubricants

Motoyuki Murashima[1)*], Takazumi Yamada[1)], Noritsugu Umehara[1)], Takayuki Tokoroyama[1)]

[1)]Department of Micro-Nano Mechanical Science and Engineering, Nagoya University, Japan
*Corresponding author: motoyuki.murashima@mae.nagoya-u.ac.jp

Since solid lubricants are used in extreme environments, there is a strong need to extend their lifespan. This paper demonstrates a novel active friction control method using machine learning to achieve long life of solid lubricants. Without friction control, the MoS_2 life increased with the number of contact points. Applying the active control significantly extended the MoS_2 life by 30 times. As a result, the active control avoided rubbing the worn-out position of the MoS_2, resulting in the long-lifespan. In conclusion, the active friction control using machine learning has proven to be effective for the long life of solid lubricants.

Keywords (from 3 to 5 max): active friction control, machine learning, long life, solid lubricant

1. Introduction

In recent years, active friction controlling has been attracting attention due to its high adaptability and multifunctionality [1]. Solid lubricant (e.g., MoS_2, graphite, and PTFE) is an important tribo-material which realizes low friction, especially under extreme conditions (e.g., high temperature and high vacuum). The present paper demonstrates a novel active friction control method for realizing long life of solid lubricants.

2. Methods

We established a contact point control system which simulates a morphing surface [1]. The system had 12 air-cylinders on which ball specimens were attached (Fig. 1). The position of each cylinder (i.e., extend and retract) was changed to control the distribution of the contact positions against the plate specimen (Fig. 2). We used a MoS_2 coating on an Al plate. The ball specimen was made of SUJ2. In the present paper, we used genetic algorithm for machine learning to obtain a suitable control for long life of the solid lubricant.

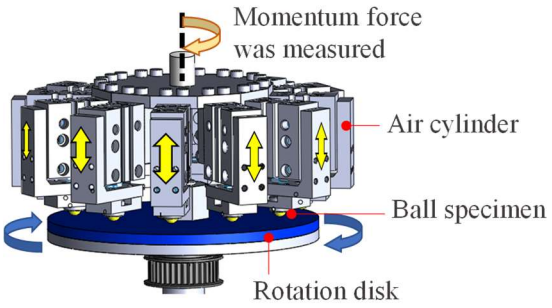

Figure 1: A schematic of the contact point control system with 12 air-cylinders and a counter material.

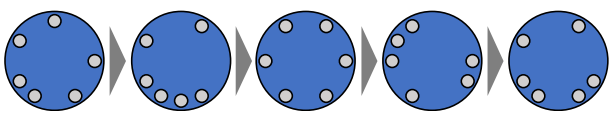

Figure 2: An example of transition of contact position distribution (n_c=6).

3. Result and Discussion

First, we conducted friction test without active control, where contacting balls were fixed thorough the tests. As a result, the more contact points, the longer MoS_2 life (Fig. 3). The result can be observed due to the reduce in a contact pressure with many supporting points. Figure 4 shows a clear evidence that the active friction control significantly extends the life of the MoS_2. Especially for the n_c=6, the life was 30 times longer than without control condition. As a result of the surface observation, the active friction control detected the worn-out position of the solid lubricant, and then it controlled the cylinder movements so as not to rub the worn-out position. In conclusion, we have clarified that the active friction control using machine learning is very effective for the long life of the solid lubricants.

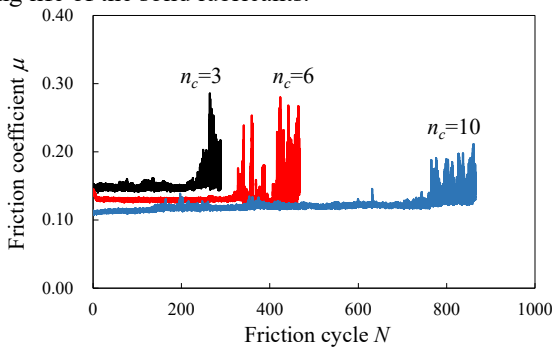

Figure 3: Friction evolution of the MoS_2 coating with different contact point. Friction coefficient suddenly increases shortly after MoS_2 coating is worn out.

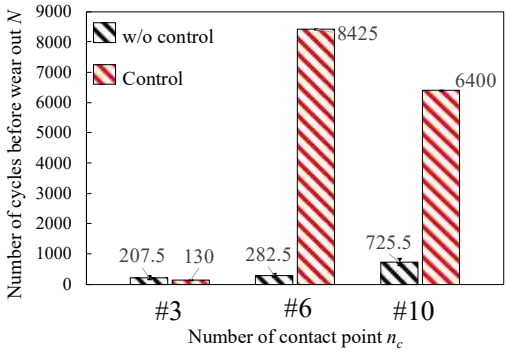

Figure 4: The extended life of MoS_2 using active friction control.

4. References

[1] Murashima M. et al., "Intelligent tribological surfaces: from concept to realization using additive manufacturing," Int J Mech Mater Des, 15, 2019, 757-766.