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Detection of wear transition using change in frequency of AE signals

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ABSTRACT – Adhesive and abrasive wear are the two main mechanisms of mechanical wear. Tribological properties between these wear mechanisms are very different. Since wear transition could be an obstacle to running machineries, it is important to identify the changes in wear state. In this study, to detect wear transition, changes in the frequency spectrum of acoustic emission (AE) signals were examined by the friction and wear experiments using metal pin and abrasive paper. It was found that wear transition could be identified from the occurrence of high frequency AE signals.

1. INTRODUCTION

Wear represents a large part of causes of trouble on machinery. Mechanism of wear can change in various conditions. In mechanical wear, there are two main mechanisms: adhesive wear and abrasive wear. Tribological properties between these wear mechanisms are extremely different. Since wear transition could be an obstacle to running machinery, it is important to identify the changes in wear state.

Acoustic emission (AE) technique is one of the diagnostic methods used for machineries that is performed by measuring elastic stress waves occurred when materials deform and fracture. From various experiments we have previously done, we have indicated that measuring AE signals is very useful to identify and evaluate tribological processes. In our previous study [1, 2], it was found that the features of frequency spectrum of AE signals differ from wear mechanisms. In this study, we carefully looked at the changes in the frequency spectrum and the amplitude of AE signals to detect wear transition. It was found that wear transition could be identified from occurrence of AE signals which has a specific frequency peak.

2. EXPERIMENTAL METHOD

Experiments were performed using a pin-on-disk type friction and wear tester. Figure 1 shows a schematic diagram of the experimental setup. A wide-band type AE sensor (frequency response: 0.5–4 MHz) was mounted onto the upper part of a pin specimen to measure AE signals. An aluminum pin was used and slid onto an abrasive paper bonded onto a steel disk to reproduce wear transition from abrasive wear to adhesive wear. Three abrasive papers with different abrasive grains (#600, #1000 and #2000) were used to compare the transition point. The experimental conditions used in this study was summarized in Table 1. Each experiment was performed four times. All experiments were performed under dry condition in air at a room temperature.

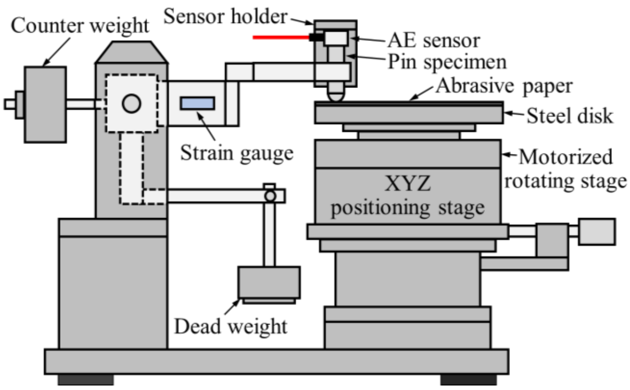

Figure 1 Schematic diagram of the experimental setup.

Table 1 Experimental conditions.

Pin/Disk	Al/abrasive paper (#600, #1000 and #2000)
Normal load *W*	0.98 N
Sliding velocity *v*	13 mm/s
Sliding distance *L*	140 m (840 revolutions)
Atmosphere	dry, in air, at room temperature
AE amplification factor	90 dB
AE band-pass filter	HPF: 500 kHz LPF: non-filter

3. RESULTS AND DISCUSSION

Figure 2 shows the micrographs of sliding surface for the #1000 abrasive paper during the initial stage and late stage of sliding. It clearly shows that the loading onto the abrasive paper took place in Fig. 2 (b) because the spaces on the abrasive paper were completely filled after sliding. It was found from the observations that wear debris from the pin specimen filled the spaces of the abrasive paper as wear progresses also in other abrasive papers.

Since the frequency spectrum differs according to the wear mechanism [1, 2], the type of wear can predicted by looking at them closely. For example, high frequency peaks around 1 MHz in the frequency spectrum are only detected during adhesive wear. Figure 3 shows typical frequency spectra of the AE signal waveforms observed during the initial stage and late stage of sliding for the #1000 abrasive paper. During the initial stage, low frequency peaks below 0.5 MHz were observed. On the other hand, during the late stage, high frequency peaks at around 1 MHz were observed. All experiments showed similar trends like shown in Fig. 3. From the observations and the features of the frequency spectra of AE signal waveforms, wear mechanism changed from abrasive wear to adhesive wear during the experiment.

To examine the wear transition, the results for each grain size were analyzed and the changes in their frequency spectrum in different stages were compared. Figure 4 shows the comparison of occurrence of the AE signals with high frequency components. After reaching a maximum value, the occurrence of high frequency AE signals either gets saturated or gradually decreases. It appears that at the time when the occurrence of high frequency AE signals increase rapidly is the point where wear transition shifts from abrasive wear to adhesive wear. Each point of wear transition in Fig. 4 was evaluated and summarized in Fig. 5. Looking at the data, the timing of wear transition occurs earlier in the #2000 abrasive paper with the finest grain size.

As mentioned above, we were able to successfully detect the wear transition from abrasive wear to adhesive wear from looking closely at the high frequency components of AE signals. This finding could be applied in detecting the loading of grinding wheels.

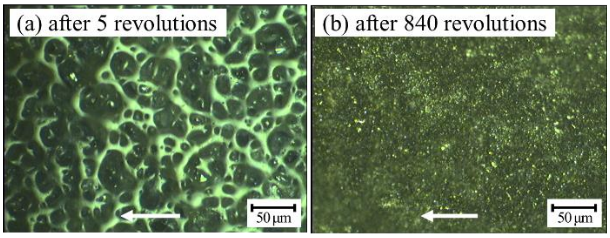

Figure 2 Observations of sliding surface for abrasive paper for (a) the initial stage and (b) late stage of sliding.

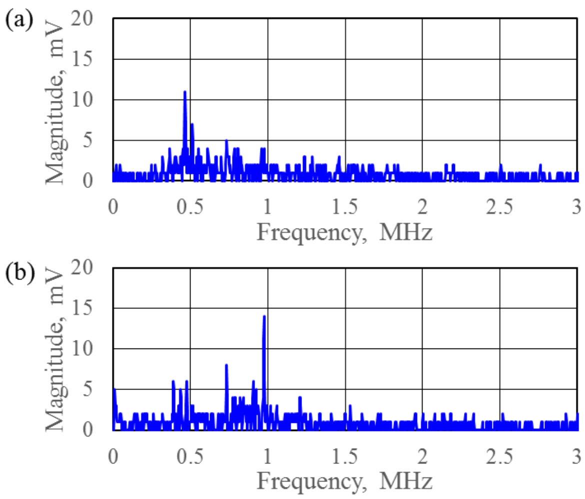

Figure 3 Typical frequency spectra of AE signal waveforms for (a) the initial stage and (b) late stage of sliding for the #1000 abrasive paper.

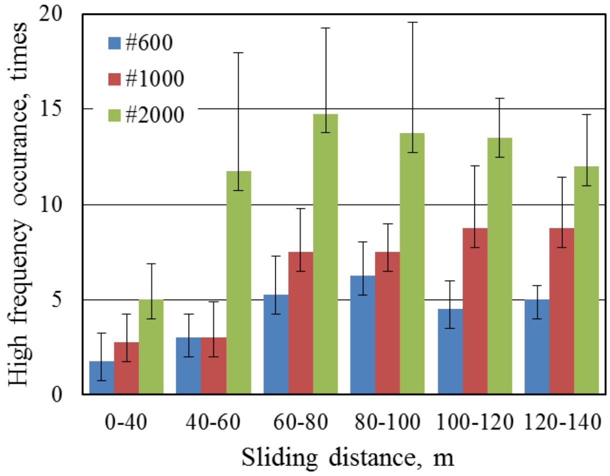

Figure 4 Comparison of frequency of the AE signals which have high frequency components.

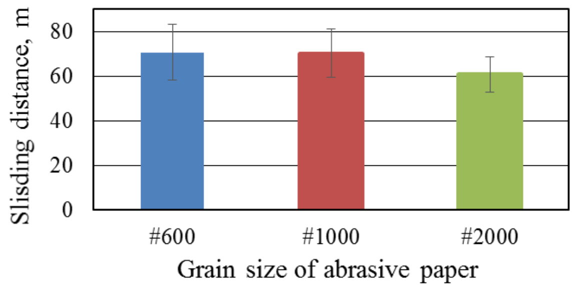

Figure 5 Comparison of the transition point of wear mechanism evaluated from the occurrence of high frequency.

4. CONCLUSIONS

In this study, we have examined the changes in the frequency spectrum of the AE signals during the transition from abrasive wear to adhesive wear by sliding an aluminum pin on abrasive paper. From the experiments, the following conclusions were obtained:

(1) When the loading of abrasive paper occurs, high frequency peaks in the frequency spectrum of AE signal waveforms are generated at around 1 MHz.

(2) Wear transition point can be predicted from the occurrence of high frequency AE signals, and that wear transition can be detected in the order of abrasive grain sizes from fine to rough.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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