Mechanism of High Friction of the Aluminum Surface
Textured by Laser Micro Texturing

Yuki SATO1, Yosuke TSUKIYAMA2*, Isami NITTA2, Hiroshi SHIOMI3
1 Graduate School of Science and Technology, Niigata University, 8050, Ikarashi2-nochou, Nishi-ku, Niigata, Japan
2 Institute of science and Technology, Niigata University, 8050, Ikarashi2-nochou, Nishi-ku, Niigata, Japan
3 Japan Aerospace Exploration Agency (JAXA), 2-1-1, Sengen, Tsukuba, Ibaraki, Japan

*Corresponding author’s email: tsukiyama@eng.niigata-u.ac.jp

Introduction. Friction increase technology, although there are few study examples compared with friction reduction technology such as lubrication technology, is important in determining the performance of the fastening component. As an example that needs the friction increase technology, there are mechanical elements that cause problems mainly due to slippage such as loosening and fretting. In order to prevent these or reduce wear, it is considered effective to promote plastic deformation of the material at the friction interface of the joint and to suppress the generation of wear debris(1). In previous studies, authors succeeded in gaining the high coefficient of static friction by laser micro texturing technology to Aluminum materials. However, mechanism of this technology is not clear at present. So in this study, we aimed to clarify the mechanism of friction increase technology.

Materials and methods. In this study, we conduct friction test by plane contact of two plate specimens. The normal load is 450N, the sliding speed is 12mm/min, and the sliding distance is 3mm. The schematic of the tester is shown in Figure 1. The one of plates is aluminum material (A2017) and the other plate is ceramic material (Al2O3). Laser irradiation and vacuum annealing were conducted only to aluminum plate. We created two types of aluminum plates by laser processing, the one is not-irradiated (Flat Plate), and the other is irradiated with a defocused-laser and only heat was applied without deformation (Defocused). Furthermore, vacuum annealing is conducted to two types of plates, and a total of four types of plates are created. The hardness is measured using the nano-indentation hardness tester (ENT-1100b, Elionix). Table 1, shows the nano-indentation hardness.

<table>
<thead>
<tr>
<th>Type of Plate</th>
<th>H_R [N/mm²]</th>
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<tbody>
<tr>
<td>Flat</td>
<td>2273.6</td>
</tr>
<tr>
<td>Flat annealed</td>
<td>1117.5</td>
</tr>
<tr>
<td>Defocused</td>
<td>1726.9</td>
</tr>
<tr>
<td>Defocused&amp;annealed</td>
<td>1114.4</td>
</tr>
</tbody>
</table>

Table 1 Hardness

Fig. 1 The schematic of test equipment

Result and Discussion. Figure 2 shows the transition of the coefficient of friction obtained by the friction test. Figure 3 shows the scanning electron microscopy (SEM) images of the surface of aluminum plate after the friction test. In the SEM images, friction marks are found on the entire surface of the plate, so it is considered that extreme biased contact don’t have occurred. In Flat annealed and Defocused& annealed, the coefficient of friction increased in the dynamic friction area. In the SEM images, a wider friction mark was confirmed in the annealed plate, and it was found by the hardness test that the metal was softened by the annealing. It is thought that the crystal grains that had been fined by both machining and defocused-laser processing and coarsed by annealing. In the observation image of friction marks after the test, the area where plastic deformation of metal occurred became wider in the annealed plates. Transferred amount to the opposite surface was also much, and the coefficient of friction increased in those plates on which much-amount transfer is observed. It is considered that adhesion is promoted in the plastic deformation area and the coefficient of friction is increased. It is confirmed that the plastic deformation area is wider in defocused samples than flat ones. Defocused samples are softer than flat ones, therefore, it is considered that the heat of laser processing has the same effect as annealing.

Fig. 2 Result of friction test

Fig. 3 SEM images of aluminum plates after sliding

Conclusions. In order to clarify the mechanism of the effect of increasing the coefficient of friction of laser microtexturing on aluminum materials, the following conclusions were obtained as a result of friction tests using vacuum annealed specimens.

(1) By annealing, the hardness of the specimen decreased, therefore plastic deformation is promoted, and the area of adhesion is likely to increase. These lead to an increase in the coefficient of friction.

References.