Wear Characteristics by Ti Coating of Al 7075

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Abstract. Al 7075 alloys are widely used in many mechanical parts because of their low density, light weight, and corrosion resistance. However, when mechanical parts are used in extreme environments such as high speed, high temperature, and high pressure, wear occurs more than allowable. To solve this problem, research and development of surface thin film deposition technology are increasing. Therefore, in this study, the wear characteristics were studied by depositing Ti films with excellent mechanical properties on Al 7075 according to the surface roughness by the deposition time. Results showed that 60' sputtered specimens after polishing with alumina had the best wear resistance. In addition, the surface roughness of the base material and the deposition time of the thin film affected the wear resistance.

1. Introduction

Recently, extensive research and development have been focused on various materials such as aluminum, magnesium, and functional plastics to achieve weight reduction in automotive and machinery industries [1]. Among them, aluminum is a representative material applied for the purpose of weight reduction of products because it has about 1/3 of iron specific gravity. In particular, Al 7075 is widely used in various mechanical parts because of its excellent strength, corrosion resistance, and thermal conductivity [2]. However, when mechanical parts are used in extreme environments such as high speed, high temperature, and high pressure, wear occurs more than allowable [3]. To solve this problem, research and development on surface thin film deposition techniques have been increased [4, 5]. Surface thin film deposition technology is a method for improving mechanical properties by depositing a material with excellent wear characteristics on the surface of materials [6, 7]. Therefore, mechanical properties should be considered when depositing a thin film on a material. In addition, the effect of surface roughness of the base material and the deposition time of the thin film on wear characteristics need to be studied.

Thus, the objective of this study was to investigate wear characteristics after depositing Ti with excellent wear resistance on Al 7075 with various surface roughness values through DC magnetron sputtering.

2. Material and methods

In this study, a total of 13 samples of Al 7075 with diameter of 32 mm and height of 10 mm were prepared as base materials. In order to know the wear resistance according to the surface roughness of
the base material, the surface was polished with # 400, # 800, # 1200, and #Alumina, respectively. The roughness was then measured. After measuring the surface roughness, each specimen was deposited with a Ti thin film by time. Table 1 shows conditions used to deposit a thin film. All conditions except deposition time were the same. Twelve specimens were prepared by varying the deposition time according to roughness. In addition, each specimen was compared based on the base material (13) for which thin film was not deposited. Conditions used for each specimen are summarized in table 2. For each specimen, wear characteristics were determined using a TRIBOSS PD-102 abrasion testing machine. Experimental method was carried out with a ball on disk method using a zirconium with ball diameter of 12.7 mm. The rotational speed of the ball was 60 RPM. The experimental time was 30 minutes and the load was set to be 0.2 kg. The wear test can be used to calculate the friction coefficient and the abrasion loss. A scanning electron microscope (SEM) was used to observe the resulting wear track.

3. Result and discussion

3.1. Surface roughness measurement
Table 3 shows surface roughness value of the base material for each specimen. Average value was obtained from 15 measurements for each specimen. The higher the particle size, the lower the roughness value.

3.2. Friction coefficient analysis
Figure 1 is a graph showing the coefficient of friction according to the roughness of the Ti thin film deposition time. In the graphs (a), (b), and (c), the friction coefficient decreased as the deposition time increased, but the friction coefficient of the 90' sputtered specimen was higher in the graph. It is thought that such a phenomenon occurred because the thin film was excessively deposited and the bond ability with the base material was reduced.

| Film Material | Deposition Time | Base Vacuum [torr] | Working Vacuum [torr] | Plasma Factor [W] | Temperature |
|---------------|-----------------|--------------------|-----------------------|-------------------|-------------|
| Ti            | Each Conditions | $5.0 \times 10^{-6}$ | $2.0 \times 10^{3}$   | 200               | RT          |

| Deposition Time | #400 | #800 | #1200 | #Alumina |
|-----------------|------|------|-------|----------|
| 30'             | 1    | 2    | 3     | 4        |
| 60'             | 5    | 6    | 7     | 8        |
| 90'             | 9    | 10   | 11    | 12       |

| #400 | #800 | #1200 | #Alumina |
|------|------|-------|----------|
| 0.45 | 0.35 | 0.31  | 0.23     |
3.3. SEM observation result

Figure 2 shows the surface of the specimen on which the base material and the Ti thin film are deposited at a magnification of 33 times using a scanning electron microscope (SEM). It was observed that debris agglomerated due to the Ti thin film deposited (left). In the case of the base material (right), it was observed that no debris appeared. Many agglomerated debris were found, especially in 90° sputtered specimens. In the test process, it was confirmed that the thin film material adhered to the counterpart material. This is because the adhesion part of the two friction surfaces were sheared by the friction and peeled easily from the deposited thin film. In 90° sputtered specimens, it is thought that more debris was generated due to excessive deposition of thin films and poor bonding with the base material.

Table 4 is a table that summarizes the width and length of wear tracks for each specimen. The pattern is similar to the friction coefficient graph. The wear tracks of 30° and 60° sputtered specimens were narrower as the surface roughness decreased. The lower the roughness of the 90° sputtered specimen, the wider the track.

3.4. Wear loss measurement result

Figure 3 is a graph of the wear amount of each specimen. The 30° and 60° sputtered specimens showed a decrease in wear with surface roughness. In particular, the 7 and 8 specimens showed lower wear than the base metal. On the other hand, in 90° sputtered specimens, the lower the surface roughness value, the higher the wear.

Through this study, it was confirmed that the surface roughness and the deposition time of the thin film influence the wear resistance.

Figure 1. Friction coefficient graph by surface roughness; (a) #400, (b) #800,(c) #1200,(d) #Alumina.
Table 4. Average wear track width (mm).

|   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|   | 1.60| 1.50| 1.38| 1.47| 1.28| 1.28| 1.00| 0.80| 0.84| 0.84| 0.97| 0.95| 0.81|

Figure 2. Photograph of SEM wear track (x33).

Figure 3. Wear loss graph.

4. Conclusion
In this study, we carried out wear tests to examine effects of surface roughness and film thickness of base material on wear properties.

(1) As a result of the analysis of wear characteristics, specimens with 30' and 60' sputtering tended to have a small friction coefficient, wear track width and wear as the deposition time increased. In contrast, the 90' sputtered specimens tended to increase the coefficient of friction as the surface roughness decreased. The wear tracks showed debris. Particularly, more debris was observed in 90' sputtered specimens.

(2) Among all the specimens, 60' sputtered specimen (8) after polishing with alumina showed lower abrasion coefficient, narrower wear track, and less abrasion resistance than the base metal.

(3) In this experiment, it was confirmed that the adhered portions of the two friction surfaces were sheared by friction and peeled easily from the deposited thin film to show the appearance of adhesion wear.

Through this study, it was confirmed that the surface roughness and the thickness of the thin film influence the improvement of wear resistance. Based on these findings, the development of composite materials has economic and technical advantages and is worth investing in R & D. In addition, further experiments are planned based on the results of this study.

5. References

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