SURFACE MODIFICATION OF ALUMINUM ALLOY WITH Nd-YAG LASER

Masatoshi ENOMOTO and Sadao KOKUBO
SHOWA Aluminum Corporation
Inuzuka 480, Oyama, Tochigi, JAPAN

ABSTRACT

Surface modification of Aluminum alloys is investigated to increase their wear-resistance with combination of spraying and laser irradiation. Effects of Si content in spraying powder, temperature of base metal and laser energy were investigated. Wear-resistance increased with Si content, laser pulse energy, temperature of base metal. Wear-resistance of these surface modified aluminum is superior to those of steel and SUS 304 on reciprocating wear test.

Key Words :*Aluminum, Laser, surface modification, wear resistance*

1 INTRODUCTION

Aluminum alloys are currently used for various components of industrial products. These materials are available for reducing the weight of them. but shall be taken care of their poor wear-resistance. Many researches on surface modification of these materials have been made [1 − 7]. These researches are focused on corrosion resistance [1 − 3] ,change of microstructures [4,5] and wear-resistance [6,7]. Especially, the last property is strongly required for applying aluminum alloys for industrial use. In case of improving wear-resistance of them, low Si content(less than 35%) coating is applied before laser irradiation. Recently, water atomized fine aluminum particles are developed in Japan and laser surface modification of aluminum alloys using these particles is pursued by authors. This paper describes effects of Si contents, temperature of base metal and laser energy on wear-resistance of A6063 in comparison with steel and SUS304.

2 Experimental Procedure

2-1 Materials used

AISI A6063-T6 was used for this experiment. Dimension of test tieces is 50mmwx60mmlx6mmt. Water atomized Al-Xwt%Si(X=40.50.60and70) powder were used for spraying to investigate the effect of Si content on wear-resistance of laser irradiated surface after spraying. Water atomized Al-50wt%Ni powder was used for spraying to investigate the effect of temperature of base metal on its wear-resistance.

2-2 Laser alloying

Low pressure spraying was conducted with forementioned poder before laser irradiation. Nd-YAG laser was used under conditons as below. Pulse energy was changed 10J/P, 20J/P and 30J/P. Pulse width was 1,5ms and frequency was 7 Hz. Focal length f=300mm lense was used and distance between nozle and work piece was 43mm. Beam diameter on the work piece was 2mm. Ar gas was used for preventing oxidation of alloying surface during laser irradiation(See Fig,1). Travelling speed of work pieces was 100 mm/min. Work pieces sprayed with Al-50wt%Ni powder were heated up 423K and 573K with electric heater placed on the firebrick.

2-3 Wear testing

Reciprocated wear testing was conducted with 4mm ϕ tool steal pin and rubbing length was 50mm. SUS 304 test coupons were also tested for comparison.

3 Results and discussion

3-1 Surface appearance after laser irradiation

Smat was observed on the laser irradiated surface with icreasing laser energy at room temperature. It was considered that this smat consisted of fine Mg oxide which Mg from A6063 had reacted oxigen in atomosphere. Smooth surface after laser irradiation was observed at low pulse energy. With increasing laser energy, much quantity of base metal melted and it was affected by gas dynamics from nozzle. No deffects such as cracks, voids and undercut on the surfacce appeared.

3-2 X-ray diffraction analysis after laser irradiation

X-ray diffraction analysis on the laser- irradiated surface is shown in Fig.2. X-ray diffraction analysis of sprayed layer is also shown in Fig.2. Si peak is going to high with increasing Si content in sprayed powder. After laser irradiation, Si peak is going to low and Al peak is going to high with increasing laser energy. This is why Al content in alloyed layer increases with laser energy due to dilution from base metal. Same tendency is analyzed on alloyed surfaces with using higher Si content powder.

3-3 Optical microscopic observasion of cross section

Microstructures of sprayed layer at cross section are shown in Fig.3. In spite of Si content in powder, voids or cavities are observed in each sprayed layer and its surface reveals rough. Microstructure of laser-irradiated layer at cross section was shown in Fig.4. It is shown that primary Si is suprisingly fine and uniformly dispersed in alloyed layer. Si attack at grain baondary of base metal is observed with increasing laser energy due to grain boundary diffusion of Si.

3-4 Microhardness distribution at cross section

Microhardness distribution of sprayed layer is shown in Fig.5. As shown in this figure, hardness at cross section of sprayed layer increases with Si content in spraying powder.

Microhardness distribution at cross section after laser irradiation is also shown in Fig.5. It decreases after laser irradiation but does not change with laser energy. Moreover, microhardness is kept constant in alloyed layer. It is considered that as shown in Fig.4, uniformly dispersed fine primary Si in alloyed layer strongly affectes on hardness distribution. As the temperature of base metal(A6063) increased, microhardness of alloyed layer decreased using Al-50wt%Ni powder.

3-5 Wear testing

Wear resistant properties are shown in fig.6. Though weight loss due to wear increases with increasing laser energy, it is less than that of SUS304. This property does not changed even when Si content in powder changes. Hardness of SUS304 is Hv160 and that of alloyed layers is higher than the former. This is why wear resistance of laser alloyed layer is superior to that of SUS304. Uniform distribution of primary Si in alloyed layer is also strongly affected on wear resistant property. Effect of temperature of base metal on wear resistant property is shown in Fig.7. Wear resistant property increases with increasing temperature of base metal. Microcrackings were observed at the cross section of alloyed layer without heating base metals. Howver, as increasing the heating temperature of base metal during laser irradiation, microcrackings reduced. So, it was considered this effect affected on wear resistant property.

4 Conclusion

Laser surface modification was applied for increasing wear resistant of Aluminum alloys. Nd-YAG laser beam was irradiated onto sprayed surface with water atomized Al-Si and Al-Ni powder. Results after experimental trials are described as below.

1)Wear property of laser alloyed surface of A6063 was superior to that of SUS 304.

2)As increasing the Si content of spraying powder, wear resistance of alloyed surface incrreased. This is why fine primary Si disperses in alloyed layer after laser irradiated onto sprayed surface.

3)Microcrackings in alloyed layer reduced with increasing the heating temperature of base metal. Then, wear resistance of alloyed layer after laser irradiated onto Al-50wt%Ni sprayed layer.

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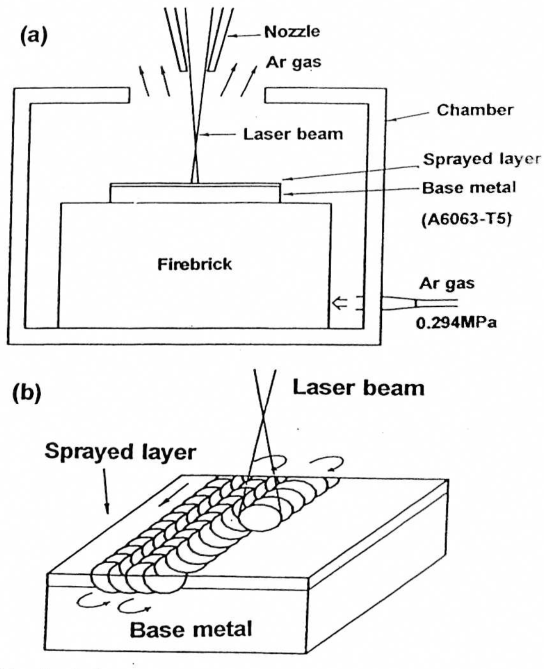

Fig. 1 Schematic illustration of laser remelting process;(a)Apparatus, (b)Procedure of laser remelting.

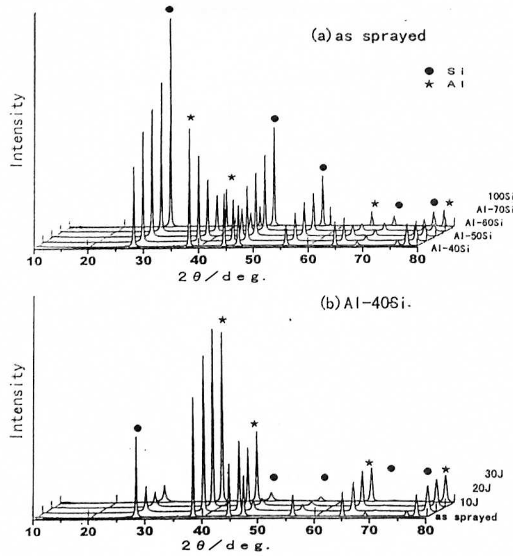

Fig.2 X-ray diffraction analysis of as sprayed and laser irradiated surface

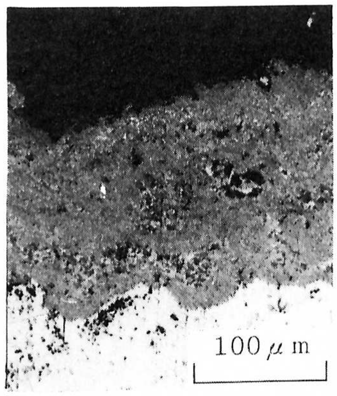

Fig.3 Microstructure of as sprayed layer(Al-40wt%Si)

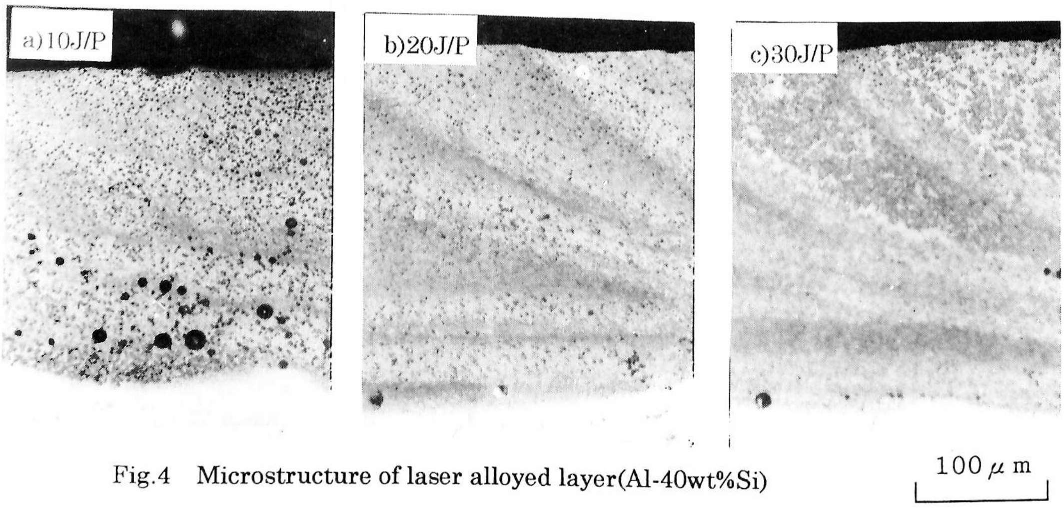

Fig.4 Microstructure of laser alloyed layer(Al-40wt%Si)

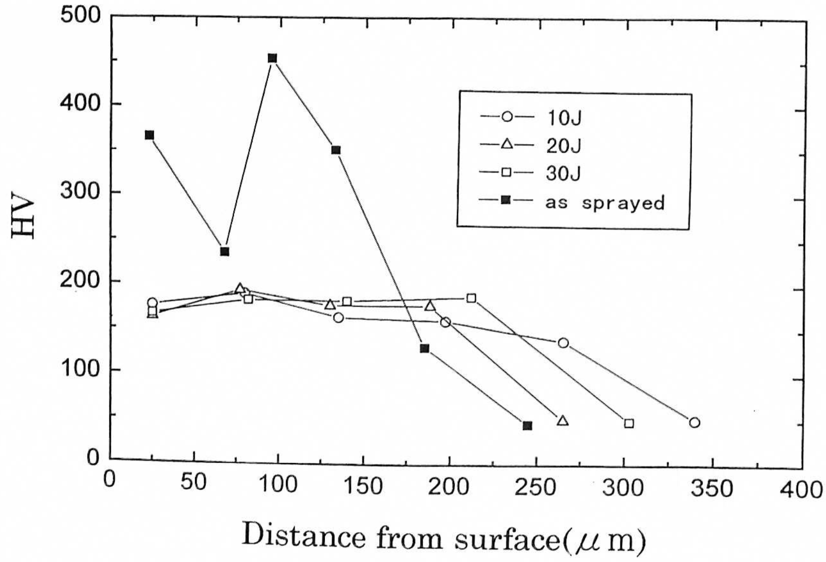

Fig.5 Hardness distribution of laser alloyed layer(Al-40wt%Si)

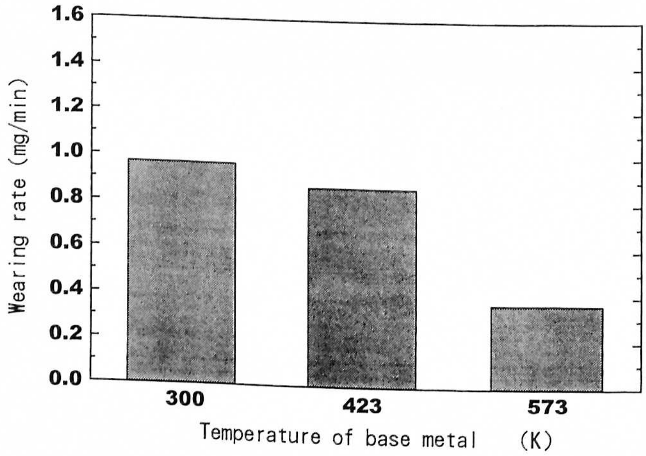

Fig.6 Effect of temperature of base metal on wearing rate

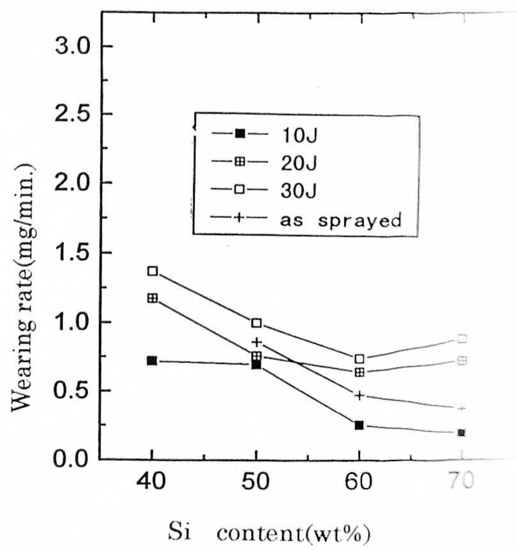

Fig.7 Effect of Si content on wearing