Surface modification of aluminum die castings in ADC12 alloy

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Abstract The effects of laser scan speed and coating condition on the surface hardening of aluminum diecasting alloy were investigated using laser alloying process with a 2.5KW YAG continuous laser. The microstructure and hardness of laser treated layer were characterized. The microhardness value of the laser-treated layers are 250-400 and 1100Hv for the coatings with plasma-sprayed Ni alloys and WC-17%Co, respectively. SEM observation showed fine $NiAl_3$ particles are dispersed in the microstructure of laser-treated after spray-coating of Ni alloy. The Laser melting treatment results in refinement of surface structure for WC-17%Co coating.

Keywords *surface modification, plasma-spray, aluminum die casting alloy, YAG laser, hardness*

1. Introduction

Aluminum die casting alloys are commonly used in engeneering because they are light and have good fluidity, castability, mechanical properties. However, under demanding service conditions, such as in severe wear, their performance can be limited. As a cost effective alternative to bulk alloys the wear of aluminum alloy may be enhanced by means of high energy density laser and electron beams to modify the surface structure. Laser induced surface hardening of aluminum alloys can be achieved with surface alloying. The hardness of a laser-treated surface layer has been reported to range from 300 to 1200Hv for aluminum alloys[1].

The research described in the present paper aims at studying the laser modified microstructure and hardness of aluminum die casting alloys as a function of various plasma-sprayed Ni alloy and WC-17%Co coating and laser processing parameters.

2. Experimental procedure

Aluminum die casting alloy with chemical composition given in Table 1 was used. Cast plates of170X50X7 mm were used to prepare 6X30X60mm parallelpipedic samples for the surface laser treatment experiment. Table 2 indicates output power, scan speed and coating conditions during the tests. The sample surfaces were coated with Ni plating, plasma-sprayed Ni alloys and WC-17%Co alloy. A 2.5kW YAG continuous wave laser was used at a laser output power of 2kW. The microstructure of the laser-treated samples were characterized by means of scanning electron microscope (SEM) and EDX in a traverse cross-section of treated-zone and Vickers hardness was measured at different depth.

Table1 chemical composition of aluminum die casting alloy(mass%)

Si	Cu	Mg	Fe	Al
10.03	1.53	0.26	0.37	bal

Tabie2 plasma spraying condition used

Primary gas	Argon
Secondary gas	Nitrogen
voltage	48~56V
current	750A
spray distance	200~250mm

Table3 experimental conditions

Specimen No.	coating condition	Laser power(kW)	scanning speed (m/min)
1	original state		
2	Ni plating	2	1~3
3	Ni-10Co coated	2	1~3
4	Ni-18.9Cr coated	2	1~3
5	WC-17Co coated	2	2~4

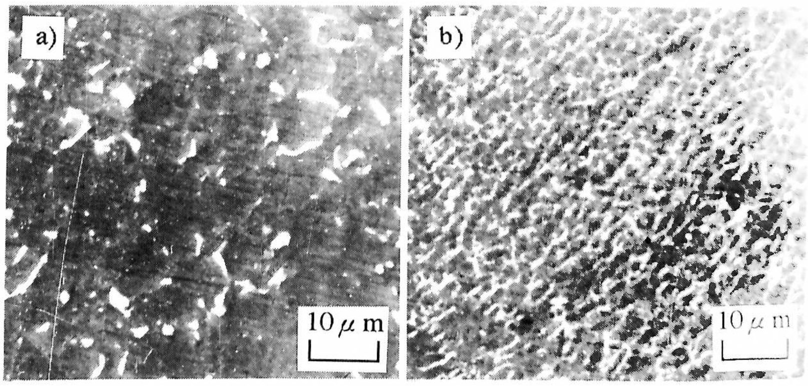

Fig. 1 Microstructures of starting alloy and laser melted layer in the aluminum die casting alloy.
a) starting alloy, b) laser melted layer

3. Results and discussion

The starting microstructure of the aluminum die casting alloys consists of aluminum matrix with eutectic Si particles. This microstructure has an average hardness of 100Hv. The laser treatment produced a fine structure. Fig. 1 shows the microstructure of laser-treated sample of a 2kW and at a scan speed of 1m min-1. The formation of the fine microstructure did not increse the

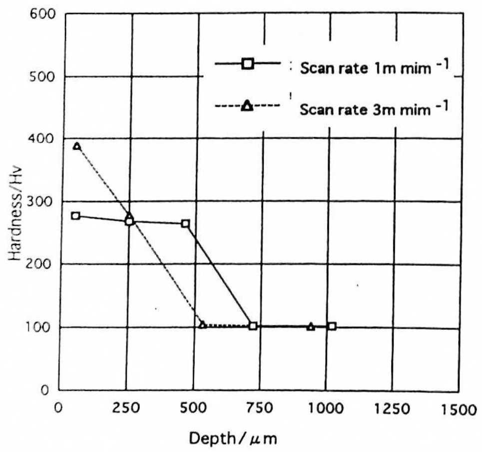

Fig.2 Variation in hardness with depth of aluminum die casting alloy coated with Ni plating and laser-treated.

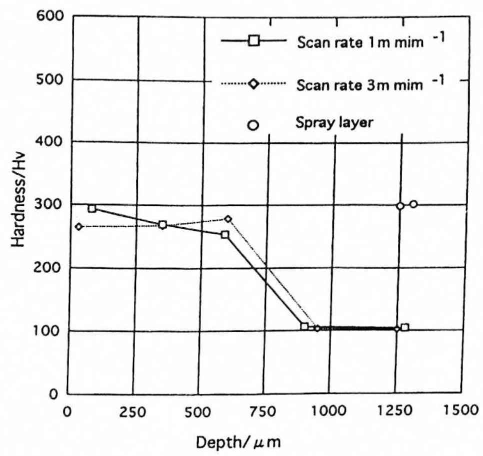

Fig.3 Variation in hardness with depth of aluminum die casting alloy coated with Ni-10CoNi alloy and laser-treated.

hardness of surface treated layer. Figs.2~4 show variation in Vikers hardness with depth of aluminum die casting alloys spray-coated with various Ni alloys and laser-treated. The hardness of laser-treated layer was substantially higher than the substrate. The hardness of surface treated alloys is 250-400Hv, depending on coating condition and scanning speed, which is substantially higher

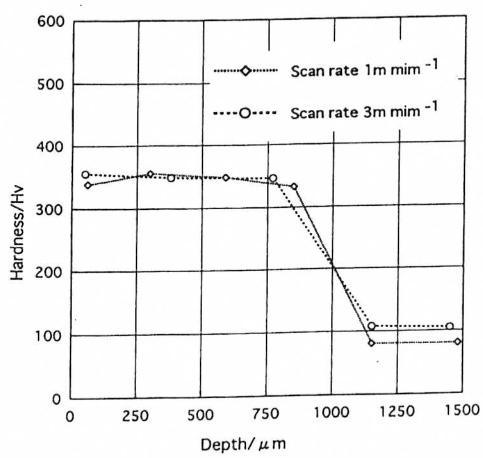

Fig.4 Variation in hardness with depth of aluminum die casting alloy coated with Ni-16.9Cr alloy and laser-treated.

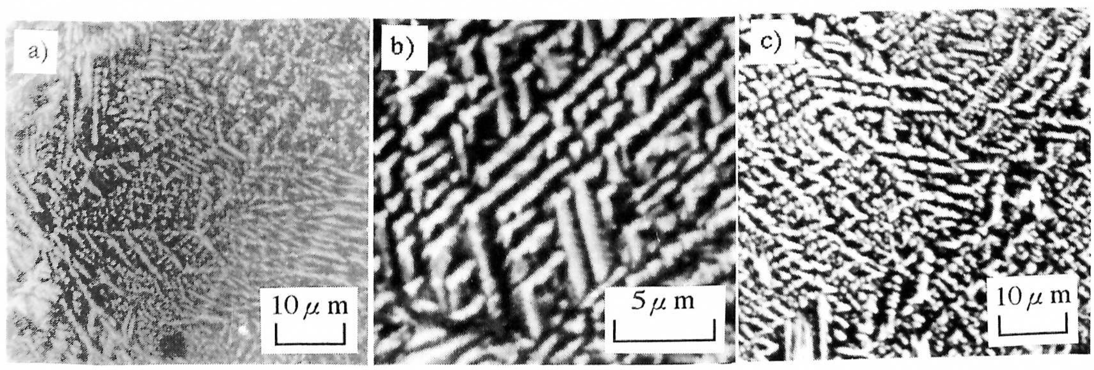

Fig.5 Microstructures of surface layers laser-treated after coating at various conditions
a)Ni plating, b)Ni-10Co spray-coated, c)Ni-16.9Cr spray-coated

thanthat of the sub-strate.The highest hardness is obtained at the scan speed at 3m min^{-1} in the caseof Ni plating.

A homogeneous layer with an hardness of 350Hv was obtained . for Ni-19.6Cr alloy coating .Fig.5 illustrates microstructures of aluminum die casting alloys laser-reated after coating at various conditions.These micrographs exhibit a fully dendrite microstructure as shown in Fig.5. EDX analysis showed these dendrite structures a re identified to be $NiAl_3$.[2)]. Porosity is commonly observed in the surface treated zone as shown in Fig.6 Fig.7 shows the variiation in hardness with depth of the aluminum die casting alloy coated with plasma-sprayed WC-17%Co and laser-treated. The hardness of the coating which has a distinctive layed is about 900Hv and significantly increased conpared with the alloy substrate. Fig.7 also indicates that the laser melting treat-ment increases hardness of the surface layer up to 1100Hv.This i ncrease in hardness can be explained in

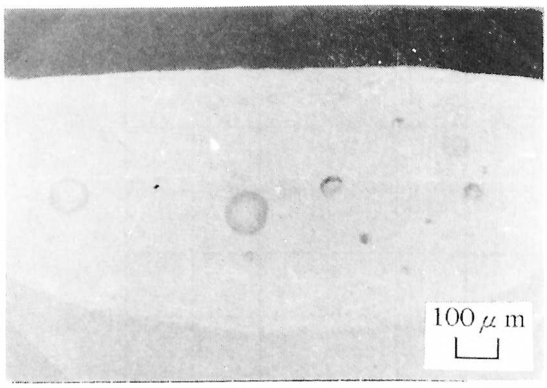

Fig.6 Macrostructure showing the porosity in the aluminum die casting alloy laser-treated after Ni plating .

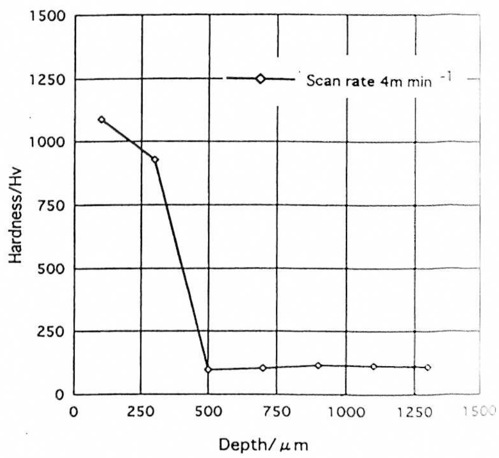

Fig.7 Variation in hardness with depth of aluminum die casting alloy coated with plasma-sprayed WC-17 Co coating alloy and laser-treated.

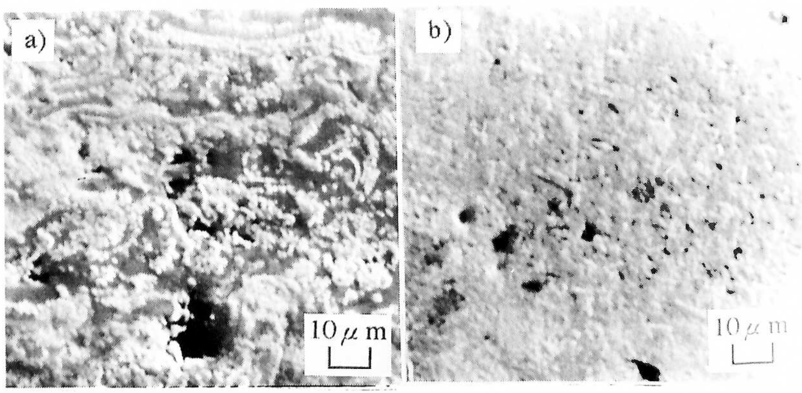

Fig.8 Microstructures of the plasma-sprayed WC-17Co coating. a) as-sprayed,b)laser-treated

structure as shown in Fig.8[3-4].

4. Conclusion

1. The hardness of laser melted surface layer was 250-400Hv, when aluminum die casting alloy surface are coated with Ni plating and plasma-sprayed Ni alloy coating. Fine $NiAl_3$ were dispersed in the microstructure of the laser melted layer.

2. Laser melting treatment resulted in refinement of surface structure in the plasma-sprayed WC-17%Co coating on a aluminum die casting alloy and increases the hardness of surface layer to 1100Hv.

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