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Improvement mechanical properties of Inconel and Monel alloys synthesis by laser coating

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ABSTRACT

This study is looking after proceeding a dual coating process consisting of Aluminum and Silicon metals on different alloys (Inconel, and Monel alloys), using laser Nd: YAG (1600 mJ) technique as an energy source. These alloys are known to be used for manufacturing petroleum towers. The effect of diffusion coating on alloys was studied by comparing corrosion resistance, hardness (Vickers hardness type) and X-ray diffraction tests with pre-coating results. After laser coating, it was found that there was a decrease in corrosion rate in Inconel alloy but the Monel alloy showed an increase in corrosion rate compared to pre- Laser coating. Both alloys (Inconel and Monel) show lower hardness values after coating compared with their values before coating.

1. Introduction

Surface technology includes a wide range of technologies including electroplating, thermal spraying, electron beam, and laser technology. Laser technology is characterized by being a clean source of heat with unique optical properties, making it accessible to a wide range of methods used in surface engineering from heating to synthesis of finished components. Fig. 1 shows different laser techniques with surface engineering. In general, the laser beam focuses to a small spot with sufficient energy density to absorb it from the surface to be painted and turned into heat to achieve surface heating [1].

Super alloys are the major class of materials used for the high temperatures in the fact that they are the only commercially available materials that retain their mechanical and corrosion / oxidation resistant properties at high temperature (up to 0.9 Tm). Super alloys are currently used in many high temperature fields from gas turbines used in aircraft, marine and industrial applications, to space vehicles, nuclear reactors, steam power plants, and petrochemical equipment. This study will concentrate on nickel-based super alloys. Nickel-base super alloys are defined as those alloys which have Ni as their primary constituents (30 –75%). Major alloying element additions can include Al, Co, Fe, Mo, Nb, Ta, Ti, and W. Nickel-base super alloys draw their strength from solid-solution strengthening and by second-phase intermetallic precipitation [2].

Inconel and Monel alloys were used in this study, the first characterized by its high resistance to corrosion and heat in addition to its excellent mechanical properties and high strength [3]. The second is characterized by its solid alloy hardening when cooling and has high strength and hardness for a wide range of temperatures.

Table 1 shows some properties of Inconel® 600 [4].

The chemical composition of Inconel 600 alloy represents in Table 2 [4].

Composition of Monel® is shown in Table 3 [7].

Some properties of Monel® 400 alloy shows in Table 4 [5].

The laser coating technology is an advanced technique used to improve the surface properties of many components and equipments. The laser coating is characterized by being dense, free of defects, non-porous and high adhesion strength with the basic material. The coating of modern components with laser gives their surfaces high resistance against wear, corrosion and high temperatures [6]. Many of the basic characteristics of the laser make it very useful for many important industrial applications including laser processing. These characteristics include directionality, monochromaticity, coherence, and light brightness of the laser light. High power lasers such as Nd-YAG lasers [7] or CO_2 lasers [8] can produce large energy and well focusable laser beams that can be used in a number of important industrial applications including drilling, cutting, welding, hardening and laser coating.

The objective of this research is to study the mechanical properties of Inconal and Monel alloys after coating with Aluminum

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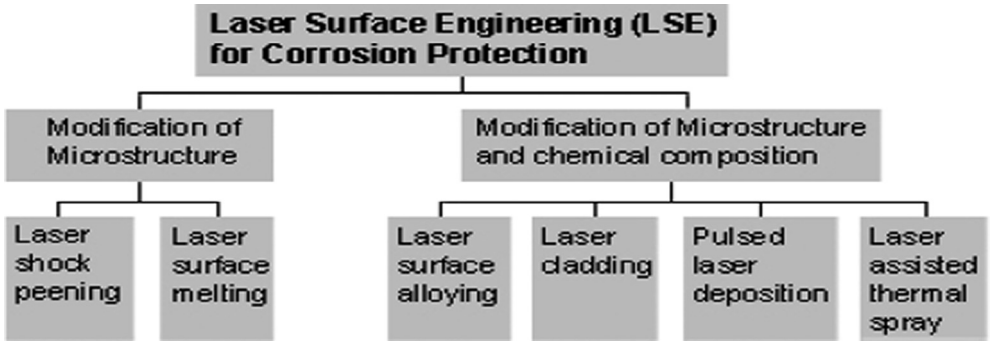

Fig. 1. Different laser techniques with surface engineering [1].

Table 1
Gives some inconel 600 alloy physical properties [4].

Density g/cm^3	Tensile psi	Tensile Mpa	Yield psi	Yield Mpa	Elongation %	Hardness, HV
8.47	99.000	683	45.000	310	43	160

Table 2
Shows elements percentage in Inconel® 600 alloy [4].

Alloying redirects	Ni	Cr	Fe	Si	Mn	C	Cu	S
weight presented %	72.0	15.5	8.0	0.5	1.0	0.15	0.5	**0.015**

Table 3
Shows elements percentage in Monel® 400 alloy [5].

Alloying g redirects	Ni + Co	C	Mn	Fe	S	Si	Cu
weight presented %	63.0 min	0.3 max	2.0 max	2.5 max	0.024 max	0.5 max	**28.0–34.0**

Table 4
Some physical properties of Monel® 400 alloy.

Density, g/cm^3	Melting range, °C	Modulus of Elasticity, 10^3 ksi			
		Tension	Compression	Torsion	Poisson's ratio
8.80	1300–13,500	26.0	26.0	9.5	0.32

and Silicon metals using Nd: YAG laser (1600 mJ) technique as energy source.

2. Experimental Part

Both two alloys samples were cut in properly instruments to achieve the (3 * 2 cm) dimensions. Fig. 2 shows a photographic picture for the samples.

- Coating producer based on Dole diffusion coating process, in which the mixture consists of:
  - Master alloys: (Al & Si) represent the principle materials of coating supplies as powder.
  - Inert filler: (Al_2O_3)
  - Activator: (NH_4Cl).

Table 5 shows the ratio of coating mixture used in this study.

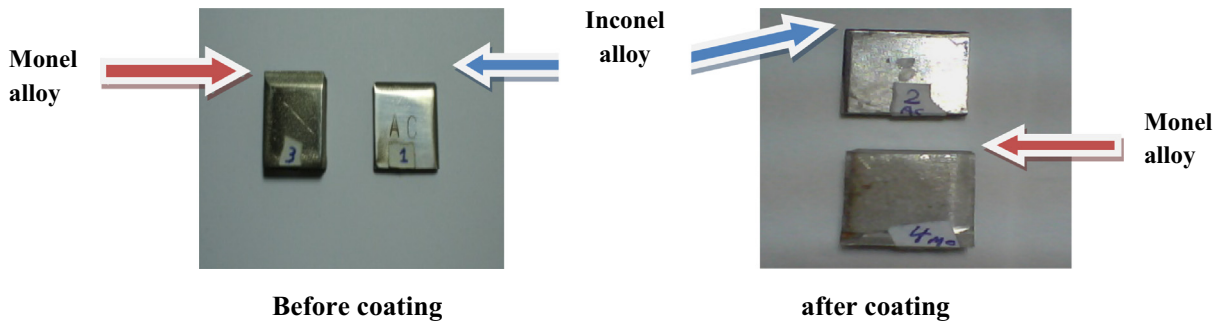

Fig. 2. Shows photographic picture for test samples before and after coating process.