A Review on Laser Surface Alloying

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Abstract - *Laser alloying is a processing method for material which utilizes the high power of density available from a laser source to heat and melt the material surface while injecting the alloy elements / compounds powders on the melt pool. Modification of material surface properties can be well influenced by the addition of alloying powders, there is a forming inter-metallic compounds through chemical reactions between the material and powders. An inter-metallic compounds are a solid phase consisting of two or more metallic elements in definite proportions, these phases is generally characterized by very high hard material. A number of parameters such as laser power, beam diameter, laser scanning speed, powder feed rate during large area alloying should be well controlled to achieve the desired enhanced surface properties.*

Key Words: Aluminium, Laser Surface Alloying, Piston Ring, Ti, Ni.

1.INTRODUCTION

Aluminium is the second most used metal after steel. It is bright, shiny, and light. It is in group 3 on the periodic table. Aluminium has an excellent electric conductivity, high strength to weight ratio, with a specific weight of 2.7 g/cm^3, which is about one-third that of steel and has high corrosion resistance. It has many applications, especially in combination with other elements to form high strength alloys. Aluminium alloys are divided into wrought and cast products. Cast alloys are directly cast into their final form by one of various methods, such as sand-casting, die or pressure die casting. Wrought alloys are initially cast as ingots or billets and subsequently hot and/or cold worked mechanically into the final desired form. There are 9 series of wrought alloys. These are designated by a 4 digit number that may be preceded or followed by letters. The first digit indicates the alloy group number. The second digit indicates alloy modifications. The third and fourth digits indicate the aluminium purity.

Laser alloying is a processing method for material which utilizes the high power of density available from a laser source to heat and melt the material surface while injecting the alloy elements / compounds powders on the melt pool. Modification of material surface properties can be well influenced by the addition of alloying powders, there is a forming inter-metallic compounds through chemical reactions between the material and powders. An inter-metallic compounds are a solid phase consisting of two or more metallic elements in definite proportions, these phases is generally characterized by very high hard material. A number of parameters such as laser power, beam diameter, laser scanning speed, powder feed rate during large area alloying should be well controlled to achieve the desired enhanced surface properties.

2. LITERATURE REVIWES

2.1 Problem Definition

Wear of material is the process of removal of material from two solid surfaces in solid-state contact. It occurs when solid surfaces are in rolling motion or sliding motion relative to each other. In a well-designed tribological system, the removal of material is a slow process but it is continuous and steady. Similar to friction, the wear of material is also a very complicated phenomenon, which has various mechanisms and factors are involved. Several type of wear phenomena occurs like, wear of an unlubricated metal pair sliding in a dusty atmosphere may be termed dry wear, metallic wear, sliding wear, scratching wear, abrasive wear depending on the emphasis intended. To know the amount of wear undertaken, by direct contact of Al alloy with metal counter surface, it is necessary to experimentally evaluate and measure the corresponding friction and wear. The test to be carried out under various operating condition and under controlled conditions. With a view to generate new performance data, we have chosen three alloys viz. Experiments are to be carried out on standard pin-on-disc machine, at ambient temperature and under dry operating condition. There- fore, the purpose of this work was to determine the dry sliding friction.

2.2 Objectives

1. To carry out laser beam surface alloying for Aluminium.

2. To determine required parameters for material surface coating by laser surface hardening process.
3. To determine the friction and wear of the Aluminium.
4. To reduce the wear rate of Aluminium by addition of binary combination of metallic powder.
5. To improve the life period of Aluminium by addition of binary combination of metallic powder.
6. To improve the all over properties of aluminium.

3. ALUMINIUM

Aluminium is the most abundant metal and the third most common element comprising 8% of the earth's crust. The versatility of aluminium makes it the most usable metal after steel.

3.1 Annual Demand of Aluminium

Worldwide demand for aluminium is around 29 million tons per year and about 22 million tons is new aluminium and 7 million tons is recycled aluminium by scrap. The use of recycled aluminium is economically and environmentally very good. To produce 1 ton of new aluminium tt takes 14,000 kWh. There is no difference in quality between new virgin and new recycled aluminium alloys.

3.2 Applications of Aluminium

Pure aluminium material is very soft, ductile, and corrosion resistant and has a high electrical conductivity. Pure aluminium is widely used for conductor cables and foil, but alloying with other elements is necessary to provide the higher strengths than pure is needed for other applications. Pure aluminium is one of the lightest engineering metals, having good strength to weight ratio superior to steel. By utilizing various combinations of its properties such as lightness, strength, corrosion resistance, recyclability and formability, is being employed in an ever-increasing number of applications.

3.3 Alloy Designations

Aluminium is the material which commonly alloyed with copper, zinc, magnesium, silicon, manganese and lithium. Small additions of chromium, lead, bismuth and nickel, titanium, zirconium are also made and iron is present in small quantities. There are over 300 wrought alloys in world but 50 in regular common use. They are generally identified by a four figure system which originated in the USA and is now universally accepted system. Table 1 describes the system for wrought aluminium alloys. Cast alloys have similar designations and use a five digit system alloys.

Table -1: Designations for wrought alloys[8].

Alloying Element	Wrought
None (99%+ Aluminium)	1XXX
Copper	2XXX
Manganese	3XXX
Silicon	4XXX
Magnesium	5XXX
Magnesium + Silicon	6XXX
Zinc	7XXX
Lithium	8XXX

4. COATING

A coating is a covering on material that is applied to the surface of any object, usually known as the base or substrate in general. In many cases that we deal with coatings and coatings are applied to improve surface properties such as appearance, corrosion and wear resistance, and also scratch resistance. Some new coatings are being formulated these days and they are using nanotechnology to create surface protection. Also many products that are used in construction of buildings are essentially coming in the form of coated products like color bound steels. In many other cases the substrate that is being used is generally a wafer on which coating is applied. Here in these cases the coating forms an essential part of the finished product.

5. DIFFERENT COATING PROCESSES

1. Vacuum evaporation.
2. Vacuum deposition.
3. Thermal spraying.
4. Sputter deposition.
5. Spraying.
6. Sol-gel.
7. Pulsed laser deposition.
8. Plating.
9. Plasma spraying.
10. Plasma electrolytic oxidation.
11. Physical vapor deposition.
12. Metal organic vapour phase epitaxy.
13. Magnetron sputtering.
14. Laser coating.
15. Ion plating.
16. Ion beam mixing.
17. Ion beam assisted deposition.
18. High velocity oxygen fuel.

19. (ESAVD) Electrostatic spray assisted vapour deposition.
20. Electroplating.
21. (EBPVD) Electron beam physical vapour deposition.
22. Electro less plating.
23. Chromate conversion coating.
24. Chemical vapor deposition.
25. Chemical and electrochemical techniques.
26. Cathode arc deposition.
27. Anodizing.

6. LASER ALLOYING

Laser alloying of material surface is a advanced material processing technology that produces an extremely dense and crack-free structure in developed material which displays excellent bonding with the base material. Laser coating gives rise to new components with high resistant surfaces against wear even at high temperatures or low temperatures. For different applications, laser alloying offers a wide range of possible coating materials.
The advantages of material laser alloying include minimal heat input, less impact on material mechanical properties. The laser produces line energy there by melting the material and powder to deposit. Process parameters plays an important role in both surface quality and surface microstructure.
There are clear and significant advantages of laser coating over standard welding, cladding or hard facing.

6.1 ADVANTAGES

- Better technique for coating of any shape.
- It increases life-time of wearing part by 6-7 years.
- A lot of material flexibility (metal or ceramic).
- Improves upon the materials inherent susceptibility to wear and oxidation.
- Improve wear resistance capacity.
- Increase life of material.
- Increase tribological properties of Al materials.

7. SUMMARY

It seems apparent from the foregoing overview that aluminum surface alloys possess a number of very attractive characteristics which together with their very light weight and it make them extremely attractive for many applications. Further, when you are looking for an ideal material for a special application their versatility with respect to options of how to strengthen and shape them provides an amazing variety of choices.

The as-built material in this study showed good performance under high friction and sliding also. Machining the material didn't enhance the fatigue life at higher stress levels but an enhancement observed at the lower stress levels. On the other hand, heat treatment considerably improved the material wear performance. The optimum fatigue life was achieved when the material were heat treated and machined with feasible parameters. The increase in the wear life via heat treatment process was attributed to the induced ductility, microstructure transformation, and reduction of residual stresses and wear rate of surface of material. Failure under friction and sliding always originated at surface or sub-surface defects and propagated along the melt pool boundary.

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