HARDNESS AND WEAR RESIST OF Al SHAPE MEMORY ALLOY FABRICATED BY POWDER METALLURGY

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ABSTRACT: Al shape memory alloy specimens has been fabricated using powder metallurgy technique with vacuum sintering environment , three rang of powder weight percentage has been added. Micro hardness and sliding wear resist has been tested followed by X-ray diffraction, SEM and EDX for micro structure observation. The experimental test for the samples has showed that the increase of powder weight percentage in the master alloy has a significant effect on increasing the hardness and decreasing the wear resist therefore it will enhance the mechanical properties for this alloy. Because of the increasing the utilization of alloy as biomaterial. It was observed that there are higher number of aluminium presented in the formation of the composite. The research is devoted toward characterization fabricated samples from gas atomized alloy powder by powder metallurgy route.

KEYWORDS: Al coating, laser metal deposition, Powder metallurgy, shape memory alloy, Scanning Electron Microscopy (SEM)

I. INTRODUCTION

Shape memory alloys (SMA's) are metals, which exhibit two very unique properties, pseudo-elasticity, and the shape memory effect. Arne Olander first observed these unusual properties in 1938 but not until the 1960's were any serious research advances made in the field of shape memory alloys [3]. The two unique properties described above are made possible through a solid state phase change that is a molecular rearrangement, which occurs in the shape memory alloy. Typically when one thinks of a phase Change, a solid to liquid or liquid to gas change is the first idea that comes to mind. A solid state phase change is similar in that a molecular rearrangement is occurring, but the molecules remain closely packed so that the substance remains a solid. In most shape memory alloys, a temperature change of only 10 C is necessary to initiate this phase change. The two phases, which occur in shape memory alloys, are Martensite, and Austenite as shown. The unusual properties mentioned above are being applied to a wide variety of applications in a number of different fields.

The combination of these unique characteristics has led to the development of various applications such as stents, filters, and orthodontic wires. Also Shape memory alloys have been used in automobiles for applications ranging from impact absorption to sensing and actuation. In addition to the aerospace, transportation and medical industries, there are many other fields and applications that incorporate SMAs.

Aluminium alloys can be categorized as heat treatable or non-heat treatable, based on whether or not they respond to precipitation hardening. The heat treatable alloys contain elements that decrease in solid solubility with decreasing temperature, and in concentrations that exceed their equilibrium solid solubility at room temperature and moderately higher temperatures. The most important alloying elements in this group include copper, lithium, magnesium and zinc. However, the focus in this research paper will be on Aluminum-Copper alloy [6].

Aluminum–copper alloys typically contain 2–10 wt% Cu, generally with smaller additions of other elements to form an important family of Al alloys. Both wrought and cast aluminum–copper alloys respond to subsequent ageing and solution heat treatment, with an increase in hardness and strength and a decrease in elongation [1]. The introduction of copper to aluminium can reduce corrosion resistance and ductility. The most common applications for these alloys are in aerospace, military vehicles and rocket fins.

Quasicrystalline materials were discovered in the Islamic architecture and art during the period of 13th to 15th century. Initially, it was a pattern of networking zigzag lines and now has developed to be able to construct complex periodic patterns and two-dimensional geometric illustration of quasicrystalline structures as shown. Dr. Penrose is credited for the discovery in a semi-periodic geometry which was achieved by utilization of two tiles to cover a plane. This became first tiling to present fivefold rotational symmetry and foundation that describes an icosahedral quasicrystalline phase. The hybrid coatings (Al-Cu-Fe) is one of the abundant multi-component metallic systems consisting of phases belonging to the group of quasi-crystalline structures. The most common structure that has been observed in Al-Cu-Fe is icosahedral structure. This structure is irregular in all four directions (implying that the structure will not repeat along any axis) and has a 20-sided geometry. This is one of the reason that they have unique mechanical, electrical and thermal properties due to which increasing research is being conducted [4]. The icosahedral (Al-Cu-Fe) phase is stable in a very narrow compositional range and it is usually obtained in a metallurgical manner in the form of bulk crystals. However, aluminium alloys generally do not meet the requirements for improved toughness and resistance to fatigue therefore, it will be advantageous to achieve a composite from titanium alloy and hybrid coatings that can increase its application in an aerospace industry and other industries as well.

II. LITERATURE SURVEY

E. T. Akinlabi, et.al [2] described diffraction peak of this phase but it was left undetermined as a complex structure represented by ψ [4]. The most common structure that has been observed in Al-Cu-Fe is icosahedral structure. This structure is irregular in all four directions (implying that the structure will not repeat along any axis) and has a 20-sided geometry. This is one of the reason that they have unique mechanical, electrical and thermal properties due to which increasing research is being conducted. The icosahedral (Al- Cu-Fe) phase is stable in a very narrow compositional range and it is usually obtained in a metallurgical manner in the form of bulk crystals.

F. Cheng *et al* [5] described the other titanium alloys play an essential role in the aerospace industry as they are used in Boeing B787 and Airbus A350XWB. There are components that are made of titanium alloys which include engine parts, landing gears and anti-crash frames. In the past, these components were produced utilising high strength super stainless-steel alloys which make them very heavy. The use of titanium alloys can improve the aircrafts weight-to-fuel ratio.

D. Vaissiere , et.al [7] described use of titanium alloys can improve the aircrafts weight-to-fuel ratio. Since 1920, high strength aluminum alloys have always been used as airframe materials. The aerospace industry has many restrictions and requirements from the materials being used. These requirements include lower weight, improved toughness, increased corrosion and resistance to fatigue. Due to this, aluminium alloys are the key materials currently used in the aerospace industry.

R. Cobden et.al [8] described about Aluminium alloy plate is used in a large number of aerospace applications, ranging in complexity and performance requirements from simple components through to primary load bearing structures in aircraft such as the Boeing 777 and Airbus A340. However, aluminium alloys generally do not meet the requirements for improved toughness and resistance to fatigue therefore, it will be advantageous to achieve a composite from titanium alloy and hybrid coatings (Al-Cu- Fe) that can increase its application in an aerospace industry and other industries as well.

III. METHODOLOGY

The Laser Metal Deposition process employed the deposition of Al-Cu-Fe coating powder on titanium substrate through the powder feeding hoppers with the laser beam attached to the robot arm.

The deposition of the hybrid coating powder was made on 5 mm thick rectangular titanium piece of 72 mm x 72 mm. The coating powder was fed into the hoppers with the gas flow rate set at 2l/min. A total of three coatings deposits were produced on each titanium block under the set of process parameters. The experiments were carried out by varying the scanning speed from 0.8 to 1.2 m/min and constant laser power of was varied between 800 to 900W. While the gas flow rate was also kept constant at 2l/min. The deposited aluminium tracks were characterized through microstructural evaluation, microhardness measurement. A set of deposited Al-Cu-Fe coating tracks on the titanium substrate is shown in Fig. 1.

The samples were cut using an abrasive wet cutting machine into smaller mountable pieces and hot mounted using polyfast resin. The mounted samples were then grounded and polished for the microscopic examination. The samples were etched using a combination of 4ml of nitric acid, 100ml of water and 3ml of hydrofluoric acid. The microscopic examination of the etched sample was conducted under Olympus optical microscope. X-Ray Diffraction (XRD) test was conducted to determine the phase, size, grain orientation and etc. of this quasicrystal material.

Fig.1: Deposited Al-Cu-Fe Coating Tracks On the Titanium Substrate

Microhardness measurements were conducted across the cross section of the deposited hybrid coating tracks using digital microhardness tester. All the tests were conducted in accordance to the ASTM standards.

Microscopic Analysis: The Microstructure, Hardness and X-Ray diffraction laser metal deposited hybrid coatings (Al-Cu-Fe) and the substrate (grade five titanium alloy). The microstructure of the deposited coating powder was observed under the optical microscope and the scanning electron microscopy (SEM). The microstructural evolution was investigated in order to establish the effect of scanning speed on the tracks. The bonding of the coating into the titanium substrate were also investigated. Typical microstructure of the deposited coating powder at 0.8m/min. Fig. 2 shows the various sample regions such as the deposition width, height and the height of the Heat Affected Zone (HAZ).

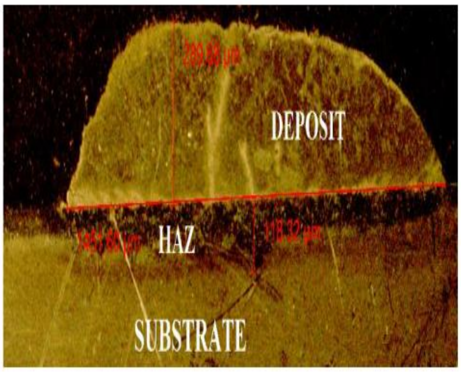

Fig.2: Microstructure Of Deposited Aluminium At 0.5m/Min And Dimensions Of The Regions.

The results show increasing the laser power increases the geometrical properties such as the height of HAZ, width and height of the deposit.

IV. RESULT ANALYSIS

The measured dimensions of the deposited height, deposited width and the HAZ of the deposited coating track are presented in Table I.

Table I. Dimensions Of Deposited Al-Cu-Fe Track

Sample	Scanning speed (m/min)	Deposit Width (mm)	Deposit Height (mm)	HAZ Height (mm)
Ti6Al4V/ Al-Cu-5Fe	0.8	1.518	0.278	0.115
Ti6Al4V/ Al-Cu-7Fe	0.8	1.497	0.259	0.121
Ti6Al4V/ Al-Cu-10Fe	0.8	1.644	0.274	0.125

Table II. Calculated Parameters Of Deposited Al-Cu-Fe Track

Sample	Scanning speed (m/min)	Dilution (%)
Ti6Al4V /Al-Cu-5Fe	0.8	29.26
Ti6Al4V /Al-Cu-7Fe	0.8	31.84
Ti6Al4V /Al-Cu-10Fe	0.8	31.32

Plotting the graph of Deposit height, Heat affected zone (HAZ) and deposit width as a function of scanning speed (Fig. 3, Fig. 4 and Fig. 5), it can be seen that these geometrical properties decrease with increasing scanning speed. This is due to a decrease in the amount of powder delivered per unit length, a reduction in the interaction time between the laser and the substrate as well as the energy input per unit length.

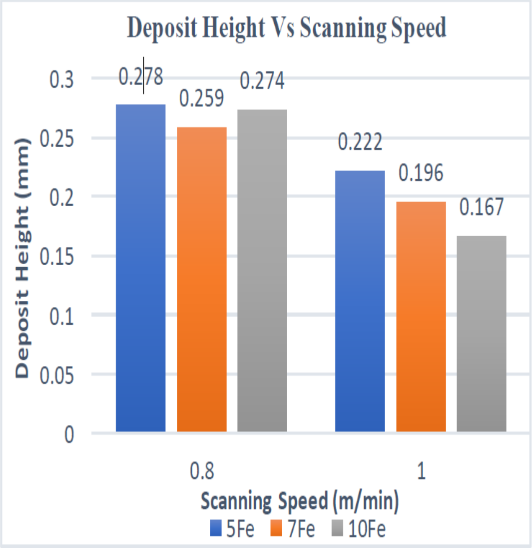

Fig.3: Deposit height vs. scanning speed

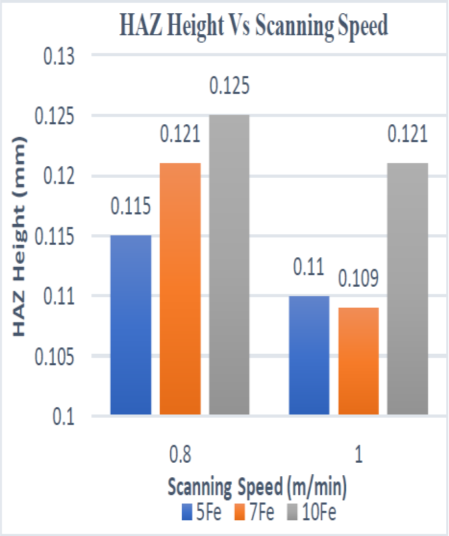

Fig.4: HAZ Vs. scanning speed

However, this is not true for graph of dilution as a function of scanning speed which increases in scanning speed results in dilution to increase. This is due to the ratio of change between the clad area above and below the substrate. The clad area below the substrate usually indicates the amount of the substrate material that has mixed with the material addition. Thus, high dilution of the clad layer is associated with a steep increase in the clad area below the substrate with a negligible increase in the clad area above the substrate. It is observed that the clad area above the substrate decreases more significantly than the clad area below the substrate which results an increase in dilution with an increase in the laser scanning speed.

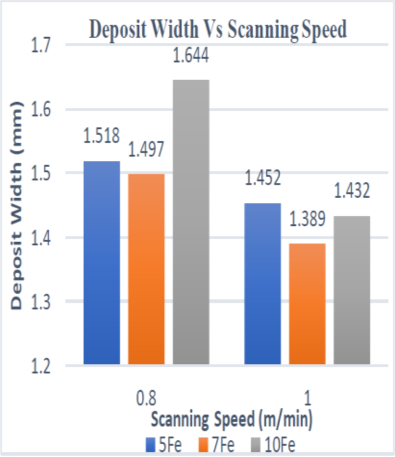

Fig.5: Deposit width Vs. scanning speed

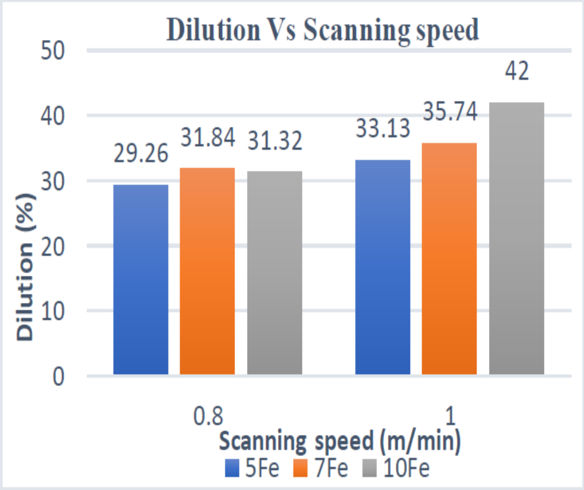

Fig.6: Dilution vs. scanning speed

V.CONCLUSION

The effect of scanning speed on the laser metal deposited Al-Cu-Fe coating on Ti6Al4V substrate during laser metal deposition was successfully studied. The results obtained from material characterization were consequently presented and discussed. Fine bonding between the coating and substrate was observed. The microstructural evaluation revealed increasing scanning speed will decrease the powder efficiency and the geometrical properties of the clad. It was evident that increasing scanning speed increases aspect ratio and dilution. XRD result illustrated the distribution of various phases and indicated that an increase in scanning speed will decrease the amount of Fe presented in composited formation during laser metal deposition process. It is observed that there are higher number of aluminium presented in the formation of the composite.

VI. REFERENCES

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