

Experimental Investigation of Surface Treatment for Titanium Using Sand Blasting and Shot Peening Method

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Abstract - Grade 2 titanium is a pure alpha titanium, why pure alpha titanium is due to the alpha phase of titanium is a close packed hexagonal and its beta phase of titanium is body centered cubic. During the process of alloying elements the titanium atoms will organize either in alpha or beta version. It has good corrosion resistance which can be used in marine industry to avoid corrosion in the huge structures and with its ductility and non-magnetic properties, the choice of operation to work in which field can be varieties in option. Grade 2 titanium is otherwise known as Workhorse due to the versatility to do in many fields like piping systems, heat exchangers, oil and gas components and many other industrial components.

Keywords: Pure alpha titanium, corrosion resistance, formability, ductility, non-magnetic, workhorse.

I. INTRODUCTION

Ti-Grade 2 is one of the most common alloys, which belongs to the (α) class of titanium alloys. Alloying elements are used for phases' stabilization and for improving the mechanical properties and resistance to corrosion of the titanium alloy. It is well known that, for biomedical applications, Ti-Gr2 combined with vanadium and aluminium is one of the most widely used alloys for orthopedic implants. However, it is important to create surface roughness to facilitate the process of osteointegration. There is not an optimum surface roughness, but some publications report an approximate value of 4 μm .

Sand blasting

A very common technique to facilitate osteointegration through surface roughness is sandblasting with copper slag particles (Cu_2S). The size, shape, and kinetic energy of the particles, are important variables which influence the value of the surface roughness. In the sandblasting process, the particles are shooting as a consequence of the impulse provided by air pressure as 400 cfm, allowing a gain of kinetic energy, which is directly proportional to the density, volume, and the square of the shooting velocity. The gain of kinetic energy is represented in the following equation.

$$Ec = \rho \cdot \left(\frac{2}{3}\right) \cdot \pi \cdot r^3 \cdot V^2$$

Shot peening

The test sample for shot peening treatment are prepared from a rod of 100mm length and cut into breath 60mm and 5mm thickness. In order to remove the induced stresses due to grinding and machining, the cut samples are heat treated at 550°C for 35 min, followed by air cooling. Metallographic polishing is done on the samples first using four different grades of silicon carbide abrasive papers of different grit sizes of 400, 600, 800 and 1000 and subsequently using alumina. Final cleaning was done with acetone in an ultrasonic cleaner for 15min. Ti-grade 2 plate samples are shot peened at different pressures 1.5,2,3,3.5 bar and for different exposure time durations 5,10,15,20 min using carbon steel shots of 0.6mm diameter. A total of 16 shot peened test pieces are evaluated at different exposure time and pressure conditions. The potency of shot peening is determined using a standard Almen process using the test strip.

1.1 Background of analysis

The aim of the present work was to investigate the effect of the sandblasting treatment and the behavior of the Cu_2S particles in the surface modification of Ti-grade 2 samples. This study allows the understanding of the surface properties of the Ti-grade 2 alloy, which depend of the physical and mechanical characteristics of the employed abrasive, and also exert a great influence in the mechanical and biological response of the material. The surface of the titanium alloy' samples were transformed using a sandblasting device. The pressurized air in the device, projects the abrasive Cu_2S particles at a 90° angle. The distance between the nozzle and the sample surface was 0.1 m. The air pressure was 0.3 MPa. For particle sizes between 400 – 600 μm , sandblasting was carried out for 2, 3, 4, 6, 7, and 10 seconds. Topography of the modified samples was analyzed by scanning electron microscopy (SEM) in a microscope with an acceleration voltage of 25 kV.

In general, mechanical surface treatments can induce high compressive residual stresses in near surface regions due to

the local plastic deformation and changes in microstructure leading to improved wear resistance and fatigue resistance of metallic materials. Shot peening is an economic and potential surface engineering technique mostly employed to alleviate failures due to wear, fatigue and corrosion fissure of industrial metallic structural parts such as turbine blade, dove tail joints, gears etc.

Hence, there is essential for achieving an optimum condition of fore mentioned changes in surface attributes, which is neither a simple nor a undemanding task. In this regard, a rational, robust and effective process control technique is very much required.

During Shot peening process, amount of compressive residual stress induced in the surface and beneath the surface has a direct influence on the functional properties such as fatigue resistance and stress corrosion resistance of peened work materials. Hence there is a great need for controlling and regulating the SP process parameters in order to induce a beneficial compressive residual stress.

The present study aims to comprehend the influence of SP process parameters on work material by examining the change in the material surface characteristics. The influence of the SP parameters (peening pressure, exposure time) on the surface layer properties like surface roughness, residual stress profile, surface coverage area and peening intensity are studied. Hence, optimizing the SP process parameters and determining the compressive residual stress in peened sample with optimum process parameters are the aim and scope of the present study. Correlating the SP process parameters with the obtained results may be certainly beneficial, which leads to better and more accurate control on SP process. Further peened component could be deployed in strategically technological applications.

II. LITERATURE SURVEY

Leyens et al. (2013) - Titanium alloys have been widely used in aviation industry, exploitation of ocean, artificial implants of human body and so on, for their excellent properties, such as high melting point, high corrosion resistance, high specific strength and bioactivity.

Gurdeep Singh Deol (2015) - The surface chemical analysis reveals the presence of several contaminants such as C, S, P, Si and Mg on the specimen surface after being blasted with the steel slag balls.

Laneza et al., (2015) - Carried out an enhancement of tribological performance and fatigue life improvement of titanium and titanium based alloys is of current interest due to their increasing industrial applications. Though SP process is

a fairly well established technique until now, but many industries are not able to apply it effectively. This could be attributed to the challenge in controlling as well as optimizing the various process parameters concurrently.

Fathallah et al., (2013) - In fact, in most of the situations, the SP process parameters are improperly selected (larger shot size, excessive peening, higher velocities, etc). Thus it may lead to the degradation of properties of peened surface, through introduction of detrimental features such as micro-cracks, overlaps, rough surfaces etc, resulting in inferior fatigue behavior of shot peened components.

Jebahi et al. (2016) and Skowronek (2007) - In fact, complex problems involving a multiple factors are efficiently handled and investigated through factorial experiments. The usage of appropriate scientific methods for experimental planning, investigation and analysis could significantly reduce the extensive time duration for conducting experiments and high cost involved.

Andrea Avanzinia et al. (2019) - In the present study, axial fatigue tests were performed in order to study the fatigue behaviour of AlSi10Mg samples produced by DMLS and, subsequently, sand-blasted.

Alireza Malekahmad et al. (2020) - Since it has been proven that higher stress and lower grain size can accelerate corrosion in metals, this article is to find the optimum procedure to increase the corrosion resistance of API-X60 steel.

K. N. Abushgair (2017) - Flap peening process increases the hardness of surface of the metal; so, this, in turn, causes the fatigue life of the metal to increase.

Mahagaonkar et al. (2018) - carried out experimentations employing the design of experiment method to investigate the influence of shot peening parameters such as peening pressure, exposure time and nozzle distance on the micro-hardness of steel samples.

Aylott and Laassithiotakis (2019) - made use of DOE procedure to select the best shot peening process parameters to introduce greater magnitude of compressive residual stress in SAE8620 steel samples.

III. RESULTS AND DISCUSSIONS

3.1 Hardness Result

Rockwell Hardness

Titanium Grade 2

Sample No: Base	Hardness value	Scale	Load Kgf
T Base	94 HRC	C-Scale	150
T Base	96 HRC	C-Scale	150
T Base	95 HRC	C-Scale	150



Rockwell hardness – Base material

Shot peening:

Sample No:SHP-1	Hardness value	Scale	Load Kgf
T coated	86 HRC	C-Scale	150
T coated	97 HRC	C-Scale	150
T coated	89 HRC	C-Scale	150
T coated	96 HRC	C-Scale	150
T coated	98 HRC	C-Scale	150
T coated	97 HRC	C-Scale	150



Rockwell hardness – Shot peening

Sand blasting:

Sample No:SB-1	Hardness value	Scale	Load Kgf
T coated	62 HRC	C-Scale	150
T coated	81 HRC	C-Scale	150
T coated	92 HRC	C-Scale	150
T coated	93 HRC	C-Scale	150
T coated	98 HRC	C-Scale	150
T coated	97 HRC	C-Scale	150



Rockwell hardness – Sand blasting

3.2 Sem Analyzing

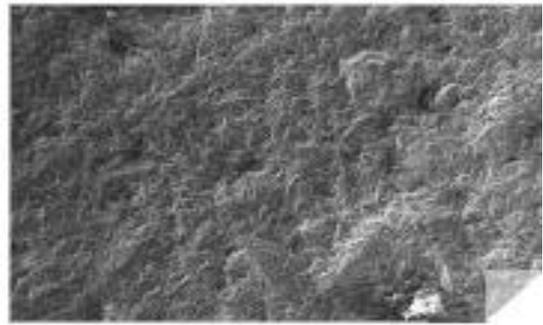
Base material:



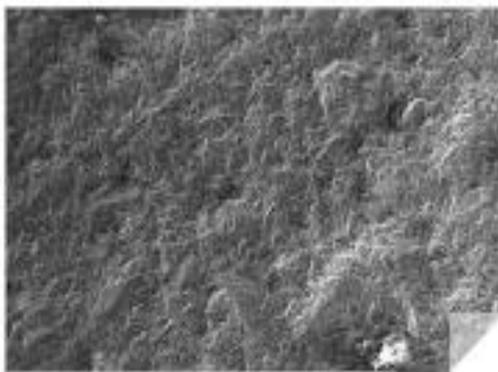
First layer



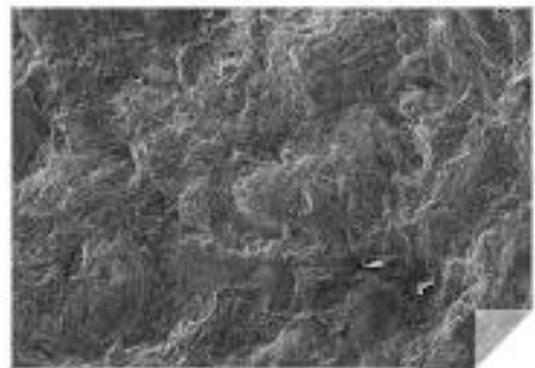
Second layer



Third layer



Third layer

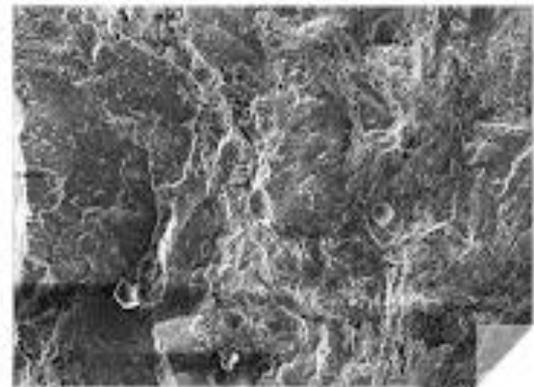


Fourth layer

Sand blasting:-Sample-SB-1

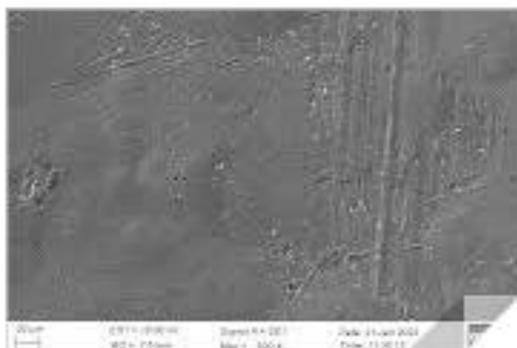


First layer

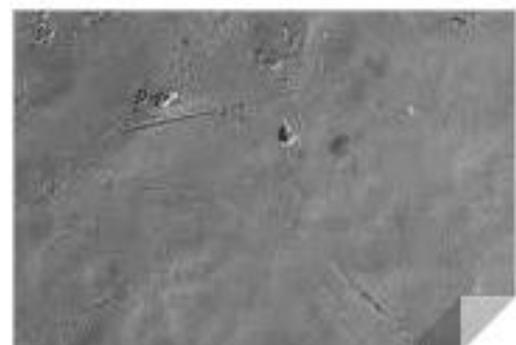


Fifth layer

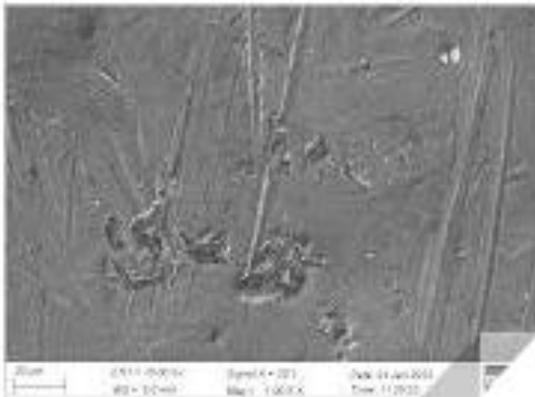
Shot peening:-Sample-SH-1



Second layer



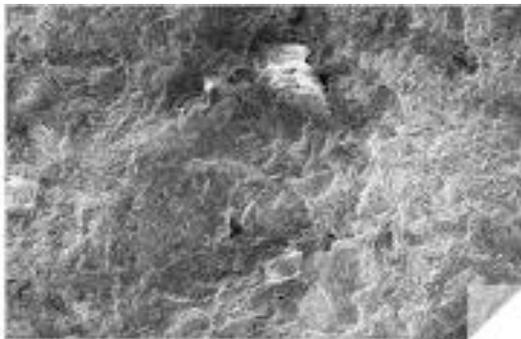
First layer



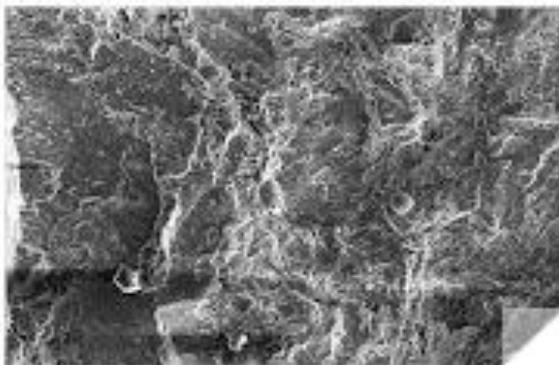
Second layer



Third layer

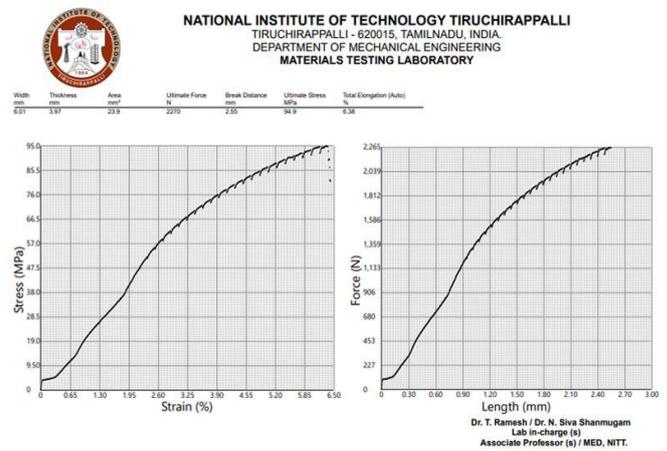


Fourth layer



Fifth layer

3.3 Tensile Test



Tensile test graph

IV. CONCLUSION

A combined glass copper slag particle for shot peen and silica particle for sand blasting flow was demonstrated for the first time to be an effective method of depositing a layer of base material, surface of titanium alloys. This HA deposition technique was compared with the Co Blast process in which the coatings were deposited by simultaneous bombarding the titanium alloy with both other abrasive and the same HA powder particles. HA coatings from the two deposition methods exhibited similar testing process.

It get resulted that shot peen is better than sand blast.

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