Effect of Standoff Distance During Waterjet Peening Interaction with Titanium Alloy

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Effect of Standoff Distance During Waterjet Peening Interaction with Titanium Alloy

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Abstract *: In the present research a detailed effect of standoff distance water jet peening with the variation of jet presurre on the flat titanium alloy surface has been studied. During the experimentation, at a traverse speed of 30 mm/s accidently the change in standoff distance was encountered in the repeated test. Same treatment condition) which has been reported in this work. The frequency was f = 20 kHz at the pressure of p = 70 MPa with variation in standoff distance was increased from 20 mm up to 100 mm (with step distance of 20 mm) during the treatment process. The change in microstructural was observed using scanning electron microscopy (SEM). The strengthening mechanism on the surface and sub-surface region due to the plastic deformation phenomenon caused by the impact of the waterjet peening was evaluated by Vickers micro hardness test. The micro hardness test was conducted along the depth of the treated region to analyze the effects in the sub-surface layers by scanning the surface by optical Micro Prof FRT profile meter in order to analyze the erosion phenomenon with the variation of standoff distance and jet pressure during the treatment process. The results obtained indicates that the variation in standoff distance has a significant impact on the surface hardness number of the titanium alloy. The above observations elaborated the effect of standoff distance were better and effective of the applied technology for the surface treatment of titanium alloy*

Keywords — *Waterjet peening, titanium alloy. frequency, standoff distance, surface hardness number.*

I. INTRODUCTION

Advanced material technology is currently developing very rapidly, one of its applications is the biomaterial field. Ideal biomaterials are materials that have good biocompatibility, good mechanical properties and easy manufacturing processes [1]. In general terms, biocompatibility describes conditions where there is no harmful interaction between foreign material and the body. Biocompatibility is a system that includes physical, chemical, biological, medical and design aspects (Spenser, et al., 1998). Ductility, thoughness, creep and wear resistance are mechanical properties needed for biomaterials, while fabrication methods, consistency, comfort levels and production costs are the manufacturing characteristics that ultimately determine the choice of implant material usage [1,10].

One type of metal implant material that is often used is Commercially pure titanium (Ti CP) and extra low interstitial Ti-6Al-4V (ELI). Pure Titanium metal and Titanium alloys have better biocompatibility and biomechanics than other metals [1]. Titanium has the ability to attach to bone called osseointegration. In osseointegration, bone comes in direct contact with the surface of the implant so that bone growth occurs around the implant (Khang, et al., 2008). Titanium is also inert and corrosion resistant because it can form a passive layer, the titanium oxide layer (TiO2). This layer is insoluble in body fluids thus preventing the release of metal ions which can react with body tissues [11]. Titanium alloys are the only alloys that do not contain sensitizing elements and do not cause hypersensitivity, as are Titanium alloys - 6% Aluminum - 4% Vanadium.[1]. With these advantages, Titanium is the most widely used as an implant base material and makes it ideal as an implant material.

The surface is important in biomaterials, interactions on the surface of the implant with body fluids show the body's response to the implant and the development of the implant surface / tissue. Titanium is one of the materials in which the degree of resistance of integration between the material and body tissue is influenced by surface quality [2] In addition, osseointegration in the implant process is strongly influenced by the level of adsorption of specific proteins on the surface of the implant [9]. With an effective porosity level of 0.93% to 1.9% for biomaterials. [11]). The process of protein adsorption can be increased by increasing the surface roughness of the implant material and selecting hydrophilic implants [7]. The residual stress on the surface layer can increase hardness, improve fatigue properties, improve adhesion and abrasion. Residual stress, hardness and adhesion indicate a qualitative relationship.

Surface mechanical treatments, such as deep rooling, shot peening, hammering, etc., can significantly improve the strength behavior of metal materials due to the formation of nanocrystalline structures on the surface and hardening of the strain [7]. Sandblasting and shot peening techniques are not only able to make the surface of the material rough, but also can increase the mechanical strength of the material through the surface grain refinement mechanism. However, both techniques have the potential to damage the surface structure, increased surface roughness, accompanied by voids on the surface, will trigger stress crack corrosion which affects the strength of fatigue [4,5] Titanium alloy surface hardening technology with carbon and nitrogen diffusion methods has been developed by [11], the weakness can only be done at high temperatures 1073 K, complicated and expensive. Further, the waterjet technology for surface treatment has been developed by [6], to improve the weaknesses of the sandblasting and shot pening processes. In addition, the waterjet treatment process is more efficient than the Ultrasonic Shot Peening Process (USSP) so that this technique is widely developed on an industrial scale to obtain nanostructured surface coatings without changing its chemical composition...

In the present study, In the present study, a new treatment for the enhanching surface hardness number using waterrjet peening applied to titanium alloy. The effect standoff distance water jet pening applied to titanium alloy is described, and its effectiveness is discussed on the basic of the micro structures and the surface hardness number of the titanium alloy.

II. MATERIAL AND METHODE

The titanium alloy Ti-6Al-4V sample of size 1000 mm x100 mm x10 mm having mechanical and chemical properties mentioned in Table 1 was subjected to the treatment process water jet peening machine. water jet machine peening constitutes: a HAMMELMANN HDP 253 plunger pump (maximum operating pressure of 250 MPa and flow rate of 40 l/min). The sample was clamped on the working table with the water jet pening positioning at 90° to the treated surface Figure 1.. The treatment was performed under the experimental conditions mentioned in Table 2 with variation in z from 20 mm to 100 mm (z changing by 20 mm at every 20 mm treated region) under each condition. The surface topography of the treated region was analyzed under a scanning electron microscopy (SEM). To determine the effect of this plastic deformation the hardness measurements along the depth of the treated region was conducted using Vickers Hardness testing machine Shimadzu HMV Micro Hardness Tester under a load of 10 Kg for 50 Kg..

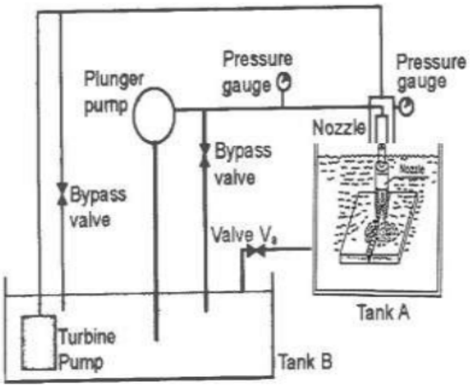


Fig.1 Apparatus Water Jet Peening
Soyama..H.et al..(2004)

TABLE 1
MATERIAL COMPOSITION AND MECHANICAL PROPERTIES

Material		
Ti-6Al-4V	Chemical composition	Ti = 90%, Al = 6%, V = 4%
	Mechanical properties	(Hardness HV) 190, E = 110 GPa, σ_t = 500 MPa, σ_y = 210 MPa, ϵ = 10%

ASTM F 136

TABLE 2
EXPERIMENTAL CONDITIONS.

Nozzle Type	d [mm]	P [MPa]	f [kHz]	z [mm]
Circular	1,15	70	20	20-100

III. RESULTS AND DISCUSSION

A. *Surface Hrdness Number*

For fifth the standoff distance as compare to the surface hardness number of initial untreated sample, shawn in Fig.2. There was a significant increase in the surface hardness observed after the surface treatment process by water jet peening. This increase in surface hardness occurs to a depth of 200 µm. The maximum of surface hardness number are 370 Kg/mm^2 at the standoff distance of 40 mm and minimum 273 Kg/mm^2 , at standoff distance of 100 mm.This is because the power generated at this standoff distance are well developed and has sufficient impacting energy to cause large plastic deformation on the impacting surface. At the standoff distance of 20 mm, the resulting hardness rate was 340 Kg/mm^2 lower than booths 40 mm and 60 mm at the standoff distance. Because the water pressure was not focused so the impact energy produced was low not sufficient impacting energy to cause large plastic deformation on the impacting surface.

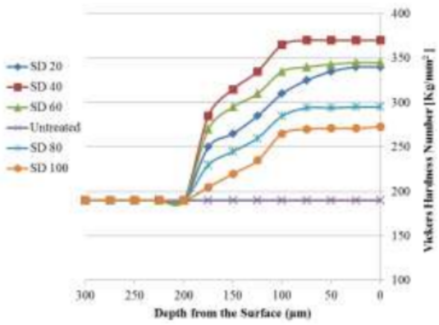
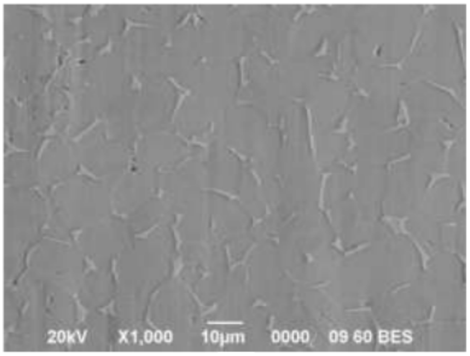


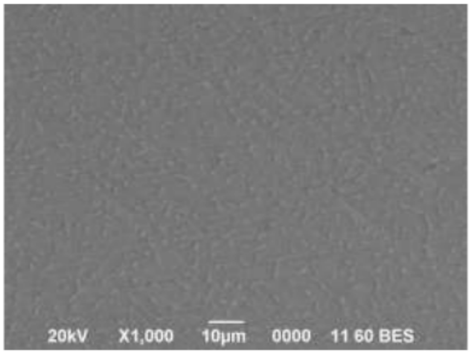
Fig.2. Effect Standoff Distance for Surface Hardness Number

B. *Microstructural Topography*

From the above analysis the range of the standoff distance shows distinct microstructure due to surface treatment water jet peening.. Instead of analyzing all the samples five samples were selected from the above range of standoff distance. Through the analysis of the microstructural topography of the treated surface the erosion phenomenon of the treatment process by water jet peening technology can be understood more widely. The several magnified images at selected locations at a magnification of 1000 X is presented in the Fig. 3. It shows the surface topography of the samples treated under samet conditions with slight variation in standoff distance 20 mm, 40 mm, 60 mm, 80 mm, and 100 mm. Based on the microstructure photo with SEM in Figure 3, it is understood that the change in standoff distance on the surface treatment of jet peening wters on Ti-6Al-4V alloys affects the change in the value of hardness. Hardness value is inversely proportional to stand off distance when the standoff distance is higher than 20 mm. This increased hardness value is caused by the impact energy of the water jet peening process which results in plastic deformation and dislocation movement in Ti-6Al-4V alloy material. The smaller the standoff distance, the impact energy is greater. But at a 20 mm standoff distance, the jet pressure from fluorescent water is out of focus so the impact energy is smaller than the 40 mm standoff distance.
The hardness value increases respectively in the standoff distance variations (100, 80, 60, and 40 mm) are 273, 295, 345 and 370 Kg s. The increase in the value of violence is caused by changes in impact energy caused by changes in jet pressure force. The change in standoff distance causes the β phase to transform into the α phase as shown in Figure 3. The greater the standoff distance, it will inhibit the formation of the α phase, so that the beta phase formed becomes more numerous, so the violence rate is lower. The formation of the α phase affects the hardness value of the alloy, because the α phase has a HCP crystal structure that has harder characteristics. Therefore the Ti-6Al-4V alloy which is water jet peening at a standoff distance of 40 mm has a higher hardness value compared to the hardness value of the Ti-6Al-4V alloy in other conditions. This is due to the fact that the α and phase α 'phases are formed more as shown in Figure 3b.



a



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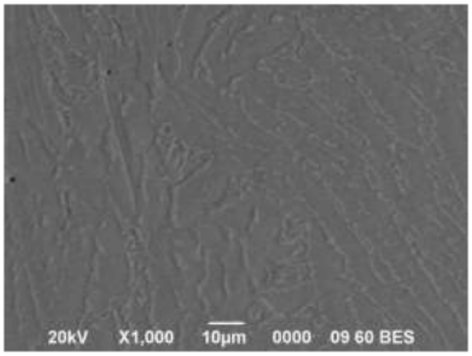

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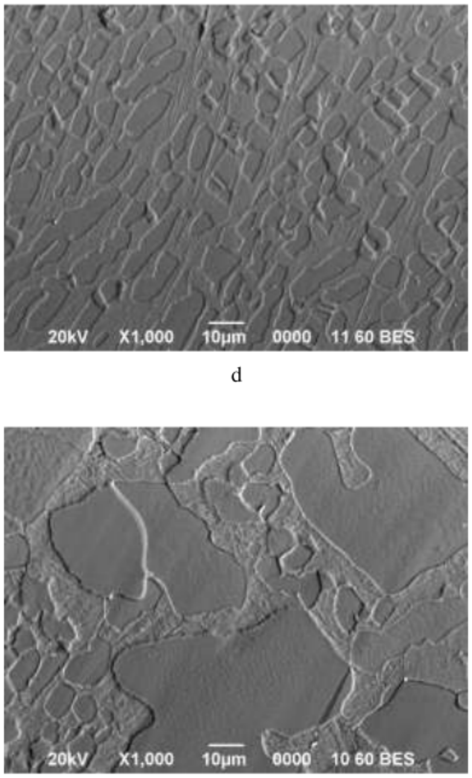

d

e

Fig 3. Micro Structure on Water Jet Peening at Standoff Distance 20m, b. 40 mm,. c. 60 mm, d. 80 mm, e. 100 mm

IV. CONCLUSION

The This study is an approach to determine the optimum standoff distance and also the effect of the erosion phenomenon occurring during the treatment by water jet peening. From the present study following conclusions can be drawn:

- The changeat different standoff distance causes the change in the erosion phenomenon due jet pressure This is due to the shorter standoff distance produced at a higher surfafe hardness
- The surface quality of the material has been enhanced by the treatment of water jet peening the standoff distance variation has shown a significant effect on its surface integrity.

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