INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.9 Issue 11,
NOVEMBER 2021
Pg: -01-09

SURFACE MODIFICATIONS BY ABRASIVE BLASTING ON TITANIUM AND ALLOYS BEFORE PVD COATINGS

G.Santhosha Rathnam
g.santhoshirathnam@gmail.com

ABSTRACT: - Surface preparation plays an important role before coating on the substrate. Which increases bond strength, removal of rust, scale, burrs, edge profiling. Different surface modifications among abrasive blasting give effective results. This study evaluates Al_2O_3, glass granet sand, Al metal grits in terms of particles to the titanium surface. Alumina oxide (Al_2O_3) grits with various sizes are widely used for surface modifications. Grit-blasting is often used as a stand-alone titanium pre-bond treatment. However, sandblasting with Al_2O_3 grits also introduces impurities to the surface of the Ti. The present work shows the analysis of an abrasive blasting process using different abrasive particles on Ti6Al4V surfaces. In contrast to the case for aluminum, grit-blasting treatment of titanium is one of the best procedures for obtaining good initial joint strength. Six commercially pure grade 5 (CP5) titanium cylinders were grit-blasted using various grits. The surface roughness average (R_a) of all grit-blasted plates was measured. The metallic samples were first characterized by optical microscopy (OM), revealing a α+β microstructure. before and after sandblasting by alumina grit blasting particles. The Al_2O_3 particles used had a grit particle size between 20µm,24µm, or 36µm with a median particle size (d13) of 600 µm, on the surface. The surface roughness (Ra) was calculated by hardness testing machine and the surface finish was observed before and after sand-blasting. Kinetic energy by a factor of 3.5 is the change in the size of the particles generated a loss upon particle. PVD coatings are widely used nowadays to reduce the wear of the substrate. By this process it was observed, exerting a polishing effect on the surface of the Ti-6Al-4V alloy gives effective results before coating.

Keywords: *Abrasive blasting, Sand blasting, Glass beads, Alumina grit, Garnet sand, plastic media, Surface roughness,*

1. Introduction

We need to know for sandblasting Abrasive Materials are effective. Without knowing Sandblasting Abrasive Media, you cannot get desired performance by the sand-blasting machine. So it is necessary to take an insight as to the sandblasting material. Generally, the Sand-blasting machine is utilized for removing rust and preparing a surface to receive the new coat of paint. In the process of sandblasting such as sand, glass beads and other sandblasting abrasive are being used at high speed across the surface. Firstly in sandblasting process, we need to determine what kind of material and equipment is required for effective sandblasting. Apart from it, you also need to analyze the degree of work and the type of sandblasting abrasive media; tools are required for effective sandblasting. Meanwhile, the types of material used for different surface depends on how difficult the removal. So it is mandatory to know more about the abrasive blasting material & instructions for the excellent sandblasting work. Here is the detail of the sandblasting abrasive material for effective sandblasting. Air-driven abrasive blasting is one of the most efficient and cost-effective ways of enhancing the mechanical adhesion between metals and coating systems.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.9 Issue 11,
NOVEMBER 2021
Pg: -01-09

Glass bead:

To obtain a finish with no profile, Glass Bead is the product of choice. The non-metallic spherical beads provide effective cleaning, polishing, deburring, peening of metal, plastic, and rubber materials.

Granet Sand:

Garnet is a hard, heavy, durable abrasive. It can be recycled up to 5 times without a loss in performance. Garnet can be used for cleaning steel in various applications including shipbuilding and repair, tanks, offshore platforms, and pipelines. It is also used to provide a surface finish for powder coaters.

Aluminum oxide:

(SandBlasting abrasive) is fused electrically by using alumina and other materials also. It has higher hardness and greater toughness than other materials. Aluminum oxides are fast and effective for removing rust, mill scale, paint, carbon deposits, and other deposits on metal surfaces. Aluminum oxide Grit can remove deposits from our substrate or blasting surface at twice the speed as sand, without all the health risks involved in the process like in a sandblasting machine. Usually, there are two types of Aluminum Oxide sandblasting materials highly demanded in the market. Have a look at the details:

Brown Aluminum Oxide**:**

Brown Fused Alumina (BFA) is produced by a reduction fusion of high quality bauxites in electric arc furnaces. It is both a hard and tough material with high strength, making it an excellent abrasive grain for applications such as grinding wheels, sandpaper, blasting media, metal preparation, lapping, polishing, and grinding. Its thermal properties make it an excellent raw material for refractory applications. It contains less than 1.6% free silica; therefore it is safer to use than sand. Long with it, its grit size is consistent and cuts much faster than sand,

White Aluminum Oxide**:**

One type of grit-blasting material that might avoid this problem is titania (TiO_2). However, as TiO_2 is as hard as the titanium surface, its roughening effects are inferior to Al_2O_3. Consequently, sandblasting with TiO_2 grits is less effective. White Aluminum oxide has similar hardness and greater toughness than other sandblasting material. It is the best material for the harder things to remove rust and making a smoother surface. When titanium and its alloy surface are sandblasted, it is important to choose the appropriate material and size of the blasting grits to be used. Traditionally, the main consideration for choosing the grits is their surface roughening effects [2]. Based on this criterion, a common choice of the blasting material is alumina (aluminum trioxide, Al_2O_3*)*, which is understood to create good surface textures on the titanium alloy. One often neglected aspect, however, is that sandblasting also has a major drawback: it introduces impurities to the titanium material due to residuals of the blasting grits. Such impurities are believed to negatively affect biocompatibility, bioactivity, corrosion resistance, mechanical properties, most importantly, the osseointegration of the titanium material. This is in particular a problem for Al_2O_3 grits because they tend to adhere (embed) onto the titanium surface during sandblasting, and the resulting impurities are rather difficult to remove. So far, we are not aware of a systematic comparison of various blasting materials considering both their roughening effects and the impurities introduced on the titanium surface. This study aims at comparing and contrasting various powder materials and their grit sizes for sandblasting titanium by evaluating both the surface topography and the residual impurities of the blasted titanium surface. The hypothesis for this study was that using silicon-glass beads or aluminum powders in sandblasting titanium surfaces would introduce fewer impurities than using Al_2O_3 grits [3]. For a given blasting material, a larger grit size would leave fewer residues on the titanium surface. Ti-6Al-4V is one of the most common alloys, which belongs to the ($\alpha+\beta$) class of titanium alloys, due to the presence of aluminum and vanadium. These alloying elements are used for phase stabilization and for improving the mechanical properties and resistance to corrosion of the titanium alloy. Ti-6Al-4V is one of the most widely used alloys for various applications. However, it is important to create surface roughness to facilitate the process of osseointegration.

Relatively coarse, sharp clean abrasives are required to prepare substrate surfaces for thermal spray applications. Metcolite™ grits are formulations of various grades of fused aluminum oxides and contain titanium dioxide as a toughener. They have been specially developed for optimum hardness and durability.

When using Metcolite™ aluminum oxide grits, the resulting surface profile is determined by the size of the grit, which should be appropriately chosen for the application. For very thin or very smooth coatings, a very fine grit is recommended to avoid that the surface profile is affected by grit inclusion. For very thick coatings, a rough blasted surface is important to maximize surface area. For self-fluxing coatings, surface preparation with steel grit is recommended. Metcolite is not the preparation media of choice for these coatings. Grit blasted surfaces should be properly cleaned before coating to ensure proper bonding of the coating. When blasting with Metcolite, follow the recommendations for pre-blast and post-blast cleaning of the surface. An improperly blasted surface may hold an excessive aggregate of embedded particles which will interfere with the bonding of the thermal sprayed coating. Excessive grit is almost as bad as oil and grease contamination. Surfaces must be properly degreased before blasting to avoid bonding failure of the coating.

Metcolite grit can be used for surface roughening of a component before the application of a thermal spray coating to ensure good bonding of the coating to the substrate. The prepared surface must be coated as soon
Due to their corrosion resistance, good fatigue strength, and acceptable fracture toughness, titanium alloys are being widely used in orthopedic and dental implants [4], the chemical process industry [2], and automotive and aerospace structural parts [5-6]. Titanium demonstrates poor tribological properties mainly because it is susceptible to failure by galling and high and unstable friction coefficients against common bearing materials [7, 8]. Therefore, a variety of surface treatments and coatings have been developed for use with titanium and its alloys [9, 10].

A very common technique to facilitate osteointegration through surface roughness is sandblasting with alumina particles ($Al2O3$). The size, shape, and kinetic energy of the particles, are important variables that 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, allowing a gain of kinetic energy, which is directly proportional to the density, volume, and square of the shooting velocity. The gain of kinetic energy is represented in the following equation.

$$Ec=\rho.(2/3).\pi.r^3.V^2 \quad \text{Equation 1.1}$$

Chemical composition:

1.1 Experimental procedure

Titanium alloy Ti6Al4V of blocks (10 mm×15mm)) were machine-cut and polished by Al_2O_3 particles used had a granulometric distribution between**,**24µm, or 36µm with a median particle size (d13) of 600 µm, on the surface[11]

1.2 Chemical composition :

	Weight Percent (nominal)		
Product	Al2O3	TiO2	Total Others
All Metcolite Products	94	3.5	2.5

1.3 Different products particle size and apparent density:

Product	Apparent Density mm	ASTM Mesh a Grit Size bg/cm2
Metcolite 14	14	1.83
Metcolite C	20	1.92
Metcolite F	24	1.90
Metcolite F36	36	1.74
Metcolite VF	54	1.75

n Metcolite 14: Use on hard (HRC 50 – 65) and thick surfaces to get maximum roughness.
n Metcolite C: Use where the coating thickness will be greater than 0.25 mm (0.010 in), and where the roughest blasted surface is required.
n Metcolite F: Use where the coating thickness will be less than 0.25 mm (0.010 in), and where a very rough surface is not required or cannot be tolerated.
n Metcolite F36: Use when coatings are thin and fine and when the substrate surface does not require heavy roughening and the substrate hardness is in the range of HRC 40 – 50.
n Metcolite VF: Use to prepare substrates for thin coatings that will be used as-sprayed or lightly finished, such as by brushing or glass-beaded.

1.4 Specifications of a sandblasting machine used in Oerlikon:

Specifications	Sandblasted machine (compressed air blasting	
	High pressure	Low pressure
Field of application °	For thick-walled components	For thin-walled components
Blasting material	Corundum 54 / AL2O3	Corundum 54 / AL2O3
Particle size	250 – 350 [µm]	250 – 350 [µm]
Jet pressure	3 - 4 [bar] Dependent on wall strength of component Warning: evenness tolerances/check for warping	1 - 3 [bar] Dependent on wall strength of component Warning**:** evenness tolerances/check for warping
Distance between jet nozzle and workpiece	10 – 20 [cm]	20 – 30 [cm]
The Angle of jet the workpiece	70° – 90°	30° – 50

1.5 Sandblasting and determination of average roughness (Ra):

The surface of the titanium alloy' samples was modified using a sandblasting device[12]. The pressurized air in the device projects the abrasive Al2O3 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 24µm, or 36µm, sandblasting was carried out At each sandblasting time, Ra was measured, by hardness testing machine in three different parallel zones of the modified surface. The topography of the modified samples was analyzed by scanning electron microscopy (SEM) in a microscope (JEOL JSM-6390) [13]

2 Results and Discussions

2.1 metallographic analysis

The alloys are observed under the microscope before and after blasting

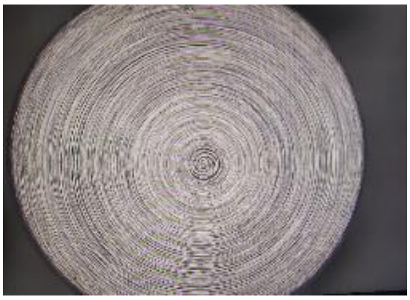


Figure 1 microstructure of Ti6Al4V before micro blasting

Figure 2 microstructure of Ti6Al4V after micro blasting

The alloys hardness was tested by using a hardness machine and the max and min hardness is tabulated below

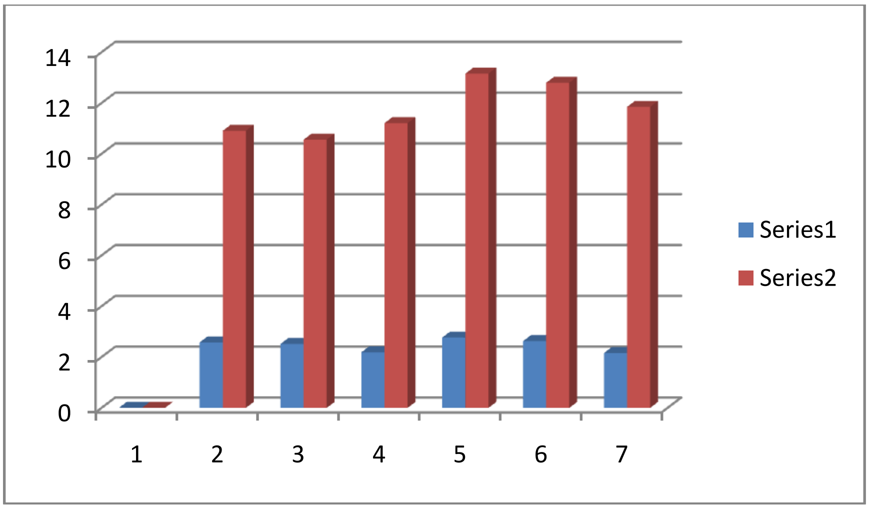
Roughness (μm) (Before blasting)	Ra=2.58 Rz=10.91	Ra=2.52 Rz=10.56	Ra=2.19 Rz=11.21	Ra=2.77 Rz=13.16	Ra=2.63 Rz=12.80	Ra=2.16 Rz=11.85
Roughness (μm) (After blasting)	Ra=2.21 Rz=11.62	Ra=1.12 Rz=5.37	Ra=1.06 Rz=6.57	Ra=1.64 Rz=7.73	Ra=1.01 Rz=5.02	Ra=1.20 Rz=7.34

IJRAME
INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051
Vol.9 Issue 11,
NOVEMBER 2021
Pg: -01-09

Table-1: Max and Min Roughness values before and after blasting

3.2. Sandblasting process and determination of surface roughness (Ra)

Once the sandblasting process was carried out, the Ra and Rz were measured on the metallic surfaces.
Table 1 shows the values of Ra and Rz obtained as a function of sandblasting time when the particle size was maintained in the range of 24µm, or 36µm.



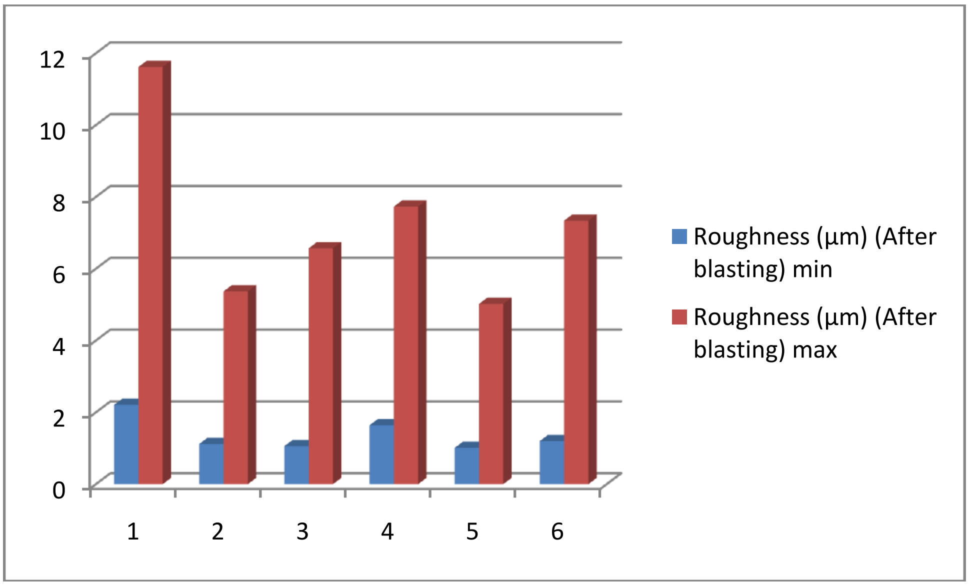


Figure 3 Histogram of average surface roughness of the Ti6Al4V samples (n = 33) as a function of sandblasting time, using a particle size in the range of 420- 600µm.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.9 Issue 11,
NOVEMBER 2021
Pg: -01-09

In the above figure 3, it can be observed that there is an optimum roughness value of 3.4 µm at 7 seconds of sandblasting ($p < 0.1$). However, this value decreases to 3.1 µm when the time is increased to 10 seconds. This phenomenon is possibly a consequence of the rupture of the alumina particles when impacting the surface.

The micrographs shown in Figure 3.3 correspond to Ti-6Al-4V surfaces before and after the sandblasting treatment. Figure 3.3a shows the unmodified surface, where only grinding marks caused during sample preparation can be appreciated. Figure 3.3b shows a substantial change in surface morphology, the product of the plastic deformation associated with the impact of alumina particles.

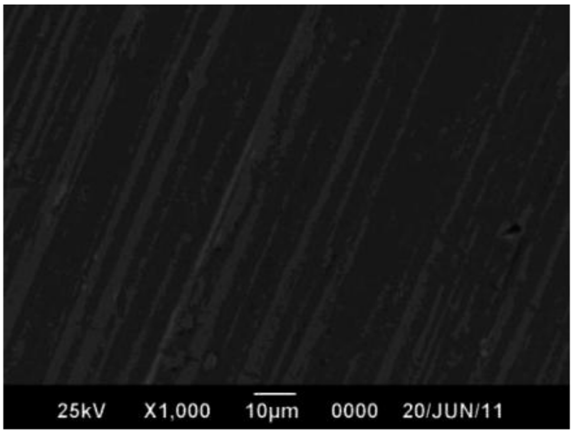


Figure 3.3a. Scanning electron micrograph of unmodified Ti6Al4V at 1000X.

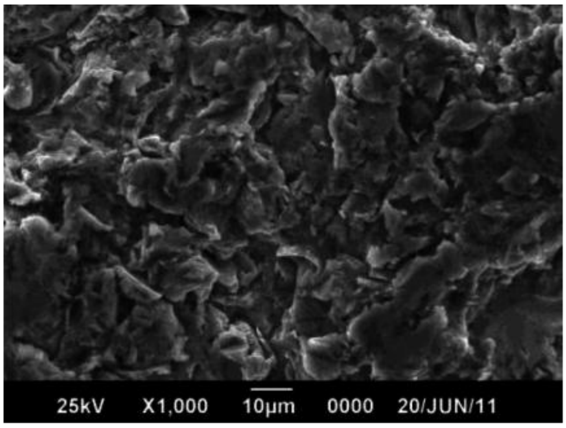


Figure 3.3b. Scanning electron micrograph of sandblasted Ti6Al4V at 1000X.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Vol.9 Issue 11,
NOVEMBER 2021
Pg: -01-09

3.3. Characterization of the abrasive particles

Figure 3.4 shows the results obtained from granulometric distributions of the abrasive particles, before and after the sandblasting process.

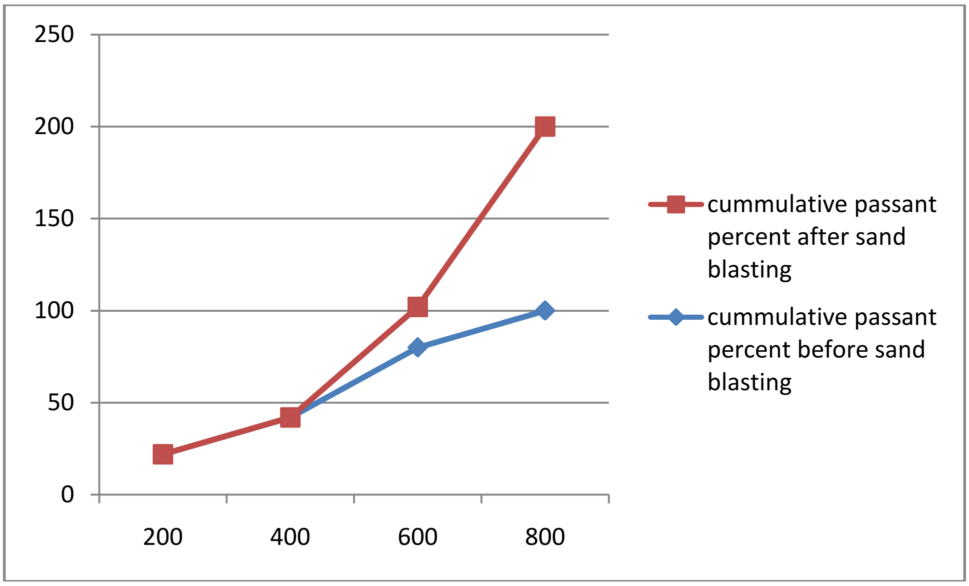


Figure 3.4. Granulometric cumulative curves showing d36 of the abrasive granulometric distributions before and after sandblasting.

Emphasizing the granulometric curves in Figure 3.4, it is established that the medium particle size, d36, is 670 µm for a granulometric distribution before sandblasting process, and 450 µm after this process. This result indicates a clear decrease in the abrasive particle size. This fact is empirical evidence that the particle fracture is associated with the tendency to decrease roughness, with prolonged sandblasting times.

CONCLUSION This study suggests that sandblasting is a technique to give surface preparation before coating which increases bond strength between coating and material. Especially the titanium surface with Al_2O_3 is more effective in removing existing Si contaminants on the polished titanium surface than SiO_2 glass or Al grits. Given the same material, a larger grit size introduces fewer residues as observed in this study.

4. REFERENCES

[1] P. Fauchais, M. Fukumoto, A. Vardelle, M. Vardelle, Knowledge concerning splat formation: an invited review, J. Therm. Spray Technol. 13 (3) (2004) 337–360

[2] Guo CY, Matinlinna JP, Tang ATH (2012) A novel effect of sandblasting on titanium surface: static charge generation. J Adhes Sci Technol 26:2603–2613

[3] Residual Contaminations of Silicon-Based Glass, Alumina and Aluminum Grits on a Titanium Surface After Sandblasting Cecilia Yan Guo, Jukka Pekka Matinlinna, James Kit-Hon Tsoi & Alexander Tin Hong Tang

[4] M. Yoshinari, K. Matsuzaka, T. Inoue, Y. Oda, M. Shimono, Bio-functionalization of titanium surfaces for dental implants, Materials Transactions 43 (2002) 2494–2501.

[5] K.W. Bird, Resista-clad titanium in the chemical process industries, in Proceedings of the 1998 TMS Annual Meeting, February 16, 1998–February 19, 1998, Minerals, Metals & Materials Soc (TMS), San Antonio, TX, USA, 1998, pp. 245–253.

[6] Y. Yamashita, I. Takayama, H. Fujii, T. Yamazaki, Applications and features of titanium for the automotive industry, Nippon Steel Technical Report (2002) 11–14

[7] O. Schauerte, Titanium in automotive production, Advanced Engineering Materials 5 (2003) 411–418.

[8] T. Bell, H. Dong, Surface engineered titanium – the automotive metallic material of the 21st century, in:.

[9] K.G. Budinski, Tribological properties of titanium alloys, Wear 151 (1991) 203–217.

[10] U. Wiklund, I.M. Hutchings, Investigation of surface treatments for galling protection of titanium alloys, Wear 250–251 (2001) 1034–1041. [8] A. Bloyce, P.H. Morton, T. Bell, Surface engineering of titanium and titanium alloys, in: C.M. Cotell, J.A. Sprague, J.F.A. Smidt (Eds.), Surface Engineering, ASM International, Materials Park, OH, 1994, pp. 835–851.

[11]Oerlikon manual Technical Specifications

[12] M. Melli, A. Grimaud, A.C. Leger, P. Fauchais, and J. Lu, Alumina Grit Blasting Parameters for Surface Preparation in the Plasma Spraying Operation, J. Therm. Spray Technol., 1997, 6(2), p 217-227

[13] Darvell BW, Samman N, Luk WK, Clark RKF, Tideman H (1995) Contamination of titanium casting by aluminum oxide blasting. J Dent 23:319–322

[14] Aparicio C, Gil FJ, Fonseca C, Barbosa M, Planell JA (2003) Corrosion behavior of commercially pure titanium shot blasted with different materials and size of shot particles for dental implant applications. Biomaterials 24:263–273

[15]. K. Poorna Chander, M. Vashista, K. Sabiruddin, S. Paul, and P.P. Bandhopadhyay, Effect of Grit Blasting on Surface Properties of Steel Substrates, Mater. Des., 2009, 30, p 2895-2902

[16] Aparicio C, Gil FJ, Fonseca C, Barbosa M, Planell JA (2003) Corrosion behavior of commercially pure titanium shot blasted with different materials and size of shot particles for dental implant applications. Biomaterials 24:263–273

[17] International Conference on Advances in Surface Treatment: Research and Applications, ASTRA, November 3, 2003–November 6, 2003, International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad, India, 2004, pp. 12–19

[18] Alumina grit blasting parameters for surface preparation in the plasma spraying operation M. Mellali, A. Grimaud, A. C. Leger, P. Fauchais & J. Lu

[19] Surface Preparation Of Steel Substrates Using Grit-Blasting D. J. Varacalle, Jr. D. Deason W. Rhodaberger E. Sampson D. Post Guillen