iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: VII Month of publication: July 2019

DOI: http://doi.org/10.22214/ijraset.2019.7025

Investigation into the Super Finishing of Hole Surface of Titanium Grade-2 using One-Way Extrusion Honing Process

H P Raju[1], Sreenivasa Murthy B P[2]
[1]*Professor, Department of Mechanical Engineering, P.E.S.C.E, Mandya-571401, Karnataka state, India.*
[2]*PG Scholar, Lecturer, Department of Mechanical Engineering, GPT, Bagepalli, Chikkaballapur-561207, Karnataka state, India.*

Abstract: The surface requirements of engineering components vary widely depending on where the surface is being applied for. Fabrication of surfaces having desired characterises on materials possessing high hardness is the need of the hour to effectively overcome the contemporary application challenges. The surface generation of these difficult to cut material carrying intricate and unable to reach geometries could not be met by existing conventional finishing processes. So, several non-conventional finishing techniques were developed to meet the ever-growing requirements, among them, Extrusion Honing or Abrasive Flow Machining that works on flexible media carrying abrasive particles acting as tool can successfully fine finish the surface.

In the present study, the effect of process parameters of one-way extrusion honing on the surface characterises of Titanium Grade 2 is undertaken. The surface roughness is studied using stylus type surface measuring instrument and surface texture of the specimen before and after the process is analysed using SEM images. The results show a significant enhancement in surface finish using EH/AFM process and the process found quite capable in removing the surface irregularities and producing surface with enhanced overall surface integrity.

Keywords: Intricate shapes, Extrusion Honing, flexible media, abrasives, Titanium Grade 2, surface roughness, SEM.

I. INTRODUCTION

The Extrusion Honing (EH) or Abrasive Flow Machining (AFM) is one of the non-conventional finishing processes developed to improve the surface characteristics of hard materials carrying difficult to reach geometries / shapes. The extrusion honing process consists of machine, tooling and media. The process utilises the visco-elastic property of Silicone polymer and abrading characteristics of abrasive particles coupled together to form a working media and this media is made to pass through the extrusion passage formed by the tooling and workpiece under high pressure. The process can be equated to grinding machining operation. The media passing through the confined space, exerts force onto the workpiece surface and abrades the surface. Thus, the media behaves like grinding tool with abrasives in it as cutting edges. However, the tool in EH remains a flexible one. Through EH/AFM, polishing, deburring, removing recast layers and to remove stress raisers on the surface. AFM can lead to an accurate, repeatable and reliable surfaces yielding 90% improvement in surface finish with effective reduction in overhead costs associated with finishing operation [1]. Material removed and surface finish achieved under AFM process is mainly influenced by media viscosity and within first few cycles of the process most part of the surface finish is achieved [2]. Loveless studied the effects of AFM on surfaces produced by various machining operations namely; turning, milling, grinding and WEDM. The surface finish and total material removal achieved on WEDM'd found to be higher than other pre-machined surfaces. Initial irregular and uneven flow lines becomes straight indicating media flow path [3]. With increased extrusion pressure and concentration, active grain density and radial force increases, leading to an increase in percentage reduction of Ra and high material removal [4]. The hardness of material and its initial surface roughness found to govern the material removal rate and surface finish achieved in the process, with softer material yielding better results than harder one. Among all the factors governing the machining process, abrasive concentration plays a dominant role followed by mesh size, number of cycles and flow speed of media [5]. Abrasive media used in the process possesses good usability property. Deep tool marks in workpieces could not be removed, implying that a small grinding forces are operating in AFM process [6].AFM helps in enhancing surface integrity of the workpiece surface by inducing compressive residual stresses. The effect of AFM has been observed only beneath 10 µm from the outer layer leaving behind the bulk of the material property unchanged [7]. Bell mouthing resulting due to unguided media flow at the exit worsens the roundness (form) factor from entry to exit along the passage length. The diameter of the hole varies unevenly along the length with increasing number of passes revealing uneven material removal [8]. The surface parameters found to improve rapidly during early phases of honing owing to

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VII, July 2019- Available at www.ijraset.com

removal of dominant surface asperities, followed by progressive improvement due to crest flattening with deterioration of surfaces in later stages. The out of roundness appears to decrease with AFM process [9-10].
In the current study, extrusion honing operations were performed on Titanium Grade 2 at laboratory using an indigenously designed and fabricated EH set up. A selected grade polymeric material as carrier with silicon carbide (SiC) as abrasives owing to its high hardness have been used in developing media for conducting finishing operations. The extrude honed surface of Titanium Grade 2 have been evaluated in terms of surface finish parameters and the results show positive response.

II. EXPERIMENTATION

The fabrication of hole, preparing working media and precision finishing of hole using a one-way extrusion honing system constitutes the present experimental study. The surface roughness parameters of specimens were evaluated after each honing trials and SEM images were used to analyse the effect of honing on surface texture.

A. Workpiece Material

Extrusion Honing process was conducted on a standard Titanium Grade 2 (UNS R50400) material, which is rightly called as 'workhorse' of the commercially pure Titanium sector owing to its wide range of usability. Its application horizon has been kept expanding since its usage owing to its exceptional mechanical properties with high resistance to corrosion, cavitation and erosion. Aerospace and aeronautical industry is the prime consumer of titanium due to high strength to weight ratio coupled with high temperature properties. Due to high resistance to corrosion for water and chemicals, it is being prime material in marine, chemical processing and in nuclear structures. Because of its biocompatible and inertness to body fluids its presence in medial sector is been increasing. The chemical composition and mechanical properties of Titanium Grade 2 is listed in table 1 and table 2 respectively.

TABLE 1
Chemical Composition of Titanium Grade 2

Element	Concentration [wt.%]
Carbon, C	0.1 Max
Iron, Fe	0.3 Max
Hydrogen, H	0.015 Max
Nitrogen, N	0.03 Max
Oxygen, O	0.25 Max
Titanium, Ti	Balance

TABLE 2
Mechanical Properties of Titanium Grade 2

Properties	Metric
Ultimate Tensile strength	343 MPa
Yield strength	275 - 410 MPa
Vickers Hardness	145
Density	4.51 g/cm^3

B. Media Preparation

The most important aspect in Extrusion Honing is the preparation of working media. In this study, the working media is developed by using a select grade polymer carrier and silicon carbide (SiC) abrasive particles of 36 grit size. Abrasives with volume fraction (35%) of base polymer, were mixed thoroughly using an in-house fabricated silicone media mixer.

C. Specimen Prep+N9-aration

Test specimens of Titanium Grade 2 possessing Ø 25 mm and length 12 mm were prepared from its stock. These specimens were initially drilled for holes of diameters 6 mm, 8 mm and 10 mm using a carbide drill bit. Before conducting trials, initial surface roughness parameters of specimens were measured using Surfcom 130 roughness measuring instrument.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VII, July 2019- Available at www.ijraset.com

D. Experimental Trials

For the present study, a laboratory fabricated extrusion Honing system was used. The system is a one-way Extrusion Honing machine where the media is extruded in one direction. The system consists of a media chamber attached to a hydraulic cylinder and direction control valve. The media chamber is a piston cylinder configuration, where piston movement is actuated hydraulically. An end cap is used to close the open end of media chamber and it also acts as tolling helping in channelizing the media to the extrusion region. Provision is made on the end cap surface to hold the fixture carrying test specimens rigidly. As piston performs forward stroke, the flexible media enters the specimen from one side, hones the surface that comes in contact to it and leaves the specimen on the other side. This extruded media is collected using a collector. Each individual specimen was honed for 10 passes under constant experimentation conditions. Table 3 illustrates the machining parameters of present EH process. The surface roughness parameters were evaluated for each pass after cleaning the specimen surface with acetone and evaluations were done at three distinct locations on both entry and exit sides of the specimen.

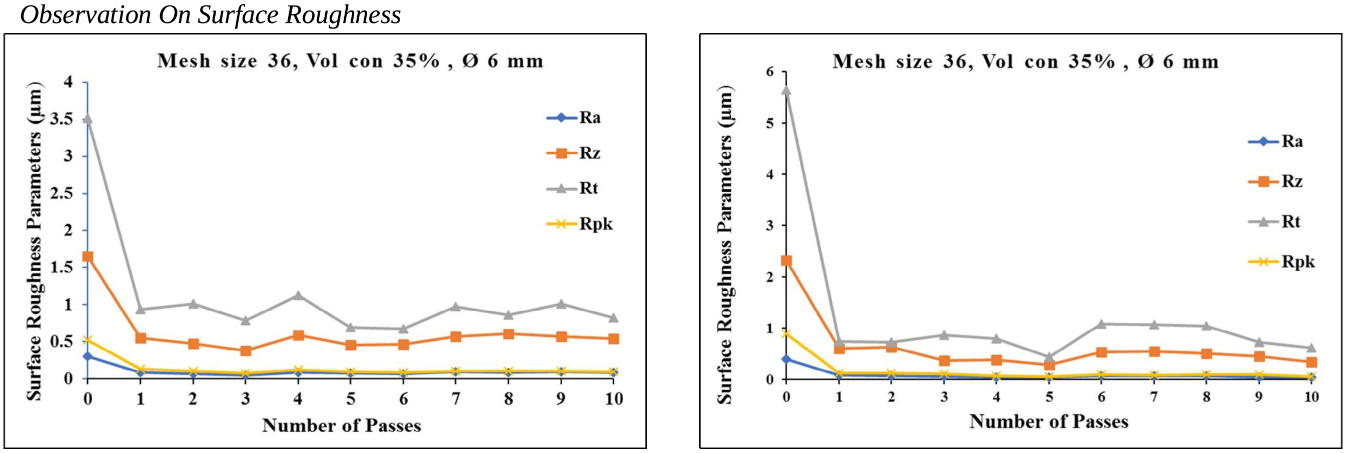
TABLE 3
Extrusion Honing Process Parameters

Parameters	Details
Number of passes	10
Hole diameter (mm)	6, 8 and 10
Abrasive mesh size	36
Volume fraction of Abrasive (in %)	35
Pressure(bar)	60
Temperature	Ambient
Stroke length	600 mm

III. RESULTS AND DISCUSSION

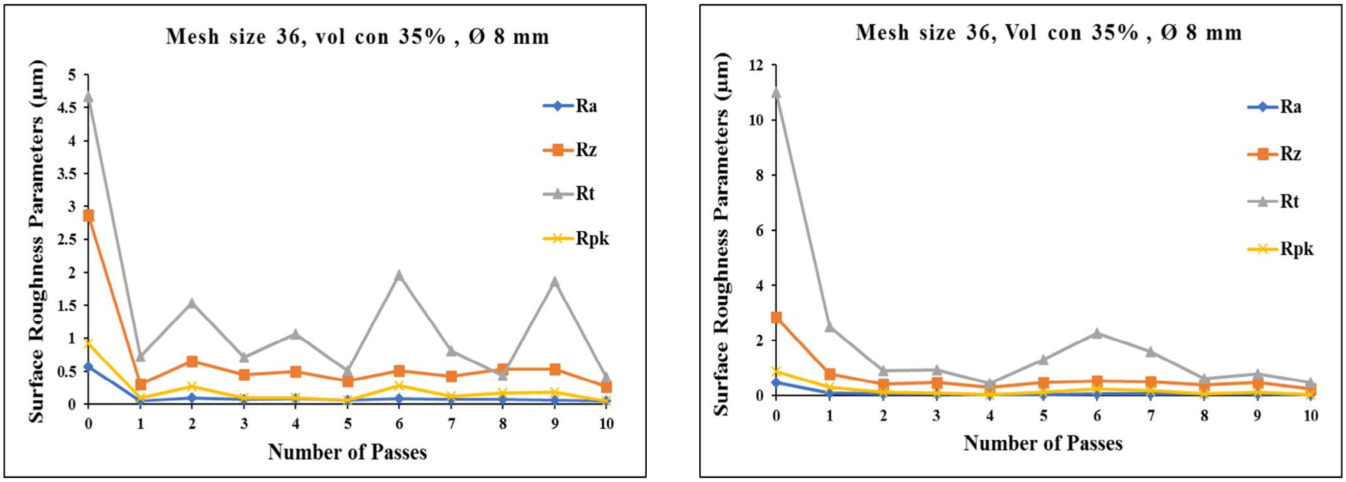
The primary purpose of this work is to eliminate unevenness and to achieve a fine surface finish by applying extrusion honing process on Titanium Grade 2. After each finishing process, the honed surface of specimens was evaluated in terms of its surface finish parameters (Ra, Rt, Rz and Rpk). Graphs were plotted for the parameters obtained after each experimental for hole diameter of 6 mm, 8 mm and 10 mm specimens.

A. Observation On Surface Roughness



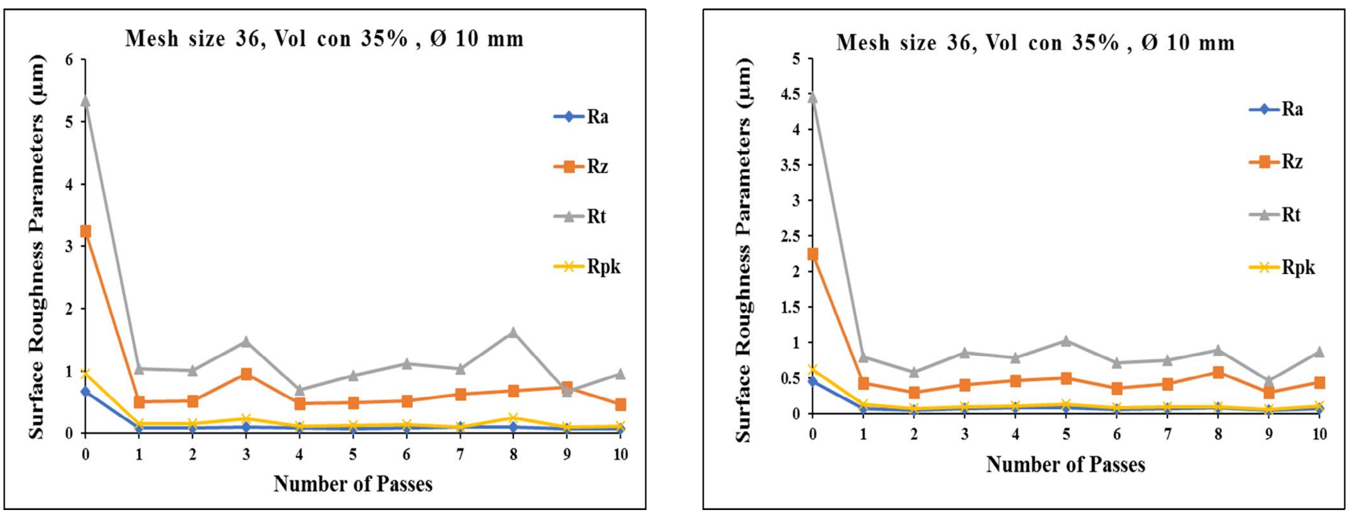
(a) (b)

Fig 3.1: Surface roughness parameters v/s number of passes for Ø 6 mm; (a) Entry side (b) Exit side



(a) (b)

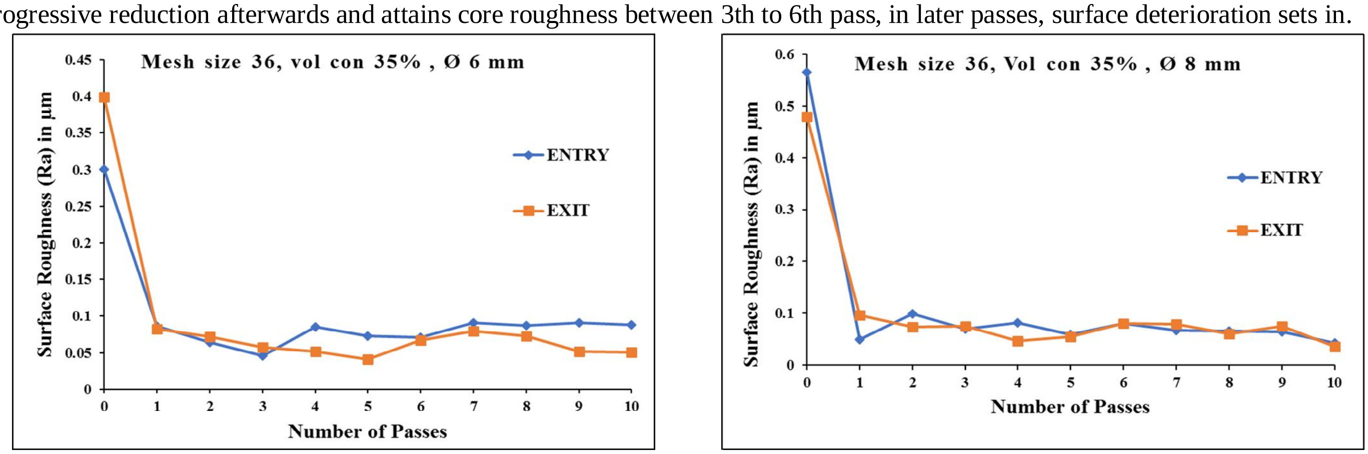
Fig 3.2: Surface roughness parameters v/s number of passes for Ø 8 mm; (a) Entry side (b) Exit side



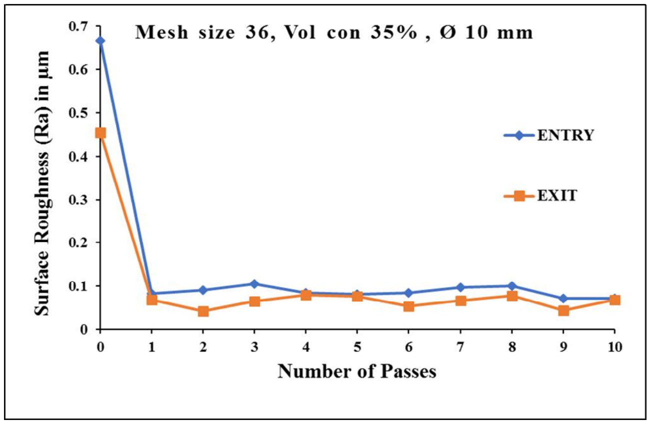
(a) (b)

Fig 3.3: Surface roughness parameters v/s number of passes for Ø 10 mm; (a) Entry side (b) Exit side

Fig 3.1, 3.2 and 3.3 depicts the effect of honing on roughness parameter on both entry and exit sides respectively. From the corresponding figures, it is observed that, there exhibits a drastic decline in surface roughness parameters after 1st pass followed by a progressive reduction afterwards and attains core roughness between 3th to 6th pass, in later passes, surface deterioration sets in.

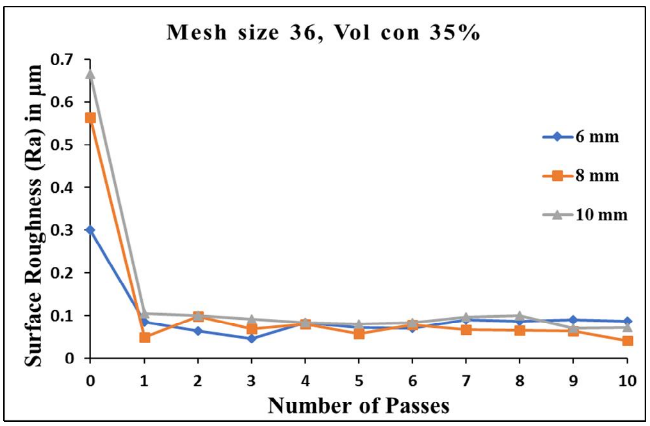


(a) (b)

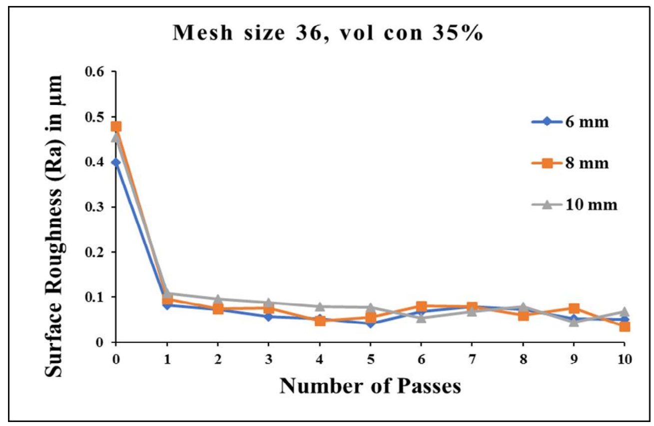


(c)

Fig 3.4: Surface roughness (Ra) at Entry and Exit side v/s number of passes; (a) Ø 6 mm, (b) Ø 8 mm and (c) Ø 10 mm



(a)

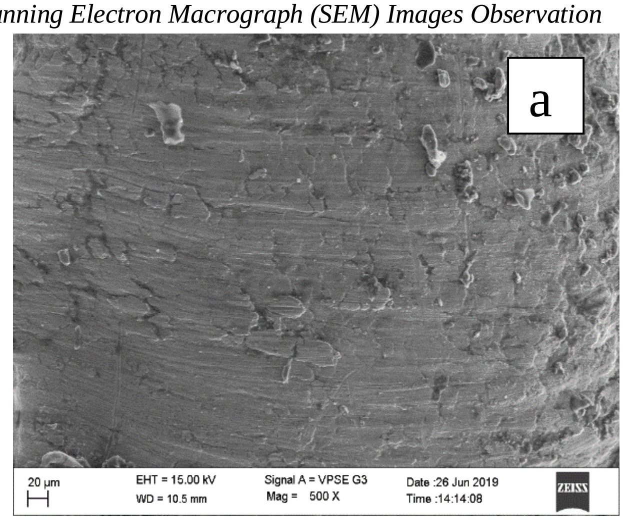


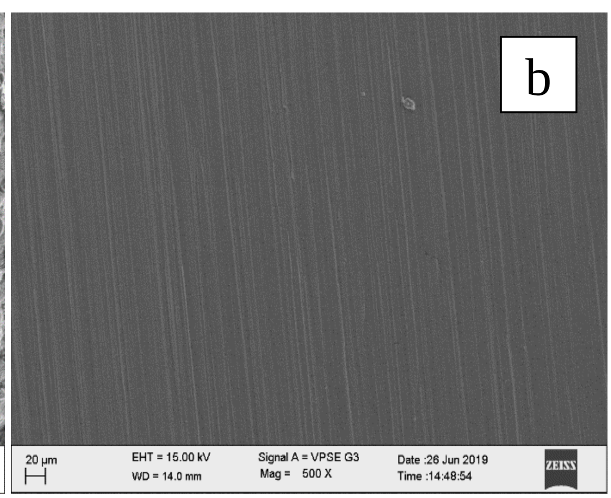
(b)

Fig 3.5: Surface roughness (Ra) for all specimens v/s number of passes; (a) Entry side (b) Exit side

Fig 3.4 compares the surface roughness (Ra) achieved on both entry and exit side of the specimens. It can be seen that, Ra along exit side of the media is better than the entry side. Fig 3.5 compares the variation in Ra for specimens of all diameters. It can be seen that, there exhibits an inverse relationship between the diameter of hole and the surface finish achieved during the process. As the diameter of the hole decreases, the surface finish achieved increases.

B. Scanning Electron Macrograph (SEM) Images Observation





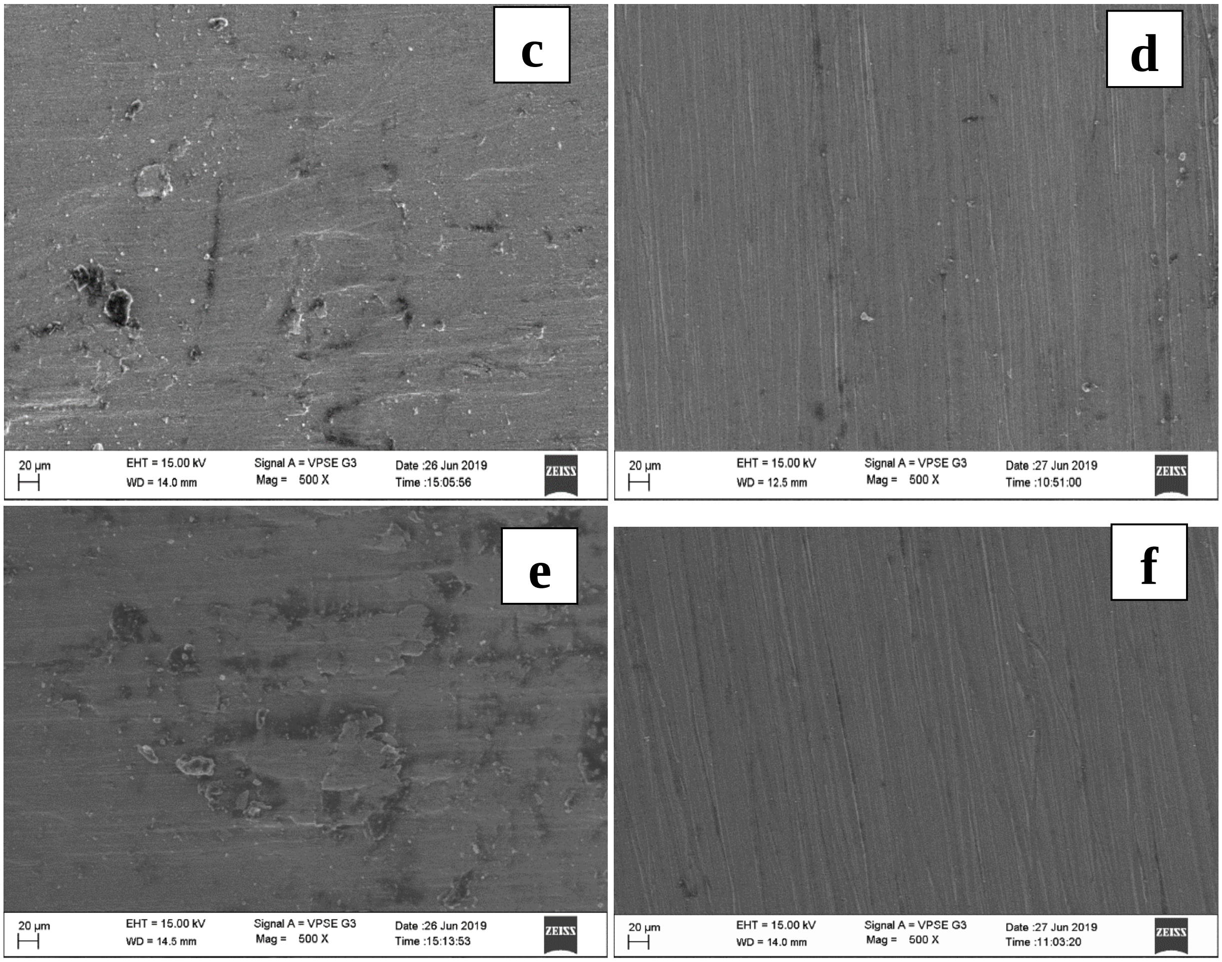


Fig 3.6: SEM images for 500 magnification; (a) Ø 6 mm, Zero pass (b) Ø 6 mm, Ten Passes (c) Ø 8 mm, Zero pass (d) Ø 8 mm, Ten Passes (e) Ø 10 mm, Zero pass (f) Ø 10 mm, Ten Passes

From the above SEM images (fig: 3.6), it can be seen that the uneven initial tool feed marks and macro surface irregularities of drilling operation have been effectively removed and replaced with a fine surface having a uniform lay.

IV. CONCLUSION

In the present study, Extrusion Honing of Titanium Grade 2 was carried on using a select grade silicone polymer and silicon carbide (SiC) abrasive particles. The extrusion Honed surface of Titanium Grade 2 were measured at three distinct positions on both entry and exit side of the abrasive media flow. From the present experimentation results, following conclusion could be drawn,

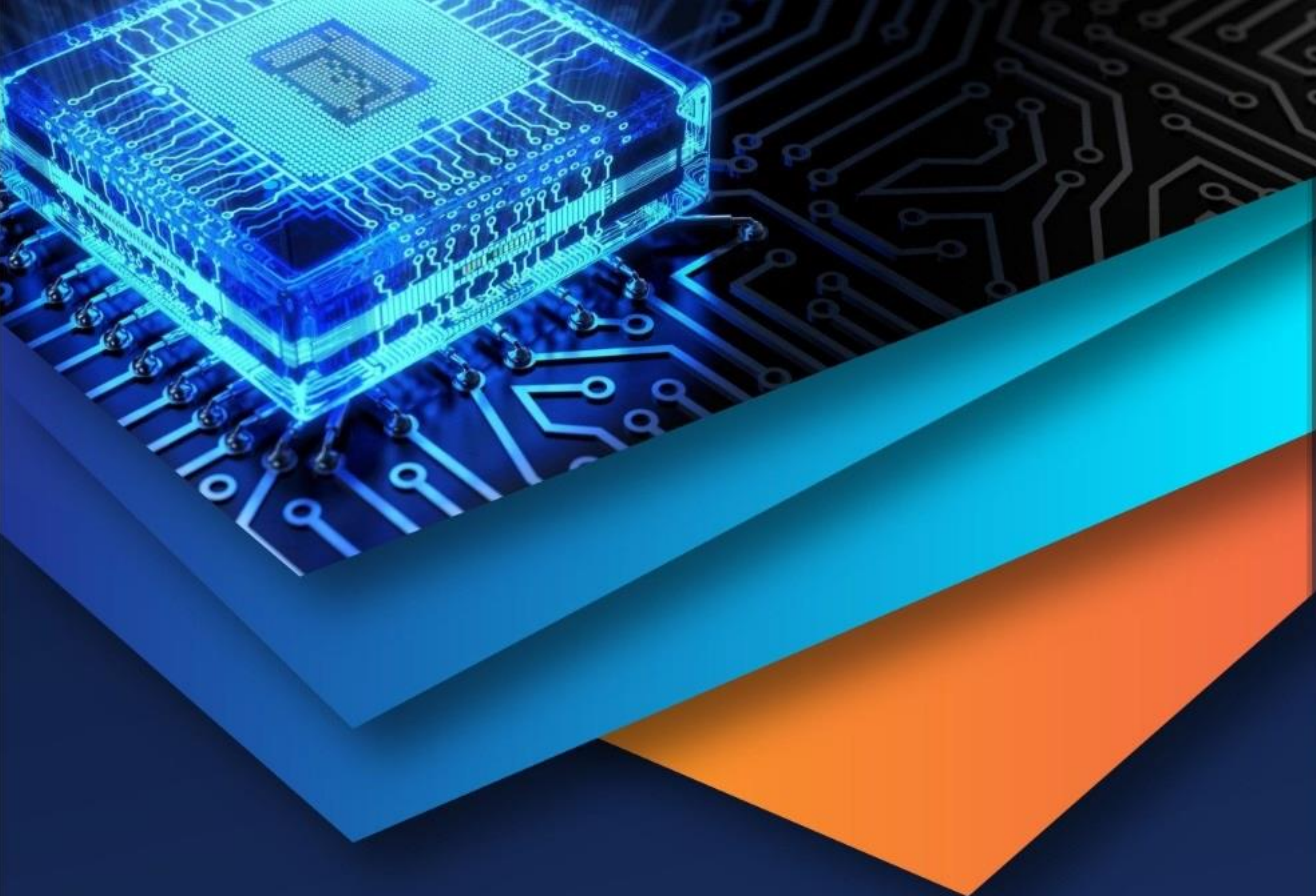
A. The present experimental conditions with select grade silicone polymer and SiC abrasives capable of producing a good surface finish on Titanium Grade 2.
B. Surface finish increases substantially after first pass followed by a progressive improvement and once the surface attains core roughness, surface starts to deteriorate.
C. Surface finish of specimen at media exit side is better than the media entry side.
D. The surface finish achieved increases as the extrusion zone cross sectional area decreases.
E. The uneven lay pattern of drilling has been replaced with a uniform lay.

V. ACKNOWLEDGEMENT

The authors would like to thank AICTE, New Delhi India, for their financial support to the project “Micro Finishing of Internal Primitives through Extrusion Honing Process” No.8023/BOS/RPS-123/2006-07. Authors also would like to thank Mr.N L Murali Krishna, professor, Department of Industrial and Production Engineering, PESCE Mandya for kind help during experimentation.

REFERENCES

[1] L.J. Rhoades, Abrasive flow machining: a case study, Journal of Material Processing Technology 28 (1991) 107–116.
[2] R.E. Williams, K.P. Rajurkar, Stochastic modelling and analysis of abrasive flow machining, Transactions of the ASME, Journal of Engineering for Industry 114 (1992) 74–81.
[3] T.R. Loveless, R.E. Willams, K.P. Rajurkar, A study of the effects of abrasive flow finishing on various machined surfaces, Journal of Material Processing Technology 47 (1994) 133–151.
[4] V.K. Gorana, V.K. Jain, G.K. Lal, On the effect of cutting forces and active grain density on surface roughness in abrasive flow machining, Int. J. Mach. Tool Manuf. 44 (2004) 201–211.
[5] Jain V.K., Adsul S.G., Experimental investigations into abrasive flow machining, International Journal of Machine tool and Manufacturer, 40 (2002), pp.1003-1021.
[6] Wang A. C. and S.H. Weng, Developing the polymer abrasive gels in AFM processes, Journal of Materials Processing Technology 192–193 (2007) 486–490.
[7] Kenda J, Pusavec F, Kermouche G and Kopac J, "Surface Integrity in Abrasive Flow Machining of Hardened Tool Steel AISI D2" Procedia Engineering 19 (2011), pp 172 – 177.
[8] Bahre D, Brunnet H, Swat M. Investigation of one-way abrasive flow machining and in-process measurement of Axial Forces. 5th CIRP conference on High Performance Cutting. 2012; p. 419-24.
[9] Raju H P, Narayanasamy K, Srinivasa Y G and Krishnamurthy R "Characteristics of extrude honed SG iron internal primitives" Journal of Materials Processing Technology 166 (2005), pp 455–464.
[10] Devadath, V R, Raju H P, A study of the effect of extrusion honing on Hastealloy c 22 using abrasives of different mesh sizes, international journal of current research in life sciences, Vol, 07, No 02, pp.1029-1035, February,2018.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY