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Study of Surface Roughness Parameters of Super Finished Hole Surface of Beryllium Copper by Extrusion Honing Process

H P Raju[1], Savitha D R[2]
[1]Professor, Department of Mechanical Engineering, PESCE Mandya, Karnataka, India.
[2]PG Scholar, Lecturer, Department of Machine Tool Technology, Govt. CPC Polytechnic Mysuru, Karnataka, India.

Abstract: A new non-traditional finishing process known as Extrusion Honing(EH) also called abrasive flow machining (AFM) is used to deburr, radius, polish and remove recast layer of components in a wide range of applications. Material is removed from the workpiece by flowing a semisolid selected grade silicone abrasive-laden medium across the surface to be finished. Areas inaccessible to traditional methods, and complex passages, can be finished to high quality by this process. The process embraces a wide range of feasible applications including aerospace, dies and moulds, automotive parts, medical components, etc.

In the present experiment Beryllium Copper is used as work material. The effects of different process parameters, such as number of cycle and concentration of abrasive, on surface finish are studied. The dominant process parameter found is concentration of abrasive, followed by number of cycles. Experimental results are discussed. The machined surface texture is studied using scanning electron microscopy (SEM). Results show a significant improvement in surface finish and EH/AFM is capable of removing the micro cracks and recast layer.

Keywords: Extrusion honing, beryllium copper, Surface finish, Abrasive Flow Machining, Silicone, AFM.

I. INTRODUCTION

Extrusion honing(EH) is a process to finish super alloys which are very difficult to machine, but using a semi solid paste to force through the inaccessible areas or cavities which are not possible to finish by other methods. This technique is ideal for all internal complex services like slots, cavities which are difficult to reach with other polishing techniques. It smoothes, finishes rough surfaces and mainly used to remove material burrs, to form radii and to polish.

The abrasive medium used in this process is a mixture of abrasive particles and visco-elastic polymer. Silicone carbide, aluminium oxide, boron carbide and diamond particles may be used as abrasive particles. carrier medium may be used polyborosilicone. This medium of abrasive laden polymer is passed through the workpiece. Abrasive particles penetrate the Workpiece surface work piece depending upon the radial pressure acting on it. The medium acts as a deformable stone to finish concave, convex, as well as complex shaped components.

Some of the researchers have deliberated the application of finished surface by abrasive flow machining.

Rhodes [1] developed abrasive flow machining which is used as finishing process for applications are from medical component and critical aerospace to high production volumes of parts.

Jain and Adsul [2] investigated on the effects of different process parameters, such as number of trials, concentration of abrasive, abrasive mesh size and media flow speed, on material removal and surface finish are studied. The dominant process parameter found is concentration of abrasive, followed by abrasive mesh size, number of cycles, and media flow speed.

Kavithaa T S et,al [3] conducted a research on “Abrasive flow finishing process-a case study”. The journal features the practical adeptness of the developed abrasive flow machining system which is outlined for effective nanometric finishing and burring of complex components.

Loveless et.al [4] studied the effects of AFM on surfaces produced by turning, milling, drilling and WEDM. WEDM surfaces were greatly enhanced by AFM. They observed that extrusion pressure have no noticeable effects on surface finish while viscosity of media considerably affects the surface finish enhancement.

Jain and Adsul [5] investigated effect of process parameters such as extrusion pressure, number of cycles, viscosity, abrasive concentrations and grain size on performance parameters like surface finish and material removal in AFM.

Raju H P et.al [6] evaluated improved surface properties in terms of surface roughness, bearing area fraction, out of roundness, induced residual stress and macrography.

Lingaraju K N and Raju H P [7] issued a journal on "Surface Finishing using Extrusion Honing Process on Monel- 400", in which they concluded that Surface finish at the exit side is exceptional than the entry side due to more desirable contact of the abrasive particles in the media at the exit side.

Raju H P et.al [8] concluded that Inconel 600 surface finish parameters show a progressive improvement till thirteenth pass in both entry and exit side of the specimen beyond which the surface starts deteriorating and Surface at the exit side is better than entry side due to better contact with abrasive medium.

In the present study, extrusion honing processes were performed on super alloy Beryllium Copper at laboratory using EH built set up. A selected grade, polymeric material as medium and silicon carbide as abrasive particles has been used for finishing process. Extrusion honed surface of Beryllium Copper have been evaluated in terms of surface finish parameters and the results show positive response.

II. EXPERMENTAL DETAILS

Experiment conducted on one way Extrusion honing machine built in Laboratory and surface parameters are evaluated for each trial. Surface roughness parameters measurements were taken at entry and exit positions for ϕ6mm, ϕ8mm and ϕ10mm. Finally, SEM images of work pieces before and after the 10 EH passes were taken.

A. Work Material details

UNS C17200 beryllium copper alloys are ductile and produced in mill hardened and heat treatable tempers. These alloys are used for all applications, which require high strength, stiffness and good conductivity.

1) Applications

The following are the major applications of the UNS C17200 copper:

a) Electrical/electronic connectors
b) Current carrying springs
c) Precision screw machined parts
d) Welding electrodes
e) Plastic molds/4 3
f) Corrosion resistant components
g) Liquid-fuel rockets have used rocket nozzles made of pure beryllium.
h) Beryllium metal is used for lightweight structural components in the defense
i) Aerospace industries in high-speed aircraft, guided missiles, spacecraft, and satellites

2) Properties of Beryllium copper

a) High electrical and thermal conductivity.
b) Good resistant to erosion, Machinability, Strength.
c) Fabrication is easy.
d) Non magnetic.
e) Identifiable Colour.
f) Welding, brazing and soldering can be done
g) Easily done by plating and lacquering.

TABLE 2.1
Chemical composition of beryllium copper

Element	Content %
Cu	97.9
Be	1.9
Co	0.20

TABLE 2.2
Physical properties of beryllium copper

Properties	Metric
Density	8.25 g/cm^3
Melting point	866 ^0C

TABLE 2.3
Mechanical properties of beryllium copper

Properties	Metric
Hardness, Rockwell B	80.0-85.0
Tensile strength, Ultimate	1280-1480 Mpa
Tensile strength, Yield	965-1205 Mpa
Elongation at break	15.0-30.0 %
Modulus of elasticity	125-130 Mpa
Poisson ratio	0.300
Machinability	20%
Shear modulus	50.0 Gpa

B. Specimen Preparation

Beryllium Copper specimens of 25 mm diameter and length 12 mm were cut from bar stocks and drilled by using carbide drill bits to prepare holes of diameter ϕ6mm, ϕ8mm and ϕ10 mm specimens as shown Fig.2.1(a). Initially, specimens were washed with acetone to remove the clogged particles. Surface roughness parameters were measured using a surface roughness measuring instrument (Surfcom 130A) before conducting the experiment.

Abrasive media is prepared by thoroughly mixing silicon carbide abrasives with silicone polymer using abrasive media mixer as shown in Fig.2.1 (b). The volume fraction of 35% silicon carbide abrasives with Silicone polymer as shown in Fig.(c) was used.

(a)

(b)

(c)

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C. Experimental Procedure

First, the extrusion honing machine as shown (Fig. 2.2) is switched on, the actuation of directional control valve in forward direction results in abrasive media to extrude through the specimen from one side and exits out at the other. After each trial the test specimens were thoroughly cleaned with acetone solution to remove residue polymer and other dust particles and surface roughness parameters were measured at 2 locations (drill bit entry side and drill bit exit side) for each and every pass the specimens by Surfcom 130A. (Fig.2.4) This procedure is repeated for 10 passes and results were tabulated and finally, Graphs were plotted for number of passes on X axis verses surface roughness parameters on Y axis.

Fig 2.2: Extrusion honing machine

Fig 2.3: Extrusion honing process

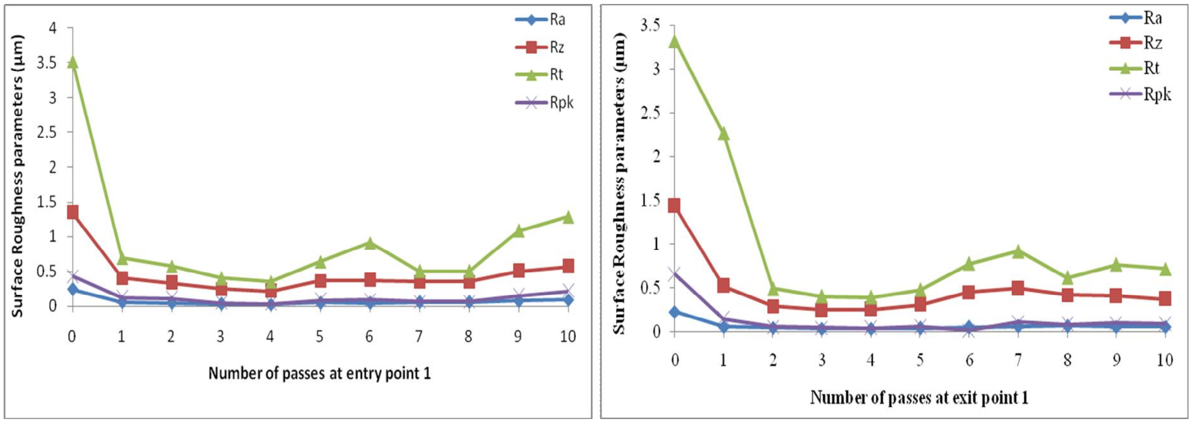
Fig 2.4: Surface roughness measuring instrument (Surfcom 130A)

TABLE 2.4
Extrusion Honing Process Parameters

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

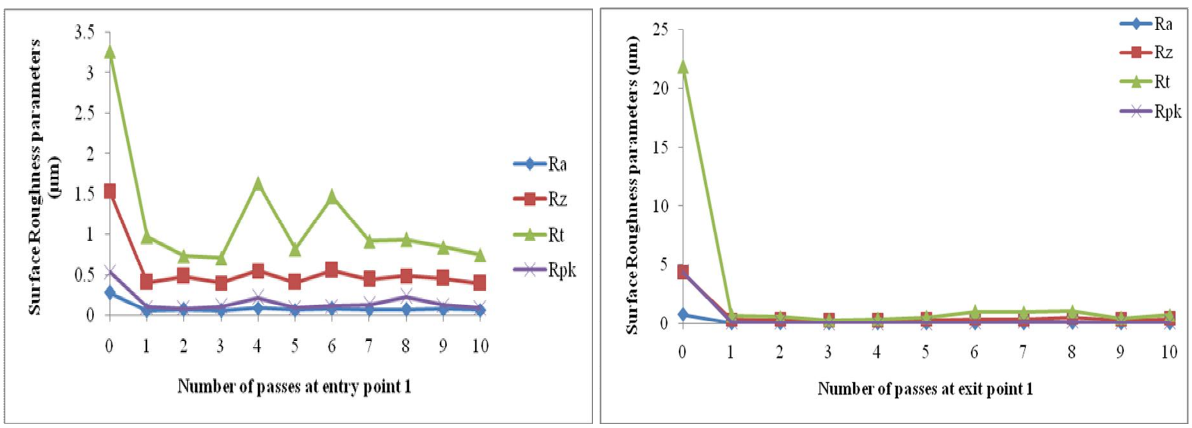
III. RESULTS AND DISCUSSION

Extrusion honing is essentially used as surface finishing operation. The main intend of this work is to explore the influence of extrusion honing process parameters on surface finish. Following Graphs show the variation of surface roughness parameters for Beryllium Copper. Here surface roughness parameters Ra, Rz, Rt, Rpk have been measured at two locations (entry side and exit side) of the specimen for ϕ6mm, ϕ8mm, and ϕ10mm**.**



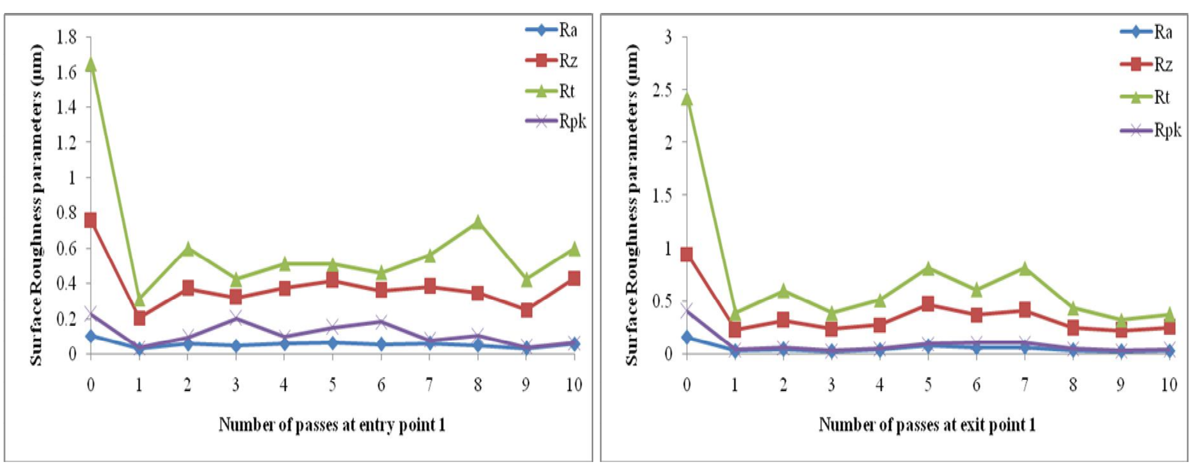
(a) (b)

Fig.3.1: Effect of surface roughness parameters v/s Number of passes for ϕ6mm hole at (a) Entry side and (b) Exit side



(a) (b)

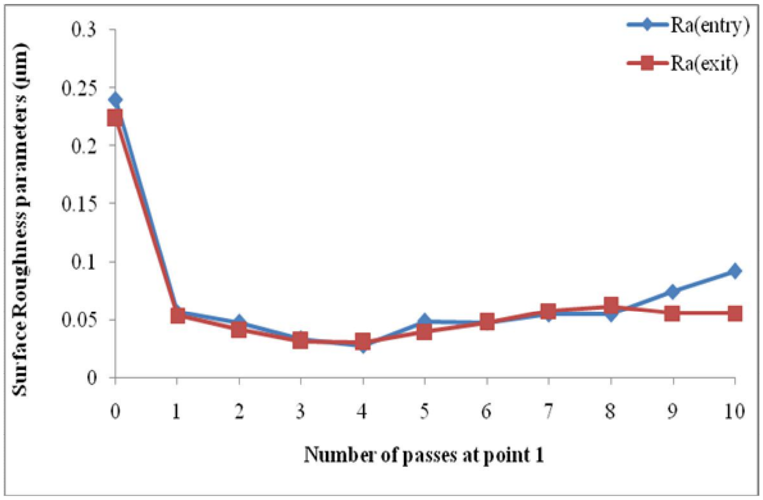
Fig.3.2: Effect of surface roughness parameters v/s Number of passes for ϕ8mm hole at (a) Entry side and (b) Exit side



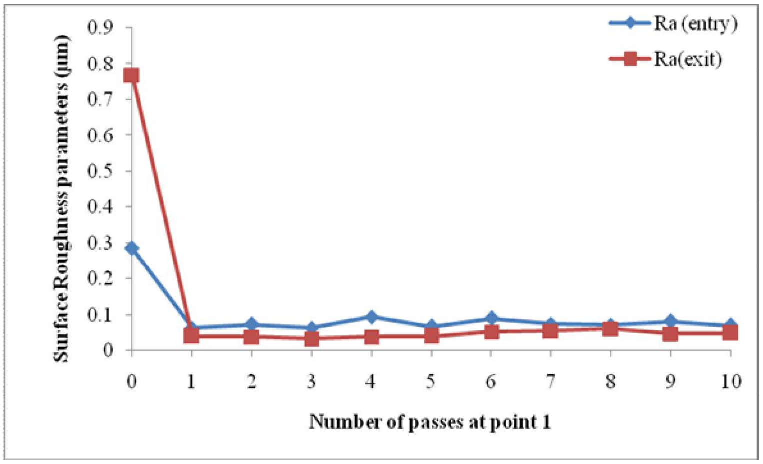
(a) (b)

Fig.3.3: Effect of surface roughness parameters v/s Number of passes for ϕ10mm hole at (a) Entry side and (b) Exit side

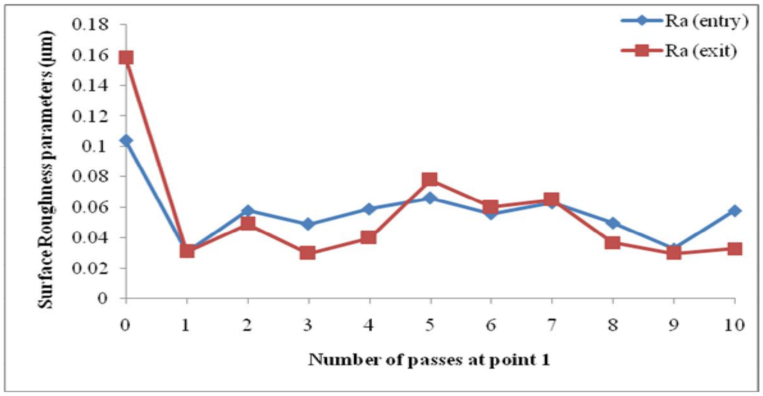
In all the above graphs it explains that Zero pass shows the initial surface roughness before extrusion honing. It can be seen from the figure, that there is a severe change in surface roughness parameters in the first pass. As the number of passes increase there is a steady improvement in the surface roughness. later there is rise in surface roughness parameters at some passes. Further as the number of passes increases their surface roughness parameters improve. Later surface roughness improves till 10th pass.



(a)



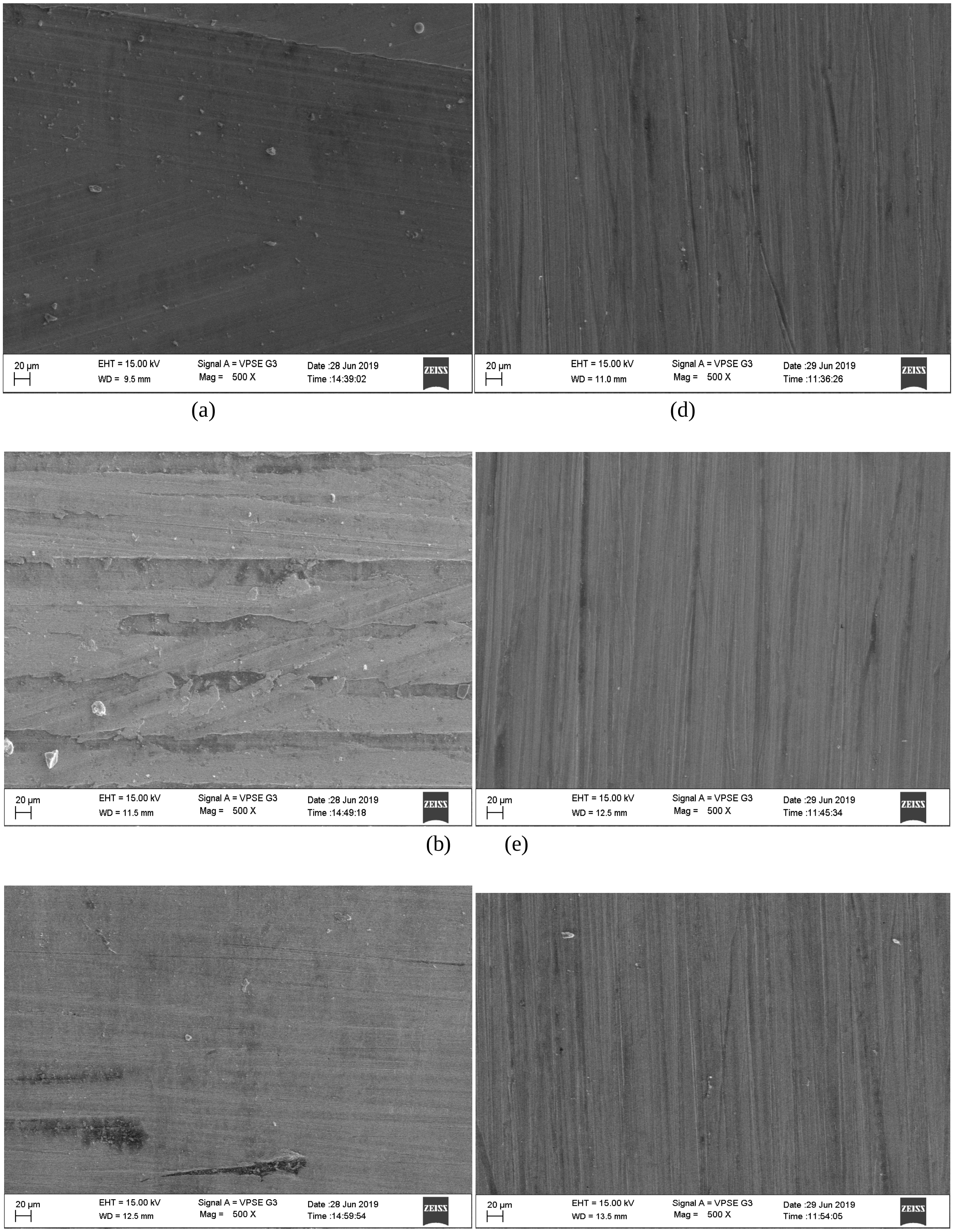
(b)



(c)

Fig. 3.4: Effect of surface roughness parameters v/s Number of passes at Entry side and Exit side (a) for ϕ6 mm (b) for ϕ 8mm (c) for ϕ10mm holes.

The above graphs were plotted for obtained results, it shows for Zero pass the initial surface roughness before extrusion honing. It can be seen from the figure, that there is a severe change in surface roughness in the first pass. As the number of passes increase there is a balanced improvement in the surface roughness. By comparing the results from graphs, it shows surface roughness at exit side for all the three diameters ϕ6 mm, ϕ 8mm and ϕ10mm were better than entry side.



(a) (d)

(b) (e)

(c) (f)

Fig. 3.5: SEM Images for (a) drilled surface of ϕ6mm hole (b) 10 EH passes surface of ϕ6mm hole (c) surface of ϕ8mm hole (d) 10 EH passes surface of ϕ8mm hole (e) surface of ϕ10mm hole (f) 10 EH passes surface of ϕ6mm hole

Drilled and extrusion honed surfaces of Beryllium copper is observed using Scanning electron microscope. The drilled lay pattern is revealed in fig. a), fig. c) and fig. e) for ϕ6mm, ϕ8mm and ϕ10mm respectively. After 10 passes of abrasive laden medium under 60 bar pressure through the work surface, drilled lay pattern is wiped off; texture of particle flow and abrasion scratches can be seen in these figures. An improvement in surface finish and breakdown of asperities is depicted in fig (b),fig (d) and fig.(f)

V. CONCLUSIONS

In this paper we investigated the surface parameters of Beryllium copper has been carried out with silicone polymer and SiC abrasives of 36 mesh sizes. Conclusions can be drawn as follows

A. The Select grade of polymeric medium can be used as abrasive carrier medium in extrusion honing.
B. The extrusion honing process with a pressure of 60 bar, abrasive particles of mesh size 36 and of volume fraction 35% and 10 EH passes shows good results in finishing of Beryllium Copper material.
C. At the entry side of the specimen, severe reduction in surface roughness parameters occurs at early stage within 3^{rd} pass to 4^{th} pass, after that there was continuous improvement in surface finish parameters up to 9th pass, beyond which the surface starts deteriorating.
D. For initial passes there is more material removed because more amount of asperities present in that pass. And as number of passes is increases material removal decreases. This is due to the reduction in the number of cutting edges of the abrasive particles.
E. Exit side shows better surface finish obtained than entry side of media for material.
F. It was also observed that exit side the core roughness is obtained.
G. SEM images of extrusion honed surface observed that the micro cracks and recast layer has been successfully removed by EH process.

VI. ACKNOWLEDGMENT

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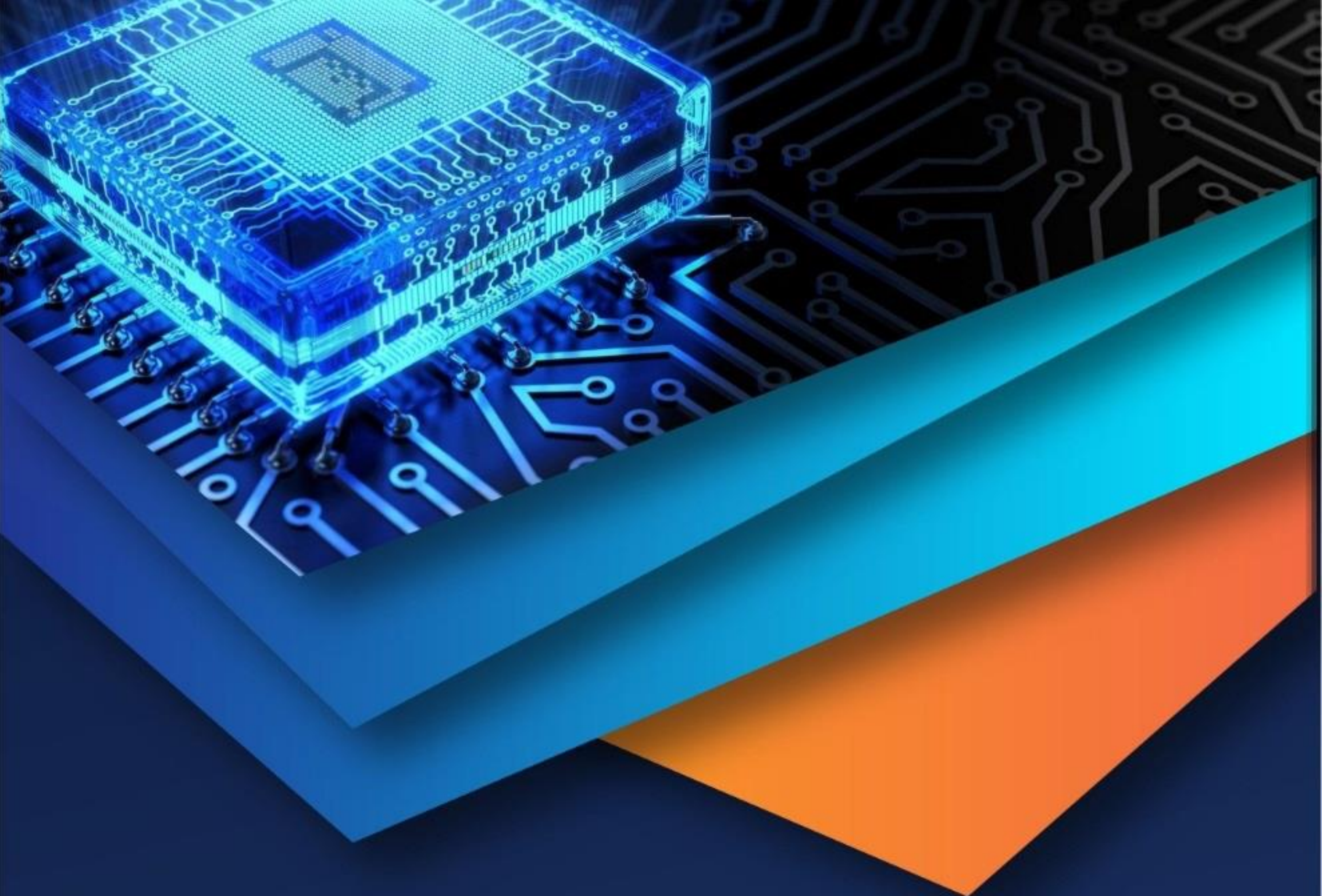

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