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Investigation the Surface Characteristics of Copper Using Extrusion Honing Process

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Abstract

Extrusion Honing is an advance machining process which is used to machine complex shape and is used to deburr, remove recast layer and radius surfaces and it is also known as Abrasive Flow Machining. This experiment uses a developed Extrusion Honing machine and an experiment employing abrasive flow machining was conducted on copper. In this experiment AFM parameters such as abrasive particle size, concentration, and number of cycles were carried out. In the optimization work surface roughness taken as output. The surface finishing is better with use of abrasive flow machining process as compared to other flow machining processes. It promises to provide accuracy and economy needed for manufacturing. Material is removed by flowing abrasive laden media under pressure through the work piece surface to be finished. The abrasive media applied during this process is a semisolid visco-elastic abrasive laden polymeric media which carries silicon carbide grains. In this study, Extrusion honing of Copper has been performed in a hydraulic operated EH setup using select grade of polymer as a carrier medium and Silicon Carbide (SiC) grits of 36 mesh size as abrasives. The internal surface finish results are evaluated in terms of surface roughness (R_a, R_z, R_t and R_{pk}) for 6 mm, 7 mm, 8 mm, and 9 mm hole diameter. The processed surfaces were measured and analyzed with the help of surface roughness tester and Scanning Electron Microscope (SEM). Results show a significant improvement in surface finish and EH/AFM is capable of removing the micro cracks and recast layer.

Key Words: *Surface finish, Extrusion honing, Copper, Abrasive Flow machining, Silicone, SiC.*

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I. INTRODUCTION

Extrusion Honing is very efficient, suitable for the finishing of complex inner surfaces. In recent years, hybrid-machining processes have been developed to improve the efficiency of a process by clubbing the advantages of different machining processes and avoiding limitations. It is experimentally confirmed that abrasive flow machining can significantly improve surface quality of nonlinear runner, and experimental results can provide technical reference to optimizing study of abrasive flow machining theory.

The process of abrasive flow machining produces a smooth, polished finish using a pressurized media. The medium used in abrasive flow machining is made from a specialized polymer [1]. Extrusion Honing/Abrasive Flow Machining is an industrial process used in metal working. This process is used to finish the interior surfaces of cast metals and produce controlled radii in the finished product. The process of abrasive flow machining produces a smooth, polished finish using a pressurized media. The medium used in abrasive flow machining is made from a specialized polymer. Abrasives are added to the polymer, giving it the ability to smooth and polish metal while retaining its liquid properties. The liquid properties of the polymer allow it to flow around and through the metal object, conforming to the size and shape of the passages and the details of the cast metal. Abrasive flow machining equipment is made in single and dual flow systems. In a single flow system, the abrasive media is forced through the project at an entry point and then exits on the other side, leaving a polished interior to mark its passage. For more aggressive polishing, the dual flow abrasive flow machining system might be employed. In dual flow system, the abrasive media flow is controlled by two hydraulic cylinders. These cylinders alternate motions push and pull the media through the project. This delivers a smoother, highly polished end result in much less time than a single-flow system.

Today, EH enjoys the status of one of the best processes for finish machining of inaccessible contours on difficult to machine components of a wide range of metallic materials.

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II. LITERATURE REVIEW

Ramandeep Singh et.al [1] has explained a magnetic field has been applied around the work-piece being processed by MFAAFM and an enhanced rate of material removal was achieved. The following conclusions can be drawn from the study: Magnetic field significantly affects MR. The slope of the curve indicates that MR increases with magnetic field. At 0.4 Tesla magnetic field density MR is maximum and then there is marginal variation upto 0.6 Tesla. Thereafter the MR reduces sharply.
Sunil Kumar Yadav et.al [2] reported that AFM is a well established advanced finishing process capable of meeting the advance finishing requirements in various sectors of applications like aerospace, medical and automobile. It is commonly applied to finish complex shapes for better surface roughness values and tight tolerances. Though there are many advantages of AFM process, but it has a few disadvantages also, such as low material removal and surface finishing rate, and incapability to correct the form geometry. The better performance is achieved if the process is monitored online. So, acoustic emission technique is used to monitor the surface finish and material removal but ended with only marginal improvement. To achieve an accurate and efficient finishing operation without compromising the finishing performance, input parameters and output responses, many modified processes such as Magnetic Abrasive Flow Machining (MAFM), Drill Bit Guided Abrasive Flow Finishing (DBGAFF), Centrifugal Force Assisted Abrasive Flow Machining (CFAAFM), R-AFF Spiral Polishing Method etc are used. In spiral polishing, CFAAFM and DBGAFF processes, the probability of role of additional tooling which is at the middle of the slug has less influence on the finishing direction of active abrasive grain. But later this problem is solved by rotating the work piece itself. It makes the active abrasive grains to follow helical path, which improves the contact length of the active abrasive grain with work piece.
Jitender Panchal et.al [3] concluded that it is generally applied to finish complex shapes for better surface roughness values and tight tolerances. It is possible to increase the performance of conventional AFM by providing additional motion to the media. But the major shortcoming of this process is slow finishing rate. So continuous efforts are being made to increase finishing rate, improve surface texture and to some extend to improve MRR. If higher the Extrusion pressure and speed of the piston higher will be the material removal rate and surface finish.
Loveless et.al [4] studied the effect of viscosity of media on surface finish. They found that viscosity is the only parameter which significantly affects the surface finish. They found the relationship between initial surface finish and percentage improvement in surface finish is non-linear.
Jain Raj et.al [5] have described the concepts of a stochastic methodology, which generates and statistically evaluates the interaction between spherical abrasive grains and work piece surface. The simulation enables prediction of the active grain density at any concentration and mesh size. A microscopic technique has also been developed to determine abrasive grain density. Grain density increases with increase in abrasive mesh size and percentage concentration of abrasives. The proposed stochastic simulation can be easily extended for simulation of surface generation in abrasive flow machining.
Sehijpal Singh et.al [6] presented a magnetic field has been applied around a component being processed by abrasive flow machining and an enhanced rate of material removal has been achieved. Empirical modeling with the help of response surface methodology has led to the following conclusions about the variation of response parameters in terms of independent parameters within the specified range. Magnetic field significantly affects both MR and *R*a. The slope of the curve indicates that MR increases with magnetic field more than does *R*a. Therefore, more improvement in MR is expected at still higher values of magnetic field. For a given number of cycles, there is a discernible improvement in MR and surface roughness. Fewer cycles are required for removing the same amount of material from the component, if processed in the magnetic field. Magnetic field and medium flow rate interact with each other. The combination of low flow rates and high magnetic flux density yields more MR and smaller *R*a. Medium flow rate does not have a significant effect on MR and *R*a in the presence of a magnetic field MR and *R*a both level off after a certain number of cycles

III. EXPERMENTAL DETAILS

Experiment conducted in Extrusion honing built in Laboratory and surface parameters are evaluated for each trial. Surface roughness measurements were taken at entry and exit positions. Finally, SEM photographs of work pieces before and after the EH process were taken.

3.1 Work Material details

Mankind has used copper since the ancient times. Its mechanical properties and structure are well explored and known. Application of copper in many branches of industry, e.g. in production of wires, copper-based solar power collectors, integrated circuits and generally in electronics, is intensive and has been steadily increasing in recent decades. Copper can be also recycled very effectively and represents a relevant engineering material also for the future.

3.2 Properties of copper

1. High electrical and thermal conductivity.
2. Good corrosion resistance, Machinability, Strength.
3. Ease of fabrication.
4. Non magnetic.
5. Has a pleasing colour.
6. Can be welded, brazed, and soldered

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Easily finished by plating and lacquering.

Table 3.1: Mechanical properties of Inconel 600

Density	8.96 g/cm³
Hardness	56 BHN
Tensile strength	387 MPa
Yield strength	220 MPa

3.3 Specimen preparation

Copper specimens of 25 mm diameter and length 12 mm with hole diameter of 6, 7, 8 and 9 mm. The specimens were initially drilled using HSS drill bits and thoroughly 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 (Fig 3.1). The volume fraction of silicon carbide abrasives with Silicone polymer used was 30%.

Fig 3.1: Copper specimens and Silicone media mixer

3.4 Experimental Procedure

Initially the extrusion honing machine 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 clogged polymer and other dust particles and surface roughness parameters were measured at 2 locations (drill entry side and drill exit side). Also for each and every pass the specimens were weighed using a electronic balance. This procedure is repeated for 10 passes and results were tabulated and finally, Graph will be plotted verses number of passes on X axis and surface roughness parameters on Y axis.

Fig 3.2: Extrusion honing process

Fig 3.3: Electronic weighing Machine

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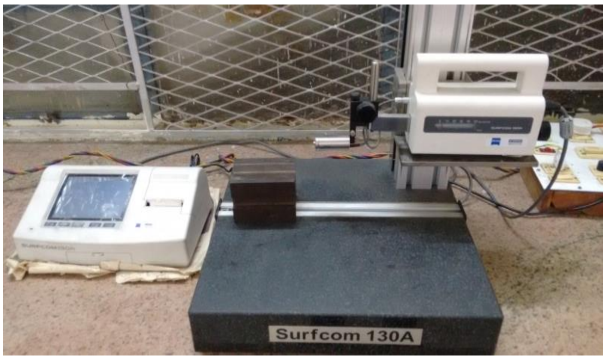


Fig 3.4: Surface roughness measuring instrument (Surfcom 130A)

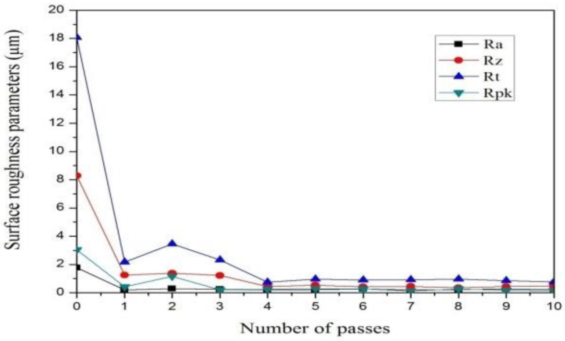
Table 3.2: Extrusion Honing Process Parameters

Parameters	**Details**
Number of passes	10
Hole diameter (mm)	6, 7, 8, 9
Abrasive mesh size	36
Volume fraction of abrasives	30%
Pressure	60 bar
Temperature	Ambient
Stroke length	600

IV RESULTS AND DISCUSSION

Extrusion honing is mainly used as surface finishing operation. The main aim of this work is to investigate the influence of extrusion honing process parameters on surface finish. Following plots show the variation of surface roughness parameters and material removed for Copper. Here Ra, Rz, Rt, Rpk have been used as the surface roughness parameters and are measured at 2 locations (entry side and exit side) of the specimen**.**

4.1 Surface Parameters Graphs



Graph 4.1: Hole dia 6 mm (Drill entry) effect of number of passes on surface roughness.

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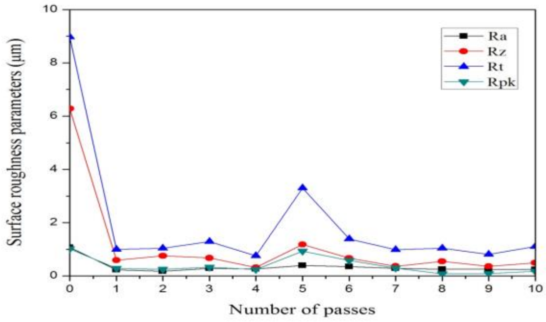
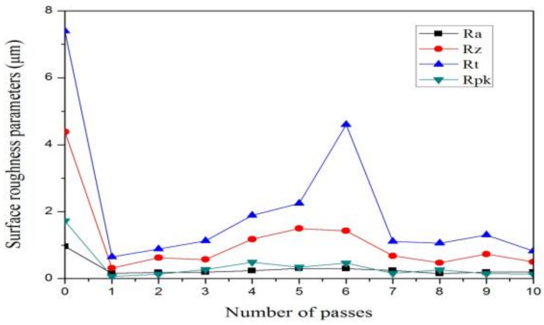
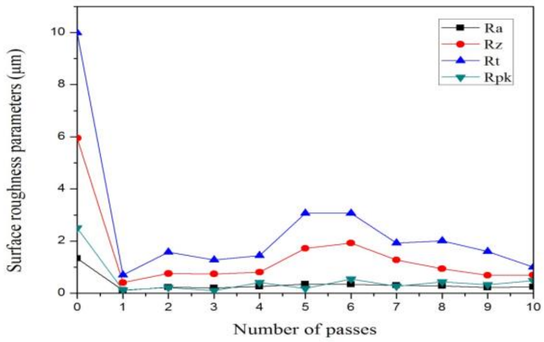


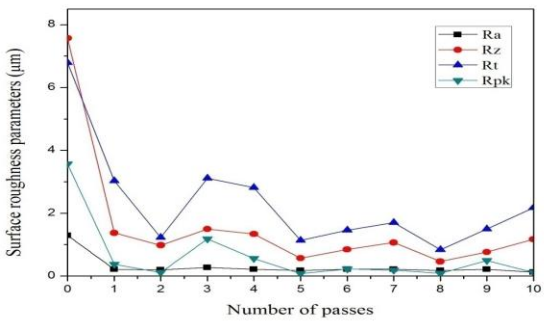
Graph 4.2: Hole dia 6 mm (Drill exit) effect of number of passes on surface roughness.



Graph 4.3: Hole dia 7 mm (Drill entry) effect of number of passes on surface roughness.



Graph 4.4: Hole dia 7 mm (Drill exit) effect of number of passes on surface roughness



Graph 4.5: Hole dia 8 mm (Drill entry) effect of number of passes on surface roughness

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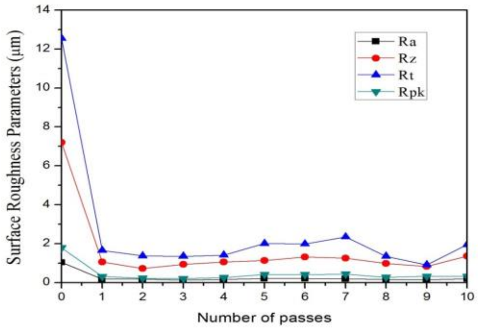
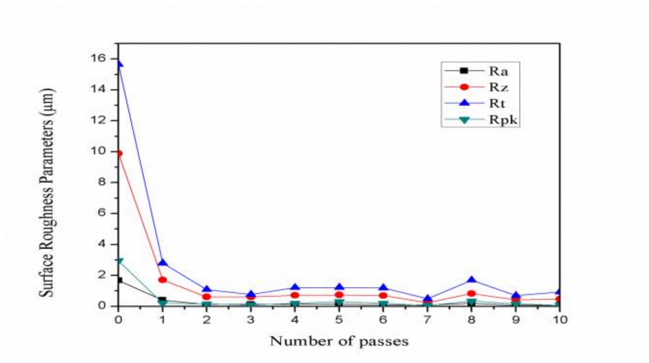
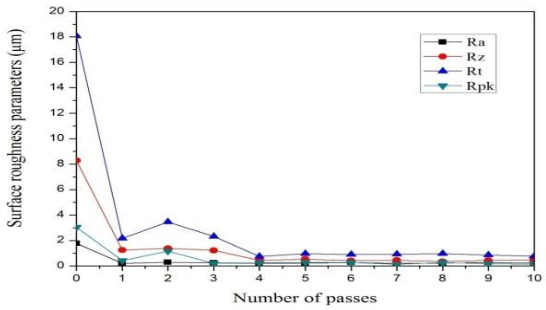


Graph 4.6: Hole dia 8 mm (Drill exit) effect of number of passes on surface roughness



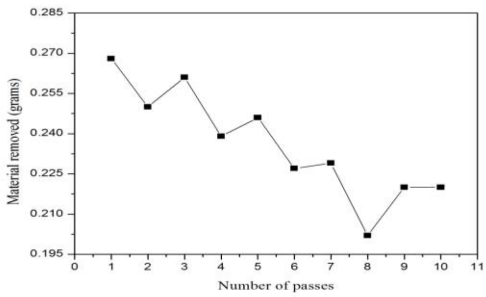
Graph 4.7: Hole dia 9 mm (Drill entry) effect of number of passes on surface roughness



Graph 4.8: Hole dia 9 mm (Drill exit) effect of number of passes on surface roughness

In all above graphs indicates that Zero pass shows the initial surface roughness before extrusion honing. It can be seen from the figure that there is a drastic change in surface roughness parameters in the first pass. As the number of passes increase there is a gradual improvement in the surface roughness. later there is rise in surface roughness parameters in 3^{rd} or some passes. Further as the number of passes increase their surface roughness parameters improves. Later surface roughess improves till 10th pass. Further 10^{th} passes surface roughness starts deteriorating.

4.2 Material removed from Specimens Graphs



Graph 4.9: Material removed from 6 mm dia specimen

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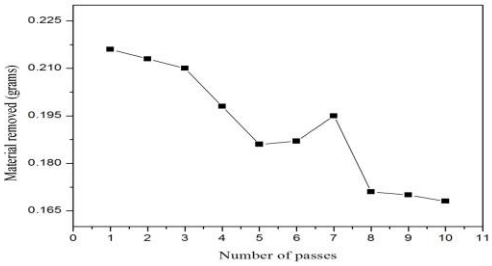
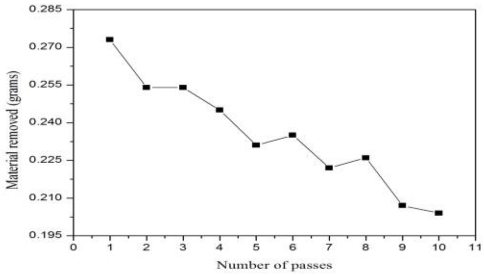
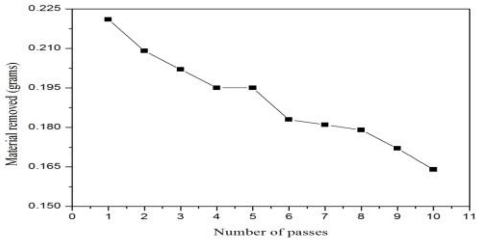


Graph 4.10: Material removed from 7 mm dia specimen



Graph 4.11: Material removed from 8 mm dia specimen



Graph 4.12: Material removed from 9 mm dia specimen

From the above graph that material removal from the specimens tends to decrease as the number of passes increase. At some passes (6^{th}, 7^{th} , and 8^{th}) there is rise in the material removal, which is because of the removal of more amount of aspirities present in that pass. Further material removal decreases as the number of pass increases. This is due to the reduction in the number of cutting edges of the abrasive particles.

4.2 SEM images for Copper specimen after Carrying EH Process of Passed Surfaces

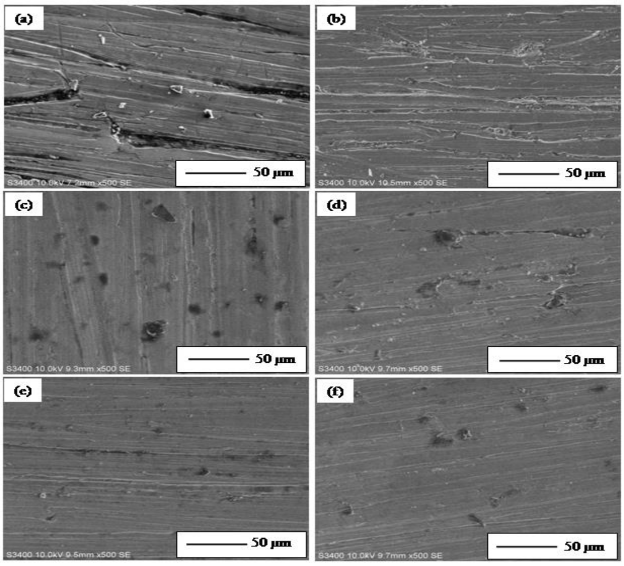


Fig 4.1: SEM Images for (a) Zero pass (b) Two pass (c) Four pass (d) Six pass (e) Eight pass (f) Ten pass

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Drilled and extrusion honed surfaces of copper is observed using Scanning electron microscope. The drilled lay pattern is revealed in fig 4.1 After two passes of abrasive laden medium under high pressure through the work surface, drilled lay pattern is wiped off; texture of particle flow and abrasion scratches can be seen in fig 4.1 (b). A progressive improvement in surface finish and folding of aspirities is depicted in Fig 4.1 (c) Four pass, (d) Six pass, (e) Eight pass and (f) Ten pass respectively.

V CONCLUSIONS

In this paper we investigated the surface parameters of copper has been carried out with silicone polymer and SiC abrasives of 36 mesh size. Following conclusions can be drawn.

1. The Select grade of polymeric medium can be used as abrasive carrier medium in extrusion honing.
2. The extrusion honing process with 60 bar pressure, abrasive particle size of 36 and of volume fraction 30% and 10 EH passes shows good results in finishing of Copper material.
3. At the entry side of the specimen drastic reduction in surface finish 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 9_{th} pass, beyond which the surface starts deteriorating.
4. It was also observed that exit side the core roughness is obtained.
5. Better surface finish obtained exit side of than entry side of media for material.
6. For initial passes there is more material removed because more amount of aspirities present in that pass. And as number of passes are increases material removal decreases. This is due to the reduction in the number of cutting edges of the abrasive particles.
7. SEM images of extrusion honed surface observed that the micro cracks and recast layer has been successfully removed by EH process.

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