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Characteristics Study of Inconel 718 Surface Generated By Extrusion Honing Process

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***Abstract:* -- Extrusion honing (EH) process is employed to deburr, polish or radius surfaces and edges by flowing a silicone abrasive medium over the surface to be finished. Such finishing operations play a vital role in producing method of machine components. EH could be a time consuming process, even though EH is employed within the industries particularly in the case of finishing complicated internal and external shapes. In EH process, medium is the key elements that control the finishing process. Though, commercially available abrasive medium are very expensive and its affordability is an issue, especially for price sensitive industries. Inconel (718) material is widely used in aerospace industries, hence it has been chosen for the characteristics study through EH process. In the present study silicone and silicon carbide abrasive is chosen as the medium. Surface roughness parameters are used as a means of determining the performance of the EH process. The main experimental parameters are the abrasive concentration, number of passes and keeping constant hydraulic pressure. It is observed that the roughness parameters Ra, Rz, Rt and Rpk decreases after 15 passes and 25% of volume fraction of abrasive concentrations were used for the experimentation.**

***Key words:* Extrusion, Honing, Surface characteristics, Inconel 718**

I.INTRODUCTION

Most of the components used in automobile and aerospace industries are replaced by advanced materials such as Metal Matrix Components and Inconel. Among them Nickel-based super alloy development for aerospace applications began in the 1930s. There is a strong trend in the aerospace industry towards reducing weight of the components. To meet these demands, the designers are introducing even more difficult material to machine, particularly in drilling operations [1]. Drilling can be described as a process where a multi-point tool is used to remove unwanted materials to produce a hole. During the drilling process, the most important factor affecting the cutting tool performance and work piece properties is cutting temperature that emerges between drill bit and chip [2]. Traditional Finishing processes have limitations in meeting the surface finish requirements of high end technological products. Conventional finishing processes are of little/no help in finishing intricate and irregular shapes, especially internal geometries. It is difficult to finish complex contours of components like turbine blades [3]. Parts with intersecting holes, complex shapes, inaccessible and difficult to reach internal passages will not render themselves to these processes to be performed. And also, advent of newer materials of higher hardness has compounded the finishing problem further [4]. Extrusion honing process was developed about fifty years ago to enhance the performance of automotive racing engines. The other name of the extrusion honing is abrasive flow machining. The demand for this process increased rapidly among car and motorcycle owners and soon caught the attention of professional racing teams worldwide. Today it ranks among the most sought after performance improvement available to car and motorcycle enthusiasts [5&6]. There also is a growing interest among personal watercraft and high-performance truck owners as well.

II. EXPERIMENTAL WORK

2.1 SELECTION OF MATERIAL

There is a strong trend in the aerospace industry towards reducing weight of the components. Hence inconel materials are used. Inconel 718 has been used in the present experiment.

Inconel 718 is a nickel-chromium-molybdenum alloy designed to resist a wide range of severely corrosive environments, pitting and crevice corrosion. This nickel steel alloy also displays exceptionally high yield, tensile, and creep-rupture properties at high temperatures. This nickel alloy is used from cryogenic temperatures up to long term service at 649° C. One of the distinguishing features of Inconel 718 composition is the addition of niobium to permit age hardening which allows annealing and welding without spontaneous hardening during heating and cooling. Table 2.1 shows the chemical composition of Inconel 718.

Ni	50.0
Fe	25.0
Cr	14.0
Cu	0.30
Mo	2.80

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Nb	4.75
C	0.10
Mn	0.35
P	0.15
S	0.15
Al	0.25
Co	1.0
B	0.15
Si	0.35
Ti	0.65

Table 2.1: Chemical composition of inconel 718 in weight (%).

2.2 Brinell Hardness Test

The Brinell hardness is considered as the best suited hardness testing for materials as it has larger area of indentation compared to other methods of indentation hardness. The Brinell hardness test of the inconel 600 have been carried out with a 10mm diameter hardened steel ball at a load of 500, 1000 and 1500kgs to avoid excessive indentation. The full load has been applied for 30 seconds and the diameter of indentation has been measured from a projection of the indentation on the screen with the help of tool maker microscope. The Brinell scale characterizes the indentation hardness of materials through the scale of penetration of an indenter, loaded on a material test-piece. The test is carried out with the reference value of the international standard.

2.3 MEDIUM

Silicone polymers, more properly called polysiloxanes, do not have carbon as part of the backbone structure. Various organic groups such as methyl or the benzene ring may be bonded to the silicon as shown below. Silicones are water repellent, heat stable, and very resistant to chemical attack. They find many uses in oils, greases, and rubberlike materials. Silicone oils are very desirable since they do not decompose at high temperature and do not become viscous. Other silicones are used in hydraulic fluids, electrical insulators and moisture proofing agent in fabrics. For the work it has been used as a medium it is also called as silly putty.

2.4 ABRASIVE

Silicon carbide is a popular abrasive in modern lapidary due to the durability and low cost of the material. In manufacturing, it is used for its hardness in abrasive machining processes such as grinding, honing, water- jet, abrasive jet cutting and sandblasting. Particles of silicon carbide are laminated to paper to create sandpapers and the grip tape on skateboards.

Fig 2.1: Silicon carbide abrasive.

2.5 Experimental Work:

Experimental work are carried out for the Inconel 718 alloy material on Extrusion honing machine to study the surface roughness of the material

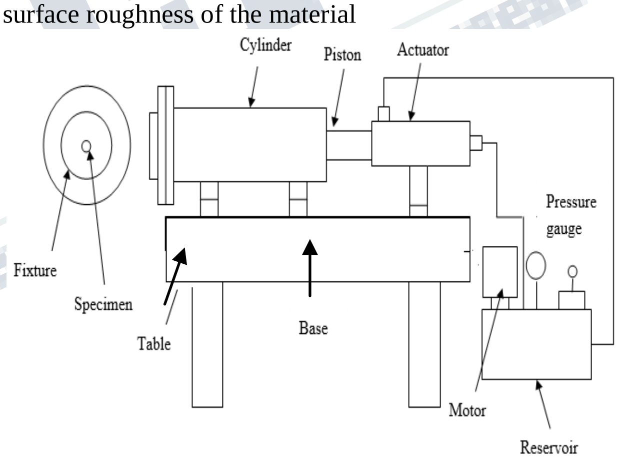

Fig 2.2: Extrusion honing machine setup.

A precision hole honing (polishing) in EH/AFM uses a hydraulic cylinder to push the abrasive medium through the hole with the help of a actuator. Because of the abrasive particles in the polymer, the surface and edge of the hole is finished by the pressurized motion. Fig.2.2 shows the machining diagram of the EH.

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Machine	Extrusion honing machine
Motor rpm	1440
Control	Direction control valve
Cylinder size	Ø 135mm × 635mm

Table 2.2: Specification of the Extrusion honing machine.

The abrasive is mixed in the silicone rubber by a rolling and mixing machine. In order to obtain a uniformly mixed medium. Finally, the abrasive medium is put into the round barrel and the workpiece is fixed in the fixture, and machined using pressured hydraulic system. The flexible honing is a high precision method in abrasive. In this experiment, the best machining condition is expected to be found to make high accuracy holes in EH/AFM.

2.6.1 SURFCOM 130A

Surfcom 130A (Fig.2.3) is a compact, hand-held surface tester. There is no easier way of measuring, evaluating and documenting surface roughness. Surfcom 130A measures not only flat, horizontal, but also vertical, overhead surfaces and simple measurement to waviness. In addition, 30 complete data records can be stored in the built-in memory and recalled at any time. It has the capability to measure roughness average (Ra), average maximum height of the profile (Rz), Rt and Rpk.

Fig 2.3: Surfcom 130A

Roughness Parameter considered in the present work are Ra, Rz, Rt and Rpk, these are measured to the length of 4mm on the 3 points of the specimen which are 120° to each other. Figure 2.3 shows the Surfcom 130A instrument used for the present study.

III. RESULT AND DISCUSSION

The main purpose of this experiment is to investigate the EH effect on the surface when silicone and silicon carbide abrasive is chosen as the medium. Surface roughness improvement are used as a means of determining the performance of the EH. The main experimental parameters are the abrasive concentration, the abrasive meshes, no of passes and the hydraulic pressure.

From the tabulated reading the graphs are plotted on the Inconel 718 alloys. The roughness parameters measured are Ra, Rz, Rt and Rpk, these reading are measured at 3 points of the hole.

POINT 1

The Inconel 718 specimen was extruded for the condition below.

- Grain size: 36
- Percentage of abrasive (sic): 25%
- Hydraulic pressure: 60 bar
- Hole size: Ø 8

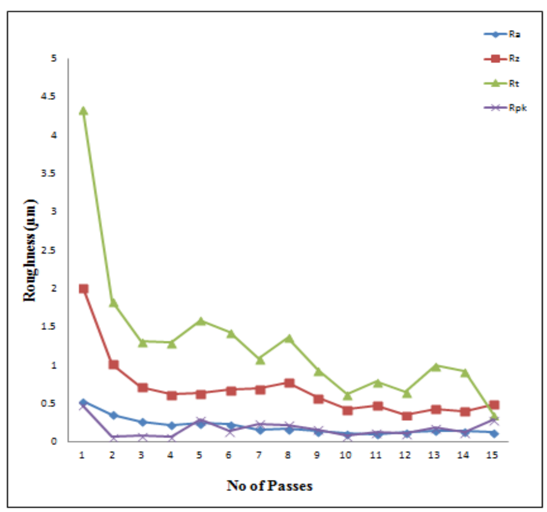

Fig 3.1: Inconel 718 at point-1 the effect of no of passes on

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the surface roughness.

From the figure (3.1) it can be seen that the roughness value improves as the no of passes increases. The finishing effect is affected by the abrasive size in the extrusion honing machine. And the efficiency is also changed in the different abrasive size.

Further fig indicates the number of passes increases the roughness value decreases. Initially the percentage improvement values are high because of availability of peaks in the early stages of the machining, but as these peaks get machined the percentage improvement in roughness values slowly decreases.

POINT 2

The specimen is indexed 120° to point-2 under the same parameter consideration the values tabulated and graph is plotted as same as the before.

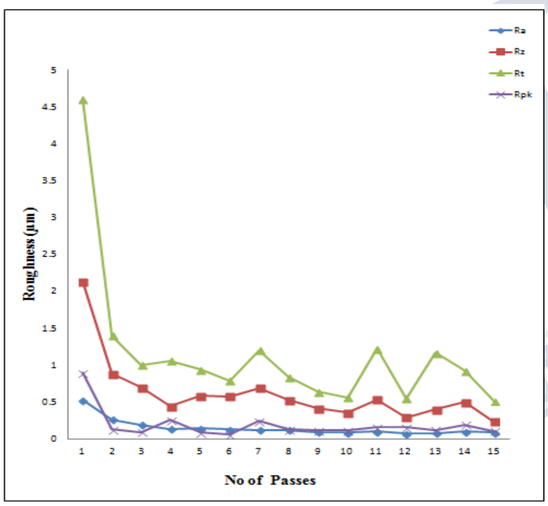

Fig 3.2: Inconel 718 at point-2 the effect of no of passes on the surface roughness.

Figure (3.2) indicate the variation in the surface roughness of Inconel 718 alloy at point -2 beginning from the 1st pass to the 5th pass.

Further fig shows the surface roughness improving gradually from 6th to 10th passes. From 6th pass it attains steady roughness hence there will be no much improvement. Normally the roughness value improves as the no of passes increases. The finishing effect is affected by the abrasive size in the extrusion honing machine. And the efficiency is also changed in the different abrasive size.

Surface roughness improved gradually from 11th to 15th passes. As the surface finish increases there will be improvement in the roughness. Core roughness is predicting that no further improvement, further it may lead to digging of the surface. As the number of passes increases the roughness value decreases. Initially the percentage improvement values are high because of availability of peaks in the early stages of the machining, but as these peaks get machined the percentage improvement in roughness values slowly decreases.

POINT 3

The specimen is indexed 120° to point-3 under the same parameter consideration the values tabulated and graph is plotted as same as the before.

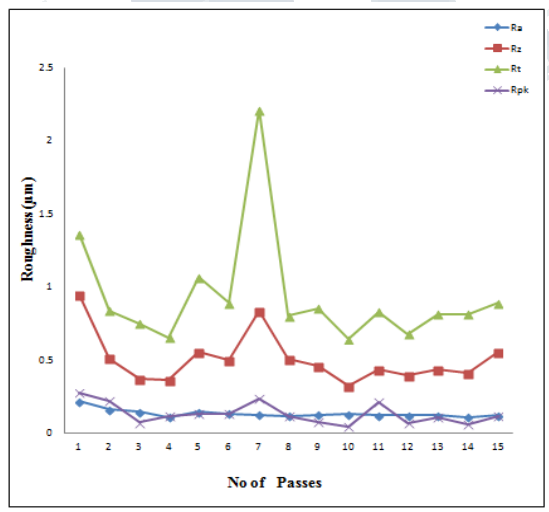

Fig 3.3: Inconel 718 at point-3 the effect of no of passes on the surface roughness.

Figure (3.3) shows the surface roughness improving gradually from 6th to 10th passes. From 6th pass it attains steady roughness hence there will not much improvement. Normally the roughness value improves as the no of passes increases. The finishing effect is affected by the abrasive size in the extrusion honing machine. And the efficiency is also changed in the different abrasive size.

Further in the fig it can be observed that the surface

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roughness improved gradually from 11th to 15th passes. As the surface finish increases there will be improvement in the roughness. Core roughness is predicting that no further improvement, further it may leads to digging of the surface.

As the number of passes increases the roughness value decreases. Initially the percentage improvement values are high because of availability of peaks in the early stages of the machining, but as these peaks get machined the percentage improvement in roughness values slowly decreases.

IV. CONCLUSIONS

- Basic one-way EH investigations were performed by using a silly putty medium with silicon carbide abrasive particles. The inconel alloy718 workpice showed a significant surface improvement in Ra, Rz, Rt and Rpk after 15 EH passes. Further passes may cause pitting of the material from the parent material.
- Analyzing the 3 stages of the process.
  - The surface roughness improved gradually from 1st to 5th passes.
  - From 6th pass it attains steady roughness hence there will be no much improvement.
  - At 11th to 15th passes it achieves core roughness, a further pass causes pitting or worn as the graph impends to decrease surface finish will be decreased.
- EH is used in the industries especially in the case of finishing complex internal and external shapes. However, in this process, medium is the key elements that control the finishing process. Though, commercially available abrasive medium are very expensive and its affordability is an issue, especially for price sensitive industries.

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