The International Journal of Engineering and Science (IJES)
|| Volume || 6 || Issue || 12 || Pages || PP 01-07 || 2017 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Neural Network Modeling for Extrusion Honing of Super Alloys

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ABSTRACT

Extrusion Honing (EH) is a nontraditional machining process also known as Abrasive flow machining (AFM) that deburr, clean, polish, remove recast layer as well as micro cracks by flowing pressurized semisolid abrasive laden visco-elastic media over the surfaces. This paper presents details of experiment and also modeling of Extrusion Honing by Artificial Neural Network (ANN). The results showed abrasive concentration influence on material removal and surface finish.

Keywords: *Artificial Neural Network, Extrusion honing, Surface finish, Abrasive Flow Machining, Silicone.*

Date of Submission: 11-09-2017 Date of acceptance: 14-12-2017

I. INTRODUCTION

Abrasive flow machining is used to deburr, polish, or radius surfaces and edges [1]. Experimental investigations have been carried out by various researchers to investigate the effects of process parameters like extrusion pressure, number of cycles, viscosity, abrasive concentration and grain size on the output responses namely, surface finish and material removal during EH.

Jain and Adsul [2] reported that softer material has higher material removal and more improvement in surface finish (ΔR_a) compared to harder material.

Gorana et al. [3] reported that extrusion pressure, abrasive concentration and grain size affect the cutting forces, active grain density and finally reduction in surface roughness (R_a value).

Mamilla Ravi Sankar et al. [4] reported that R-AFF can produce 44%better ΔRa and 81.8% more MR compared to the AFF process. Accordingly, R-AFF generates micro crosshatch pattern on the finished surface that can improve lubricant holding capabilities.

Jain and Jain [5] reported that machining action in AFM compares to grinding.

Gorana et al. [6] shown that the axial force, radial force, active grain density and grain depth of indentation, all have a significant influence on the scale of material deformation in AFM. Their theoretical and experimental results show that the rubbing mode of material deformation dominates; however, some evidences of ploughing during AFM are also present.

Dirk Bahre et al. [7] shown higher piston pressure will lead much faster to the desired surface finish.

Liang Fang et al. [8] reported that media viscosity decreases continuously with increasing temperature. Media temperature increases with increasing cycles, which means media viscosity decreases with cycles increasing. AFM tests shows that increasing cycles extensively decrease materials removal and surface roughness decreasing efficiency.

Jain et al. [9] reported that as extrusion pressure increases, material removal also increases. Material removal is higher at initial cycles, and is negligible after certain number of cycles (say, 20 or so). For same extrusion pressure and number of cycles, increase in Δ*R*a for conical surface is less compared to cylindrical surfaces.

Eckart Uhlmann et al. [10] reported that rising temperature leads to descending viscosity of the grinding medium, hence the abrasive removal rate is sinking. By raising the processing pressure and reduction of the flow cross-section, the fluid velocity and the removal rate are increasing.

Jain and Jain [11] developed stochastic simulation model from which they showed that 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.

A-Cheng WANG et al. [12] reported that inserting a similar shape of the mold core into the hole results uniform roughness on the surface.

Liang Fang et al. [13] reported that smaller workpiece hardness, larger particle radius and higher normal load promote grooving of the particles. Sharper particles are much more easy to groove.

Jain et al. [14] used neural network for optimum selection of machining conditions in abrasive flow machining which shows a good agreement with experimental results for a wide range of machining conditions. To validate the optimization results of the neural network approach, optimization of the AFM process has also been carried out using genetic algorithm (GA).

Mamilla Ravi Sankar et al. [15] reported that R-AFF can produce 44% better ΔR_a and 81.8% more MR compared to AFF process.

Kenda et al. [16] shown AFM is capable to remove EDM damaged surface and significantly improve surface roughness. Moreover, it is capable of inducing high compressive residual stresses to the machined surface, in a very thin sublayer of ~10 μm, and so prove that AFM offers an alternative finishing process, beneficial from the surface integrity and productivity point of view.

Mamilla Ravi Sankar et al. [17] reported that MRg increases as extrusion pressure and number of cycles increase but decreases as weight percentage of MRg oil in the medium increases. It is concluded that the mechanism of finishing and material removal in case of alloy is different form that in case of MMC.

Wang and weng [18] investigated the performance of pure silicone rubber (P-silicone) and silicone rubber with additives (A- silicone) with Silicone carbide (SiC) abrasives on Mild steel (SKD-11) as a workpiece material. They used abrasive mesh size of #24, #100, and #320 and abrasive concentration of 33%, 50%, 60%, 66%, and 71% with hydraulic pressure of 500psi and abrasive weight of 600g. From the study they concluded that the silicone rubbers can give high efficiency in AFM. And the working temperature can be maintained at a constant value when the high viscosity abrasive medium is used. Therefore, a precise surface can be obtained during the same machining condition.

Mamilla Rave Sankar et al. [19] reported that as the yield shear stress increases, the material removal increases. At low viscous component, the medium possesses high elastic component so radial force is high and material removal is also high. As the viscous component increases the radial force gradually decreases, so the material removal decreases.

Kar et al. [20] reported that butyl rubber, Sic abrasives and naphthenic oil mixed media shows good performance compared to natural rubber based media. As the abrasive loading increases, the improvement in surface roughness increases. But at the high percentage (above 78%) of abrasive loading, the flow becomes difficult as well as carrier acts as inefficient binder for abrasives.

Raju et al. [21] performed extrude honing on SG Cast Iron (600grade) using a laboratory model of hydraulically actuated extrude honing set-up using a select grade of polymer as abrasive carrier medium. SiC grit of 36 mesh size is used as abrasive. Study reveals that extrude honing process in the lower pressure range yields reasonably good results in finishing SG Cast Iron.

In Extrusion Honing (EH), abrasive concentration, abrasive grit size, viscosity of the abrasive media, extrusion pressure, geometry of machining surface, are the factors which influence on material removal and surface roughness. Material properties like hardness and ductility also influence upon material removal and improvement in surface roughness. Abrasives with higher grit size give better surface finish with lower material removal while abrasives with lower grit size give higher material removal but higher surface roughness.

In the present study, extrusion honing operations were performed on Titanium Grade 2 at laboratory using indigenously built EH set up. A selected grade polymeric material as medium and silicon carbide as abrasives has been used for finishing process. Surface roughness parameters were measured for each pass. Material removal were taken from the work piece before and after the EH process and the results show positive response.

II. EXPERIMENTAL PROCEDURE

Extrusion honing experimentation was conducted in an indigenously built EH set up at laboratory and surface parameters and, material removal were evaluated after each trial. Surface roughness measurements were taken at different positions both at entry and exit sides.

2.1 Material details

2.1.1 Work material

Titanium Grade 2 (UNS R50400) is a standard engineering material for applications which require resistance to corrosion and heat. The alloy also has excellent mechanical properties and presents the desirable combination of high strength and good workability. The chemical composition of Titanium Grade 2 is shown in Table 1. Mechanical properties of Titanium Grade 2 is shown in Table 2. The versatility of Titanium Grade 2 has led to its use in a variety of applications from structural applications in aerospace and aeronautical industry to chemical, oil and petroleum industries. The material strength and oxidation resistance at high temperature make it useful for many applications in the heat–treating industry. In the aeronautical field, it is used for a variety of engine and airframe components. The alloy is a standard material of construction for marine engineering, chemical processing and nuclear reactors.

Table 1

Element	Concentration [wt.%] Titanium Grade 2
Carbon	0.1 Max
Iron	0.3 Max
Hydrogen	0.015 Max
Nitrogen	0.03 Max
Oxygen	0.25 Max
Titanium	Balanced

Chemical Composition of Titanium Grade 2.

Table 2

Density	4.51 g/cm^3
Ultimate Tensile strength	344 N/mm^2
Yield strength	275 N/mm^2
Vickers Hardness	145

Mechanical Properties of Titanium Grade 2.

2.1.2 Carrier medium

In the present study, a selected grade of polymer was used as working medium and commercially available silicon carbide of 36 grit size was used as abrasive. Silicon carbide (40% and 60% vol.) was thoroughly mixed with polymer medium using a laboratory built silicone media mixer. Extrusion honing process parameters are shown in table 3.

2.2 Specimen preparation

Titanium Grade 2 specimens of Ø25 mm and length of 12 mm were used for experimentation. The specimens were initially prepared by drilling for different hole sizes of 7, 8, 9 and 10mm. Surface parameter (R_a) is measured initially and its value found in the range of 1 to 5 µm. After washing the specimen with acetone, extrusion honing trials were conducted.

2.3 Experiment trials

The experiment setup was designed and fabricated in the laboratory to perform extrusion honing. This set up is a one way type of EH process that is the medium flows in only one direction. It consists of an abrasive media cylinder coupled to a hydraulic cylinder; to control the actuation the directional control valve has been utilized. Abrasive media cylinder is a piston cylinder arrangement with end cap which has a fixture for housing the workpiece. The fixture is designed to mount the workpiece easily to the end cap of the extrusion cylinder. Abrasive media enters the workpiece from one side and extrudes out at the other side. The extruded abrasive media is collected in the collector. The specimen was honed for 15 passes under similar conditions and after each pass surface was cleaned with acetone and surface finish parameter (R_a) was measured at three different locations on the workpiece. The surface roughness measurements were taken with surfcom surface roughness tester, Surfcom 130A with a stylus of tip radius 2µm. The cut-off length chosen for measurement was 0.8 mm with 4 mm traverse length. Care was taken to measure the roughness at the same location before and after the experiments. The material removal was measured before and after the experiments with Afcoset ER-200A electronic balance having a least count of 0.001mg.

III. RESULTS AND DISCUSSION

Typical observed parametric influence of surface characteristics of extrusion honed Titanium Grade 2 is illustrated through Fig.1 to Fig.9. Fig.1 to Fig. 8 shows the surface roughness in terms of R_a at entry and exit sides respectively for Titanium Grade 2. Fig. 9 shows material removal for titanium grade 2. It is seen that there is a visible and drastic reduction in R_a values during early passes of extrusion honing for titanium grade 2 and there will be gradual improvement in later passes. Once the surface attains core roughness, surface deterioration sets in later passes.

3.1 Observation of surface roughness and material removal

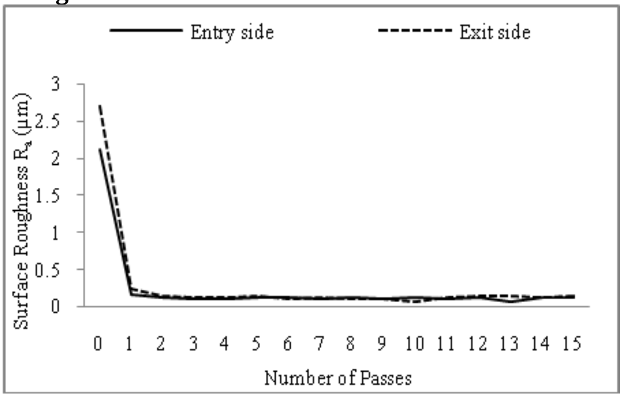

Fig.1 Surface Roughness (R_a) v/s Number of passes at entry side and exit side for ϕ7mm specimen

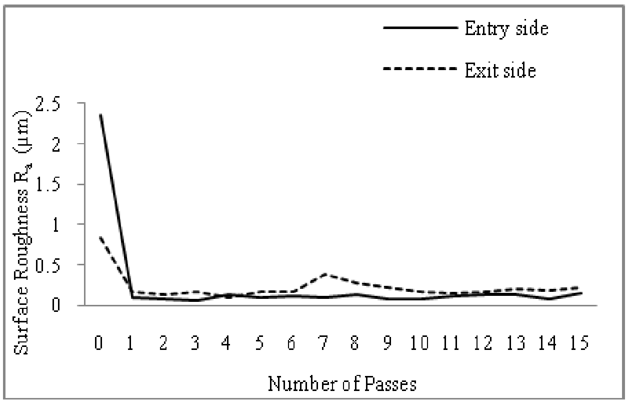

Fig.2 Surface Roughness (R_a) v/s Number of passes at entry side and exit side ϕ8mm

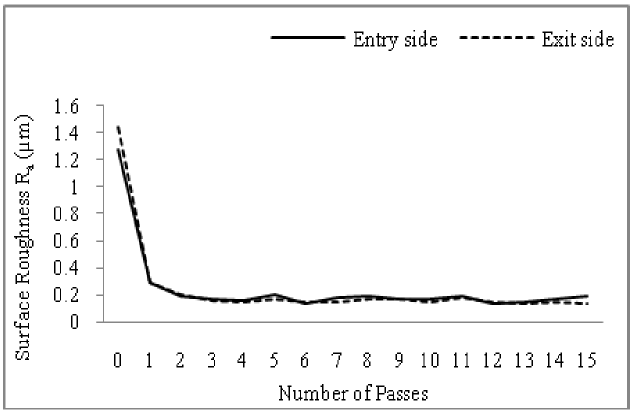

Fig.3 Surface Roughness (R_a) v/s Number of passes at entry side and exit side for ϕ9mm specimen.

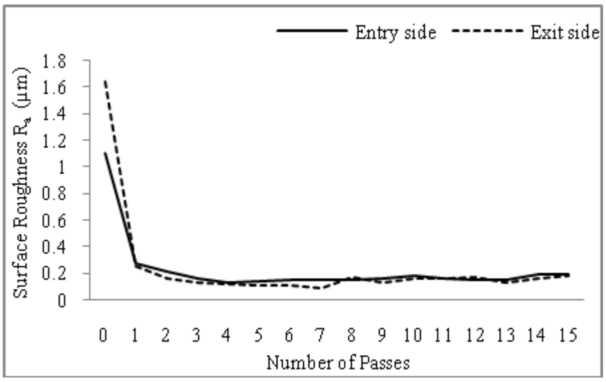

Fig.4 Surface Roughness (R_a) v/s Number of passes at entry side and exit side for ϕ10mm specimen.

In formulation of neural network, 6 x 720 matrix is used as input matrix. In this matrix, diameter of hole, abrasive concentration, side, point of evaluation, location of evaluation and number of passes were input variables. Surface roughness parameters were output values. Each surface roughness parameter for 6 mm and 11 mm hole diameter specimen were simulated separately. For simulating surface roughness parameter, 1x180 matrix is used. A single layer feed forward network with backpropogation learning and Levernberg – Marquardt algorithm is used. Number of neurons and number of layers were selected by trial and error method. Better results were obtained for single layer network with 20 to 25 neurons.

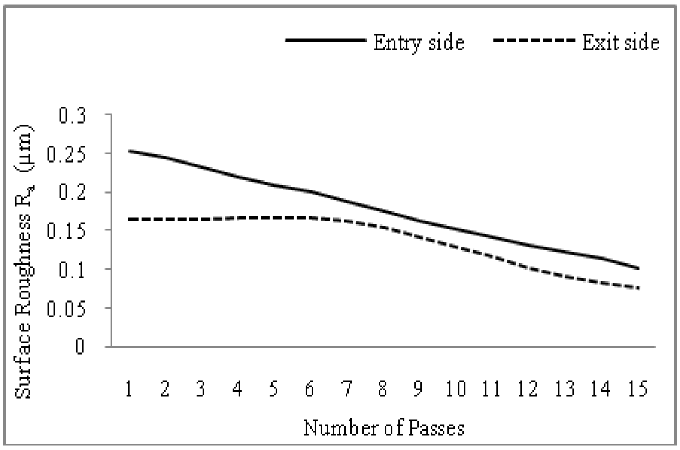

Fig.5 Surface Roughness (R_a) v/s Number of passes at entry side and. exit side for ϕ6mm specimen

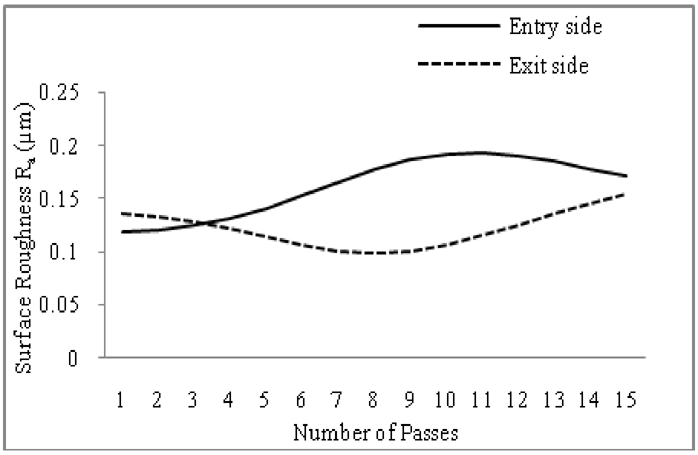

Fig.6 Surface Roughness (R_a) v/s Number of passes at entry side and exit side for ϕ11mm specimen

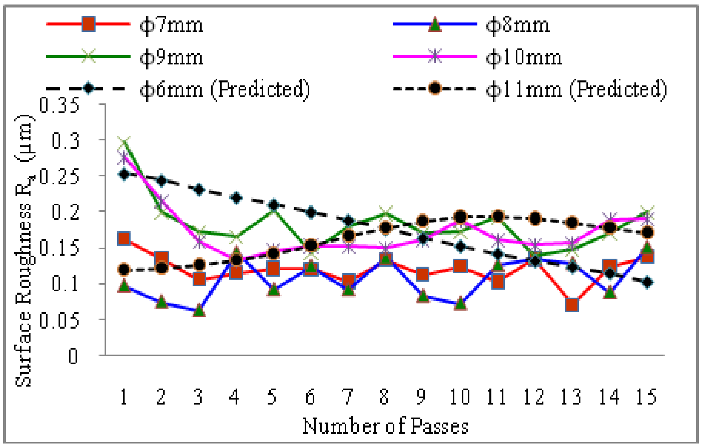

Fig.7 Surface Roughness (R_a) v/s Number of passes at entry side.

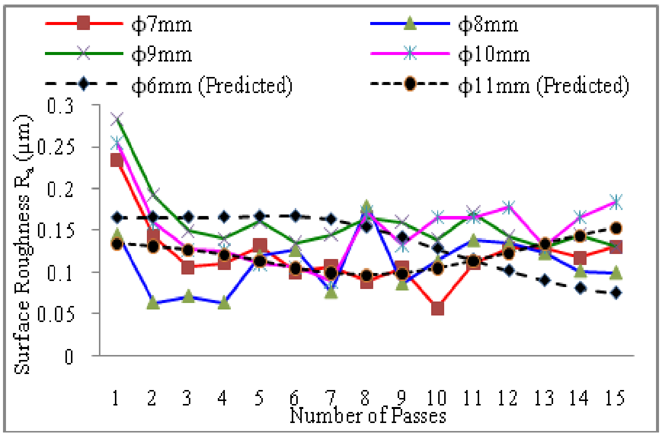

Fig.8 Surface Roughness (R_a) v/s Number of passes at exit side.

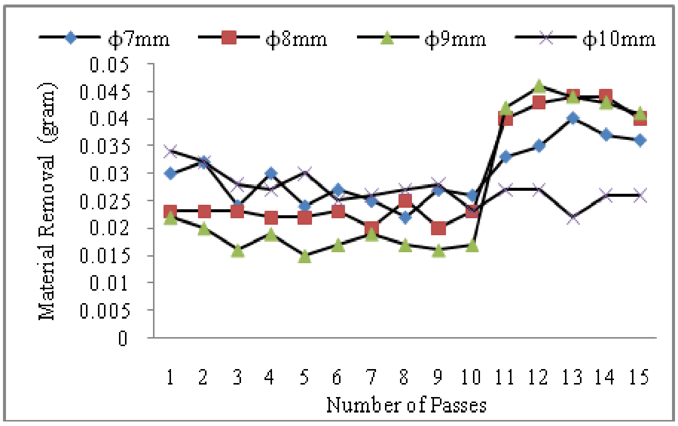

Fig.9 Material Removal (gram) v/s Number of passes.

IV. CONCLUSION

In this paper, an investigation has been made on Titanium Grade 2 work piece to study the influence of process parameters on surface finish and material removal. The samples that were processed by EH have been pre-machined by drilling process. Basic one-way extrusion honing was performed using a silicone polymer with SiC abrasives. The surface finish was measured on workpiece at three different locations on entry side and exit side of the abrasive media flow. The results of this study led to the following conclusions:

1. The select grade of polymer can be used as abrasive carrier medium in extrusion honing.
2. Extrusion honing of internal surfaces of Titanium Grade 2 has been carried out with abrasive polymeric media.

3. Surface finish at polymer exit side is better than surface finish at polymer entry side due to better contact with abrasive medium.
4. As the abrasive concentration increases, material removal increases.
5. Surface finish improves drastically up to 3 passes and then improves gradually.
6. Once the surface attains core roughness, surface deterioration sets in thereafter.
7. Under similar machining conditions, number of passes required for a surface to attain its core roughness increases as hole diameter reduces.
8. Experimental data of surface roughness parameters is used for Artificial Neural Network modeling of EH process and model is used to predict surface roughness parameters of 6 mm and 11 mm diameter specimens.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support provided by AICTE New Delhi, project entitled “Micro Finishing of Internal Primitives through Extrusion Honing Process” project No.8023/BOS/RPS-123/2006-07. Authors also acknowledge Mr. K.Ravi, Foreman, Department of Industrial and Production Engineering, for kind help during experimentation.

REFERENCES

[1]. Lawrwnce J. Rhodes and Hilary A. Clouser, Abrasive Flow Machining, ASM Handbook, Volume 16: Machining, p 514 - 519

[2]. Jain V. K. and S. G. Adsul, Experimental investigations into abrasive flow machining (AFM), International Journal of Machine Tools & Manufacture 40 (2000) 1003–1021

[3]. Gorana V. K., V. K. Jain and G. K. Lal, Experimental investigation into cutting forces and active grain density during abrasive flow machining, International Journal of Machine Tools & Manufacture 44 (2004) 201–211

[4]. RaviSankar M., V.K.Jain and J.Ramkumar, Rotational abrasive flow finishing (R-AFF) process and its effects on finished surface topography, International Journal of Machine Tools & Manufacture 50 (2010) 637–650

[5]. Rajendra K. Jain and V.K. Jain, Specific energy and temperature determination in abrasive flow machining process, International Journal of Machine Tools & Manufacture 41 (2001) 1689–1704

[6]. Gorana V. K., V.K. Jain and G.K. Lal, Forces prediction during material deformation in abrasive flow machining, Wear 260 (2006) 128–139

[7]. Dirk Bähre, Horst Brünnet and Martin Swat, Investigation of one-way abrasive flow machining and in-process measurement of axial forces, Procedia CIRP 1 (2012) 419 – 424

[8]. Liang Fang, Jia Zhao, Kun Sun, Degang Zheng and Dexin Ma, Temperature as sensitive monitor for efficiency of work in abrasive flow machining, Wear 266 (2009) 678–687

[9]. Jain V. K., Rajani Kumar, P.M. Dixit and Ajay Sidpara, Investigations into abrasive flow finishing of complex workpieces using FEM, Wear 267 (2009) 71–80

[10]. Eckart Uhlmann, Vanja Mihotovic and Andre Coenen, Modelling the abrasive flow machining process on advanced ceramic materials, Journal of Materials Processing Technology 209 (2009) 6062–6066

[11]. Rajendra K. Jain and V.K. Jain, Stochastic simulation of active grain density in abrasive flow machining, Journal of Materials Processing Technology 152 (2004) 17–22

[12]. A-Cheng WANG, Lung TSAI, Kuo-Zoo LIANG, Chun-Ho LIU and Shi-Hong WENG, Uniform surface polished method of complex holes in abrasive flow machining, Transactions of Nonferrous Metals Society of China 19(2009) s250-s257

[13]. Liang Fang, Jia Zhao, Bo Li and Kun Sun, Movement patterns of ellipsoidal particle in abrasive flow machining, Journal of Materials Processing Technology 209 (2009) 6048–6056

[14]. Rajendra Kumar Jain and Vijay Kumar Jain, Optimum selection of machining conditions in abrasive flow machining using neural network, Journal of Materials Processing Technology 108 (2000) 62-67

[15]. Mamilla Ravi Sankar, V.K. Jain and J. Ramkumar, Experimental investigations into rotating workpiece abrasive flow finishing, Wear 267 (2009) 43–51

[16]. Kenda J., F. Pusavec, G. Kermouche and J. Kopac, Surface Integrity in Abrasive Flow Machining of Hardened Tool Steel AISI D2, Procedia Engineering 19 (2011) 172 – 177

[17]. Mamilla Ravi Sankar, J. Ramkumar and V. K. Jain, Experimental investigation and mechanism of material removal in nano finishing of MMCs using abrasive flow finishing (AFF) process, Wear 266 (2009) 688–698

[18]. Wang A. C. and S.H. Weng, Developing the polymer abrasive gels in AFM processs, Journal of Materials Processing Technology 192–193 (2007) 486–490

[19]. RaviSankar M., V.K.Jain, J. Ramkumar and Y. M. Joshi, Rheological characterization of styrene-butadiene based medium and its finishing performance using rotational abrasive flow finishing process, International Journal of Machine Tools & Manufacture 51 (2011) 947–957

[20]. Kamal K. Kara, N.L. Ravikumar, Piyushkumar B. Tailor, J. Ramkumar and D. Sathiyamoorthy, Performance evaluation and rheological characterization of newly developed butyl rubber based media for abrasive flow machining process, journal of materials processing technology 2 0 9 (2 0 0 9) 2212–2221

[21]. Raju H. P., K. Narayanasamy, Y.G. Srinivasa and R. Krishnamurthy, Characteristics of extrude honed SG iron internal primitives, Journal of Materials Processing Technology 166 (2005) 455–464

Lingaraju K N " Neural Network Modeling for Extrusion Honing of Super Alloys.” The International Journal of Engineering and Science (IJES), vol. 6, no. 12, 2017, pp. 01-07.