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Effect of Process Parameters on Surface Roughness of Mild Steel with Different Heat Treatments in CNC Lathe

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ABSTRACT

In turning operation, productivity is indirectly affected by material removal rate and quality is affected by surface roughness. This study is focused on the effect of input process parameters on surface roughness of mild steel with different heat treatment processes. Experiments are conducted on CNC Lathe with different rotational speed and feed as input parameters. Different heat treatment processes like annealing, normalizing and quenching are done on mild steel rod and plain turning operation is performed. Surface roughness for all heat treated turned surface is measured using Talysurf. Regression models are developed for all three-heat treated process to predict the surface roughness. The effect of feed and rotational speed on surface roughness for all heat-treated samples are studied. It is observed that surface roughness decreases with increase in rotational speed and increases with increase in feed. Surface roughness is minimum at N= 1500 rpm, F=0.1mm/rev at normalizing followed by quenching, annealing, and standard. Comparing all the processes at rotational speed for N=500rpm and 1000rpm, the minimum surface roughness is obtained for quenching heat treatment process. Similarly comparing all the processes at same rotational speed for N=1500 rpm, the minimum surface roughness is obtained for normalizing heat treatment process.

*KEYWORDS—**CNC Lathe, Heat Treatment, Regression Model, Surface Roughness and Turning***

1. INTRODUCTION

Turning is mostly used operation on lathe machine and surface roughness is an important factor in grading the quality of product. Gupta et al. [1]applied Taguchi method for conducting the experiments and presented multiple output optimization of high speed CNC turning.Ahilan et al. [2] proposed the advancement of neural network models for machining variablesandexperiments are performed based on Taguchi's design of experiments. Mummaret et al. [3] investigated the effect of uncoated PVD and CVD coated cemented carbide inserts and cutting factors on surface roughness in CNC turning and utilized artificial neural network model.Marani et al. [4] developedfuzzy logic model for forecasting surface roughness of machined Al–Si–Cu–Fe die casting alloy. The machining parameterscutting speed, feed rate and depth of cut were improved according to surface roughness values.Tugrul et al. [5] formulated regression and neural network model for anticipating surface roughness and tool wear in hard turning.Ilhan and Cunkas [6] observed that neural network model approximatesthe surface roughness with high precision compared to the multiple regression model. Yonglin et al. [7] developed fuzzy neuron adaptive modeling to anticipate surface roughness under process variations in CNC turning. Muhammad et al. [8] investigated tool wear prediction system in the turning process utilizing an adaptive neuro-fuzzy interpretation system and aninnovative statistical signal analysis method. Saini and Pradhan [9] observed the effect of CNC turning process parameters like feed, cutting speed and depth of cut onsurface roughness and material removal rate. Gowda et al. [10]studied the ideal process parameters for turning process in order to automate the system.

This work presents the impact of input process parameters viz. feed and rotational speed on surface roughness of mild steel with different heat treatments in CNC lathe.

2.EXPERIMENTAL WORK

Different heat treatment processes like normalizing, annealing, and quenching are done on mild steel rod of diameter 25mm and length 30mm. Turning operation is performed on these specimens as per full factorial

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design with rotational speed and feed as input parameters, each at three levels as shown in Table 1. So total no. of experiments conducted for all four cases viz. annealing, normalizing, quenching and standard (without heat treatment) are $4*3^2$=36 as shown in Table 2.

Table 1. Process Parameters and their levels

FACTORS	Level 1	Level 2	Level 3
ROTATIONAL SPEED (N), rpm	500	1000	1500
FEED(F), mm/rev	0.1	0.2	0.3

Table 2. Design Matrix as per full factorial design

	ANNEALING (A)		NORMALIZING (N)		QUENCHING (Q)		STANDARD (S)	
Expt. No.	Rotational Speed	Feed	Rotational Speed	Feed	Rotational Speed	Feed	Rotational Speed	Feed
1	500	0.1	500	0.1	500	0.1	500	0.1
2	500	0.2	500	0.2	500	0.2	500	0.2
3	500	0.3	500	0.3	500	0.3	500	0.3
4	1000	0.1	1000	0.1	1000	0.1	1000	0.1
5	1000	0.2	1000	0.2	1000	0.2	1000	0.2
6	1000	0.3	1000	0.3	1000	0.3	1000	0.3
7	1500	0.1	1500	0.1	1500	0.1	1500	0.1
8	1500	0.2	1500	0.2	1500	0.2	1500	0.2
9	1500	0.3	1500	0.3	1500	0.3	1500	0.3

Talysurf is used to measure the surface roughness and measured values are shown in Table3.

Table 3. Surface Roughness for all processes

Expt. No.	Surface Roughness (Ra), µm			
	ANNEALING (A)	NORMALIZING (N)	QUENCHING (Q)	STANDARD (S)
1	2.4133	2.3475	2.35	2.3475
2	3.065	2.265	2.2475	2.265
3	3.4425	3.5125	2.735	3.5125
4	0.87	1	0.87	0.89
5	0.8734	1.1	0.9725	0.901
6	1.223	1.32	1.28	1.32
7	0.701	0.76	0.756	0.795
8	1.005	0.94	1	0.94
9	1.325	1.2625	1.0675	1.2625

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3. DEVELOPMENT OF REGRESSION MODEL

The regression modelof surface roughness for all different heat treatments annealing, normalizing, quenching processes and standard processare obtained for predicting the surface roughness using datafit software.The regression coefficients for annealing, normalizing, quenching and standard specimens are 0.9875, 0.9613, 0.9888 and 0.9624 respectively which is very near to 1 and so can predict the surface roughness with good accuracy.

FOR ANNEALING

R=5.9506-9.4828*E-3*N+5.3156*F+3.8661*E-6*N*N-2.0566*F*F-1.3039*E-3*F*N

FOR NORMALIZING

R=1.91000-5.06233E-03*N+22.13166*F+2.74600E-06*N*N-10.85000*F*F-1.19599E-02*F*N

FOR QUENCHING

R=5.05245-6.64417E-03*N-1.91167*F+2.60733E-06*N*N+10.30833*F*F-3.67499E-04*F*N

FOR STANDARAD

R=5.25222-6.72166E-03*N-3.99166*F+2.83166E-06*N*N+26.54166*F*F-3.31249E-03*F*N

4. RESULTS AND DISCUSSION

4.1 EFFECT OF PROCESS PARAMETERS ON SURFACE ROUGHNESS

Regression model is used to plot the graph between feed and surface roughness at different rotational speed to know its effect on surface roughness. Figure 1, Figure 2,Figure 3, Figure 4 plots the graph between feed and surface roughness for all fours cases annealing, normalizing, quenching and standard respectively at all three levels of rotational speed. It is found that with an increase in rotational speed, surface roughness is decreasing whereas with an increase in feed,surface roughness is increasing.It is observed that surface finish is better in normalizing process followed by annealing, quenching and standard.

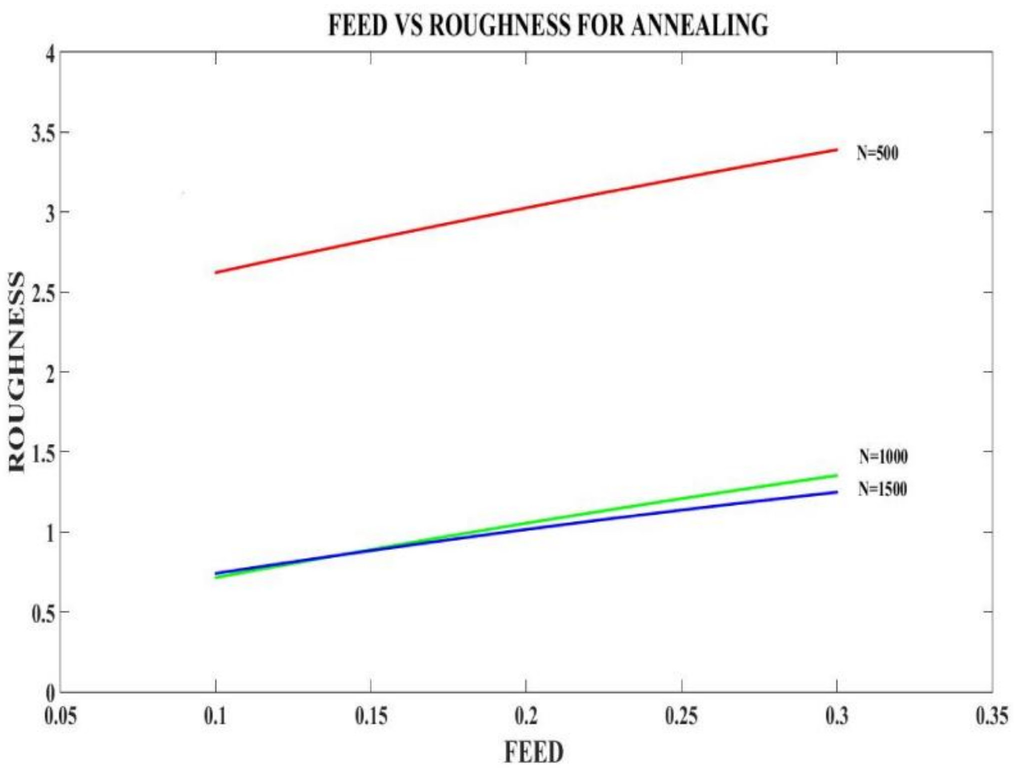

Fig 1: Feed Vs Roughness for Annealing

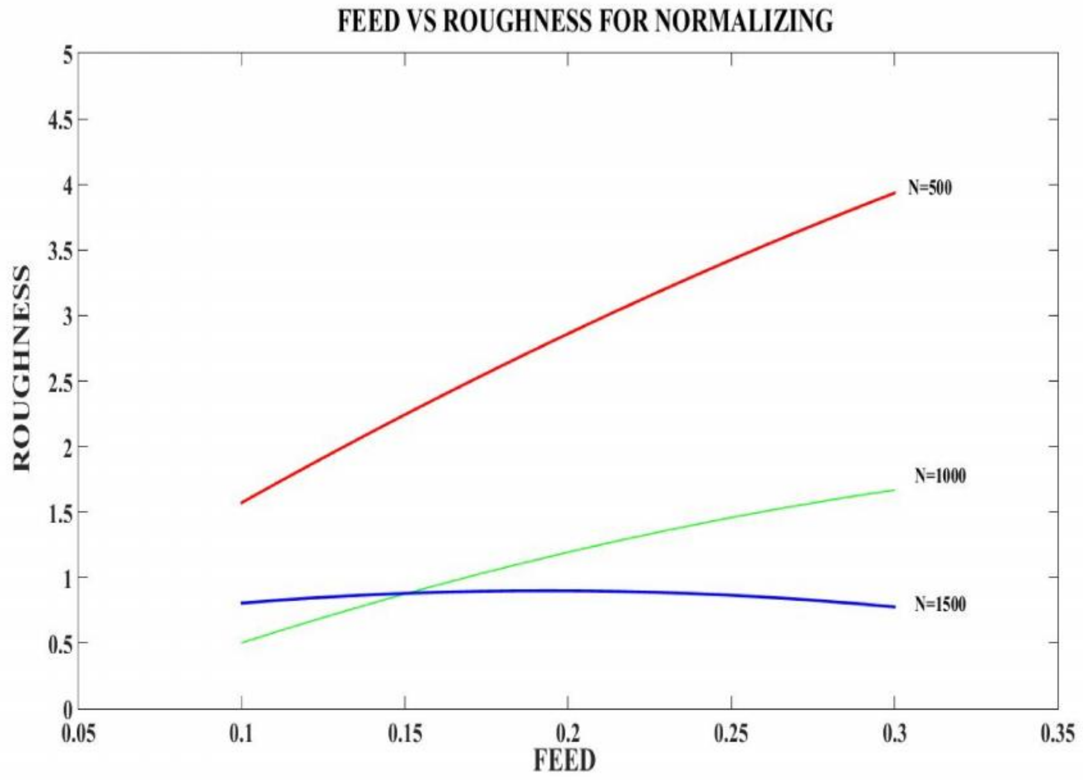

Fig 2: Feed Vs Roughness for Normalizing

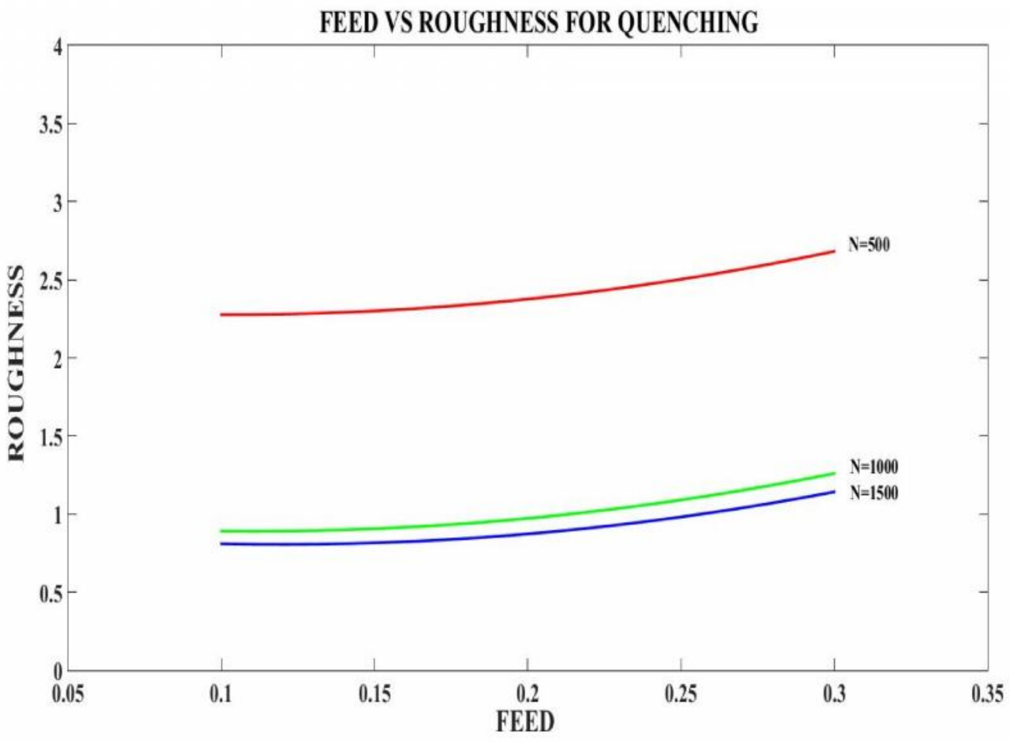

Fig 3: Feed Vs Roughness for Quenching

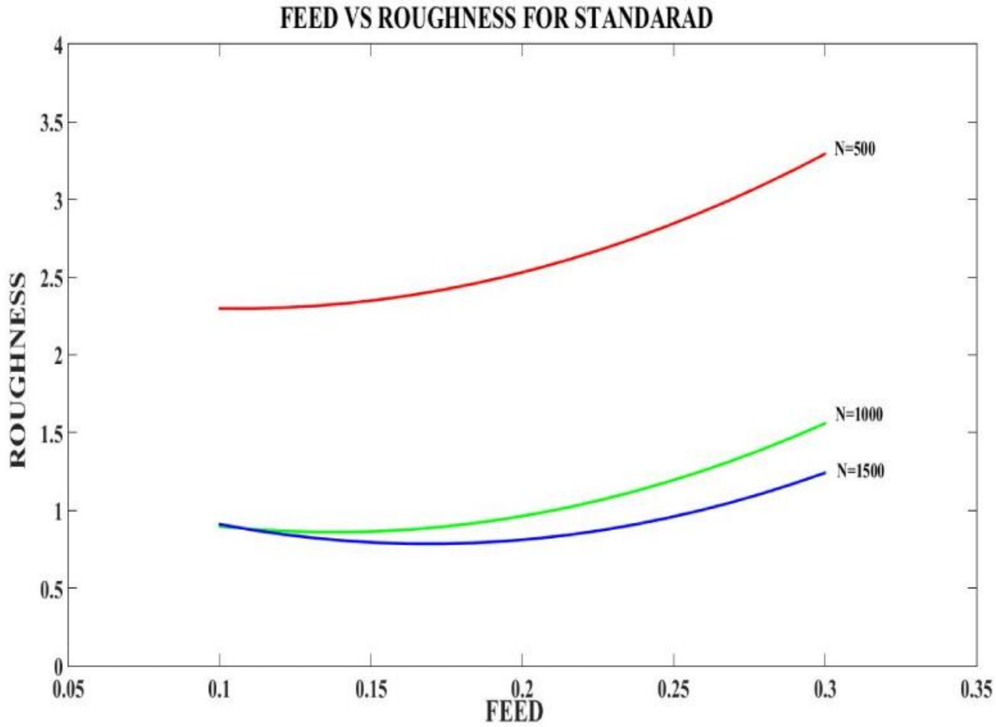

Fig 4: Feed Vs Roughness for Standard

4.2 FEED VS SURFACE ROUGHNESS FOR ALL THE PROCESSESS AT DIFFERENT SPEEDS

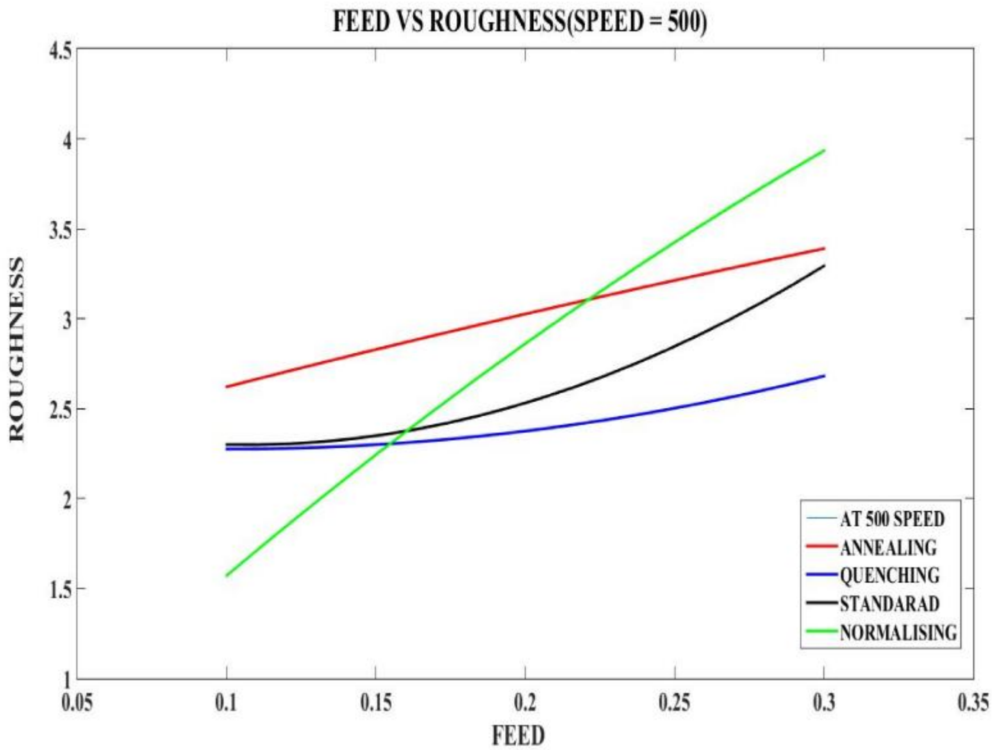

Fig.5Feed Vs Surface Roughness at Speed=500 Rpm

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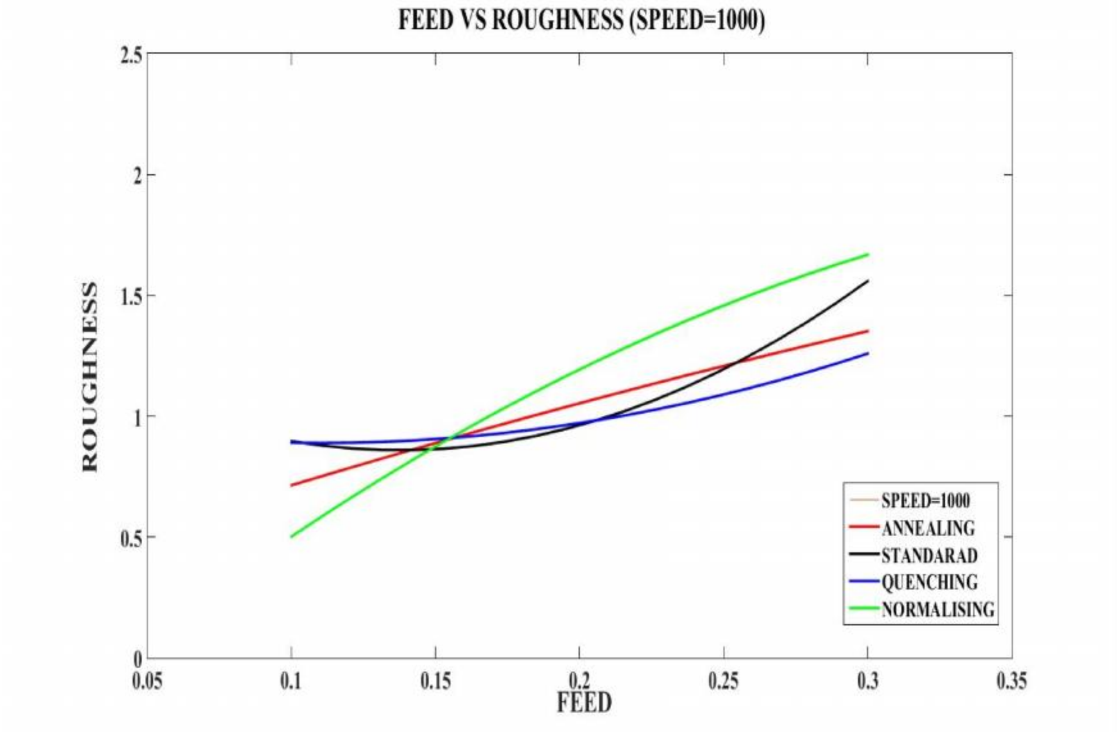

Fig.6Feed Vs Surface Roughness at Speed 1000 Rpm

Figure 5, Figure 6 andFigure 7 shows comparison of feed vs roughness for all the processes at rotational speed 500, 1000 and 1500 rpm respectively. Comparing all the processes at rotational speed for N=500rpm and 1000rpm, the minimum surface roughness is obtained for quenching heat treatment process. Similarly comparing all the processes at speed for N=1500rpm, the minimum surface roughness is obtained for normalizing heat treatment process.

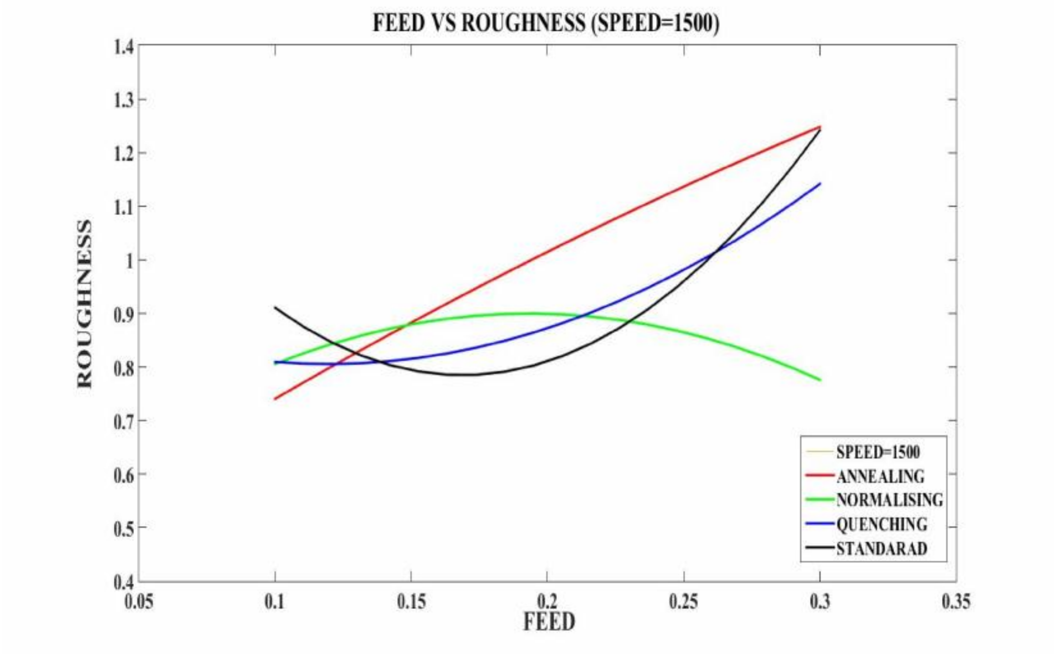

Fig.7 Feed Vs Surface Roughness at Speed1500 Rpm

5.CONCLUSIONS

The conclusions drawn from this experimental study are as follows

1. The regression models are developed and regression coefficients for annealing, normalizing, quenching and standard specimens are 0.9875, 0.9613, 0.9888 and 0.9624 respectively.
2. As the rotational speed increases, surface roughness decreases. Also as the feed increases, surface roughness increases.
3. It is observed that surface finish is better in normalizing process followed by quenching, annealing and standard.
4. Comparing all the processes at rotational speed for N=500rpm and 1000rpm, the minimum surface roughness is obtained for quenching heat treatment process.
5. Comparing all the processes at same speed for N=1500rpm, the minimum surface roughness is obtained for normalizing heat treatment process.
6. At lower speed i.e., 500rpm quenching is the best process and at higher speeds i.e., 1500rpm normalizing is the best process for good surface finish.

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