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Experimental Investigation of Surface Roughness & Material Removal Rate of EN-31 Alloy Steel

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Abstract : The influence of machining parameters on MRR and surface roughness during CNC turning of EN-31 Steel using tungsten carbide inserts. From the experimental result it is concluded that cutting speed is most significant effect on surface roughness and MRR. For minimum surface roughness optimum parameters are 0.15 mm/min feed rate, 2000 rpm speed and 0.6 mm depth of cut. Also optimum parameters for MRR were 0.3 mm/min feed rate, 1600 rpm speed, 0.6 mm depth of cut. Based on the Taguchi approach and ANOVA results obtained from the analysis. Optimum parameter setting for material removal rate is found at feed rate, spindle speed of 1250 rpm and 0.6 mm depth of cut i.e. S2F3D3 From the ANOVA it was found that percentage contribution of depth of cut 69 % has the most significant effect followed by speed (16.69%) and feed rate (6.4%) for MRR. Optimum parameter levels for surface roughness is found at 0.1 mm/rev feed rate, 0.2 mm depth of cut and 1250 rpm speed From the ANOVA results that feed rate (57.77%) has maximum contributing factor for surface roughness. Depth of cut with contribution of 14.88% has little influence on surface roughness. From the confirmation test for the optimal settings for MRR observed that increase in S/N ratio from the initial parameters 7.49 dB. Also from the confirmation test for surface roughness it is observed that increase in S/N ratio from the initial parameter 3.59 db.

Keywords: EN-31, Taguchi, ANOVA, MRR.

I. INTRODUCTION

In manufacturing sector reducing the cost of production without decreasing the quality of product is major concerns in order to sustain competition in the market. For producing the product, surface finish is the major requirements of the customer. Surface roughness influence by wear resistance, fatigue strength, corrosion resistance, coefficient of frication and dirt on the surface.

Also higher material removal rate is desirable without decreasing the quality of the parts. Higher MRR is obtained by increasing the machining parameters like feed rate, spindle speed and depth of cut. At the same time power consumption and temperature in the cutting zone increase therefore built-up-edge formation starts and damage the surface quality.

So selection of suitable machining parameters plays an important role to achieve higher MRR. EN-31 steeling is 1 of the mostly widest using materialing.

This material has high carbon percentage, hardness, compressive strength & wears resistance therefore used in wide range of applications like punches and dies, roller and ball bearing, gudgeon pins, and heavy duty gear and ejector pins. Hard turning (above 45 HRC) the temperature induce in the cutting zone is very high, excessive heat cause tool wear and hence reduce tool life. So the selection of proper machining parameters to achieve the goals of the manufacturing industry is one of the major concerns.

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In manufacturing, the removal of undesirable material via the work piece in the forming of chipping is called machine operation. Machining is divided into five elements of manufacturing process namely casting, joining, machining, forming and powder metallurgy. Machining is the operation in which unprocessed material is removed to obtain desired dimensions by a control material removal process.

In machining the energy required is summations of total energy required in plastic deformation to break crystal structure and in overcoming the friction. The following research paper is designed as follows. Section II describes the overall previous research work whereas Section III gives methodology. Result Analysis define in section IV and last but not the least Section V concludes the paper

II. LITERATURE REVIEW

In this section, we will discuss basic introduction and high points of influence, explanations and issues in the research work by researchers in different field. Researchers have tried a lot in recent times to attain the max tensile strength.

Vishnu Vardhan Chandrasekarn et al (2013) Studied the effect of various cutting situations on a superficial level completion, powers and apparatus wear during tube turning of AISI 1020 steel. The cutting boundary were cold compacted air and nitrogen utilized against the dry machining. For each analysis one moment of cutting time is fixed at two diverse feed 0.02"/fire up and 0.04"/fire up and consistent profundity of cut of 0.125" width of cut. HSS is utilized as a cutting device material. Device wear on the rake face is to assess with the assistance of keyanace magnifying lens. [21].

Sujit Kumar Jha et al. (2014) Describes the test study concerning the impact of cutting boundary to be specific feed rates, profundity of cut, and cutting rate on the MRR during CNC turning of aluminum.

Taguchi powerful DOE procedure dependent on L9 symmetrical cluster is utilized. S/N proportion and ANOVA technique was utilized to discover rate commitment. The S/N proportion for MRR is to be determined utilizing bigger is the better models. This investigation infer that the ideal procedure boundary, as per greatest S/N proportion for the MRR feed has most critical factor after that profundity of cut and cutting rate [22].

Vikas et al (2014) completed tryout for MRR for EN 19 and EN 41 material in pass on sinking electric release machining. In this work different procedure boundary like heartbeat off time, voltage, current and heartbeat on time were considered as information handling boundaries. While MRR was considered as the reaction. Taguchi technique, L27 symmetrical cluster is utilized for expansion or predication of best mix of information boundary over material evacuation pace of two unique materials in particular EN19 and EN41.

This investigation presume that the ideal boundaries for most extreme material rate for EN 19 were current 24 amps, voltage 40v, and beat on time 400µs and beat off time 2300µs where as MRR for EN 41 are current 24 amps, beat on time 400 and beat off time 2100 µs. from the trial information it is seen that the estimations of MRR in any blend of procedure boundary was higher for EN 41 than if there should arise an occurrence of EN 19, the purpose behind that decline the % of carbon from EN 19 to EN 41 which increment the MRR [23].

Sunil J Raykar et al (2014) carried out test study to dissect surface harshness during dry machining of EN-8 steel. Relapse scientific models for surface boundary to be specific Ra, Rq and Rz were created. From these scientific models surface harshness can assess within the given scope of machining boundary.

Exploratory qualities and mathematical model worth are thought about by relapse model. From the exploratory and relapse model outcome it is reasoned that Feed has most prominent impact on surface unpleasantness for all surface harshness boundaries for example Ra, Rq and Rz and Cutting rate has most extreme impact on surface completion after that feed for surface harshness boundaries as Ra and Rq. It was seen that profundity of cut has most prominent impact after that feed for surface harshness boundary Rz [24].

Sayak Mukherjee et al. (2014) concentrated to streamline machining boundary to be specific feed, cutting velocity and profundity of cut. Material evacuation rate was chosen as a yield reaction. SAE 1020 steel bars were utilized for CNC turning activity.

Taguchi L25 symmetrical exhibit is utilized. From the trial results dependent on S/N proportion examination presumed that profundity of cut was most persuasively on MRR followed by feed. The ideal cutting boundary setting for MRR were seen at 64 m/s cutting pace, 0.3 mm profundity of cut and 0.35 mm/fire up feed [25].

Khaider Bouacha et al (2014) contemplated the impact of cutting boundaries on execution qualities 'device wear, surface unpleasantness and MRR' during hard turning. The work piece chose for this investigation is AISI52100 bearing steel and CBN utilized as a cutting apparatus embeds. Taguchi, GA, and reaction surface procedure is utilized to improve execution attributes [26].

Md. Maksudul Islam et al. (2015) utilized Taguchi strategy for getting ideal procedure during turning of ASTM A48 Gray cast iron. L9 symmetrical cluster is utilized. HSS is utilized as a cutting device. ANOVA was applied and material evacuation rate were examined. Ideal cutting boundaries and hugeness of boundaries were resolved utilizing ANOVA strategy [27].

Deveshpartap singh et al (2016) contemplated the impact of cutting boundary on surface harshness. The material chose was Aluminum. Taguchi strategy was utilized for the streamlining of procedure boundaries. Three diverse machining boundaries at three unique levels were taken. L9 symmetrical cluster is utilized. Minitab 15 was utilized for investigation.

ANOVA was utilized to confirm the outcome. In light of the Minitab 15 it is reasoned that feed rate most effect on a superficial level harshness while profundity of cut has less impact. Ideal outcomes were gotten at 0.5 mm profundity of cut, 40 mm/min feed rate and 800 rpm axle speed. ANOVA presume that feed rate was the most extreme contributed factor 54.65 % to the surface unpleasantness. While commitment of different boundaries likes cutting velocity 34.67% and profundity of cut just 10.47 % [28].

Sujan Debnath et al. (2016) did exploratory investigation to decide the impact of cutting liquid and procedure boundaries on apparatus wear and surface unpleasantness were considered. Gentle steel was chosen for turning activity and covered carbide embed is utilized for instrument. From the exploratory outcome it was infer that feed rate had the most significant factor with 34.3 % commitment on surface harshness and the cutting velocity most elevated commitment (43.1%) to the device wear. The cutting stream condition LFHV was the most ideal slicing condition to lessen the device wear and surface harshness [29].

S. Sakthivelu et al. (2017) examined the impact of machining boundaries on MRR and surface unpleasantness during CNC turning of Aluminum 6063 utilizing tungsten carbide embed. Three machining boundary were taken. Taguchi strong plan of procedure is utilized.

L9 symmetrical cluster was utilized. S/N proportion and ANOVA strategy were utilized to discover mean reaction and rate commitment. From the exploratory outcome it is reasoned that cutting velocity is most critical impact on surface unpleasantness and MRR.

For least surface harshness ideal boundaries are 0.15 mm/min feed rate, 2000 rpm speed and 0.6 mm profundity of cut. Additionally ideal boundaries for MRR were 0.3 mm/min feed rate, 1600 rpm speed, 0.6 mm profundity of cut [30].

III. METHODOLOGY

There are many standard orthogonal arrays available which are specific to no. of independent variables and levels.

Standard two-1evel, three and fourth 1evel orthogonal array are:

- Two-1evel arrays are as follows: $L_4L_8L_{12}L_{16}$ andL_{32}
- Three-1evel arraying are: L_9L_{18} andL_{27}
- Fourth- leveling array: $L_{16}L_{32}$

Here subscript indicates the no. of trials. The complete level of opportunity in an investigation chooses the no. of tests or preliminaries. The level of opportunity for singular boundaries is equivalent to the no. of levels short 0ne.

So by expanding the quantity of levels of boundaries level of opportunity additionally builds which thus will build the quantity of preliminaries. So it is prescribed to utilize two degrees of every boundary to limit the quantity of analyses.

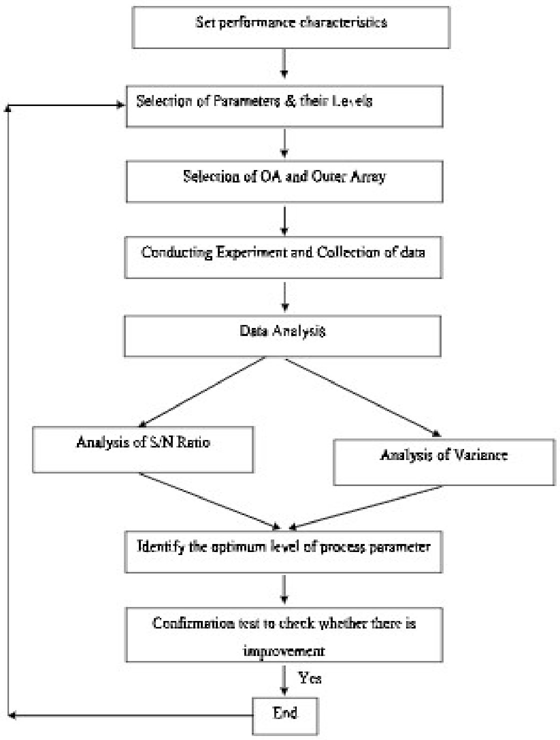

Fig 1. Proposed Flow Diagram & Design of Experiment.

Level of opportunity is given by

DOF= n-1

Where n-no. of preliminaries

A symmetrical cluster selector table is given in segment. It fulfills the disparity n>= all out level of opportunity required for boundaries and communications

In Taguchi there are two types of parameters

- Signal or controllable factors
- Noise or uncontrollable factors.

Controllable factors are those parameters which could be simply controlled by the designer. On the contrary noise factors are those that are impossible, hard and very costly to control. They cause variations in the design or process.

IV. EXPERIMENTATION

Considerable experiments were performed on CNC turning machine to obtain the objectives by the suitable selection of materials, machining parameters and cutting tool inserts during turning process.

Fig 2. EN-31steel.

The material selected for the present work is EN-31 steel. The description of size of selected material is given as:

- Number of rods- three
- Diameter – 48.3
- Length – 180 mm

Three experiments are performed on a single rod in the form of step turning. Chemical composition & m/c features of EN-31 steel are describe in tabling respectively. The work piece are used during the experiment is shown in the Figure 4.1.

V. RESULT ANALYSIS

MRR can be measured with the help of following eq^n

$$\mathbf{MRR} = \frac{\textit{Volume of the material removed}}{\textit{machining time}}$$

$$\mathbf{MRR} = \frac{\frac{\pi}{4}(Do)2-(Di)2\times L}{T}$$

Where, D_O = Outer diameter, Di = inner diameter, L = length of the work piece and T = machining time.

For the first run MRR is given by

$$\mathbf{MRR} = \frac{\pi/4(48.3)2-(47.92)2\times 60}{36.29} = \mathbf{0.112\ mm^3/sec}$$

Table 1. MRR for various process parameters

S	F	D	Time (sec)	MRR
1000	0.1	0.2	36.29	49.63
1000	0.15	0.4	24.29	146.43
1000	0.2	0.6	17.89	291.91
1250	0.1	0.4	10.02	354.97
1250	0.15	0.6	19.26	271.15
1250	0.2	0.2	14.28	126.12
1500	0.1	0.6	24.4	214.03
1500	0.15	0.2	16.42	109.68
1500	0.2	0.4	12.55	283.41

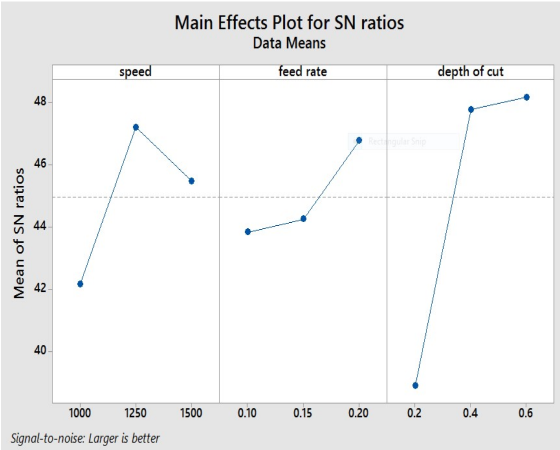

Fig 3. Plotting for SNR of Different cutting parameters for MRR.

From the principle impact plot for MRR it is a lot of away from the boundary profundity of cut has most compelling boundary following by shaft speed& federate. From the plot plainly as feed rate and profundity of cut increment MRR increment.

While increasing the spindle speed first MRR increase as S/N ratio increase but finally its decrease as spindle speed increase. Using MINITAB by selecting graph we can plot contour plots. A contour plot tells how z variable varies with the x and y variables here our z variable MRR.

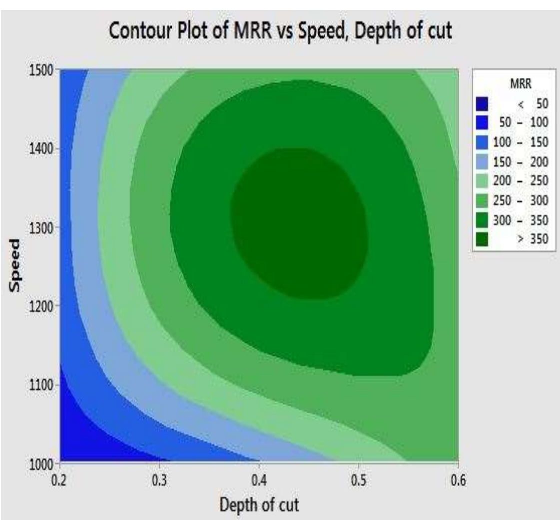

Fig 4. Contour plots for MRR v/s feed rate, depth of cut and spindle speed.

Using MINITAB by selecting graph we can plot contour plots. A contour plot tells how z variable varies with the x and y variables here our z variable MRR.

VI. CONCLUSION

In light of the Taguchi approach and ANOVA results acquired from the examination, the accompanying notable ends have been drawn Taguchi approach can be extremely effective for structure of test for the boundaries improvement. Optimum boundary setting for material evacuation rate is found at feed rate, axle speed of 1250 rpm and 0.6 mm profundity of cut for example S2F3D3.

From the ANOVA it was discovered that rate commitment of profundity of cut 69 % has the most huge impact followed by speed (16.69%) and feed rate (6.4%) for MRR. Optimum boundary levels for surface harshness is found at 0.1mm/fire up feedrate, 0.2mm profundity of cutting & 1250 rpm speed From the ANOVA results that feed rate (57.77%) has greatest contributing element for surface harshness.

Profundity of cut with commitment of 14.88% has little impact on surface harshness. From the affirmation test for the ideal settings for MRR saw that expansion in S/N proportion from the underlying boundaries 7.49 dB. Also from the affirmation test for surface harshness it is seen that expansion in S/N proportion from the underlying boundary 3.59 dB.

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