OPTIMISATION OF PROCESS PARAMETER IN CNC TURNING OPERATION FOR SS430 BY USING TAGUCHI METHOD

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ABSTRACT :-

Now a days every manufacturing industries wants to produce high quality products with lowest possible cost associated with it, so that they can survive in the bizzare market competition. So, all of them are concerning about controlling the factors which are required for producing the component. The input variables are chosen so wisely that the output response can be controlled very much accurately.

In this paper we have done two things,(a) first we have study detailed literature review on optimisation of process parameter in the turning operation. This helps us to find out how the input variable affects the output or response variables. Literature review makes it clear that the most widely used technique for process parameter optimisation is TAGUCHI METHOD. And significant order of each factor is determined by using the ANOVA APPROACH.

(b) And then we conduct an experiment based on Taguchi method using L9 orthogonal array and find out the S/N Ratio for each factor at each level of operation. This analysis helps us to find out the optimum value of each input factor which leads to the minimum surface roughness after the turning operation. We also apply the Anova approach to find out the significance level of each factor.

After conducting the turning of specimen according to L9 array, the surface roughness of each is measured and the data is fed to the minitab18, which helps us in analysis of the data.

INTODUCTION:-

Turning is a metal removing process in which unwanted material is removed in form of chips to obtain the desired shape and size. This is the most basic operation used for the metal removal. The most effective parameters or variables which affect the tuning operation are speed, feed and depth of cut. While turning, our prime focus is to obtain the material with smooth surface finish so that it is of utmost quality level and should be fit for use. But the products obtained do not exhibit good surface finish and we have to perform various finishing or polishing operations so as to obtain better quality. But these operations are very much time consuming and are very costly process. So the cost of manufacturing the component increases which is very dangerous in the market which is of very competitive nature.

So, our focus is to adjust the machining parameters in such a way that we get the optimum value that can be achieved so that minimum investment is done on polishing or finishing operations.

cutting force & surface roughness both are the very critical parameters in machining process. Cutting force is required for the calculation of power needed in machining. They affects dimensional accuracy, chip formation & workpiece deformation. Good quality of surface finish is always required in industries according to the customer requirement. This can be obtained by optimization process which we will discuss.

VARIOUS CUTTING FACTORS IN TURNING

The important factors in any turning operation are cutting speed, feed, and the depth of cut. Other parameter that affects machining are kind of material used and type of tool and its geometry, but from all those, three are the basic factors that the operator can manage by adjusting the controls. These are as:

Speed

It can be defined as the relative speed between spindle of machine and the work piece. It is generally expressed in rpm because it is the rotating speed of spindle. But the main feature for a particular turning operation is the cutting speed i.e. the value of speed at which the work piece is moving around the cutting tool. Value of cutting speed can be obtained by the product of the (rotating speed) ×(the circumference of the work piece material before the cut is started). It is articulated in meter per minute (m/min), and it refers only to the work piece. Every different diameter work piece will have a different value of cutting speed, even there rotating speed is same.

$$V = \frac{\pi D N}{1000} \text{ (m/min)}$$

Here,

V is the cutting speed in turning;

D is the initial diameter of the work piece in mm.

Feed

Feed mentions the relative motion between cutting tool and work piece and it is expressed as thee tool movement along its cutting path per unit time. In most of lathe machines, the feed rate and spindle speed are directly associated to each other. Feed is stated in mm (of tool movement) per revolution (of the spindle), i.e. mm/rev.

Depth of Cut

Depth of cut is the thickness of the material that can be removed from it in one pass. It is the distance from the uncut surface of the work piece to the final cut surface. Diameter of the workpiece reduced two times of depth of cut because during the turning process material is removed from both sides of centre of workpiece. It is expressed in mm.

Surface roughness:-

Surface roughness is an index of the product quality. It helps in determining the surface finish of the product. It is calculated by measurement of the small scale variations in the height of a physical surface. It can be measured or understand by following methods, like arithmetic mean or centre-line average (R_a), Root-mean square average (R_q), maximum peak (R_y), ten-point mean roughness (R_z), maximum valley depth (R_v), maximum height of profile ($R_t = R_p – R_v$) etc.
From all these, the most commonly used indicator for surface roughness measurement is R_a.
R_a is the arithmetic mean of variations of a series of points from the centre line or datum line. The datum line is assumed such that sum of the areas under the profile above the datum line will be equal to the sum of areas below the datum line. Generally, surface roughness is expressed in microns (μm).

LITERATURE REVIEW:-

In this paper, we are going to analyse the past work done for optimisation of process parameters. A lot of research papers are studied from past and input parameter, response parameter & optimisation techniques are identified from them. Here the literature has been reviewed as:-

Kanakaraja et al;(2014) have investigated the cutting parameters in turning operation of SAE 8822 alloy steel for optimizing surface roughness in CNC lathe operation. Carbide tool is used for machining. In this experimental work optimization technique used is Taguchi method and with the help of L9 orthogonal array experiments are conducted. The result shows that the prime affecting factor of surface roughness is ‘feed’ and after that is ‘speed’ and ‘depth of cut’.

Ranganath et al; (2015) give model of surface roughness for turning operation of EN-8 steel with the uncoated carbide inserts by using technique RSM i.e. (Response surface methodology). The model was established in the form of multiple regression equations, correlating dependent parameter surface roughness, with independent parameters such as speed, feed and depth of cut in a turning process. The plan of experiment is done by using box benhken design process. It was examined that Cutting speed has the greatest effect on the surface roughness among the selected parameters.

Kshirsagar et al; (2016) have explored the behaviour of surface roughness in turning of EN8 steel by optimization process of machining parameters by using TAGUCHI method and ANOVA. They conducting an experiment in which three level of machining parameters were selected, these parameters are speed, feed and depth of cut. In totality, 9 experiments were performed which contains codes values and observed responses. These experiments were performed in CNC machine by using coated carbide tool inserts. The statistical methods of signal to noise ratio i.e. S/N ratio and the ANOVA are applied to investigate effects of depth of cut, feed rate and cutting speed on surface roughness. The analysis of variance (ANOVA) is used to find out the most contributing factor among the given factors and the optimization of the process parameters influencing the surface roughness was obtained with the Taguchi orthogonal test design. It was found that the feed rate is the most significant factor which affecting the surface roughness R_a for turning of EN8 steel material. The surface finish decreases with increase in feed rate.

Ganesh et al (2014) have explored the behaviour of surface roughness in turning of EN-8 steel by using Genetic Algorithm optimization technique. This work emphasis on CNC turning using Cemented Carbide tool for varying rate of Spindle speed, Feed rate and Depth of cut. The experiment is conducted for Second order linear model using RSM technique. Mathematical formulation is driven out by correlating the values of responses Machining time and Surface Roughness with the contribution of Feed, spindle speed, and Depth of cut to formulate the Empirical models for the responses. The Optimization of various cutting parameters is carried out using Genetic Algorithm (GA). It was seen that the minimum value of surface roughness (Ra) obtained from GA method is 2.51 µ. Genetic Algorithm is best modelling mehod as it give the best fit of even linear models.

Madhan et al (2014) They try to optimize the setting of cutting parameters in surface roughness by applying Taguchi method. The experiments were performed in CNC machine by taking the cutting parameters as cutting speed, feed and depth of cut using coated tool insert. The material used for experiment was EN-8 steel. For three levels & three factors, L9 orthogonal array was used. ANOVA and S/N ratio were examined using MINITAB 16 software. It was found that Spindle speed is more influencing parameter for achieving lower surface roughness during turning of EN-8 steel rods. The optimum parameter achieving lower surface roughness values of EN-8 steel rod are 225 m/min of cutting speed, 0.2 mm/rev of Feed and 0.5 mm Depth of cut.

Mouli et al. (2014) have worked on optimization of cutting tool geometry by CAE Approach for Titanium Alloy. The cutting tool geometry was optimized by design of experiments (DOE) techniques and with the help of machining simulation and the analysis (Deform 3D) software by defining required material properties of titanium alloy , tool geometry , cutting parameters etc. The influences of tool geometries such back rake angle, side rake angle and nose radius while cutting titanium alloy (Ti-6AI-4V) has been studies thoroughly through design of experimental (DOE) techniques, computer aided engineering (CAE). The tool radius found to be has higher influence in generating cutting force among the cutting tool rake angles while machining titanium alloy.

Kayastha et al. (2013) has studied on optimization of process parameter in turning of Copper by combination of Taguchi and principal component analysis method. For optimization of material removal rate that is MRR and surface roughness PCA method coupled to grey based Taguchi method is implemented as multi response optimization problem cannot solved by other optimization methods. They conclude that, based on accountability proportion (AP) and cumulative accountability proportion (CAP), PCA analysis can reduce the number of response variables to be taken under consideration in optimization. This is very helpful in situations were large number of responses have to be optimized simultaneously.

Nikam et al; (2012) have investigated the effects of process parameters on surface roughness of material. The surface quality is affected by cutting speed, feed rate and depth of cut and many other parameters. In this study, they attempts to investigate the effect of cutting parameters(feed rate, cutting speed, depth of cut) and insert geometry (CNMG and TNMG type insert) on surface roughness in the finish turning of EN 8 steel. The experiments have been performed using L9 orthogonal array in a SPEED LX 200 MAJOR CNC lathe machine. Turning process carried out on the material EN 8 steel. The optimum cutting condition was found out and surface roughness was checked by the analysis of variance (ANOVA). It was found that Highest surface finish (lowest Ra) is obtained at a cutting speed of 200 m/min, feed rate of 0.2 mm/revolutions and a depth of cut of 0.5mm. Best surface roughness is obtained from CNMG 120412 FC insert than other two type of insert.

Eldhose et al. (2014) have worked on optimization of the cutting parameters of SS304 for CNC turning operation. In this research work, optimization method used is Taguchi method. They studied the effects of various parameters such as speed, depth of cut and feed on the MRR and surface roughness of the SS304 in a CNC turning machine. It was observed that the most effecting factors on MRR is depth of cut, And on surface roughness is speed & depth of cut , on machining time is feed & speed , on tool wear is speed and feed.

Qureshi et al. (2015) have studied process optimization of Cutting parameters for Surface roughness in CNC turning of P20 steel. They optimized the cutting parameters such as feed rate, depth of cut and cutting speed for the turning of AISI P20 steel for better surface finish. Taguchi's technique has been used to achieve the objective of the experimental study. L-9 Orthogonal array, Signal to noise (S/N) ratio have been used for conducting the experiments. They concluded that the combination of the high level of cutting speed (200m/min) and low level feed of (0.1mm/rev) and a middle value of depth of cut 0.1mm yield the optimum result.

DESIGN OF EXPERIMENT

It is study and planning of determining the most important input variables which are affecting the given response variable. In this present work a set of experiments are conducted for turning the work piece SS 430 by using the carbide cutting tool insert so as to get the effect of machining parameters like speed, feed, and depth of cut on the 'surface roughness'.

Taguchi method determines the optimal settings for these input process parameters, and we use ANOVA approach to investigate the influence of each cutting parameters during machining on the response variable i.e. surface roughness.

PLAN OF INVESTIGATION

This experimentation is carried out in following steps:-

1. Identifying the process parameters (e.g., cutting speed, feed, depth of cut).
2. Selection of the useful limits of these cutting parameters.
3. Developing the Taguchi design matrix (in this case L9 orthogonal array).
4. Conducting the experiment as per the design matrix.
5. Presenting the main effects and the significant interactions between different parameters in graphical forms.
6. Analysis of results and conclusions

SELECTION OF VALUES OF PROCESS PARAMETER

There are three process parameters namely cutting speed, feed and depth of cut.

Table 1.1:- input parameter values

PARAMETER	LEVEL 1	LEVEL 2	LEVEL 3
SPEED	800	1200	1600
FEED	0.15	0.10	0.05
DEPTH OF CUT	0.2	0.3	0.4

TAGUCHI DESIGN MATRIX

Here we have 3 factors or process parameter and each factor has 3 different level values. So, we select the L9 orthogonal array for designing the matrix and conducting the experiment.

Table 1.2:- L9 Orthogonal array

speed	Feed	depth of cut
1	1	1
1	2	2
1	3	3
2	1	2
2	2	3
2	3	1
3	1	3

So, the design matrix of this particular project problem will be as:-

Table 1.3:- Design Matrix

Experiment no.	**Speed (rpm)**	**Feed (mm)**	**Depth of cut (mm)**
1.	800	0.15	0.2
2.	800	0.10	0.3
3.	800	0.05	0.4
4.	1200	0.15	0.3
5.	1200	0.10	0.4
6.	1200	0.05	0.2
7.	1600	0.15	0.4
8.	1600	0.10	0.2
9.	1600	0.05	0.3

After conducting the experiment i.e. turning has been done on the workpieces, surface roughness of each workpiece is measured using surf test SJ400 machine. The table showing the measured value of each trial is given below:

Table 1.4:- Observation Table

Experiment no.	Speed (rpm)	Feed (mm)	Depth of cut (mm)	Surface Roughness (µm)
1.	800	0.15	0.2	2.23
2.	800	0.10	0.3	1.39
3.	800	0.05	0.4	4.40
4.	1200	0.15	0.3	1.35
5.	1200	0.10	0.4	2.30
6.	1200	0.05	0.2	2.18
7.	1600	0.15	0.4	0.86
8.	1600	0.10	0.2	1.11
9.	1600	0.05	0.3	1.27

The values of response parameters, find out after conducting the experiment is fed to the Minitab 18 software, and from there a response table of S/N Ratio and various plots are obtained which helps us in interpreting the observations.

RESULT & DISCUSSION

Table 1.5:- Response Table of S/N Ratio

Levels	Speed	Feed	Depth of cut
1	-7.5651	-7.2381	-4.8806
2	-5.5368	-3.6671	-2.5143
3	-0.5575	-2.7542	-6.2645
Delta	7.0076	4.4838	3.7502
Rank	**1**	**2**	**3**

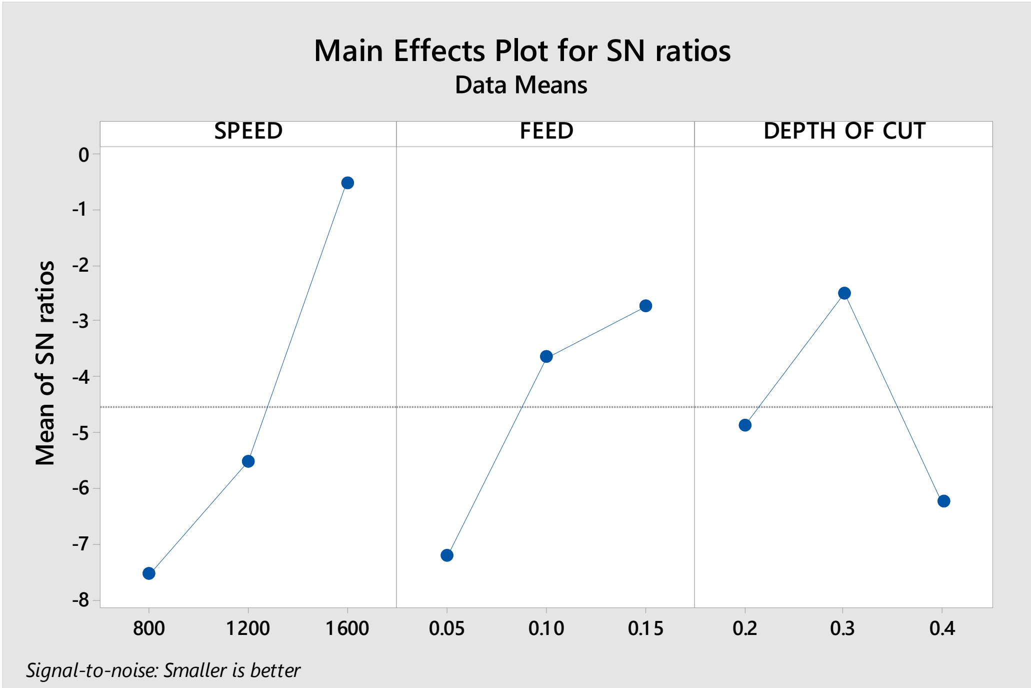

FIG.1.1- Main effect plots for SN ratio

The above graph shows that as the speed increases Surface Roughness increases first with slow rate and then at faster rate. As feed increases it increases sharply initially and then it increase at slow rate. As the depth of cut increases, the surface roughness first increases and then it decreases.

Table 1.6:- Response table for Means

Level	SPEED	FEED	DEPTH OF CUT
1	2.673	2.617	1.840
2	1.943	1.600	1.337
3	1.080	1.480	2.520
Delta	1.593	1.137	1.183
Rank	**1**	**3**	**2**

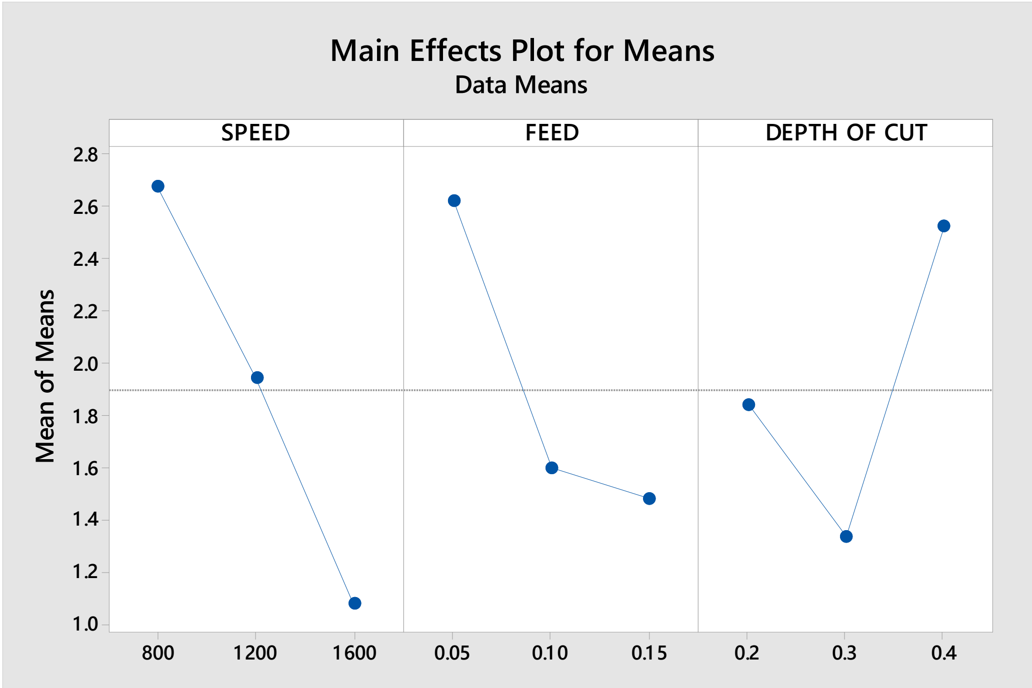

Figure 4.2- Main Effect Plot for Means

This graph shows that the as the speed increases the Surface Roughness decreases first at slow rate and then at fast rate. As the feed increases, surface roughness decreases first at fast rate and then at slow rate. As the depth of cut increases, surface roughness first decreases and then it increases.

The surface roughness is to be minimized as much as possible so we can consider smaller is better for surface roughness. Therefore the optimized solution for surface roughness is A_1, B_1, and C_3 as shown in table below:

Table 1.7:- optimal solution

Response	Speed (rpm)	Feed(mm)	Depth of Cut(mm)
Surface Roughness	1600	0.15	0.3

ANOVA FOR SURFACE ROUGHNESS:-

Table 1.8:- Factor Information

Factor	Type	Levels	Values
SPEED	Fixed	3	800, 1200, 1600
FEED	Fixed	3	0.05, 0.10, 0.15
DEPTH OF CUT	Fixed	3	0.2, 0.3, 0.4

Table 1.9:- ANOVA TABLE

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
speed	2	3.8170	41.21%	3.8170	1.9085	3.86	0.206
feed	2	2.3400	25.26%	2.3400	1.1700	2.36	0.297
depth of cut	2	2.1160	22.85%	2.1160	1.0580	2.14	0.319
Error	2	0.9895	10.68%	0.9895	0.4947		
Total	8	9.2625	100.00%				

The F values determine the significance of the parameters. Larger the F value, the greater the effect on the performance characteristic due to the change in the process parameter.

So, it is clear from this table that the most significant factor in this cutting process is cutting speed, followed by feed and then followed by depth of cut. Table given below shows the contribution factor value for each design parameter.

Table 1.10:- Contribution Table

DESIGN PARAMETER	CONTRIBUTION%
SPEED	41.21%
FEED	25.26%
DEPTH OF CUT	22.85%

Table 1.11:- Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)
0.703381	89.32%	57.27%	20.0372	0.00%

5.2 INTERACTION PLOT FOR SURFACE ROUGHNESS

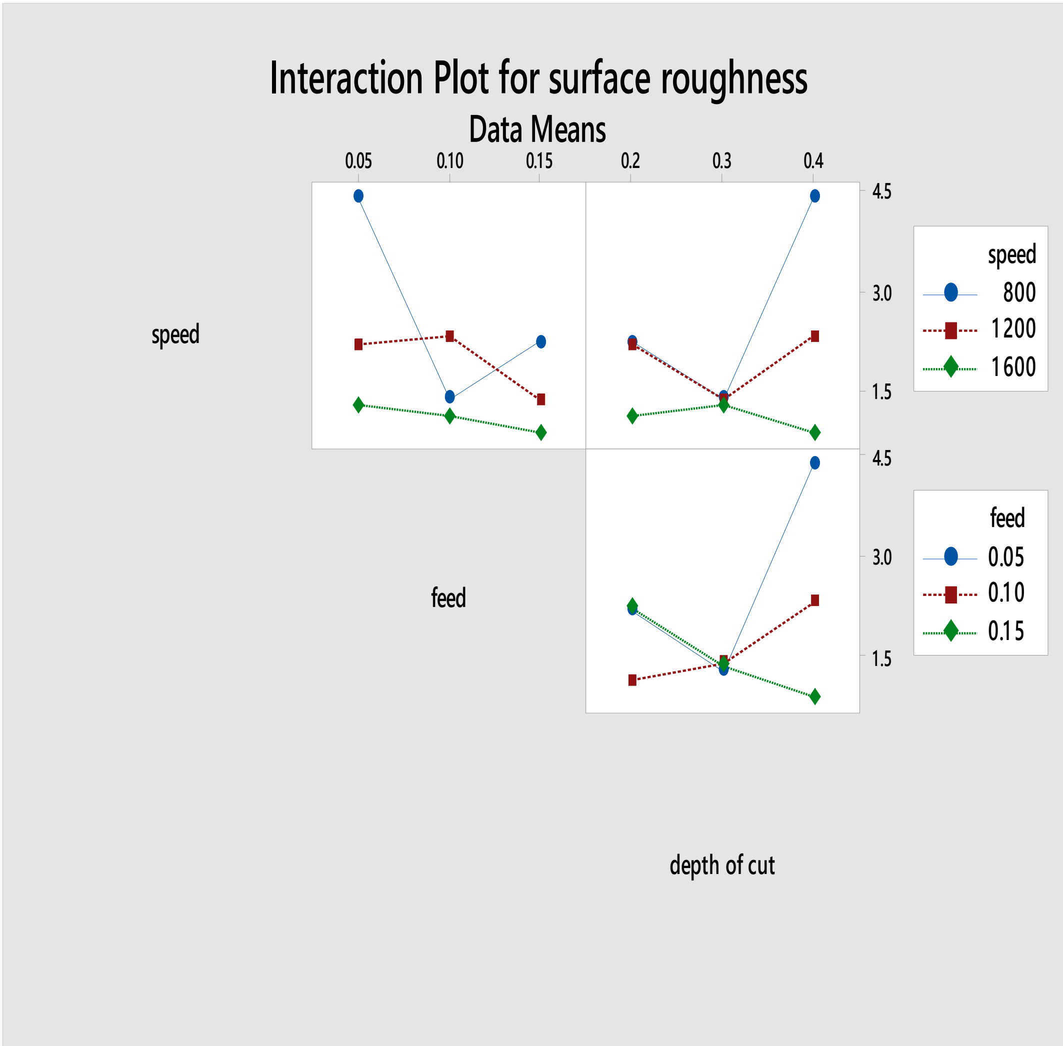

FIG.1.2:- Interaction plot for surface roughness

CONCLUSION:-

Stainless steel 430 was machined by CNC turning machine to study the effect of various design parameters on surface roughness. Based on the experiment done the following conclusions are drawn:

1. As the speed increases Surface Roughness decreases first with slow rate and then at faster rate.
2. As feed increases it decreases sharply initially and then it decrease at slow rate.
3. As the depth of cut increases, the surface roughness first decreases and then it increases.
4. 4.Surface roughness of the manufactured component mainly depends on speed, followed by feed and depth of cut.

FUTURE SCOPE

1. In present research work only three parameters i.e., speed, feed, depth of cut were included as input factors. Some other parameter such as tool material, nose radius, coolant type may also be considered as input factors.
2. The effect of parameter on MRR, tool life etc. can also be considered.
3. The effect of coolant on surface roughness can be studied.
4. Other optimization techniques such as artificial neurology can also be used.

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