Optimization of Machining Parameters on EN8 Material Using Genetic Algorithm

N. Baskar
Department of Mechanical Engineering, Saranathan College of Engineering, Tiruchirapalli
Tamilnadu, India -620012.

R. Prabhu
Department of Mechanical Engineering, Saranathan College of Engineering, Tiruchirapalli
Tamilnadu, India -620012.

R. Vaiysnavan
Department of Mechanical Engineering, Saranathan College of Engineering, Tiruchirapalli
Tamilnadu, India -620012.

R. Prakash
Department of Mechanical Engineering, Saranathan College of Engineering, Tiruchirapalli,
Tamilnadu, India -620012.

T. Naveen Kumar
Department of Mechanical Engineering,
Saranathan College of Engineering, Tiruchirapalli
Tamilnadu, India -620012.

***Abstract*:- In present scenario multi-operations in CNC plays one of the vital role in metal based manufacturing industries. Therefore selection of optimum machining parameters, tool geometry and cutting conditions etc., for the variety of materials is an important and complicated task for manufacturing industries in providing best quality at affordable cost to the customers. In the present study the influence of parameters like cutting speed, feed and depth of cut are analyzed for objective like MRR for multi-operation like Turning, Grooving, Facing & Threading. These experiments have been performed on EN8 material, according to DOE central composite technique for the different combination of input parameters which are spindle speed & feed rate. The output response is considered as MRR. The experiments are conducted for different experimental run and the empirical equation is formulated based on the experimental results. By using the empirical equation, the predicted value of MRR is calculated. The empirical equation is solved by using Genetic Algorithm. The optimal parameters obtained by Genetic Algorithm is recommended to manufacturing industries.**

keywords: CNC multi-operations, optimization, MRR, Design of Experiments ,Genetic Algorithm .

I. INTRODUCTION

From customer's view point quality is very important because the quality of the products affects degree of satisfaction of the customer during usage of the product. It also improves the good will of the company. The machining industries are facing a great challenge to achieve high quality, good surface finish and high material removal rate with a view to economize in machining. It is necessary to control the process parameters in any manufacturing process. The typical controllable machining parameters for the CNC lathe machine are speed, feed, depth of cut, tool geometry, tool material, etc. Which affects the desired output like material removal rate, surface roughness , power consumption, tool wear ,vibration etc. Optimization of machining parameters and also need to determine which parameters are most significant for required output. EN 8 carbon steel is a common medium carbon and medium tensile steel, with improved strength over mild steel, through hardening medium carbon steel .The quality of machining depends on the proper selection of materials and process cutting parameters. The main objective of this experimental investigation is to analyze machining parameters for maximizing Metal Removal rate of EN8 material.

II.LITERATURE REVIEW

This chapter presents, critical review made on the significant of CNC machining process for different combinations of material having different methods. The research work carried out by the researchers on different materials and their significance are discussed. This chapter also gives the research gap, motivation and objective of the research work.

Manu Garg et.al.,(2016) have studied to optimize the effects of cutting parameters on surface finish and MRR of EN24/EN8/EN36 by using Taguchi techniques. Speed, Feed, Nose radius & Depth of cut are the process parameters chosen. The experimentation plan is designed using Taguchi's L18 Orthogonal Array & Minitab 16 statistical software is used. It is identified that the least significant parameter is nose radius. surface roughness is mostly affected by feed rate.

Pankaj Sharma et.al.,(2013) have studied AISI H13, a chromium based hot work tool Steel optimization of two response parameters (Surface roughness and Material Removal Rate) three machining parameters (cutting speed, feed rate and depth of cut) is investigated in high speed turning of H13 in dry conditions. Taguchi's L'18 orthogonal array and analysis of variance (ANOVA) are used for individual optimization. The simultaneous optimization is done by Grey Relational Analysis approach. optimal value of the surface roughness (Ra) comes out to be 0.85 (μm) and of MRR is 488.8 (mm^3/sec). The optimum results are also verified with the help of confirmation experiments.

Mihir T. Patel et.al.,(2014) have studied the machining parameters for the CNC lathe machines are speed, feed, depth of cut, tool geometry, cutting environment, tool material, work material, etc. Which affect desired output like material removal rate, surface roughness, power consumption, tool wear, vibration etc. One of the technique widely used for optimization of machining parameters is Taguchi and ANOVA approach help to determine which parameters are most significant. Kanakaraja.D et.al.,(2014) have studied to optimize the machining parameters like speed, feed & doc using DOE with taguchi L9 orthogonal array for SAE 8822 alloy steel. Hamdi Aouici et.al.,(2011) have studied to investigate the turning operation on AISI H11(X38 Cr MoV5-1) & considering their output responses as flank wear and surface roughness using CBN tool. This experiments was conducted using Response Surface Methodology(RSM) wit input responses as speed, feed & cutting time, these were explored by ANOVA. A performance level are conducted using regression equation and output responses flank wear and surface roughness is obtained.

suresh.R et.al.,(2012) have studied to conduct the turning operation on AISI 4340 material with advanced cutting tool without using cutting fluid. This experiment is conducted using RSM with input parameters as cutting speed, feed rate, DOC & machining time to achieve output responses as machining force, surface roughness & tool wear. It results the minimum machining force and surface roughness by lower value of feed rate, DOC & machining time with higher value of cutting speed and reducing tool wear by minimizing the machining force and surface roughness. It was planned and designed by full factorial design method(FFD). Tongchao Ding et.al.,(2010) have studied to investigate the hard milling of AISI H13 steel with input responses as cutting speed, feed, radial DOC & axial DOC and to achieve output responses are cutting forces and surface roughness by using taguchi method. It results surface roughness depending some cutting parameters gives less than 0.25μm, this shows the finishing of hard milling is an alternative than grinding process in die & mould industry. Jing Xiang LV et.al.,(2015) have studied to investigate the characteristics of energy and to achieve the power models of CNC machine tools. This experiment takes 4 CNC lathes, 2 CNC milling & one machining center for the study. By considering output responses as power consumption of non-cutting motions and MRR which depends on the input parameters such as cutting fluid, spindle rotation, feed rate, turning and milling. This results in the power consumption of non-cutting motions & milling is dependent on machine tools but turning is not dependent on machine tools. Ashvin J. Makadia et.al.,(2012) have studied the effect of the main turning parameters such as feed rate, tool nose radius, cutting speed and depth of cut on the surface roughness of AISI 410 steel. A mathematical prediction model of the surface roughness has been developed in terms of above parameters. The effect of these parameters on the surface roughness has been investigated by using Response Surface Methodology (RSM). The surface roughness was found to increase with the increase in the feed and it decreased with increase in the tool nose radius. The verification experiment is carried out to check the validity of the developed model that predicted surface roughness within 6% error. R.K.Bharilyaa Ritesh Malgayab et.al.,(2015) have studied the effect of machining parameters for turning operation of given work piece, the material being Carburized Mild Steel (hard material), Aluminium alloys and Brass (soft material) which were machined on CNC machine and analysed through the cutting force dynamometer. The work enhanced surface quality i.e. surface finish & uniformity is found. This may result in reducing the cost of manufacturing in machining on high end/advanced computer controlled CNC.

Based on the literature review, it is found that most of the researches concentrated on individual operations like milling, drilling and turning. Some researches optimized the machining parameters by using optimization techniques. In experimental and theoretical analysis are carried out on different machining parameters and then machining. There is a need to investigate on component based process. To analyse several machining operations like facing, grooving, threading and turning.

III.EXPERIMENTAL WORKS

Multi-operations in CNC lathe is one of the important machining process to remove material from the work piece using single point cutting tool (Tungsten Carbide) and it is performed on the CNC lathe Sinumerik (802D) as shown in figure 3.1. In this experimental investigations, EN 8 steel rods have been selected and the work piece were prepared from the raw materials dimensions of length 80 mm and diameter 30 mm. The chemical composition of the work piece is shown in table 3.1 and the levels and ranges of input machining parameters of work piece is shown in table 3.2. Figures 3.2 and 3.3 show the work piece before and after machining process carried out in experimental work. Figure 3.4 shows the Tungsten Carbide tool insert. The total time taken for machining duration is determined by using stop watch. The amount of material removed is determined by calculating difference of volume of material before machining and volume of material after machining. This is measured by using the weighing machine. The volume of metal removed per calculate time gives the Metal Removal Rate (MRR) of the work piece during multi-operation.

FIGURE3.1.CNCLathe Sinumerik(802D)

Table 3.1 CHEMICAL COMPOSITION OF EN8 MATERIAL

ELEMENTS	C	Si	Mn	S	P
PERCENTAGE	0.36-0.44	0.10-0.40	0.60-1.00	0.50(max)	0.50

Table 3.2 LEVELS AND RANGES OF INPUT PARAMETERS

S.NO	PARAMETERS	UNITS	MINIMUM VALUE	MAXIMUM VALUE
1	Feed rate	mm/s	0.1	0.3
2	Spindle speed	Rpm	800	1200

FIGURE3.2.TEST SPECIMEN BEFORE MACHINING PROCESS

FIGURE3.3.TEST SPECIMEN AFTER MACHINING

FIGURE 3.4 MACHINE TOOL INSERT

3.1 DESIGN OF EXPERIMENTS

It is the systematic method to determine the relationship between factors affecting a process and the output of that process. It is used to find the cause and effect relationships. This information is needed to manage process inputs in order to optimize the output. In the present study central composite method is used. The experiments were conducted based on the input factors are speed & feed rate. The output responses are the Material Removal Rate . The Material removal rate is obtained by finding the difference between the weights of the specimen before and after the machining divided by machining time. The machining time is calculated by using the stopwatch**.** The experiments are conducted based on the recommendation of DOE and the corresponding levels are shown in table 3.3

Table3.3 DOE values for different levels

INPUT PROCESS PARAMETERS			OUTPUT RESPONSES			
RUN	SPEED	FEED	MACH I-NING TIME	WEIGHT(Kg)		MRR
	RPM	mm/rev	Sec	Before	After	g/sec
1	1000	0.2	120.91	0.455	0.374	0.6699
2	1000	0.2	120.66	0.458	0.374	0.6917
3	1000	0.2	120.37	0.459	0.378	0.6729
4	800	0.3	108.54	0.459	0.374	0.7831
5	800	0.1	240.94	0.459	0.382	0.3195
6	1000	0.2	120.50	0.456	0.374	0.6721
7	1200	0.1	173.91	0.458	0.372	0.5587
8	1282.84	0.2	104.21	0.453	0.371	0.7868
9	717.157	0.2	153.81	0.459	0.375	0.5461
10	1200	0.3	85.75	0.455	0.380	0.8746
11	1000	0.2	121.78	0.459	0.376	0.3432
12	1000	0.341421	88.16	0.375	0.941	0.9414
13	1000	0.058579	307.84	0.374	0.273	0.2728

TABLE 3.4 CNC MACHINE SPECIFICATIONS

S.NO	DESCRIPTION	SPECIFICATIONS
1	Maximum Swing Over Carriage	180 mm
2	Distance Between Centers	220 mm
3	Height Of Centre	165 mm
4	Spindle Bore Diameter	40 mm
5	Spindle Speed	5000 rpm

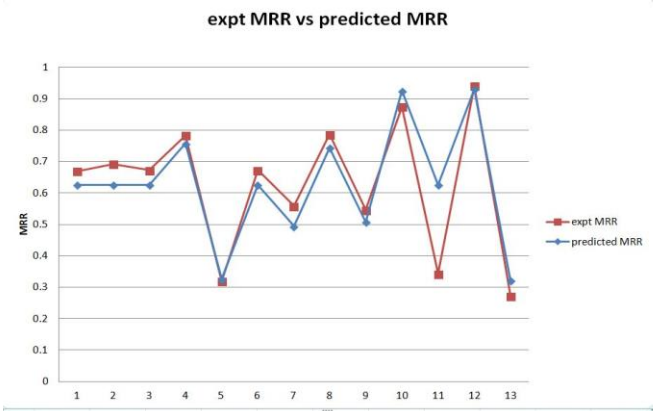
The experiments were conducted to study the effect of process parameters such like (spindle speed, feed and depth of cut) over the output response characteristics with the process parameters as given in table 3.5.

TABLE:3.5 EXPERIMENTAL RESPONSES Vs PREDICTED RESPONSES

SPEED	FEED	MRR		
		Experimental value	Predicted value	Absolute error
rpm	mm/rev	g/sec	g/sec	
1000	0.2	0.6699	0.625598	0.044302
1000	0.2	0.6917	0.625598	0.066102
1000	0.2	0.6729	0.625598	0.047302
800	0.3	0.7831	0.75734	0.02576
800	0.1	0.3195	0.32608	0.00658
1000	0.2	0.6721	0.625598	0.046502
1200	0.1	0.5587	0.493856	0.064844
1282.843	0.2	0.7868	0.744233	0.042567
717.1573	0.2	0.5461	0.506963	0.039137
1200	0.3	0.8746	0.925116	0.05052
1000	0.2	0.3432	0.625598	0.2824
1000	**0.341421**	**0.9414**	**0.930545**	**0.010855**
1000	0.058579	0.2728	0.320651	0.04785

EMPIRICAL EQUATION

The empirical equation obtained using design expert software is given below



GRAPH-1

Result and discussion:

The table 3.5 shows the input parameters and comparison of experimental and validated result for the metal removal rate. The validation is done by using empirical equation obtained by using DOE software. Table 3.5 shows that the difference between the validated metal removal rate and the experimental metal removal result is small. Thus the empirical equation for metal removal rate of EN8 is within the range of experimentation. The graph-1 shows the plot between experimental MRR Vs Predicted MRR. The predicted MRR is obtained using the empirical equation obtained from Design Expert software. The absolute error value found out from difference between experimental MRR and Predicted MRR are minimum hence the experimental and predicted value are almost equal.

=-0.22510+4.19438E-004* SPEED+2.15636 * FEED

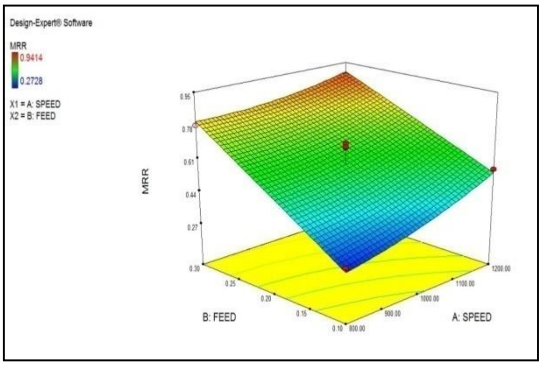
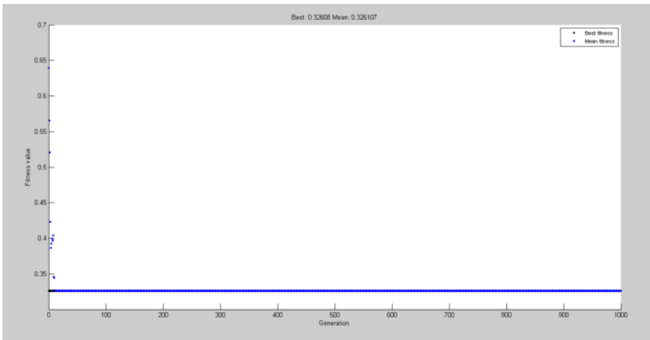


FIGURE :4.1 INTERACTION PLOT BETWEEN MATERIAL REMOVAL RATE(OUTPUT) AND SPEE& FEED (INPUT) INTERACTION PLOT 1

The Material Removal Rate (MRR) increases with increase in feed rate and spindle speed respectively. The maximum Material Removal Rate is obtained as 0.9414 g/sec at 0.3414 mm/rev feed rate and 1000 rpm. The minimum Material Removal Rate is obtained as 0.2728 g/sec at 0.058 mm/rev feed rate and 1000 rpm.

COMPUTATIONAL RESULTS

Best fitness value for material removal rate:



Above graph represents the optimal MRR value using genetic algorithm and plotted by excel method. The optimal parameter value for MRR is speed = 800 rpm & feed = 0.1mm/rev. The best fitness value = 0.326107 g/sec is obtained using the genetic algorithm.

IV.CONCLUSION:

The SINUMERIK 802D Computer Numerical Control machine is used for conducting the experimental investigation based on the central composite method in DOE to obtain the optimum level of MRR of EN8 material. The authors reported the significant conclusion based on the experimental results and analysis as listed below.

- Feed rate and speed plays major role on the machining process for MRR .

- The empirical equation for surface roughness and Material Removal Rate is obtained using Design expert software under central composite method to calculate predicted results.
- By using the genetic algorithm in the matlab software the optimal solutions of Material Removal Rate is obtained.
- The optimal Material Removal Rate is obtained as 0.32608 g/sec.

REFERENCES

[1] Manu garg, Sandeep Sangwan and Munish Kainth,"REVIEW OF MACHINING PARAMETER OF EN8&EN24 IN CNC LATHE- OPTIMIZATION OF PROCESS PARAMETER USING TAGUCHI TECHNIQUE" , 2016 International journal of engineering and technical research (IJETR) 82-85.

[2] Pankaj Sharma and Kamaljeet Bhambhir, "EXPERIMENTAL INVESTIGATION OF PARAMETER OF CNC TURNING BY TAGUCHI BASED GREY RELATIONAL ANALYSIS" , 2013 International journal of engineering research and applications (IJERA) 429-436.

[3] MihirT.patel1 and vivekA.Despande, "OPTIMIZATION OF MACHINING PARAMETER FOR TURNING DIFFERENT ALLOY STEEL USING CNC REVIEW", 2014 International journal of innovative research in science engineering and technology (IJIRSET) 9423-9430.

[4] Kanakaraja.D , Anjan.D kumar reddy , M.Adinarayana and Vamsi Krishna reddy.L, "OPTIMIZATION OF CNC TURNING PROCESS PARAMETERS FOR PREDICTION OF SURFACE ROUGHNESS THROUGH TAGUCHI'S PARAMETRIC DESIGN APPROACH", 2014 International journal of mechanical engineering and robotics research (IJMERR) 708-714.

[5] Hamdi Aouici, Mohamed Athmane Yallese, Brahim Fnides, Kamel Chaoui and Tarek Mabrouki, "Modeling and optimization of hard turning of X38CrMoV5-1 steel with CBN tool: Machining parameters effects on flank wear and surface roughness" , 2011 SPRINGER 2843-2851.

[6] Suresh.R, Basavarajappa.S, Gaitonde and Samuel.G.L,"MACHINABILITY INVESTIGATIONS ON HARDENED AISI 4340 STEEL USING COATED CARBIDE INSERT" , 2012 ELSEVIER 75-86.

[7] Tongchao Ding, Song Zhang, Yuanwei Wang and Xiaoli Zhu, "EMPIRICAL MODELS AND OPTIMAL CUTTING PARAMETERS FOR CUTTING FORCES AND SURFACE ROUGHNESS IN HARD MILLING OF AISI H13 STEEL" , 2010 SPRINGER 45-55.

[8] Jingxiang .LV, Renzhong Tang, Shun Jia and Ying Liu, "EXPERIMENTAL STUDY ON ENERGY CONSUMPTION OF COMPUTER NUMERICAL CONTROL MACHINE TOOLS" , 2015 ELSEVIER 1-11.

[9] Ashvin J.Makadia and J.I.Nanavati, "OPTIMIZATION OF MACHINING PARAMETERS FOR TURNING OPERATIONS BASED ON RESPONSE SURFACE METHODOLOGY", 2012 ELSEVIER 1521-1529.

[10] R.K.Bharilyaa Ritesh Malgayab, Lakhan Patidarc, R.K.Gurjard and Dr.A.K.Jhae, "Study of optimised process parameters in turning operation through Force Dynamometer on CNC Machine" , 2015 ELSEVIER 2300-2305.