International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

Investigation of Material Removal Rate on Mild Steel–using Taguchi Technique

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ABSTRACT

The manufacturing industries are achieving the maximum productivity by reducing the ideal time. By the help of latest technology, the manufacturing industries are reducing the wastage of material, cost of cutting operation, cutting time and human mistakes, these leads to improvement in productivity,quality, power consumption and performance of the industry. The main objective of the work is to improve the Material Removal Rate(MRR) of mild steel while performing turning operation on CNC Lathe Machine. In this investigation two input parameters have been selected to improve the material removal rate. They are tool rake angle and feed rate.These parameters are varied at constant speed to investigate their effect on material removal rate (MRR). Taguchi L6 orthogonal array is used for experimental design. An attempt has been made to model one response variable using Taguchi an ANOVA method.The experimental data was analyzed by using Minitab17 software.

Keywords

Machining, Material Removal Rate, Rake angle, feed rate, Taguchi technique

1. INTRODUCTION

Machining is a part of the manufacture of many metal products, but it can also be used on materials such as wood, plastic, ceramic, and composites. Machining is the most important of the manufacturing processes. Machining can be defined as the process of removing material from a work piece in the form of chips. The term metal cutting is used when the material is metallic.

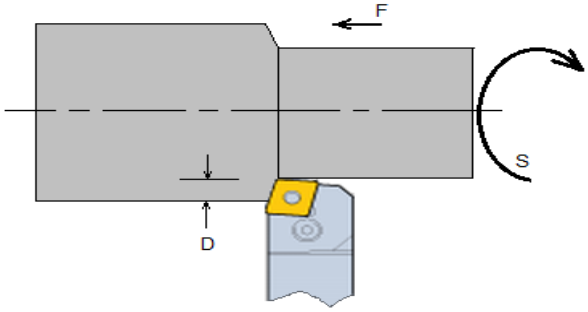

Fig 1. Principle of turning operation

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, workpiece, fixture, and cutting tool. The workpiece is a piece of pre-shaped material that is secured to the fixture, which itself is

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ISSN 2394 – 3386
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attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating workpiece and cuts away material in the form of small chips to create the desired shape.

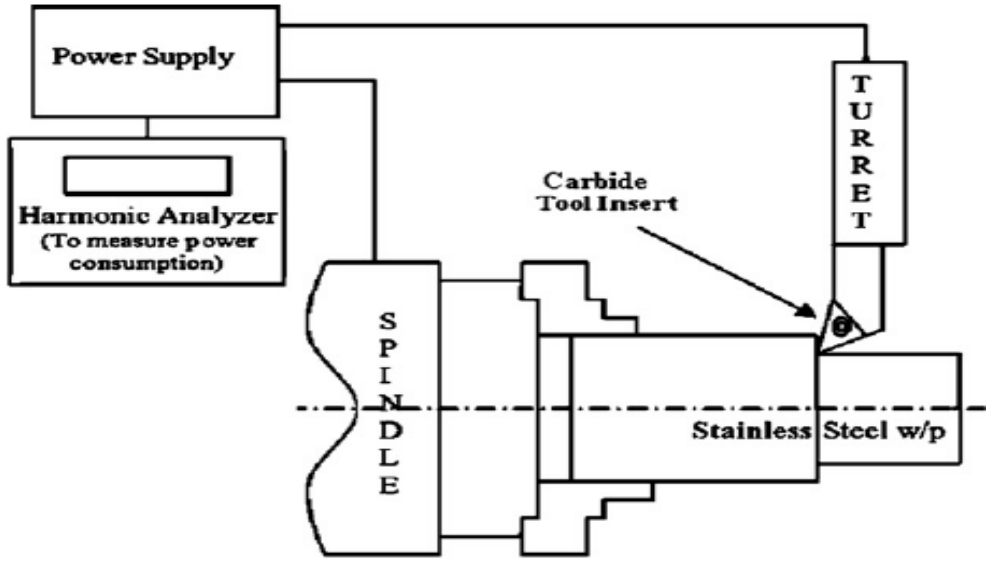

Fig 2: Line diagram for lathe machine

Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process.

The purpose of this research work is to find the influence of cutting parameters on material removal ratein turning operation. This paper presents a Taguchi's L6 orthogonal array for the optimization of the materialremoval rate for turning operation on mild steel.

ANOVA (Analysis of variance) is used to findout the most and least significant parameters.Present work focus on maximize material removal rate with the purpose of improving the performance of turning operation. In this research determining cutting parameters like rake angle and feed that maximize material removal rate is a main task for achieving overall economy of machining. Statistical design of experiment refers to the process of planning the experimental so that the proper data can be analyzed by statistical methods, resulting ina valid and reliable outcome.

2.LITERATURE SURVEY

RanganathM.S.,Vipin and Mishra [1], R.S,conducted turning operation on aluminium(6061) at dry condition. Selected machining parameters are the cutting speed of 180, 450 and 710 rpm, feed rate of 0.2, 0.315 and 0.4 mm/rev and the depth of cut (DOC) was kept constant to 0.2 mm. The effect of cutting condition (cutting speed and feed rate) on material removal rate and surface roughness were studied and analyzed. They found optimum results for minimum surface roughness are obtained at 30, 180 rpm, and 0.2 mm/rev with constant depth of cut 0.2 mm. The optimum values for maximum material removal are obtained at 20, 710 rpm, and 0.4 mm/rev with constant depth of cut 0.2 mm

R.A.Muley, A.R.K Ulkarni, R.R.Deshmukh [2], A., done research work on Optimization of Surface Finish and Material Removal Rate. They selected AISI D2 material, which is a high carbon hardened steel using for

making of dies. From the experimental results they observed that MRR in CNC turning is greatly influenced by depth of cut followed by cutting speed. There is an increase in MRR with increase in cutting speed. Optimum value of MRR is found to be 1794.37mm3/min at 180m/min. Optimum value of cutting speed is observed in between 150 to 180m/min.

SaurabhSinghvi [3], M.S.Khidiya, S.Jindal, M.A.Saloda., "Investigation of Material Removal Rate in Turning Operation. In this rake angle,feed rate, and cutting speed are selected. In which rake angle is taken as 6o,9o,12o and feed as0.05,0.07and 0.10 mm/rev. Cutting speed is taken as (52 rpm) constant. Taguchi design of experiment with L6 orthogonal array was used for experiment and minitab17 statistical software used to analysis the experimental data. The ANOVA is used to investigate which design factor and their interaction affects the response significantly. from the results they observed that t maximum material removal rate developed at 0.10 mm/rev of feed and at 6 degree of rake angle.

TayabM.D. and Nath T.[4], Research work done on Cutting Parameters Optimization for turning AA6063-T6 Alloy by Using Taguchi Method. They done work on optimization of the cutting parameters like spindle speed, feed rate, and depth of cut for minimization of Surface Roughness and maximization of Material Removal Rate (MRR) in CNC turning of Aluminum Alloy (AA6063-T6) using carbide insert tool in dry condition.Taguchi design of experiments (DOE) with L9 Orthogonal Array (OA) and Minitab- 17 statistical software is used to analyze the data.from the results they found depth of cut and cutting speed are the most significant factors for MRRand feed rate having the least influence.

MihirThakorbhai Patel [5], done research work on optimization of material removal rate by using Taguchi method. They selected speed 800, 1000, 1200 rpm. Feed (mm/rev) 0.1,0.15,0.2 and depth of cut(mm) as 0.5,1,1.5.from the experimental results they observed Depth of cut, feed and speed are the most significant factors for material removal rate.

Sayak Mukherjee, Anurag Kamal, KaushikKumar[6], done research on optimization of Material Removal Rate During Turning of SAE 1020 Material in CNC Lathe using Taguchi Technique. The selected input parameters are cutting speed,feed and depth of cut. In this work L25 orthogonal array was used to carry out the experiments and to analyze the experimental results.From the experimental results they observed that depth of Cut had the most significant effect on MRR followed by Feed.

3. DESIGN OF EXPERIMENTATION

3.1 Selection of Materials

In thisinvestigation selection of material for work piece is Mild steel round rod which having good machinibiltiy, light weight, durability and good mechanical properties. Which is having young's modulus of 2x105 and poissions ratio of 0.3 carbide toolwas selected as a cutting tool, which is very hardened material.

3.2The Experimental Design

In this investigation turning operation is performed on CNC lathe machine by considering the input parameters like Feed rate, Rake angle, cutting speed. Taguchi method was selected to get the optimum solution for Material removal rate over the given set of inputs like rake angle, cutting speed and feed rate. Thus, the modern day approach to find the optimal output over a set of given input can be easily carried out by the use of Taguchi method rather than using any other conventional methods. This method has a wide scope of use in various fields of engineering sciences. The experimental data was analyzed by using Minitab17 software.

There are three categories for analysis of S/N Ratio i.e. nominal is best, larger is better and smaller is better. For this experimental analysis, the second category i.e. "Larger is better" was chosen to reach the optimization condition as the desired condition was to get maximum material removal rate for our experiment.This experiment involves two cutting parameters rake angle and feed rate along with one response variable as material removal rate.

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Table 1.Cutting Parameters

Cutting Parameters	**Units**	**No.of Levels**	**Values for each value**	
			Level 1	**Level 2**
Rake angle	Degrees	1	6	9
Feed rate	Mm/rev	2	0.05, 0.07, 0.10	0.05, 0.07, 0.10

To determine the effect of each variable on the output response parameter, the signal-to-noise (S/N) ratio is calculated for each experiment by using Taguchi method in Minitab 17 statistical software and results are tabulated as shown below in Table-2.

4. RESULTS AND DISCUSSIONS

The following results are obtained from the Experiments. From the table-2,we can understand the effect of various input parameters on MRR.

Table-2: Material removal rate for various input parameters.

Independent Parameters			**Dependent variable**	**S/N ratio**	**Mean**
Rake angle (degrees)	Feed rate (mm/rev)	Spindle speed (rpm)	Material removal rate (mm^3/min)		
6	0.05	52	71.5485	37.0920	71.549
6	0.07	52	109.3156	40.7736	109.316
6	0.10	52	140.369	42.9454	140.369
9	0.05	52	63.804	36.0970	63.804
9	0.07	52	89.3949	39.0263	89.395
9	0.10	52	118.2319	41.4547	118.232

By using the ANOVA Minitab 17 software drawn Main effects plot for SN Ratio as well as for Main effect plots for Mean.

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IJETSR
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ISSN 2394 – 3386
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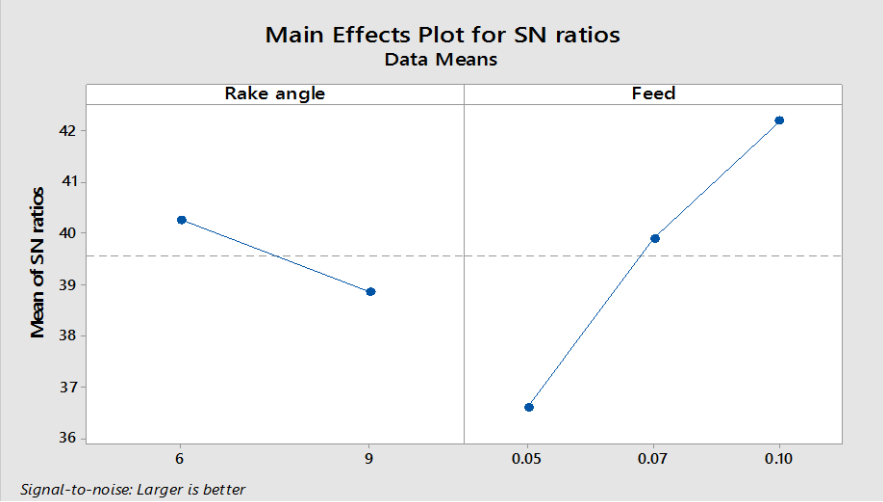

Fig 3:Main EffectsPlotfor S/N ratios.

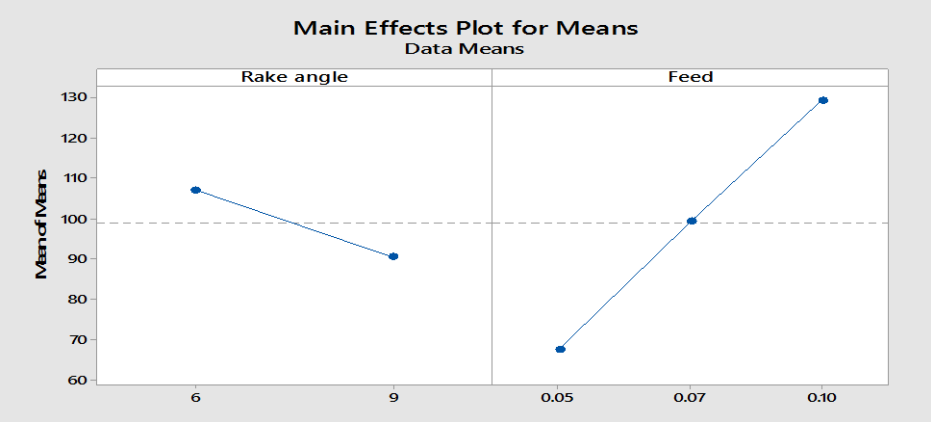

Fig 4:Main Effects Plot for Means.

The result shows that both the two parameters have their effect on the measured material removal rate. The effect of feed is more than the rake angle. Feed is the distance travelled by the tool per revolution of workpiece, so it indicates the time for cutting the material from the workpiece. Hence, for more feed rate less time is required for cutting the material in desired length which increase material removal rate.

It is clear from given data in Table-2 for a constant rake angle and spindle speed, but varying the feed rate shows more variation in material removal rate. For example, for constant spindle speed of 52 rpm and rake angle 6 degrees, changing the feed rates from 0.05mm/rev to 0.10 mm/rev show increment in material removal rate from 71.5485 mm^3/min to140.369 mm^3/min, which is more significant. There is less effect of rake angle on material removal rate as compared to feed rate as the increase in rake angle leads to a less increment in material removal rate.

4.1 ANOVA TABLEGENERATION BY SOFTWARE

ANOVA (Analysis of Variance) table is also generated by software for determination of percentage contribution of different independent parameters on the response variable by using Minitab 17 statistical software which is shown below in Table-3.Table-3: Analysis of Variance.

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Source value	DF	Seq. SS	Contribution	Adj. SS	Adj. MS	F-value	P-value
Rake angle	1	413.38	9.68%	413.38	413.38	13.77	0.066
Feed rate	2	3798.54	88.92%	3798.54	1899.27	63.25	0.016
Error	2	60.05	1.41%	60.05	30.03		
Total	5	4271.98	100.00%				

It is clear from above table that the effect of feed rate and rake angle on material removal rate (MRR) is 88.92% and 9.68% respectively.

4.2 Model Summary:

Table-4: R-sq represents the significance of experimental work.

S	R-sq	R-sq (adj.)	PRESS	R-sq (Pred.)
5.47965	98.59%	96.49%	540.479	87.35%

4.3 Regression Equation

Regression equations can help you figure out if your data can be fit to an equation. This is extremely useful if you want to make predictions from your data–either future predictions or indications of past behavior.

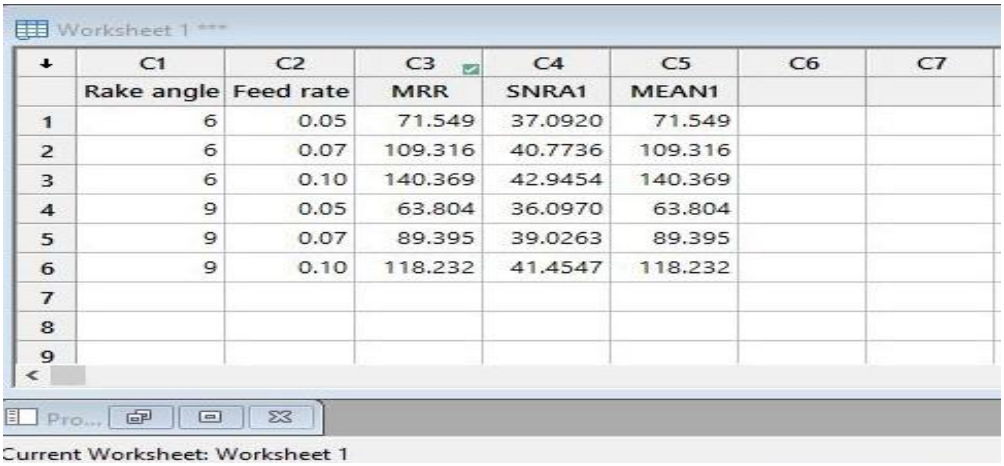
Regression equation is formulated to predict the desired material removal rate value using the two independent parameters i.e. rake angle and feed rate. This term is used for finding the co-relation between the data. In the present work, regression equation was obtained by using Minitab 17 statistical software as shown below.

Regression equation generated by Minitab 17 software is

Material removal rate (mm^3/min)= 51.3 – (5.53 * rake angle) + (1214 * feed rate)

4.4 OBSERVATIONS

From the Experimental results as we observed that the optimum condition for our input data to get maximum material removal rate (MRR) is 6 degree of rake angle and 0.10mm/rev of feed rate at constant spindle speed.The maximum material removal rate that we get from our experiment and Taguchi method is 140.369 mm^3/min.


Worksheet 1 ***

	C1	C2	C3	C4	C5	C6	C7
	Rake angle	Feed rate	MRR	SNRA1	MEAN1		
1	6	0.05	71.549	37.0920	71.549		
2	6	0.07	109.316	40.7736	109.316		
3	6	0.10	140.369	42.9454	140.369		
4	9	0.05	63.804	36.0970	63.804		
5	9	0.07	89.395	39.0263	89.395		
6	9	0.10	118.232	41.4547	118.232		
7							
8							
9							

Pro...

Current Worksheet: Worksheet 1

Table-5: Effect of Rake angle and feed rate on MRR

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- The contribution of rake angle and feed rate is 9.68% and 88.92% respectively.
- The significance of the experimental work (R-sq) analyzed by using Minitab 17 statistical software is 98.59%.
- With increase in feed rate material removal rate increases, but with increase in rake angle for same feed rate the MRR decreases.

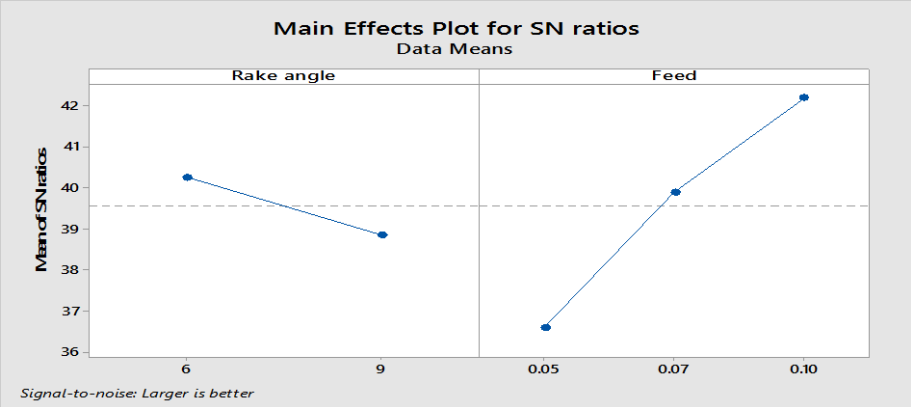

Fig 5:Main effect plot for S/N ratios in Taguchi method.

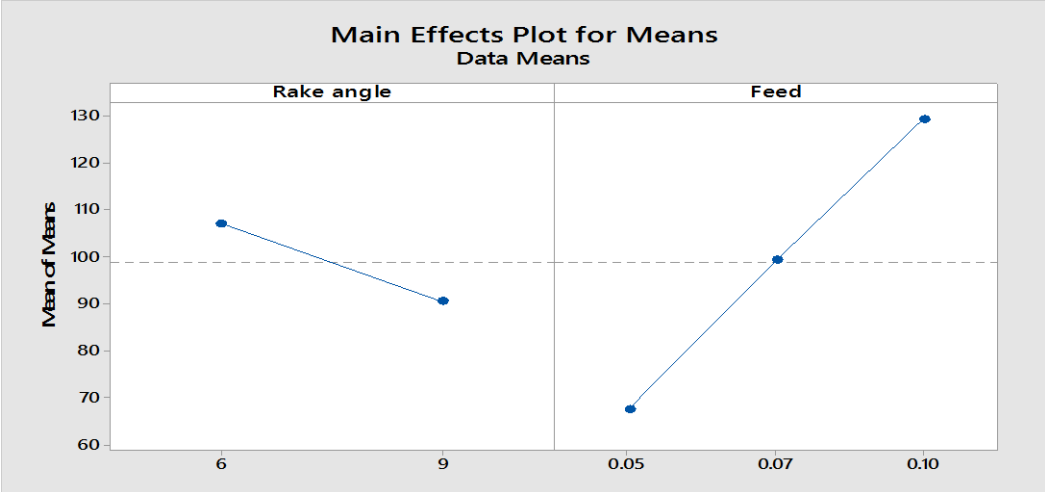

Fig:6Main effect plot for Means in Taguchi method.

5. Conclusions

After analysis of the input data of rake angles and feed rates with constant spindle speed, it is clear that maximum material removal rate is obtained at 6 degree of rake angle and 0.10 mm/rev of feed rate. Also we observed from the table-5, with increase in feed rate material removal rate increases, but with increase in rake angle for same feed rate the MRR decreases. So for Material Removal Rate the contribution of the feed rate is more than the rake angle. The maximum material removal rate that we get from our experiment byTaguchi method is 140.369 mm^3/min.This concludes that constant spindle speed same power is consumed and from analysis we got the maximum material removal rate conditions which would directly save power in large scale productions. This would also save the lead time in the industrial productions.

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