

# **EVALUATION AND OPTIMIZATION OF MACHINING PARAMETERS FOR TURNING OF DIFFERENT ALLOY STEEL USING CNC LATHE BY TAGUCHI'S METHOD**

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## **ABSTRACT**

*Alloy Steel has a wide variety of applications in different industries. The Challenge of modern machining industries is mainly focused on achieving high quality, in term of part/component accuracy, surface finish, high production rate and increase the product life with lesser environmental impact. This study investigates the use of tool materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics. Develop a methodology for optimization of cutting forces and machining parameters. Taguchi's parameter optimization method is used to evaluate best possible combination for minimum cutting force during machinability.*

**Keywords:** *Alloy Steel, parameters, cutting force*

## **I INTRODUCTION**

In today's rapidly changing scenario in manufacturing industries, applications of optimization techniques in metal cutting processes is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality product in the market. This study helpful in evaluating optimum machining parameter like tool geometry, tool Material, cutting speed, feed and depth of cut for cutting force for turning 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. Optimization of machining parameters and also need to determine which parameters are most significant for required output. One of the technique widely used for optimization of machining parameters is Taguchi and ANOVA approach help to determine which parameters are most significant.

### **1.1 Taguchi approach**

Basically, traditional experimental design procedures are too complex and not easy to use. A large number of experimental works have to be carried out when the number of the process parameters increases with their levels. TO solve this problem, the Taguchi method uses a special design of orthogonal arrays to

study the entire parameter space with only a small number of experiments. Taguchi robust design method is a most powerful tool for the design of a high-quality system. He considered three steps in a process's and product's development: system design, parameter design, and tolerance design. In system design, the engineer uses scientific and engineering principles to determine the fundamental configuration. In the parameter design step, the specific values for system parameters are determined. Tolerance design is used to determine the best tolerances for the parameters.

## II. SURFACE ROUGHNESS PARAMETERS

Surface roughness most commonly refers to the variations in the height of the surface relative to a reference plane. It is measured either along a single line profile or along a set of parallel line profiles (surface maps). It is usually characterized by one of the two statistical height descriptors advocated by the American National Standards Institute (ANSI) and the International Standardization

## III-EXPERIMENTATION

The cutting experiments were carried out on a Panther1350 Lathe under different cutting conditions are shown in Fig. 1. Machining tests were performed on an Steel bar having Diameter  $\Phi$  30mm. Experimental data and chemical composition of steel bar which was used in experiments as shown in the Table 1 and Table 2. And Cutting speeds were selected by preliminary experiments conducted on the machine. Tool material for this study was High Speed Steel (HSS-M2), Carbide and Cermet having different tool shapes A1, A2 and A3 respectively. A strain gauge type Dynamometer was used to measure thrust force ( $F_t$ ) and feed force ( $F_f$ ). Each experiment was repeated three times and results were recorded for thrust force and feed force. Taguchi parameter optimization method was used to evaluate the best possible combination for minimum cutting force during turning operation.

C	Mn	Si	P	S
0.4	0.8	0.23	0.017	0.015

Table 1 Chemical composition

Process parameter	Levels		
	L1	L2	L3
Tool shape and	HSS-	Carbide	Cermet
Cutting speed (B)	238	390	510
Depth of cut (C) mm	0.4	0.65	1
Feed (D) mm/rev	0.065	0.13	0.26

Experimental data



### MATERIAL REMOVAL RATE

Material Removal rate (MRR) in turning is the material/metal that is removed per unit time in  $\text{mm}^3/\text{sec}$ . For each revolution of the work piece, a ring shaped layer of material is removed.

$$\text{Material Removal Rate (MRR)} = v \times f \times d \text{ mm}^3/\text{sec}$$

Where,

$v$  = cutting speed in mm/sec  $d$  = depth of cut in mm

$f$  = feed in mm/rev

A process which remove metal at faster rate may not be the economical process, since the power consumed and cost factor taken into account. Due to this, to compare two processes, the amount of metal removed per unit of power consumed is determined. This is called “specific metal removal rate” and is expressed as,  $\text{mm}^3/\text{W}/\text{min}$ , if the power consumption is measured in watts.

### IV. ANALYSIS OF THE SIGNAL-TO-NOISE (S/N) RATIO

As mentioned earlier, there are three categories of performance characteristics, i.e., the lower-the-better, the higher-the-better, and the nominal-the-better. To obtain optimal machining performance, the lower-the-better performance characteristic for cutting force should be taken for obtaining optimal machining performance.

Experiment no.	of shape and	Cutting speed	Depth of cut	Feed	Cutting Force,			Cutting Force, Feed			Z force S/N	Y force S/N
					Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3		
1	1	1	1	1	145	145	155	78	87	88	-42.55	-38.3
2	1	2	2	2	263	270	270	119	127	145	-47.67	-42.37
3	1	3	3	3	604	629	619	226	217	245	-55.86	-46.21
4	2	1	2	3	314	334	363	118	128	137	-50.56	-42.13
5	2	2	3	1	235	245	235	98	108	108	-47.56	-40.4
6	2	3	1	2	284	294	304	137	147	147	-49.38	-43.16
7	3	1	3	2	402	422	441	196	206	216	-53.51	-46.28
8	3	2	1	3	314	294	304	137	128	137	-48.66	-43.55
9	3	3	2	1	275	265	304	108	98	128	-49	-40.97

Parameter	S/N ratio for Thrust force			S/N ratio for Feed Force		
	L1	L2	L3	L1	L2	L3
Tool shape and material	-49.30	-49.18	-49.39	-41.73	-41.6	-43.27
Cutting speed (B)	-47.87	-48.63	-51.0	-42.25	-41.70	-43.70
Depth of cut (C)	-47.50	-49.41	-51.96	-41.44	-41.82	-44.63
Feed (D)	-46.7	-51.19	-52.11	-39.90	-43.94	-43.96

**V. RESULTS**

Mean response referring to average values of performance characteristics for each parameter at different level were calculated (Table 4). Thrust force Z has been found minimum at 2<sup>nd</sup> level of parameter A (Tool shape and material), 2<sup>nd</sup> level of parameter B (cutting speed), 1<sup>st</sup> level of parameter C (Depth of cut), 1<sup>st</sup> level of parameter D (Feed). Analysis of variance (ANOVA) and significance of parameters: Estimation of optimum performance characteristics Optimum Thrust force Z ( $\mu F_Z$ ) was predicted at selected levels of significant parameters (A<sub>2</sub>, B<sub>2</sub>, C<sub>1</sub>, D<sub>1</sub>). Estimated Thrust force Z ( $\mu F_Z$ ) can be calculated as

$$\mu F_Z = A_2 + B_2 + C_1 + D_1 - 3 TFZ$$

Where,  $\mu F_Z$  is optimum thrust force Z, and TFZ is overall mean of thrust force Z with parameter at optimum level. From Table 2 Mean A<sub>2</sub>=290, Mean B<sub>2</sub>=271, Mean C<sub>1</sub>=250, Mean D<sub>1</sub>=223, and mean TFZ=324.

**CONFIRMATION EXPERIMENTS:**

Nine experiments (3 repetitions for each of 3 experiments) at optimal setting were conducted during turning operation recommended by investigation for thrust force Z, and feed force Y. At investigated parameters optimal levels, following was found: average thrust force, 62N; average feed force, 46N.

Source	Sum of Squares (SS)	Degrees of freedom	Variance (V)	F-ratio	Pure sum of squares (SS')=Sa- (ve*Fa)	Contribution on (P), %
A	16390.00	2	8193.05	40.29	15992.14	3.709
B	77927.53	2	38963.77	196.32	77927.53	18.40
C	150391.07	2	75185.54	378.87	150391.07	35.12
D	173819.75	2	86906.88	436.89	173819.75	41.18
E (error)	3562.52	18	198.47		3969.47	0.94
T (total)	422200.96	26			422100.96	100

Source	Sum of Squares (SS)	Degrees of freedom	Variance (V)	F-ratio	Pure sum of squares (SS')=Sa- (ve*Fa)	Contribution on (P), %
A	3478.00	2	1739.11	15.93	3258.45	5.925
B	6583.9	2	3291.95	29.97	6583.9	11.90
C	20091.55	2	10045.83	91.47	20091.65	36.53
D	22865.33	2	11432.67	104.09	22865.33	41.58
E (error)	1966.94	18	108.83		2196.66	3.69
T (total)	54955	29			54996	100

## VI CONCLUSION

There are many factors which affect the surface roughness and material removal rate (MRR) i.e. cutting conditions, tool variables and work piece variables. Cutting conditions include speed, feed and depth of cut and also tool variables include tool material, nose radius, rake angle, cutting edge geometry, tool vibration, tool overhang, tool point angle etc. and work piece variable include hardness of material and mechanical properties. In a turning operation, it is very difficult to select the cutting parameters to achieve the high surface finish and material removal rate. According to Roy, R. K. the very intention of Taguchi Parameter Design is for maximizing the performance of a naturally variable production process by modifying the controlled factors. ANOVA used to determine the percentage contribution of all factors upon each response individually. Optimum parameter level for minimum thrust force Z are 2<sup>nd</sup> level of parameter A, 2<sup>nd</sup> level of parameter B, 1<sup>st</sup> level of parameter C and 1<sup>st</sup> level of parameter D. This implies that the level of parameters at designated levels as A<sub>2</sub>, B<sub>2</sub>, C<sub>1</sub>, D<sub>1</sub> are the best combination to get minimum thrust force Z in turning of steel 8bar. Optimum parameter level for minimum feed force Y are 2<sup>nd</sup> level of parameter A, 2<sup>nd</sup> level of parameter B, 1<sup>st</sup> level of parameter C and 1<sup>st</sup> level of parameter D. This implies that the level of parameters at designated levels as A<sub>2</sub>, B<sub>2</sub>, C<sub>1</sub>, D<sub>1</sub> are the best combination to get minimum thrust force Z in turning of steel 8 bar.

## VII. LITERATURE REVIEW

- ❖ Upinder Kumar Yadav et. al. [1] have optimized of machining parameters for surface roughness in CNC Turning by Taguchi method.
- ❖ Vikas B. Magdum et. al. [2] Evaluation and Optimization of Machining Parameter for turning of EN 8 steel
- ❖ Mihir T. Pate et. al. [3] Optimization of Machining Parameters for Turning Different Alloy Steel Using CNC

- ❖ M. Kaladharet. al. [4] were conducted experiments to turn AISI 304 austenitic stainless steel using Physical Vapour Deposition (PVD) coated inserts at four levels (Speed, feed, DOC and nose radius) of cutting parameters by using Taguchi and ANOVA approach.
- ❖ J. Paulo Davim , Lui´s Figueira, “Machinability evaluation in hard turning of cold work tool steel (D2) with ceramic tools using statistical techniques; Materials and Design,” 1186–1191, 28, 2007
- ❖ Alakesh Manna, Sandeep Salodkar, “Optimization of machining conditions for effective turning of E0300 alloy steel; journal of materials processing technology,”147–153, 203, 2008.