Optimization of Cutting Parameters in Turning Operation of Al-6061 to Reduce Cutting Force

Prof. Vishal Bhagat
Assistant Professor, Mechanical Engineering
Saraswati College of Engineering,
Navi Mumbai, India
Vwbhagat123@gmail.com

Mr. Vaibhav Bawaskar
Student, Mechanical Engineering
Saraswati College of Engineering,
Navi Mumbai, India
vaibhavbawaskar4@gmail.com

Mr. Mayank kumar
Student, Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
mayank02119@gmail.com

Mr. Vijay Kewat
Student, Mechanical Engineering
Saraswati College of Engineering,
Navi Mumbai, India
Vijaykewat12@gmail.com

Mr. Roshan Koli
Student, Mechanical Engineering
Saraswati College of Engineering,
Navi Mumbai, India
Roshankoli17@gmail.com

Abstract*— Every mfg. ind. aims at production a large no. of products within lesser time so as to get lesser power consumption and also to get best quality. Research work basically use the turning operation on conventional lathe as it is most widely adopted method for machining and also plays a vital role in effecting cutting forces. This experiment shows the optimization of cutting parameters for cutting forces in the turning operation to get optimal setting of process parameters and Taguchi method is used to analyze the effect of cutting parameters while turning. The material which is used for this experiment is AL-6061 and the tool used is carbide tipped turning tool. Cutting forces measured by lathe tool dynamometer. Once the experimental work had been done, using Minitab software and Taguchi's method the best possible combination of input parameters which minimizes cutting forces are find out.

Keywords*—Al 6061, Lathe tool dynamometer, Process Parameter (Speed, Depth of cut, Feed rate), Taguchi Method, S/N ratio.

I.INTRODUCTION

Turning process is one of the machining operations perform on lathe machine so it is use for current research. Turning is a complex process where the performance depends upon cutting condition. The interaction of cutting tool with a work piece includes cutting forces that combine main cutting force, feed force, and thrust force. The knowledge of cutting forces developing in the turning process is useful for both the designer-manufacturer of machine tools and user.

The Taguchi method is used to achieve good quality in lesser no. of experiment. Many authors optimized the cutting parameters in turning operation by Taguchi method which are explained further. S.K Thangarasu [1] This paper proposed a noval model for predicting cutting force.The graph shows that the measured values are in correlation with experimentally lath tool dynamometer measured force.by choosing proper operating conditions such that the cutting force should be minimum, the surface roughness and tool wear can be controlled. T.A.Susanto and Rusdi Nor[2] The cutting speed has on effect on machining performance and that optimum cutting condition have to be determined while sustainable machining can be followed in terms of minimizing power consumption and cutting force. Dr.C.J.Rao and P.Srinari[3] The interaction of feed and depth of cut and the interaction of all the three parameters have significant influence on cutting force, where as none of the interaction effect are having significant influence on surface roughness produced. Bala Raju [4] The developed mean be used to predict. The surface finish and cutting forces in terms of machining parameters within the range of variable studied. It also help to choose the influential process parameters so that desired value of surface finish and cutting forces can be obtained. Jithin Babu and

A.Ramesh babu [5] In turning aluminium alloy, use of lower feed rate (0.25mm/rev), higher cutting speed (76m/min) and lower depth of cut (0.3mm) are recommended to get better surface test range.

The purpose of this paper is to study the effect of different cutting parameters to identify the minimum cutting forces using Taguchi method for multi objective optimization. Therefore, in this work a model is developed to monitor cutting forces on AL-6061.

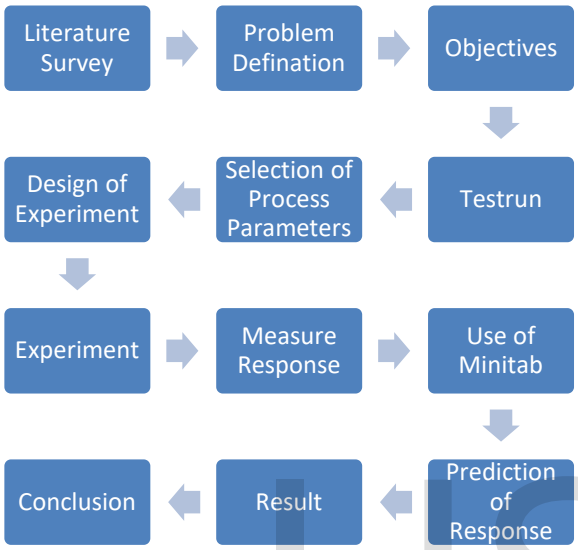

Fig. 1. Overall Methodology chart

II. Cutting Forces

Cutting forces are the forces that acts on the tool throughout any of the machining operation. In turning their are 3 forces acting which are tangential force, radial force & axial force.

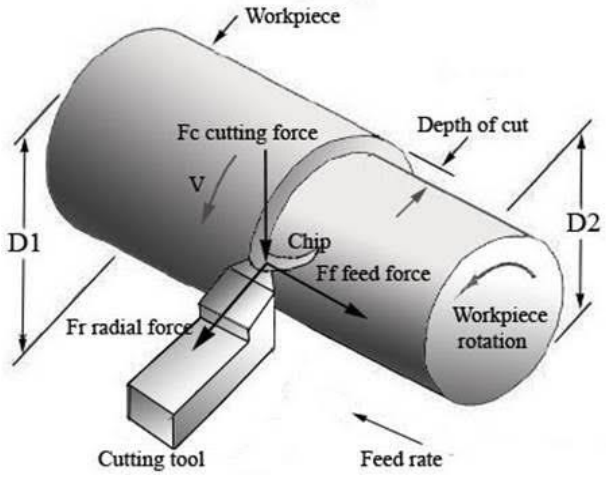

Fig. 2. Cutting Forces on Turning Operation.

III. Taguchi Method

The Taguchi methodology is used for producing high quality product at minimum cost. This method is a conventional method designs the experiment in an efficient & effective manner and analyze the process influencing parameter in lesser time. It is a modified method in design and analysis compared to traditional design and is widely used in making quality improvements. This is performed or done to find the suitable combination of parameters with the varying responses. Taguchi methodology could be a powerful tool to style improvement for quality. It's wont to notice the best cutting parameters like cutting speed, feed rate and depth of cut, etc. as the overall value will be reduced. This experiment provides some background of improvement technique applied to numerous turning processes for up Cutting forces. The Taguchi methodology is widely used to notice associate optimum setting of producing method parameters. The target of parameters style is to optimize the settings of the method parameters price for up the performance characteristics and to spot the parameters value.

Step-1: Establish the most perform, aspect effects, and failure mode.
Step-2 Establish the noise factors, Testing condition, and quality characteristics.
Step-3: Establish the target perform to be optimized.
Step-4: Establish the management factor and their levels.
Step-5: Choose the Orthogonal array matrix experiment.
Step-6: Perform Matrix Exp.
Step-7: Analyze the information, Predict min. Levels and Performance.
Step-8: Perform Verification Experiment And set up the long run Action.

IV. S/N Ratio Analysis

Single/noise magnitude relation could be alive utilized in science and engineering that compare the amount of a desired signal to the amount of ground noise. It's the magnitude relation of signal power to the noise power, usually expressed in decibels. The Taguchi methodology uses a loss perform to see the standard characteristics. Loss perform values also are converted to a S/N ratio In general, there are three different quality characteristics in S/n ratio analysis namely "Nominal is the best", "Larger is the better" and "Smaller is the better". For every level of method parameters, signal/noise ratio is calculated based on S/N.

V. Experimental Details and Measurement

In this study, a work piece made of Al-6061 was used. Its sizes were ϕ 40 x 150 mm of 3 specimens was used for the experimental work.

Fig. 3. After Turning

The experiments studies were allotted on lightweight duty All Geared Lathe Machine. The experiments were conducted under wet cutting conditions. Carbide tipped tool were used as a cutting tool material. The cutting speeds are 65, 130 and 220 rpm. The feed is use 0.06, 0.08 and 0.1 mm/rev. The cutting depth are 1, 2 and 3 millimeters were used. The cutting parameters and theirs levels were summarized in Table-1. The cutting forces was measured employing a gauge varieties shaper tool dynamometer within the sampling length of 30mm.

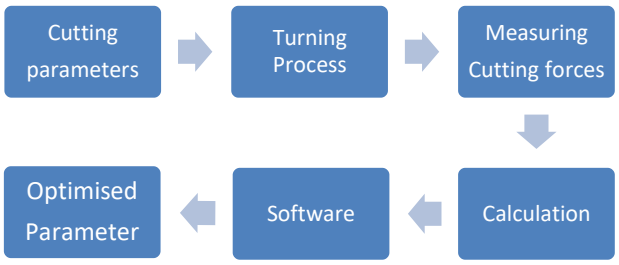

Fig. 4. Experimental scheme

Table no.1 Parameters & levels

Level	L1	L2	L3
Speed	65	130	220
Feed	0.06	0.08	0.1
DOC	1	2	3

VI. Taguchi Design of Experiment

In order to get the optimum worth of the machining parameters we can use various method such as trial and error approach, design of experiments, etc. but the result will not be most accurate. we can also use full factorial method for three parameters as taken in our case then the amount of experimental sets required will be 3^3 i.e., 27. This is a very large number of experimental sets for such an expensive material like Al-6061 which makes the method less cost effective. Therefore, we can use Taguchi method of orthogonal array where we can select the area of our requirement from the set available are L4, L8, L9, L27. For three level of design as in our case L9 and L27 are the arrays that can be used. Therefore, we selected orthogonal array L9 for 9 sets of experimentation which will be both cost effective and time saving process.

Table no. 2. L9 orthogonal array and measurement

PARAMETERS			FORCES			
Speed	DOC	Feed	Cutting Forces	Feed forces	Thrust forces	Resultant forces
65	1	0.06	15	5	3	16.09
65	2	0.08	38	15	6	41.29
65	3	0.10	41	19	8	45.89
130	2	0.06	28	15	5	32.15
130	3	0.08	38	17	6	42.05
130	1	0.10	15	6	4	16.04
220	3	0.06	30	18	1	35
220	1	0.08	10	4	3	11.18
220	2	0.10	23	13	2	26.49

In this calculation of cutting forces value by using three parameters i.e. speed, depth of cut &feed rate as shown in above table. The Table no. 2. Shown an L9 orthogonal array. There are entirely nine experiments to be conducted and every experiment relies on the mixture of level values as shown within the table. For instance, the third experiment is conducted by keeping the freelance style variable one at level one, variable a pair of at level three and variable three at level three.

Table no.3. S/N Ratio

Speed	DOC	Feed	Resultant Forces	S/N Ratio
65	1	0.06	16.09	-24.13
65	2	0.08	41.29	-32.31
65	3	0.10	45.89	-33.23
130	2	0.06	32.15	-30.14
130	3	0.08	42.05	32.47
130	1	0.10	16.04	-24.42
220	3	0.06	35	-30.88
220	1	0.08	11.18	-20.96
220	2	0.10	26.49	-28.46

Table no.3 show the calculation of s/n magnitude relation for the Resultant forces obtained from different set of experimentation. S/N ratio is calculated for the smaller the better criteria with cutting force as the performance parameter of the calculation S/N ratio is calculated using the equation.

S/N ratio = -10 log10(sum(Y^2/n))

From the calculated values of S/N ratio optimal values of variables are obtained from average table.

Table no .4. Average table.

Parameters	Level 1	Level 2	Level 3	Delta	Rank
Speed(A)	-29.89	-29.02	-26.77	3.12	2
Feed(B)	-28.39	-28.59	-28.71	0.32	3
DOC(C)	-23.18	-30.31	-32.20	9.02	1

Table no 4 shows the calculation of average value of S/N ratio divided into three levels where all the three variables are categorized in these three levels. For the 9 sets of experimental shown above the three levels are designed with three process parameters in each level.

The table additionally shows the delta and rank of the levels. The delta value is the difference of max & min value of all 3 level and the rank is given in descending order of delta value. From this rank we are able to notice the ultimate parameters which is able to provide us minimum cutting forces.

In the plots, the X coordinate axis indicates the price of every method parameters at 3 level and Y coordinate axis the response value. The most impact plots are wont to confirm the best style conditions to get the low cutting force.

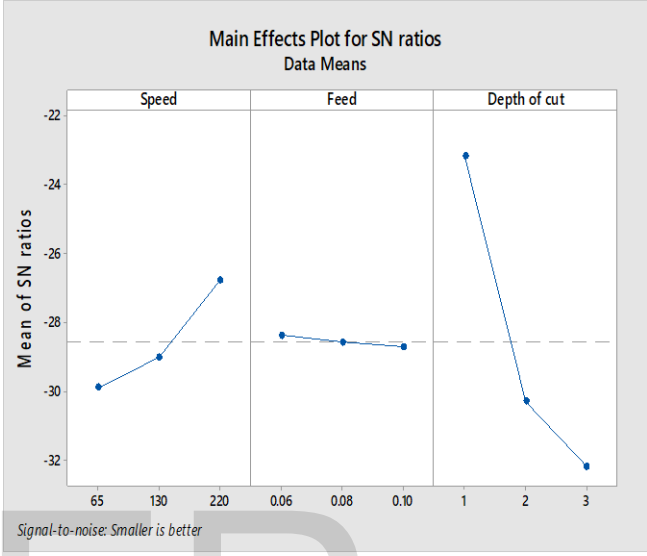

Fig. 5. Main effect Plot for SN ratio

VII. Conclusion

Result showed that Taguchi method selected the optimal parameters as speed (220), DOC (1) & feed rate (0.06). The optimization is done by Taguchi method. The cutting forces obtained by this parameter are minimum while turning on lathe machine. The below conclusion was derived from the experiments and study that were done on Al-6061 with carbide insert tool.

1. Most effective parameters are found using Taguchi experimental design that will reduce the cutting forces.
2. From the analysis it found out that depth of cut and feed rate are two factors affecting cutting forces.

References

[1] S.K. Thongarasu (2017) "Prediction of cutting force in turning operation-an Experimental approach" material science and Engineering.
[2] Rusdi Nor and Tri Agus susanto (2017) "Optimizing cutting condition on sustainable machining of Al alloy to minimize power consumption" American institute of Physics.
[3] Dr.C.J. Rao and P.Srithari (2013) "Influence of cutting

Parameters on cutting force and surface finish in Turning operation" Procedia Engineering pg 1405-1415.
[4] Bala Raju (2013) "Effect and optimization of cutting parameters on cutting forces and surface finish in turning of MS and Al "International Journal of Research in Engineering and Technology Vol12 Issue 11
[5] Jithin Babu and Ramesh Babu (2014) "Correlation among cutting parameters, surface roughness and cutting forces in turning" 5th International and 25th all India Mfg tech. Design and Research Conference.