Evaluation of Optimal Machining Parameters for Turning by Using Genetic Algorithm

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Abstract:- The experimental work for investigating and optimisation the surface roughness in Al6061 material by using cnc turning machine Aluminium 6061 has the major application in vehicle and automobile parts so we have taken aluminium 6061 for conduct the turning process. Surface roughness means the surface irregulars that were found in the workpiece. Design of experiments is used to select the different level of input parameter based on L9 orthogonal the levels of parameter are fixed for the output responses A circular cross section of aluminium 6061 have been machined for required dimensions by centre lathe. Then the experimental work was conducted on cnc turning machine. The surface roughness tester is used to calculate the surface roughness. The taguchi method is used to calculate the predicted result the regression equation from the taguchi method is used for calculate the predicted values in our work. The genetic algorithm is used for optimisation of experimental values. The feed rate is the most dominate factor affecting the surface roughness.

I. INTRODUCTION

The Quality is the important role in today's manufacturing. Manufacturing is the process of converting the raw materials, components (or) parts into finished product to satisfy the customer expectations. The manufacturing process involves the casting, forging, welding and etc. High sped turning is a machining process which is done on cnc whereas the set of experiments conducted with the different levels. The factors affecting the surface roughness is cutting tool parameters, machining and machine tool conditions and workpiece material properties. The optimization and investigation of Al 6061 were analysed in genetic algorithm. The genetic algorithm is used to obtain the optimum results of machining parameters. The surface roughness is the output parameter while machining the component. Surface roughness is the surface irregularities. There are many factors considered while machining the component in cnc lathe. The input parameters are speed, feed and depth of cut. Surface roughness is the important factor during machining of Al6061 in CNC lathe. This paper is considered about experimental investigation and optimization of machining parameters by Taguchi method. Taguchi method is used to predict the value of given value. L9 orthogonal arrays are used to conduct the set of experiments in cnc lathe. DOE is the systematic method to determine the relationship between factors affecting the process and the output of that process. The experimental work was done on cnc lathe. The experimental values were analysed in Minitab software. Then, the software gives the regression equation. From this equation, the predicted values were found and also compared with experimental values.

II. LITERATURE REVIEW

This Manufacturing is defined as the process of convert the raw material into finished product. There are many process involved in manufacturing such as casting, forging, welding and so on. In this study, the turning process have used for machining the component. In order to achieve the maximum output turning process have used.

Upinder Kumar Yadav (2012). et.al were investigated the optimization of machining parameters for surface roughness in CNC Turing by Taguchi method. Surface roughness is the main quality function in high speed turning of medium carbon steel in dry conditions. The input parameters are speed, feed and depth of cut. L27 orthogonal array and signal to noise are used in this study. The optimum value of surface roughness is 0.89. The effect of three parameters (i.e.) cutting speed, feed, depth of cut and their interactions evaluated using Anova. The prediction of surface roughness was evaluated using Anova. Deepak D (2016) et.al were studied the optimization of machining for turning of Al6061 using Robust Design Principle to minimize the surface roughness. In this study, the surface roughness produced followed by speed, feed, and depth of cut. Taguchi robust design principles are used to analyse the data. Feed rate is the most influential factor parameters that `influence the surface roughness while turning of Al6061. Sanchit Kumar Khare (2017) et.al were presented optimization of Machining Parameters in Turning of Al6061 AISI 4340 steel under cryogenic condition using Taguchi Technique. In this work, the machining Parameters are cutting speed, feed rate, depth of cut and rake angle are optimized for minimum surface roughness on AISI 4340 steel. L9 orthogonal array was used. It was observed that cutting speed and depth of cut was the most influential factors on the surface roughness. The surface roughness value is 5.32%. Ilhan Asilturk (2016) et.al were published the optimization of parameters affecting the surface roughness of co28cr6mo medical material during CNC lathe machining by using the Taguchi and RSM methods. The input parameters are spindle speed, feed, depth of cut and top tip radius. In order to achieve minimum surface roughness, the optimum value is obtained for spindle rpm, feed rate, depth of cut and top tip radius respectively 318 rpm, 0.1 mm/rev and 0.8mm. Ilhan Asiltuk (2012) et.al were investigated the Multi respect response optimization of CNC turning parameters via Taguchi method-based response surface analysis. The main objective is to achieve the better machining performance. Anova which is used to develop the mathematical model. Feed rate is the most dominant factor affecting the surface roughness. M.Venkata Ramana (2014) et.al were published the optimization and influence of process parameters on surface roughness in turning of titanium alloy. The main objective of this paper is to achieve the minimum surface roughness under dry machining with different tool materials using Taguchi method. The prediction of surface roughness carried out in the mathematical model.

Ashvin.J.Makadia(2013) et.al were studied the optimization of machining parameters for turning operations based on response surface methodology in AISI 410 steel. The main objective of this paper to study the effect of turning parameters. The input parameters are cutting speed, feed rate, depth of cut and tool tip radius. RSM is used to investigate the effect of machining parameters. The feed rate is the most influencing factor in surface roughness. The optimized machining parameters are 255m/min of cutting speed, 0.1mm/rev of feed rate, 0.3mm of depth of cut and 1.2mm of tool tip radius. Girish Kanta (2015) et.al were published the predictive modelling and optimization of machining parameters to minimize the surface roughness using artificial neural network algorithm. The two approaches used to predict and optimize a model. The two approaches are artificial neural network and genetic algorithm. The main objective of this paper is to minimize the surface roughness. The predicted and experimental values are closed to each other. The surface roughness value obtained from the ANN model with GA. Supriya subu Choudhary (2013) were investigated the optimization of surface roughness using Taguchi method and prediction of tool wear in hard turning tools. The main objective is to optimize the surface roughness and tool wear prediction. The present study involves the Tin coated tool and uncoated tool. The input parameters are speed, feed rate and depth of cut. The Taguchi method is used to predict the tool wear. The feed rate and cutting speed is the most influencing factor to minimize the surface roughness. The depth of cut is the major effect on tool wear rate. From the experimental investigation, the coated tool gives the better results as compared to the uncoated tool. Milan Kumar Das (2014) et.al were studied the application of bee colony algorithm for optimization of metal removal rate and surface roughness in EDM of EN31 too steel. In order to achieve the optimum surface roughness and metal removal rate the EDM of EN31 tool steel using artificial bee colony algorithm. The machining parameters are pulse on time, pulse off time, discharge current and voltage. RSM used to obtain the optimum surface roughness and metal removal rate. In the experimental region, the metal removal rate and surface roughness increase with increasing current and pulse on time. MRR and SR analysed using artificial bee colony algorithm. The pulse on time and discharge current are proportional to the metal removal rate and surface roughness. Siddesh Kumar N G (2016) et.al were investigated the cutting force and surface roughness during turning of aluminium metal matrix composites. In this study, AL2219, AL2219+3%B4C were fabricated by using stir casting technique. The input parameters are cutting speed, feed rate and depth of cut. The cutting speed and depth of cut are the major on influencing the cutting force and surface roughness. The cutting force increased with increasing the cutting speed. Surface roughness decreases with increasing cutting speed.

Based on the literature review, aluminium 6061 as the work piece material. It contains the major alloying elements of magnesium and silicon. The Al6061 has in light weight so, it can be used in chassis of Audi A8, bicycle frames and etc.

III. METHODOLOGY

The tool and work piece material are selected for investigation of machining parameters in turning operation. The work piece material is Aluminium 6061. The scheme of the proposed work is shown in figure 3.1. After the selection of material, turning process involved for machining the component. The turning is the process of removing unwanted material from the work piece. Then, nine different levels of experiments were done by using DOE. After that, the set of experiments done by CNC Turing.

The carbide tool used in CNC for carried out the turning operation. Surface roughness is measured by using surface roughness tester. The predicted values were evaluated by the Taguchi method. This method gives the regression equation. From the regression equation, the predicted values of machining parameters were evaluated. The predicted values were calculated by using regression equation. The scheme of the proposed work is shown in figure 3.1.

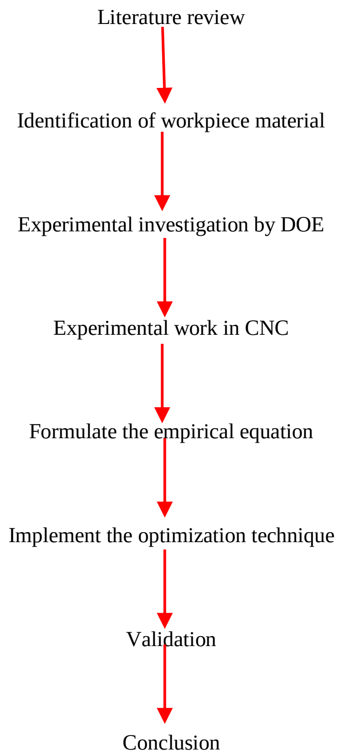

Figure3.1 Scheme of Work

IV. EXPERIMENTAL PROCEDURE

Design of experiments (DOE) is statistical method used to obtain the effect of multiple variables. The DOE in taguchi approach to optimize the product and process designs. Also, find the most influential parameters on that process. DOE is the systematic method used to obtain the factors affecting the process and output of that process. L9 orthogonal array was used to conduct the set of experiments in cnc turning. The chemical composition of the material is given in table 4.1. The input parameters range and their level are given in table 4.2.

Table 4.1 Composition of Al 6061

Component	Amount (wt%)
Mg	0.8-1.2
Si	0.4-0.8
Fe	Max.0.7
Cu	0.15-0.40
Zn	Max. 0.25
Ti	Max. 0.15
Mn	Max. 0.15
Cr	0.04-0.35
Others	0.05
Al	Balance

4.2 Levels and Ranges of Input Parameters

S.No	Parameters	Units	Level1	Level2	Level 3
1	Spindle speed	Rpm	716	1074	1791
2	Feed rate	mm/sec	0.1	0.2	0.3
3	Depth of cut	mm	0.5	1	1.5

V. EXPERIMENTAL WORK

The Aluminium 6061 of Ø: 21.344 mm, length: 80 mm were used for the turning experiments in the present study. The mechanical and physical properties of Al6061 can be shown in Table 5.1. The turning tests were carried out to evaluate the machining parameters under various turning parameters. CNC lathe used for experimental investigations

Table5.1 Mechanical and Physical properties of Al6061

Property	Value
Density (ρ)	2.70 g/cm
Young's modulus (E)	68.9 GPa (9,990 ksi)
Tensile strength (σt)	124–290 MPa (18.0–42.1 ksi)
Elongation (ε) at break	12–25%
Poisson's ratio (ν)	0.33
Melting temperature (T_m)	585 °C (1,085 °F)
Thermal conductivity (k)	151–202 W/(m·K)
Linear thermal expansion coefficient (α)	2.32×10^{-5} K^{-1}
Specific heat capacity (c)	897 J/(kg·K)

Table 5.2 Experimental Result

Ex. No	SPEED (m/min)	FEED (mm/rev)	DEPTH OF CUT(mm)	SURFACE ROUGHNESS Ra(µm) Obtained
1	716	0.1	0.5	0.3223
2	716	0.2	1	0.8533
3	716	0.3	1.5	1.756
4	1074	0.1	1	0.349
5	1074	0.2	1.5	0.6223
6	1074	0.3	0.5	1.7096
7	1791	0.1	1.5	0.319
8	1791	0.2	0.5	0.607
9	1791	0.3	1	1.6203

Figure 5.1 Turning Operation

The table 5.2 shows the experimental value of machining parameters in CNC turning. The input parameters are speed, feed and depth of cut and the output responses will be a surface roughness at a speed 716 rpm corresponding value of feed and depth of cut 0.1 and 0.5 have minimum surface roughness value. This table contains the experimental values of surface roughness. The experimental values are used to obtain the regression equation by using Taguchi method. The input parameter values are substituted in regression equation. Then, the predicted values were evaluated by using regression equation. Comparison of experimental and predicated values were carried out. Figure 5.1 shows the turning operation in CNC machine. The surface roughness tester used to obtain the surface roughness of the machined component. Figure 5.2 shows the surface roughness measurements.

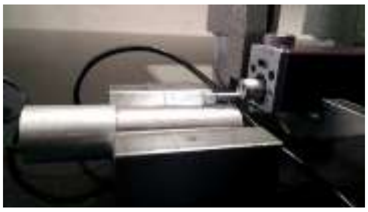

Figure 5.2 Surface roughness measurement

Validated Result for Surface Roughness using Regression Equation

A regression equation is formed by using experimental values by using the Minitab 17 software. The validation of experimental result is obtained by using the regression analysis. Regression equation is also one of the most widely used statistical tools because it provides simple methods for establishing functional relationship among variables. The regression equation is employed to develop a suitable model for predicting dependent variables from a set of independent variables. The relationship between the experimental result and validated result for this investigation is presented.

$$\text{Surface Roughness} = -0.342 - 0.000115\,(\text{SPEED}) + 6.821\,(\text{FEED}) + 0.020(\text{DOC})$$

Table 4 Experimental Result and Corresponding S/N Ratio

Ex. No	SPEED (rpm)	FEED (mm/ rev)	DEPTH OF CUT(mm)	SURFACE ROUGHNESS Ra(µm)	
				Obtained	Predicted
1	716	0.1	0.5	0.3223	0.2677
2	716	0.2	1	0.8533	0.9598
3	716	0.3	1.5	1.756	1.6519
4	1074	0.1	1	0.349	0.2365
5	1074	0.2	1.5	0.6223	0.9286
6	1074	0.3	0.5	1.7096	1.5907
7	1791	0.1	1.5	0.319	0.16413
8	1791	0.2	0.5	0.607	0.8262
9	1791	0.3	1	1.6203	1.5183

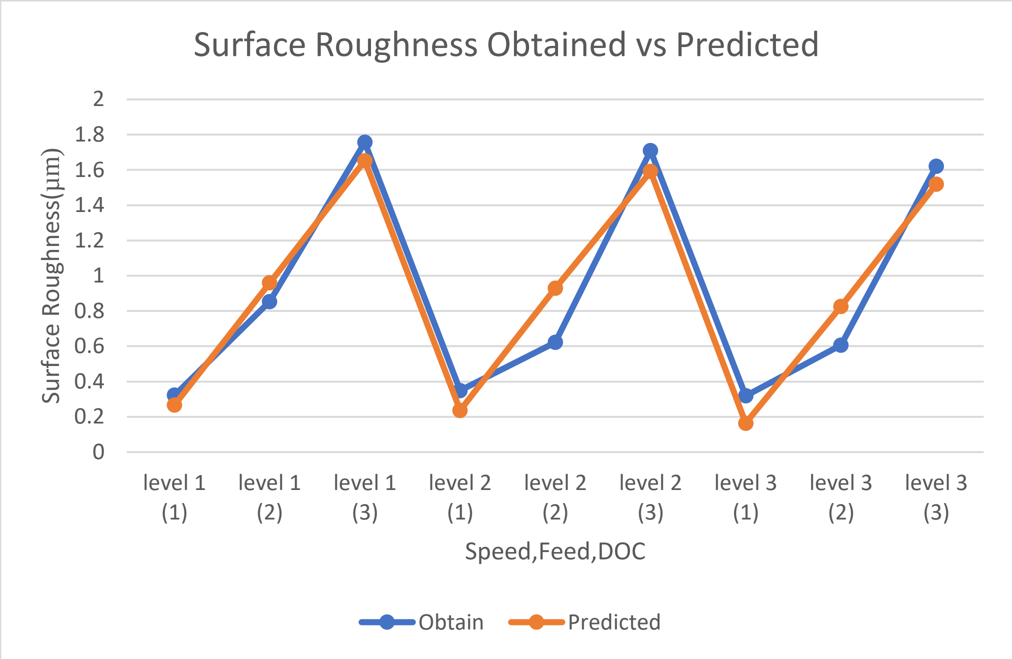

Figure 6.1 Comparison of experimental results and validated results

VI. OPTIMIZATION TECHNIQUE

In computer science and operations research, a genetic algorithm (GA) is the process of natural selection that belongs to the larger class of evolutionary algorithms (EA). Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection. The GA is the optimization technique which is used to find the best results for such inputs. In this paper, the GA is used to find the optimum value of surface roughness. In order to find best result of surface roughness, number of iterations have been formulated. The optimum value of surface roughness is 0.169736 found using the following input parameters of speed, feed, depth of cut is1791rpm, 0.3mm/rev,0.5mm.

A genetic algorithm solves optimization problems by creating a population or group of possible solutions to the problem. The individuals in this population will carry chromosomes that are the values of variables of the problem.

Operators of Genetic Algorithms

1) Selection Operator: The idea is to give preference to the individuals with good fitness scores and allow them to pass their genes to the successive generations.

2) Crossover Operator: This represents mating between individuals. Two individuals are selected using selection operator and crossover sites are chosen rand

3) Mutation Operator: The key idea is to insert random genes in offspring to maintain the diversity in population to avoid the premature convergence.

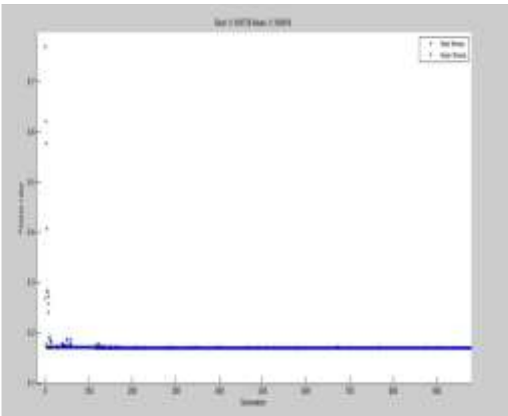

Figure7.1 Optimization Result

VII. RESULTS AND DISCUSSIONS

In the early stage, turning process is carried out to evaluate the turning process parameters. The major output responses like metal removal rate, surface roughness, temperature and machining time are determined based on the Taguchi approach. The three factors, three levels such as spindle speed (716,1074,1791) rpm, feed rate (0.1,0.2,0.3) mm/min and depth of cut (0.5, 1, 1.5) mm were considered for this research work.

Based on the Taguchi design of experiments, nine experiments were carried out to predict the surface roughness. In this investigation, 'smaller is Better' condition is selected. The experimental result of the surface roughness is shown in Figure 8.1 feed rate is major dominating parameter that affects the turning process. The best optimal parameter for surface roughness is presented in Table 8.1.

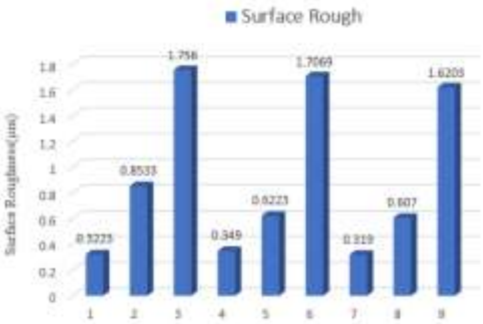

Figure 6.2 Experimental Results of Surface Roughness

Table 6.2 Optimal Parameter for Surface Roughness

Spindle Speed	Feed Rate	Depth of Cut	Surface Roughness
rpm	**mm/min**	**mm**	**microns**
1791	0.3	1.0	0.3190

VIII. CONCLUSION

The following results have found while machining the component Aluminum 6061

(i)Surface roughness is mainly affected due to the feed rate while compared to the speed and depth of cut.

(ii)The optimum value of surface roughness has found using the genetic algorithm. The optimum value is 0.169736

(iii)At level 3(3) the optimum value of surface roughness has found using the taguchi method.

(iv) The comparison results of surface roughness have been analyzed.

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