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Experimental Investigation & Performance Improvement of Aluminium Alloy 1200 in Surface Milling Machne

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ABSTRACT

Present paper outlines an investigation study to optimize the effect of the cutting speed, feed rate, Dept of cut on surface roughness of Aluminum Alloy 1200 by employing Taguchi technique. This paper deals with optimization of the selected Surface Milling Parameter, i.e. cutting speed, Feed rate, Depth of cut. Central composite designed with Three Level of milling parameter & different experiments are done using CCD, Containing 3 columns, which represent three factors, & 20 rows which represent 20 experiments to be calculated & value of each parameter was obtained. The nine experiments are performed & surface roughness is calculated for Aluminum alloy 1200 material. The investigation data were also statistically analyzed by using the ANOVA test. The practical result can be used in industry to get the desirable Surface Roughness for the work piece by using suitable parameter combination.
Keywords : Optimization, Surface Roughness, Cutting Conditions, CNC Milling, Aluminum Alloy

I. INTRODUCTION

Development in the technology as well as growing manufacturing industry; CNC Milling has achieved major importance in any manufacturing setup. Milling is the most familiar process in manufacturing setups. It is a machining process of removing material by positioning a job below a revolving tool of several teeth. This tool is referred to as a milling cutter. The multiple teeth present in the milling cutter enables the milling process to be a speedy method of machining. In manufacturing operations, soft plane finish of the manufactured parts is of tremendous importance. Surface roughness is assessed as an average surface roughness & sign 'Ra' is used. It has always been a major objective of the manufacturers to find out the good number optimized parameters of machining to obtain optimum value of Ra in manufacturing of parts. Response Surface Methodology (RSM) is adopted for this investigates with CCD method to get the optimized the surface finishes in milling process. The reason behind using CCD technique is that it can be used for building a Quadratic design surface & can determine both main effects & interactions.

Central composite design is a very expert technique given that significant information about investigation values of the variables & investigation errors by identifying minimum number of runs required. Also, central composite designs are very flexible & the availability of a number of varieties of central composite designs enables their use under different investigation regions of interest & operability. This investigation aims at determining the optimum value of Ra for milling to achieve maximum production rate & to get optimized response.

II. METHODS AND MATERIAL

A. Literature Review

There has been notice of manufacturers & researchers for optimization of processes to obtain productivity at reasonable cost. The authors [i] Study of literature survey on A Review on Parametric Optimization of Aluminum alloy- 1200 & EN-31 in CNC Surface Milling using Taguchi Method. [ii] Perform the testing to discover the effect of CNC's cutting setting on Al. alloy 6061 test samples. The relationships have been established among the significant factors, their relations with each other & optimized settings have identified for minimum value of Surface roughness. The researchers [iiI] suggested a model to guess Ra by employing Response Surface Methodology. Testing was performed for machining of low carbon steel using carbide coated tool & recognized that feed rate is a responsive parameters. The work cited by [iii] targeted feed rate & suggested the model to achieve highest MRR for preferred level of Ra using bisection method. The researchers [iv-v] suggested models to predict Surface roughness by taking into account the mutual effect of Genetic Algorithm (GA) & RSM to optimize cutting setting.

They performed testing using Tellurium-Nickel coated Tungsten carbide tool for machining of mild steel. References [vi-vii] adopted Taguchi method to find out the optimized values for CNC milling procedure. They establish signal to noise ratio using Taguchi design & along with the cutting parameters.

B. METHODOLOGY

The cutting parameters selected for the research are feed, depth of cut & cutting speed. Aluminum alloy 1200 was selected to carry out the experimentation due to its extensive use in aerospace & automobile industry. The experimentation has been carried out on the work piece & the output response (surface roughness) was obtained. The analysis has been conducted by applying RSM & CCD in Design Expert to find out the better-suited cutting parameters to optimize Ra value. The design has been validated by comparing the predicted values of surface roughness with actual values.

INVESTIGATION SETUP

The work piece material has dimensions of 100 x 75 x 50 mm & its upper side has been machined to produce a smooth surface. The constituent’s percentage of each element for the Aluminum alloy 1200 is given Table 1.The machine tool used for performing the experiments is 3-axis vertical machining centre model AME made. The machine has maximum travel of 1400 mm on X-axis, 650 mm on Y-axis & 460 mm on Z-axis. The cutting tool used in performing the experiments is a 1 inch End Mill having eight teeth & the experiments are carried out using conventional face milling process.

Figure 1. CNC Vertical Machine Center

Table-1. Percent constituents of Aluminum Alloy

Constituents	Al	Si	Zn	Cu
%	>99	<1	<0.14	<0.05

The value of Ra is measured with Surtronic Roughness checker. The machining parameters selected to perform experimentation are Cutting Speed (CS), Feed & Depth of Cut (DOC). The resultant response is Ra, which is calculated by varying the input cutting parameters.

Depending upon the material selected & as per recommendations of the tool specifications, the following cutting conditions have been selected as input factors to perform the experiments. Pilot runs have been performed for setting up of the levels as given in Table 2.

Table-2 : Physical Values & coding for the input factors

Coded Values	Levels	-1	0	1
Physical Values	Feed (mm/min)	1000	1100	1200
	Cutting Speed (RPM)	3100	3500	3900
	Depth of Cut (mm)	0.14	0.20	0.26

Using various combinations of the cutting parameters, twenty experiments have been performed & surface roughness ‘Ra’ was measured as tabulated in Table 3. For three cutting parameters, minimum 09 runs would be enough but according to the central composite design there must be 20 runs required to induce the effect of interaction terms also.

Table-3: Results of Experiments (Surface Roughness Measurement)

No. of Trials	Factors			Ra (µm)
	A	B	C	
01	0	0	0	0.587
02	0	0	1	0.512
03	0	1	1	0.485
04	1	0	0	0.520
05	1	1	0	0.621
06	1	1	1	0.351
07	0	1	0	0.581
08	1	0	1	0.503
09	-1	0	-1	0.591
10	-1	0	0	0.644
11	-1	1	0	0.613
12	-1	1	1	0.540
13	0	-1	0	0.582
14	0	-1	1	0.452
15	0	-1	-1	0.678
16	0	1	-1	0.533
17	1	-1	0	0.643
18	1	-1	-1	0.716
19	1	0	-1	0.678
20	-1	-1	-1	0.430

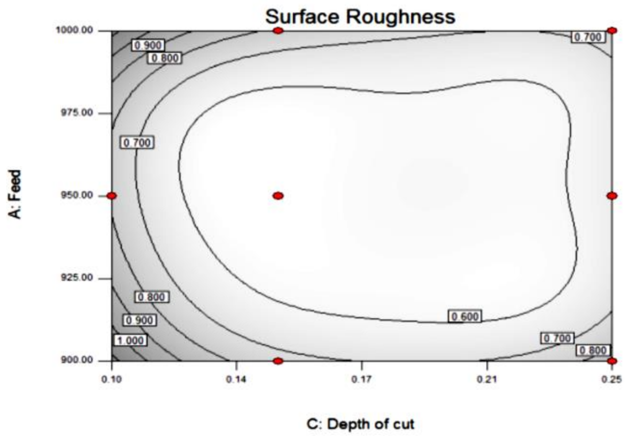

Chart-1 (c) : Feed & Depth of Cut at Cutting Speed of 3900 RPM

The point of interest in these contour maps is that one can find the estimated value of Ra at a range of feed & DOC with cutting speeds of 3100 RPM, 3500 RPM & 3900 RPM by just placing the cursor at any point on the map.

III. RESULTS AND DISCUSSION

A. Response Surface

After having a curve map for optimization of response variable, the analysis is done to designate the response variation with the input design parameters (CS, Feed & DOC). The analysis has been conducted by applying Analysis of variance (ANOVA) & a 3D response is generated.

Figure 4(a); indicates that at cutting speed of 3100 RPM, by growing values of DOC & feed the value of Ra shows a decreasing trend. Figure 4(b); indicates that at higher value of CS to 3500 RPM, the value of Ra is further declined at increased values of feed & DOC. Figure 4(c); shows that at maximum cutting speed of 3900 RPM the value of surface finish again shows decreasing trend by increasing DOC & feed values. The points on 3D surfaces show the investigation runs performed.

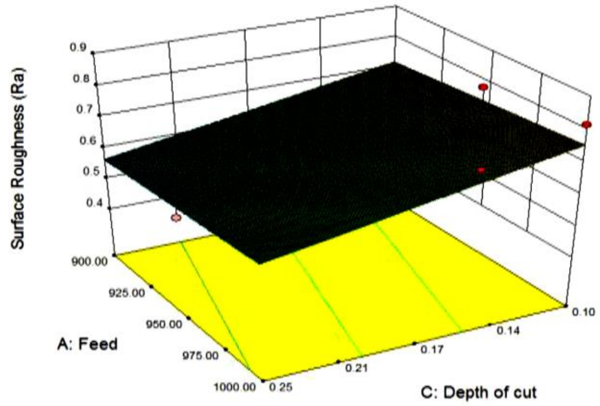

Chart-2 (a): Response Surface at C.S of 3100 RPM

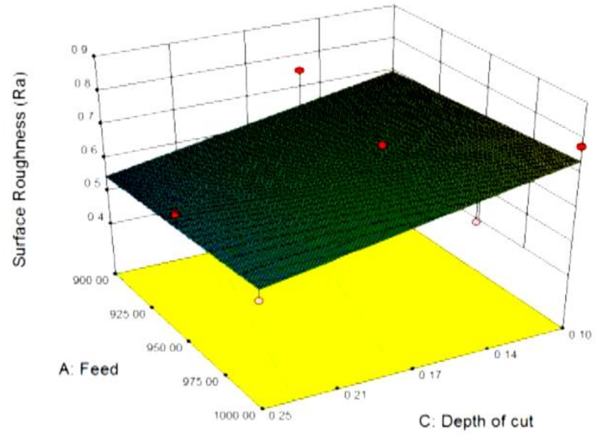

Chart-2 (b): Response Surface at C.S of 3500 RPM

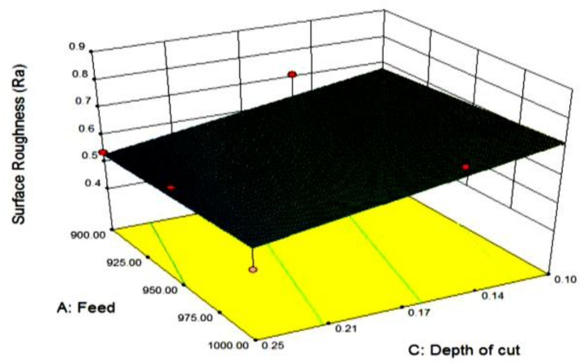

Chart-2 (c): Response Surface at C.S of 3900 RPM

B. Effects of Variation on The Output Response

The 3D model generation has been done & the next step is to analyze the effects of variations in the design values of CS, feed, & DOC on the output response. Figure 5; illustrates behavior of Ra with the variations in CS & DOC at various settings of feed rates. The X-axis in these graphs shows the depth of cut, the red inclined lines indicate the maximum cutting speed of 3900 RPM & black inclined lines indicate the minimum cutting speed of 3100 RPM. The points on the graphs indicate the investigation runs performed. Chart 3(a); indicates that minimum value of Ra is achieved at maximum values of DOC equal to 0.26 mm & CS of 3900 RPM at Feed of 1000 mm/min. Chart 3(b); shows that by increasing the Feed to 1100 mm/min the minimum value of Ra is achieved at maximum CS of 3900 RPM & by decreasing DOC from 0.26 mm to 0.20mm. Whereas, Chart 3(c); demonstrates that minimum value of Ra is achieved at maximum values of DOC equal to 0.26 mm & CS of 3900 RPM at maximum Feed of mm/min.

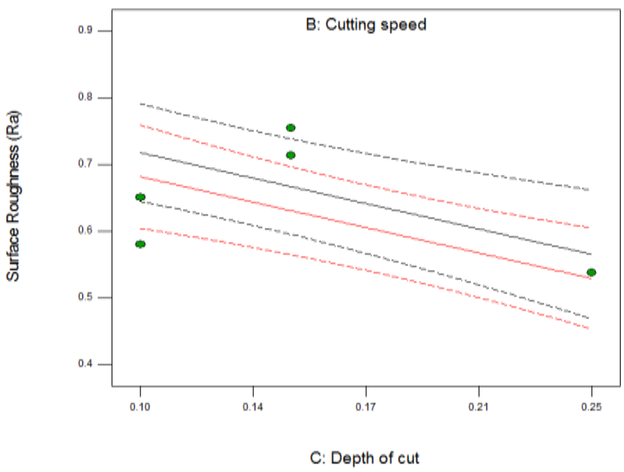

Chart-3 (a): Variations in Ra w. r. t. CS & DOC at Feed Rate of 1000 mm/minute

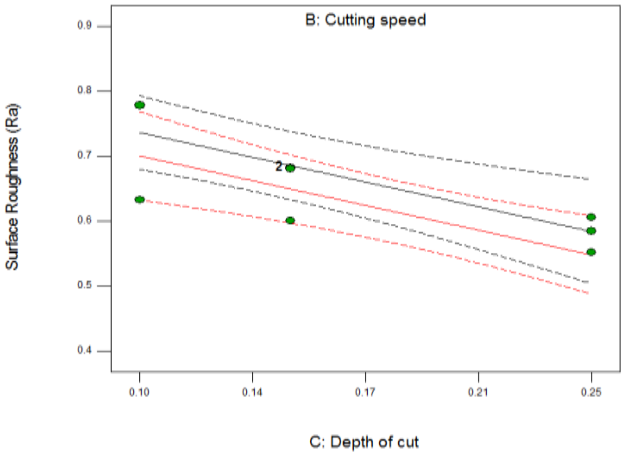

Chart-3 (b): Variations in Ra w. r. t. CS & DOC at Feed Rate of 1100 mm/minute

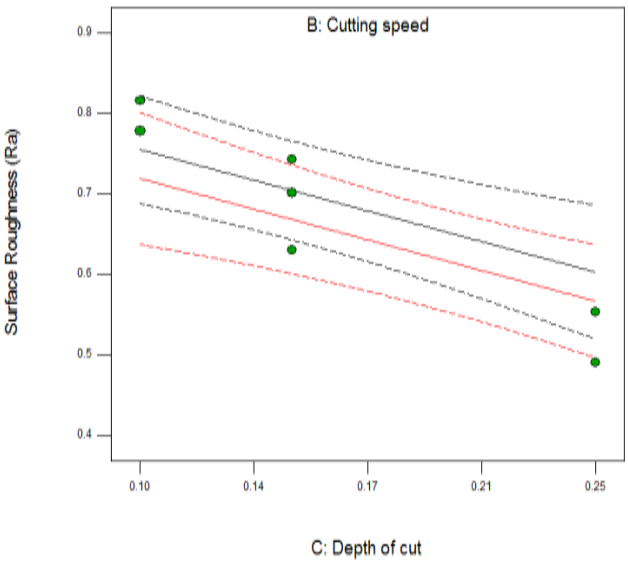

Chart-3 (c): Variations in Ra w. r. t. CS & DOC at Feed Rate of 1200 mm/minute.

C. Validations Results

A bar graph indicating the predicted values of Ra & the actual ones achieved by experimentation has been plotted, for test runs, to validate the model generated. Figure 6; indicates the predicted & actual values of surface roughness. The red bars indicate the actual values obtained by performing the experiments & the blue bars indicate the predicted values. The bar graph is used to validate Ra optimization model. It is to be noted here the actual values obtained from the experiments are Nearly equal or closer to the predicted values of Ra. Therefore, it can be suggested that the model generated is valid & suitable for optimization of surface roughness (Ra)

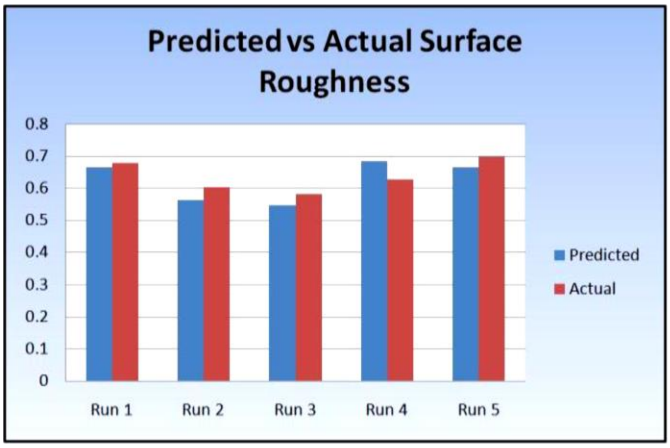

Chart-4: Predicted versus Actual values of Surface Roughness

From the contour plots & the response graphs generated, the optimum values of cutting conditions have been found for minimum output response. The lowest predicted value of Ra has been noted to be 0.352 µm & the predicted cutting parameters used to achieve this surface roughness were Feed; 1250 mm/min CS; 3900 RPM & DOC; 0.28 mm. For the purpose of validation, the investigation set up is established & the values of cutting conditions (Feed; 1250 mm/min, CS; 3900 RPM & DOC; 0.28 mm) were set again & the measured value of Ra was 0.364 µm for these cutting parameters. By comparing the actual & predicted values of Ra, it has been found that there is an error of 3.29 % in the predicted & actual value. Therefore, it is evident that the design generated is acceptable.

IV. CONCLUSIONS & RECOMMENDATIONS

a) It has been observed by experimentation & analysis that the minimum value of Ra is achieved at Depth of cut equal to 0.26 mm & spindle speed of 3900 RPM at Feed rate of 1000 mm/min (Figure 5a).

b) By increasing Feed rate from 1000 mm/min to 1100 mm/min; the minimum value of surface roughness has been achieved at spindle speed of 3900 RPM & by decreasing depth of cut from 0.26 mm to 0.20 mm (chart 3b).

c) Again by further increasing feed up to mm/min; the minimum value of surface roughness is observed at depth of cut equal to 0.26 mm at spindle Speed of 3900 RPM (chart 3c).

d) From the contour or curve plots the minimum predicted value of surface roughness or Ra value was noted to be 0.352 µm & predicted cutting parameters used to achieve this Ra were Feed equal to 1250 mm/min, Cutting Speed of 3900 RPM & Depth of Cut equal to 0.28 mm. Whereas, after using the predicted values of cutting conditions in performing the experiments the value of Ra obtained was 0.364 µm. Therefore, an error of 3.29% was observed in the predicted & actual values of Ra.

e) It is therefore accomplished that obtaining the desired value of surface finish during manufacturing of products by trial & error method is a time consuming technique & by utilizing this research this wastage of time can be saved & the desired value of surface finish can be calculated along with the cutting parameters. This investigate can be utilized to optimize the value of surface roughness for the selected material (AA 1200) as well as for other aluminum alloys.

V. REFERENCES

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