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Experimentation and Optimization of Machining Parameters in Subtractive Rapid Prototyping Machine Using AL-Alloy (Duralumin) and Compare the Surface Finish Value with Taguchi Techniques

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Abstract: *This Rapid prototyping technique has been developed very fast in past 20 years. This paper issues including product development tool, direct metal part manufacturing process parameters for machining the duralumin material are all discussed. Based on the manufacturing, the cost of the product is minimized as well as the machining time of the material is minimized to find out the best optimal value from these machining setups. Taguchi techniques are used for the best optimized process parameter values, and then determined by calculations and graphs.*

Keywords: *Rapid prototyping techniques, Process parameters, Surface roughness tester, Taguchi techniques.*

1. INTRODUCTION

Rapid prototyping is a new method of manufacturing process. It contains with CAD models, and NC programming for the given product to be manufactured and software control to the machine for control its miscellaneous function of the machine. Rapid proto typing is classified into two types first one is additive type and second one is subtractive type. Here subtractive rapid prototyping techniques, are used for machining the given product with given parameter values. The required product shape and size are created using pro-e software. The model is saved as STL file. For it is imported to the machine software for set the miscellaneous function and tool path to machine the given product. Usually, the desired cutting parameters are determined based on experience or by use of a Handbook. However, this does not ensure that the selected cutting parameters have optimal or near optimal cutting performance for a particular machine and environment. The finished product is removed from the machine table and using roughness tester the surface finish values are measured and these values are tabulated for comparing the surface finish value with Taguchi techniques using "Minitab" software.

2. Material Selection

This type of manufacturing process is conducted in AL-Alloys (Duralumin). Because of selecting this material it is used in wide range of application in aero space application. Manufacturing this type of material taken much amount of money for produced its valuable products.

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3. Machining Parameter Selection

Before manufacturing any product selection of process parameter is the main consideration. Process parameter is mainly based on type of material to be machined, type of tool material, dimension of tool, machining speed, feed depth of cut, and other specifications like capacity, work holding devices power supply of the machine also considered and taken into account. This paper discussed only in speed, feed, depth of cut for these machining setups.

Machining parameters

S. no	SPEED rpm	FEED m/min	DOC mm
1	6000	5 6 7	0.05 0.10 0.15
2	8000	5 6 7	0.10 0.15 0.05
3	10000	5 6 7	0.15 0.05 0.10

Table 1. Selected machining Parameters

4. Product Model

Using pro-e software the required product was created. And the model is saved into STL file for further upcoming process. The dimension of the product is 80X30X25 mm.

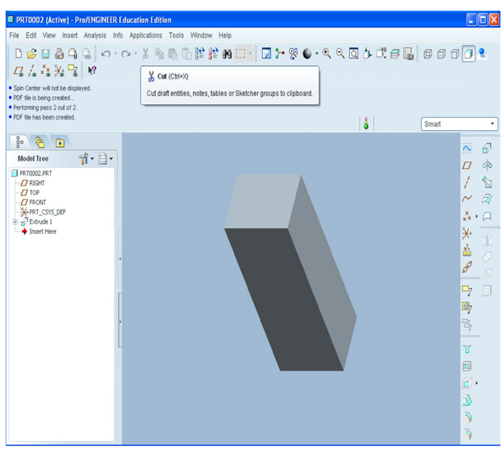

Fig1 Model of the product using Pro-e software

5. Machining Parameters Setting

The required product model is imported and created from Pro-e software in STL file. Based on the given product model the CNC program is created and saved in the file location. The work piece is placed rigidly in the machine table to with stand the machining force and vibrations. The machine miscellaneous functions are marked for manufacturing the given product. The speed, feed, depth of cut values are selected based on selection of material, tool, Tool dimensions, size of the work piece and hardness of the work material. The machining parameters are given above. Change the various process parameter condition the same operations are performed. The number of trails taken is more than two for each process parameter conditions.

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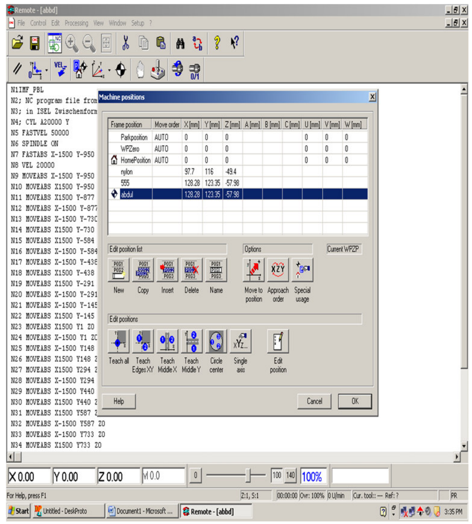

Fig 2 Machining parameters setting using Desk Proto software

6. Surface Roughness Tester

This is a one type of instrument for measuring the surface roughness value. The finished work piece is placed base table and surface roughness tester placed over it, at the required height of the work piece. The measuring probe is moved through the surface of finished product. The surface roughness tester gives the valves in digital form and the values are noted straight to its corresponding process parameter values in the table.

7. Taguchi Technique

The Taguchi technique is a powerful tool for the design of high quality systems. It provides a simple, efficient and systematic approach to optimize designs for performance, quality, and cost. The methodology is valuable when the design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the settings of design parameters and reduce the sensitivity of the system performance to sources of variation. In recent years, the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries. The experimental details of using the Taguchi method to determine and analyze the optimal cutting parameters are described next. The optimal cutting parameters with regard to performance indexes such as tool life and surface roughness are considered.

Description of the Taguchi method
Taguchi proposed that engineering in optimization of a processor product should be carried out in three steps as follows

1. System design
2. Parameter design
3. Tolerance design

In system design, the engineer applies scientific and engineering knowledge to produce a basic functional prototype design, this design including the product design stage and the process design stage. In the product design stage, the selection of materials, components, tentative product parameter values, etc., are involved. As to the process design stage, the analysis of processing sequences, the selections of production.

Equipment, tentative process parameter values, etc., are involved. Since system design is an initial functional design, it may be far from optimum in terms of quality and cost. Following on from system design is parameter design. The objective of parameter design is to optimize the settings of the process parameter values for improving quality characteristics and to identify the product parameter values under the optimal process parameter values. In addition, it is expected that the optimal process parameter values obtained from parameter design are insensitive to variation in the environmental conditions and other noise factors.

Finally, tolerance design is used to determine and analyze tolerances around the optimal settings recommend by the parameter design. Tolerance design is required if the reduced variation obtained by the parameter design does not meet the required performance, and involves tightening tolerances on the product parameters or process parameters for which variations result in a large negative influence

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on the required product performance. Typically, tightening tolerances means purchasing better- grade materials, components, or machinery, which increases cost.

However based on the above discussion, parameter the design is the key step in the Taguchi method to achieving high quality without increasing cost. To obtain high cutting performance in turning, the parameter design proposed by the Taguchi method is adopted in this paper. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal-to-noise(S/N)ratio.

Taguchi recommends the use of the S/N ratio to measure the quality characteristics deviating from the desired values. Usually, there are three categories of quality characteristic in the analysis of the S/N ratio, i.e. the-lower-the-better, the-higher-the-better, and the nominal- the-better. The S/N ratio for each level of process parameters is computed based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio. Furthermore, a statistical analysis of variance (ANOVA) is performed to see which process parameters are statistically significant. With the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted.

Three objectives can be achieved through the parameter design of the Taguchi method,

1. Determination of the optimal design parameters for a process or a product.
2. Estimation of each design parameter to the contribution of the quality characteristics.
3. Prediction of the quality characteristics based on the optimal design parameters.

8. Taguchi Analysis: Ra Vs Speed, Feed, DOC

Response Table for Complete Orthogonal array with Signal to Noise RatiosTaguchi orthogonal array Design L9 (3**3), Factors: 3 and Runs: 9Smaller is better

Level	SPEED(rpm)	FEED(m/min)	DOC(mm)
1	-0.5437	1.3797	4.8290
2	6.8582	3.2601	0.1684
3	2.2328	3.9074	3.5499
Delta	7.4019	2.5277	4.6605
rank	1	3	2

Table 3 Signal to Noise Ratio

Response Table for Means

Level	SPEED(rpm)	FEED(m/min)	DOC(mm)
1	1.0667	0.8667	0.6667
2	0.5333	0.7467	0.9833
3	0.7800	0.7667	0.7300
Delta	0.5333	0.1200	0.3167
Rank	1	3	2

Table 4 Response for means

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Main Effects Plot for Means

Main Effects Plot for S/N ratios

SPEED(rpm)	FEED(m/min)	DOC(mm)	Ra(μm)	S/NRA1	MEAN1
6000	5	0.05	0.98	0.1755	0.98
6000	6	0.1	1.08	-0.6685	1.08
6000	7	0.15	1.14	-1.1381	1.14
8000	5	0.1	0.96	0.3546	0.96
8000	6	0.15	0.39	8.1787	0.39
8000	7	0.05	0.25	12.0412	0.25
10000	5	0.15	0.66	3.6091	0.66
10000	6	0.05	0.77	2.2702	0.77
10000	7	0.1	0.91	0.8192	0.91

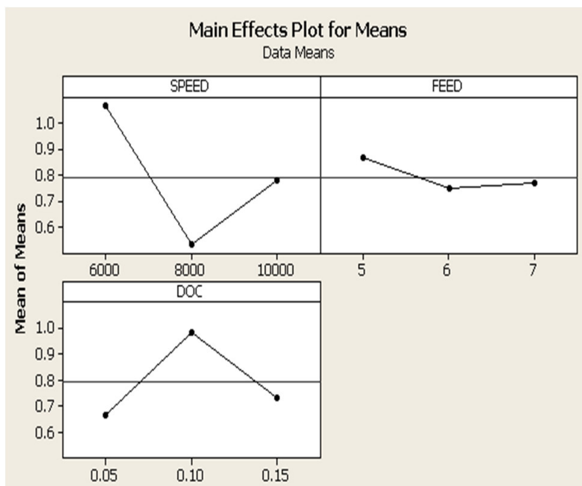

Fig 3 Graphs for main effects plot for means

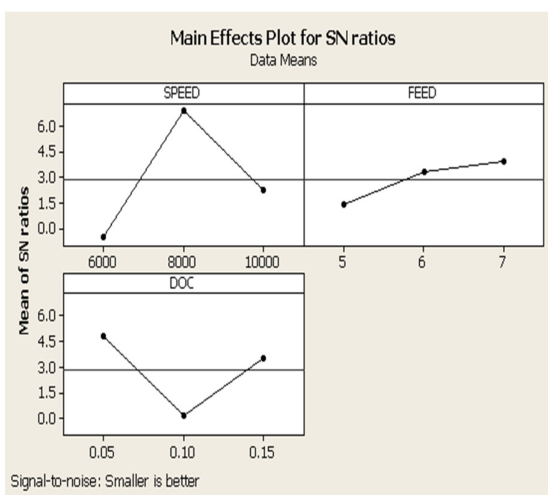

Fig 4 Graphs main Effects plot for SN ratios

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9. Results and Discussions

The process parameter values are taken based on machine specification and hardness of the selected material. The process parameters values are may be varied material to material. Based on the process parameter values, graph and calculations the best value of the optimized parameter value is determined. Each and every value is compared to the surface roughness value (Ra) the optimized value is concluded using Taguchi Quality techniques using Minitab Software.

10. Conclusion

Many issues from the improvement of Rapid Prototyping technology to the extension of applications with Rapid Prototyping techniques are presented and discussed though out the paper from the graphs and calculations finally concluded that the quality of the surface finish value are affected by these following three factors. They are ranked from in its sequences are based on analyses valve and calculated values. First speed is affecting the surface quality of the product; secondly the depth of cut is affect the quality of the product and finally the feed rate affect the surface quality of the product. The optimized valve is determined from the graphs and calculation results .the speed value is 8000 Rpm, the feed rate is 7 m/min and the depth of cut value is 0.05mm.

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