An Experimental Investigation and Parameter Optimization on Milling of Aluminum Alloy 6061

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ABSTRACT

In this paper, the experiments will be conducted to improve the surface finish quality of aluminum alloy 6061 work piece by using carbide tips. The type is bull nose tip. A series of experiments will be done by varying the milling parameters spindle speed, feed rate and depth of cut. The spindle speeds are 3500rpm, 3000rpm and 2000rpm. The feed rates are 200mm/min, 300mm/min and 400mm/min. Depth of cut is 0.2mm and 0.3mm and 0.4mm. Taguchi method is used to study the effect of process parameters and establish correlation among the cutting speed, feed and depth of cut with respect to the major machinability factor, surface finish. Validations of the modeled equations are proved to be well within the agreement with the experimental data. Taguchi method is used to study the effect of process parameters and establish correlation among the cutting speed, feed and depth of cut with respect to the major mach inability factor, surface finish. Validations of the modeled equations are proved to be well within the agreement with the experimental data.

Keywords: Milling process, Taguchi method, optimization.

1. INTRODUCTION

Milling system is one of the critical machining operations. In this operation the paintings piece is feed in opposition to a rotating cylindrical tool. The rotating device includes more than one slicing edges (multipoint slicing device). Normally axis of rotation of feed given to the work piece Milling operation is prominent from other machining operations on the premise of orientation between the device axis and the feed route; however, in other operations like drilling, milling, and so forth. The tool is fed inside the path parallel to axis of rotation. The reducing tool utilized in milling operation is known as milling cutter, which consists of more than one edge known as teeth. The system device that plays the milling operations by means of producing required relative motion between paintings piece and tool is referred to as milling machine. It provides the desired relative motion below much managed situations. These situations might be mentioned later in this unit as milling velocity; feed fee and intensity of reduce. Normally, the milling operation creates aircraft surfaces. Other geometries also can be created by way of milling system.The main objective of thiswork is to improve the surface finish quality and material removal rate of aluminum alloy 6061 work piece by using carbide tips. The type is bull nose tip. A series of experiments will be done by varying the milling parameters spindle speed, feed rate and depth of cut. The spindle speeds are 3500rpm, 3000rpm and 2000rpm. The feed rates are 200mm/min, 300mm/min and 400mm/min. Depth of cut is 0.2mm and 0.3mm and 0.4mm. DOE (design of experiments) created by TAGUCHI technique In MINITAB software**.**

2. CNC MILLING MACHINE

With the more precise demands of modern engineering products, the control of surface texture together has become more important. This review studies the various optimization methodologies, which is applied to optimize surface roughness in end milling operations. Conventional machining processes require a lot of time and effort. The accuracy achieved by such processes is not up to the level. With the invention of CNC machines, it becomes easy to do the various machining processes easily and accurately. The advancement of modern technology and a new generation of manufacturing equipment, particularly computer numerical control (CNC) machine, have brought enormous changes to the manufacturing sector. Generally, the handbook or human experience is used to select convenient machine parameters in manufacturing industry. In process planning of conventional milling, selecting reasonable milling parameters is necessary to satisfy requirements involving machining economics, quality and safety. The machining parameters in milling operations consists of cutting speed, depth of cut, feed rate and number of passes. These machining parameters significantly impact on the cost, productivity and quality of machining parts. The effective optimizations of these parameters affect dramatically the cost and production time of machined components as well as the quality of final products. In order to get specified surface roughness, selection of controlling parameters is necessary.

2.1. SURFACE ROUGHNESS

Surface roughness, commonly shortened to roughness, could be a live of the feel of a floor. It's quantified by the vertical deviations of a real floor from its perfect type. If those deviations place unit large, the floor is rough; if they may be little the surface is graceful. Roughness is normally idea of to be the excessive frequency, short wavelength element of a measured surface (see floor metrology). However, in practice it is commonly essential to understand the amplitude and frequency to verify that a floor is appropriate purpose. Roughness performs an important position in identifying however a real object can act with its surroundings. Rough surfaces on occasion wear extra quick and have higher friction coefficients than graceful surfaces (see tribology). Roughness is normally an honest predictor of the performance of a mechanical detail because irregularities inside the floor would possibly kind nucleation sites for cracks or corrosion. On the opposite hand, roughness might promote adhesion.

3. METHODOLOGY

Surface finish is one of the most important quality characteristics in manufacturing industries which influences the performance of mechanical parts as well as production cost. In actual practice, there are many factors which affect surface roughness, MRR e.g., cutting conditions, tool variables and work piece variables. Cutting conditions include speed, feed and depth of cut whereas 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 material hardness and other mechanical properties.

Table: 1 Input Parameters

Process Parameters	**Le Vel1**	**Level2**	**Level3**
Cutting Speed(Rpm)	3500	3000	2000
Feed Rate (Mm/Rev)	200	300	400
Depth of Cut(Mm)	0.2	0.3	0.4

Table:2 The L9 orthogonal array for input parameters

JOB NO.	**SPINDLE SPEED (rpm)**	**FEED RATE (mm/min)**	**DEPTH OF CUT (mm)**
1	2000	200	0.2
2	2000	300	0.3
3	2000	400	0.4

4	3000	200	0.3
5	3000	300	0.4
6	3000	400	0.2
7	3500	200	0.4
8	3500	300	0.2
9	3500	400	0.3

4. EXPERIMENTAL SETUP

Fig. 1 CNC milling machine

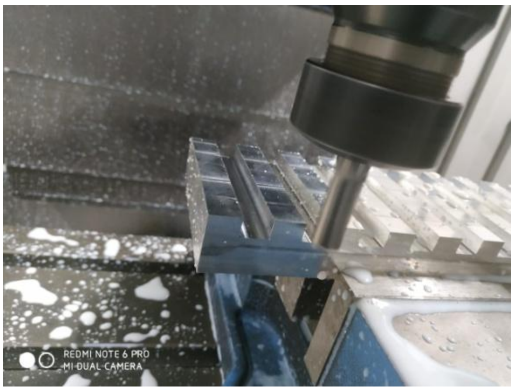


Fig. 2 Machining process.

Fig. 3Final work piece

5. RESULTS AND DISCUSSION

Tests conducted

Surface roughness measuring instrument

The Talysurf is a simple to operate high accuracy instrument capable of roughness and waviness measurement. The systems low noise axes and high-resolution gauge ensures measurement integrity.

Job No.	Spindle Speed (Rpm)	Feed Rate (Mm/Min)	Depth Of Cut (Mm)	Surface Roughness (R_a) µm
1	2000	200	0.2	0.307
2	2000	300	0.3	0.951
3	2000	400	0.4	0.921
4	3000	200	0.3	0.337
5	3000	300	0.4	0.341
6	3000	400	0.2	0.854
7	3500	200	0.4	0.261
8	3500	300	0.2	0.375
9	3500	400	0.3	0.822

Material Removal Rate (MRR)

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	MRR (cm^3/min)
1	2000	200	0.2	1.339
2	2000	300	0.3	1.5996
3	2000	400	0.4	1.7999
4	3000	200	0.3	1.67956
5	3000	300	0.4	1.91952
6	3000	400	0.2	1.43
7	3500	200	0.4	1.11
8	3500	300	0.2	1.27
9	3500	400	0.3	2.15946

TAGUCHI TECHNIQUE

Taguchi defines Quality Level of a product because the Total Loss incurred with the aid of society due to failure of a product to carry out as preferred once it deviates from the delivered target performance ranges.

$$MRR = \frac{Vol.Removed}{CT} = \frac{L*W*t}{CT} = W*t*f_m$$

This includes charges related to negative overall performance, in operation expenses (which modifications as a product a while) and any in addition prices because of dangerous issue effects of the products in use.

Signal to Noise Ratio

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The surface roughness is considered as the quality characteristic with the concept of "the smaller-the-better". The S/N ratio for the smaller-the-better is:

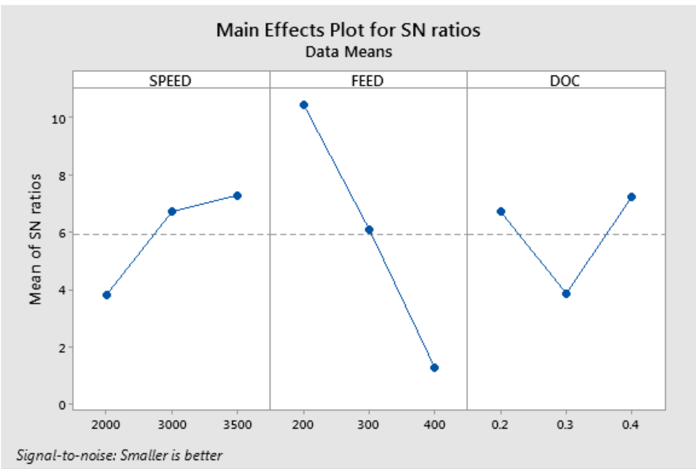
$$S/N = -10 * \log(\Sigma(Y^2)/n))$$

Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration above Equation. with the help of software Minitab 15.The surface roughness measured from the experiments and their corresponding S/N ratio values are listed in Table

Response Table for Signal to Noise Ratios

Smaller is better

Level	SPEED	FEED	DOC
1	3.803	10.457	6.716
2	6.721	6.100	3.862
3	7.296	1.263	7.242
Delta	3.494	9.195	3.380
Rank	2	1	3

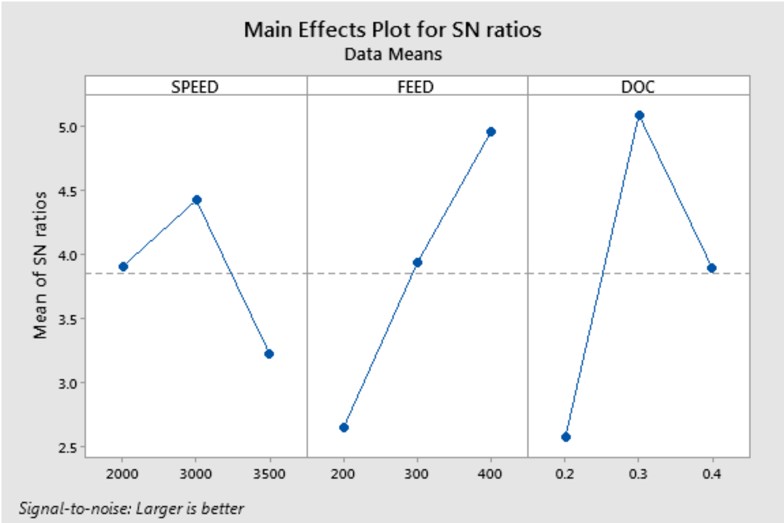


Plot: S/N ratio

Selection Of Optimal Parameter Combination For Better Material Removal Rate In milling Using Taguchi Technique

Response Table for Signal to Noise Ratios

Level	SPEED	FEED	DOC
1	3.907	2.649	2.573
2	4.425	3.940	5.090
3	3.223	4.966	3.892
Delta	1.202	2.318	2.518
Rank	3	2	1



Plot : S/N Ratio For MRR

6. CONCLUSION

In this, an attempt has been made to make use of Taguchi optimization technique to optimize cutting parameters during high speed milling of aluminum alloy 6061 using cemented carbide cutting tool. By observing the experimental results and by TAGUCHI, the following conclusions can be made:

- To get better surface finish, the optimal parameters are spindle speed – 3500rpm, feed rate – 200 mm/min and depth of cut – 0.4mm.
- To get better Material removal rate, the optimal parameters are spindle speed – 3500rpm, feed rate – 400mm/min and depth of cut – 0.3mm.

REFERENCES

[1] Mandeep Chahal ”Investigations of Machining Parameters on Surface Roughness in CNC Milling using Taguchi Technique” Vol.4, No.7, 2013 - National Conference on Emerging Trends in Electrical, Instrumentation & Communication Engineering, ISSN 2222-1727

[2] Lohithaksha M. Maiyar, Dr. R. Ramanujam, K. Venkatesan and Dr. J. Jerald, Optimization of machining parameters for end milling of Inconel 718 super alloy using Taguchi based grey relational analysis, International Conference on design and manufacturing, 64, 2013, 1276 – 1282

[3] M. Alauddin, M.A. E1 Baradie and M.S.J. Hashmi, Optimization of surface finish in end milling Inconel 718, Journal of Materials Processing Technology, 56, 1996,54.

[4] Piyush pandey, Prabhatkumar sinha, Vijay kumar, Manastiwari ”Process Parametric Optimization of CNC Vertical Milling Machine Using Taguchi Technique in Varying Condition” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) eISSN: 2278-1684,p-ISSN: 2320- 334X, Volume 6, Issue 5 (May. - Jun. 2013), PP 34-42.

[5] Aruna, M., Dhanalaxmi, V., & Mohan, S. (2010).” Design Optimization of Cutting Parameters when Turning Inconel 718 with Cermet Inserts”. International Journal of Mechanical and Aerospace Engineering 6.