Parametric Optimization of End Milling Of AISI 1018 Mild Steel by Various Lubricants with Solid Carbide End Mills.

Chintan. H. Patel[1], Chirag. P. Patel[2]
[1]Student, M.Tech, (Department of MechanicalEngineering, Ganpat University, Kherva-384012,
[2] Associate Prof., (Department of Mechanical Engineering, Ganpat University, Kherva-384012,

Abstract

This study investigated the optimization of End milling of AISI 1018mild steel by various lubricants using the Grey relational analysis method. Quaker 7101, Blasocut strong 4000 and Velvex have been selected as lubricant. All the experiment are carried out at different cutting parameter (Number of Tool Flutes, Depth of cut, Spindle speed and Feed rate) in various lubricant assisted environment.Twenty Seven experiments runs based on an orthogonal array of Taguchi method were performed. Each nine experiments were carried out in Quaker 7101, Blasocut strong 4000 and Velvex lubricant. Surface roughness, cutting force andpower consumption selected as aresponse variable.An optimal parameter combination of the milling operation was obtained via Grey relational analysis. By analyzing the Grey relational grade matrix, the degree of influence for each controllable process factor onto individual quality targets can be found. The optimal parameter combination is then tested for accuracy of conclusion with a test run using the same parameters.

Keywords: Optimization, Grey relational analysis, surface roughness, cutting force and power consumption.

I. Introduction

Milling is the process of cutting away material by feeding a work piece past a rotating multiple tooth cutter. The cutting action of the many teeth around the milling cutter provides a fast method of machining. The machined surface may be flat, angular, or curved. The surface may also be milled to any combination of shapes. The machine for holding the work piece, rotating the cutter, and feeding it is known as the Milling machine.

Among different types of milling processes, end milling is one of the most vital and common metal cutting operations used for machining parts because of its capability to remove materials at faster rate with a reasonably goodsurfacequality. Also, it is capable of producing a variety of configurations using milling cutter. In recent times, computer numerically controlled (CNC) machine tools have been adopted to make the milling process fully automated. It provides greater improvements in productivity, increases the quality of the machined parts and requires less operator input. For these reasons, CNC end milling process has been recently proved to be very versatile and useful machining operation in most of the modern manufacturing industries. Only the implementation of automation in end milling process is not the last achievement. It is also necessary to improve the machining process and machining performances continuously for effective machining and also for the fulfilment of requirements of the industries.

Application of three lubricants in machining process utilize water miscible cutting lubricant, if it can be applied properlyThe main objectives of this study investigate and evaluate the effect of different cutting parameters (spindle speed, feed rate and depth of cut, no of tool flute) on surface roughness, cutting forces and tool life during End milling of AISI 1018 material by coated carbide end mill tools of different three type of lubricant cutting environment. This three lubricant has been selected to improve the quality of the material during milling process.

One of the primary functions of cutting fluids in machining is to cool the work piece by efficiently removing heat away from the cutting zone.Higher surface finish quality and better dimensional accuracy are also obtained from cutting fluids.Today's cutting fluids are special blends of chemical additives, lubricants and water formulated to meet the performance demands of the metalworking industry. During metal cutting heat generated as a result of work done. Heat is carried away from the tool and work by means of cutting fluids, which at the same time reduced the friction between the tool and chip and between tool and work and facilitates the chip formation. Cutting fluids usually in the form of a liquid are to the formation zone to improve the cuttingcondition. Cutting fluids is one of the important aids to improve production efficiency.

Cutting fluids play a significant role in machining operations and impact shop productivity, tool life and quality of work. With time and use, fluids degrade in quality and eventually require disposal once their efficiency is lost. Waste management and disposal have become increasingly more complex and expensive. Environmental liability is also a major concern with waste disposal. Many companies are now paying for environmental cleanups or have been fined by regulatory agencies as the result of poor waste disposal practices.

II. Experimental details

2.1 Work piece material

AISI 1018 has been selected as work piece Material. It widely used for Axles, bolts, connecting rods, motor Shafts, hydraulic shafts, pump shafts, pins, and machinery parts. The diameter and Length of work piece was 200 mm and 400 mm respectively. Chemical composition of this material is Carbon 0.14 to 0.20%, Manganese 0.6 to0.9, phosphorus 0.04% max, Silicon 0.27%, Sulphur 0.50max, iron 98.81 to 99.26%.

2.2 Cutting end mills

All the experiments were performed by using solid carbide end mills of series (Art No 3021, 3680 and 3023) of different geometry. It is hard pvd coated super micro-grain carbide end mills having superior toughness and heat resistance. It is used for Finishing and light interrupted cutting of stainless steel. Different types of three tool flutes are used.

2.3 Cutting fluid

In order to perform the experiment in Quaker 7101, Blasocut strong 4000 and Velvex which is water miscible cutting Lubricant. All three lubricants forms are milky white emulsion. Suitable for all metals for machining operations where emulsifiable oil are normallyused. Emulsion strength of quaker 7101 is (10-20%), blasocut strong 4000 (3-10%) and velvex (5-10%) have been used as a cutting fluids Sometimes used successfully for even milling process.

2.4Experimental apparatus

The milling of work piece is conducted on TAKANG vmc-850 having followingSpecifications: Table size:510×1000 mm, Working size: X Axis: 850mm, Y Axis: 560mm, Z Axis: 560mm, Spindle: 800 to 12000 RPM, No of tool: 24, CNC system: Fanucoimb model, Cutting capacity: 220Cc/min, Tool Holder Pull Stud Type: MAS P40T-1-45, Power Supply: 415 v, 3ph, 50Hz, Width: 2230 mm, Depth: 2350mm, Weight: 4500kg.

2.5 Measurement of surface roughness and cutting forces

The surface roughness of the turned samples was measured with Mitutoyo make Surface roughness tester (SJ-110) and the cutting forces measured with the help of equation.

2.6Design of experiment

In this study, four controllable variables, namely, tool flutes, feed rate, depth of cut and spindle speed has been selected. In the machining parameter design, three levels of the cutting parameters were selected, shown in Table 1.

Table1.Factors with levels value

Factors	Level 1	Level 2	Level 3
No of tool flute	2	3	4
Depth of cut (mm)	0.5	0.75	1
Feed rate(mm/rev)	0.122	0.184	0.239
Spindle speed (rpm)	800	1000	1200

As per table 1, L9 orthogonal array of "Taguchi method" has been selected for the experiments in MINITAB 16. Each 9 experiments will carry out in quaker 7101, blasocut strong 4000 and velvex cutting fluid. Surface roughness, cutting force and power consumption has been selected as response variable.All these data are used for the analysis and evaluation of the optimal parameters combination.Experiment result as shown in Table2.

Table2. Experimental results.

Sr. no	TF	DOC (mm)	SS (rpm)	FR (mm)	SR (µm)	F_c (Kg)	PC (KW)
	Quaker 7101						
1	2	0.5	800	0.122	3.756	297	2.138
2	2	0.75	1000	0.184	4.355	334	1.658
3	2	1	1200	0.239	4.372	315	2.439
4	3	0.5	1000	0.239	4.172	387	2.215
5	3	0.75	1200	0.122	2.340	366	2.414
6	3	1	800	0.184	4.741	276	1.788
7	4	0.5	1200	0.184	1.611	394	2.218
8	4	0.75	800	0.239	3.836	369	1.731
9	4	1	1000	0.122	3.257	270	1.781
	Blasocut strong 4000						
10	2	0.5	800	0.122	3.247	263	1.591
11	2	0.75	1000	0.184	3.717	291	1.898
12	2	1	1200	0.239	3.696	272	1.904
13	3	0.5	1000	0.239	3.450	338	1.630
14	3	0.75	1200	0.122	2.009	324	2.241
15	3	1	800	0.184	4.077	245	2.078
16	4	0.5	1200	0.184	1.493	343	1.701
17	4	0.75	800	0.239	3.298	321	1.731
18	4	1	1000	0.122	2.681	241	1.534
	Velvex						
19	2	0.5	800	0.122	4.352	327	1.491
20	2	0.75	1000	0.184	5.453	432	2.261
21	2	1	1200	0.239	5.046	338	1.902
22	3	0.5	1000	0.239	4.574	356	2.131
23	3	0.75	1200	0.122	2.743	352	1.854
24	3	1	800	0.184	5.569	231	2.501
25	4	0.5	1200	0.184	2.183	392	1.676
26	4	0.75	800	0.239	4.492	352	1.735
27	4	1	1000	0.122	3.803	236	2.405

III. Methodology

3.1 Grey relational analysis method

In the grey relational analysis, experimental results were first normalized and then the grey relational coefficient was calculated from the normalized experimental data to express the relationship between the desired and actual experimental data. Then, the grey relational grade was computed by averaging the grey relational coefficient corresponding to each process response (3 responses). The overall evaluation of the multiple process responses is based on the grey relational grade. [5]

3.2 Data preprocessing

In grey relational generation, the normalized data corresponding to Lower-the-Better (LB) criterion can be expressed as:

$$Xi(k) = \frac{\max yi\ (k) - yi(k)}{\max yi(k) - \min yi(k)} \qquad (1)$$

For Higher-the-Better (HB) criterion, the normalized data can be expressed as:

$$Xi(k) = \frac{yi(k) - \min yi\ (k)}{\max yi(k) - \min yi(k)} \qquad (2)$$

Where xi (k) is the value after the grey relational generation, min yi (k) is the smallest value ofyi (k) for the kth response, and max yi (k) is the largest value of yi (k) for the kth response.

An ideal sequence is x0(k) (k=1, 2) for two responses. The definition of the grey relational grade in the grey relational
analysis is to show the relational degree between the twenty-seven sequences (x0(k) and xi(k), i=1, 2, . . . , 27; k=1, 2). The grey relational coefficient ξi (k) can be calculated as:

$$\xi i(k) = \frac{\min\Delta + \theta\max\Delta}{\Delta i\ (k) + \theta\max\Delta} \qquad (3)$$

Where Δi = | X0 (k) – Xi (k) | = difference of the absolute value x0 (k) and xi (k); θ is the distinguishing coefficient 0 ≤ θ ≤ 1; minΔ = ∀j min ϵ i∀kmin= | X0 (k) – Xi (k) | = the smallest value of Δ0i; and maxΔ = ∀jmax ϵ i∀kmax = largest value of Δ0i. After averaging the grey relational coefficients, the grey relational grade γi can be computed as

$$yi = \frac{1}{n}\sum_{k=1}^{n} \xi i\ (k) \qquad (4)$$

Where n = number of process responses. The higher value of grey relational grade corresponds to intense relational degree between the reference sequence x0 (k) and the given sequence xi (k). The reference sequence x0 (k) represents the best process sequence. Therefore, higher grey relational grade means that the corresponding parameter combination is closer to the optimal. [4]

IV. Results and discussions

A level standard analysis was adopted to interpret the results. This analysis is based on combining the data associated with each level for each factor. The deviation in the average results for the highest and lowest average response is the measure of the effect of that factor. The higher value of this difference is related to the largest effects of that particular factor. Data preprocessing of each performancecharacteristic and the experimental results for the grey relational according to formulas (1),(2),(3) and (4) are given in Table 3 and 4.

Table 3 Normalize value of SR, Fc and Ff for dry, wet and solid lubricant environment.

Ex NO.	Normalize value of SR	Normalize value of CF	Normalize value of PC
	Quaker 7101		
1	0.3146	0.7822	0.3854
2	0.1233	0.4838	1
3	0.1178	0.6370	0
4	0.1817	0.0564	0.2868
5	0.7670	0.2258	0.3201
6	0	0.9516	0.8335
7	1	0	0.2829
8	0.2891	0.2016	0.9065
9	0.4741	1	0.8425
	Blasocut strong 4000		
10	0.3212	0.7443	0.9193
11	0.1393	0.5098	0.4851
12	0.1474	0.6960	0.4766
13	0.2426	0.4901	0.8642
14	0.8003	0.1862	0
15	0	0.9607	0.2305
16	1	0	0.7637
17	0.3014	0.2156	0.7213
18	0.5402	1	1
	Velvex		
19	0.3594	0.5223	1
20	0.0342	0	0.2376
21	0.1544	0.4676	0.5930
22	0.2937	0.3781	0.3663
23	0.8246	0.3980	0.6405
24	0	1	0
25	1	0.1990	0.8168
26	0.3180	0.3880	0.7584
27	0.5215	0.9751	1

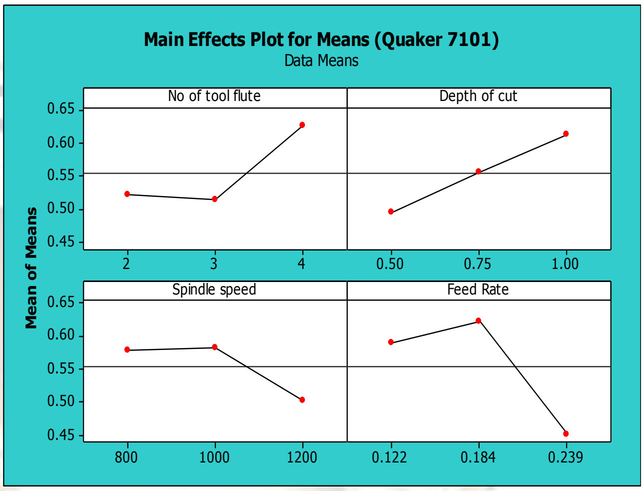
Table 4 Calculation of GRC and GRD

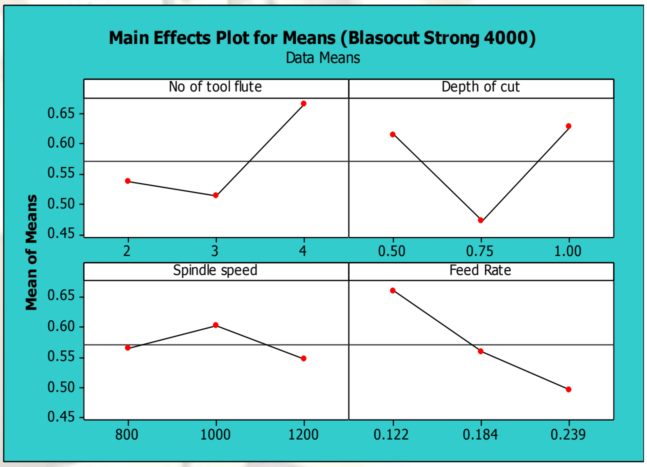
Experiment No.	GRC of SR	GRC of CF	GRC of PC	GRG	Grade No.
Quaker 7101					
1	0.4218	0.6966	0.4485	0.5223	6
2	0.3632	0.4921	1	0.6184	3
3	0.3618	0.5794	0.3333	0.4248	8
4	0.379	0.346	0.412	0.379	9

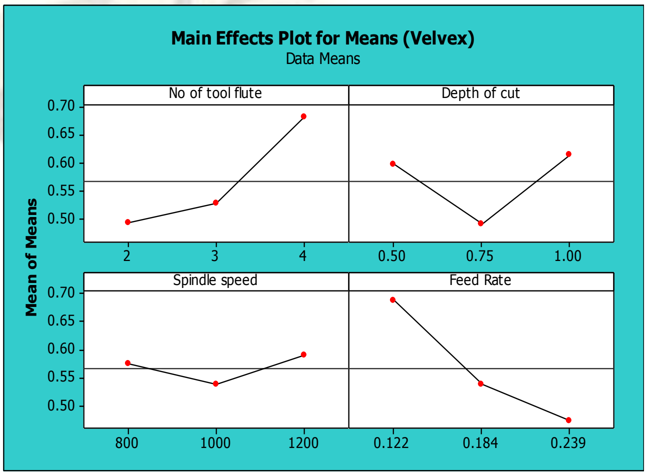
	3	4	1	2	
5	0.6822	0.3924	0.4237	0.4994	7
6	0.3333	0.9118	0.7501	0.6650	2
7	1	0.3333	0.4108	0.5813	4
8	0.4129	0.3851	0.8424	0.5468	5
9	0.4874	1	0.7604	0.7492	1
Blasocut strong 4000					
10	0.4242	0.6986	0.8610	0.6612	3
11	0.3675	0.5050	0.4926	0.4550	9
12	0.3697	0.6220	0.4885	0.4934	6
13	0.3977	0.3446	0.7864	0.5095	5
14	0.7146	0.3806	0.3333	0.4761	8
15	0.3333	0.9273	0.3938	0.5514	4
16	1	0.3333	0.6790	0.6707	2
17	0.4172	0.3893	0.6420	0.4828	7
18	0.5210	1	1	0.8403	1
Velvex					
19	0.4384	0.5115	1	0.6499	3
20	0.3411	0.3333	0.3960	0.3568	9
21	0.3716	0.4843	0.5512	0.4690	7
22	0.4145	0.4457	0.4410	0.4337	8
23	0.7514	0.4537	0.5817	0.5956	4
24	0.3333	1	0.3333	0.5555	5
25	1	0.3843	0.7318	0.7053	2
26	0.4230	0.4537	0.6742	0.5169	6
27	0.5110	0.9526	1	0.8212	1

In grey relational analysis higher the grey relational grade of experiment says that the corresponding experimental combination is optimum condition for multi objective optimization and gives better product quality. Also form the basis of the grey relational grade, the factor effect can be estimated and the optimal level for each controllable factor can also be determined. From Table 4. It is found that experiment 18 has the best multiple performance characteristic among 27 experiments, because it has the highest grey relational grade of 0.8403.

The main effects plot of grey relational grade vs. process parameter can generated by Minitab 16 statistical software to find out optimum parameter combination, is shown in graph 1.







Graph 1. Mean effect plot of grey relational grad

Vs. no of tool flutes, depth of cut, spindle speed and feed rate.

From the graph 1. It is conclude that the optimum condition for better surface finish is meeting at no of tool flutes, depth of cut, spindle speed and feed rate.The graph shows that different types of mean effect value for all machining parameters. In this graph the optimum value is calculated based on higher value of parameter which is consider as the larger is better ratio.

V. Conclusion

It is concluded that the application of quaker 7101 cutting lubricant utilize in end milling process has proved to be a feasible cutting fluid with combination of water and chemical (Emulsions), if it can be applied properly. Whose results show that there is a considerable improvement in surface roughness and quality of product created.

VI. Acknowledgment

It is a privilege for me to have been associated with Mr. C. P. Patel, Asso. Prof. of Mechanical Engg. Dept. at U.V Patel College of engineering, Kherva. During this paper work. I have been greatly benefited by his valuable suggestions and ideas. It is with great pleasure that I express my deep sense of gratitude to him for his valuable guidance and constant encouragement throughout this work.

References

[1] Patel k. p. “Experimental analysis on surface roughness of cnc end milling process using taguchi design method” ISSN: 0975-5462, International Journal of Engineering Science and Technology (IJEST) Vol. 4 No.02 February 2012.

[2] Anil Antony Sequeira, Dr. Thirumaleswara Bhatt, Dr. N.S. Sriram. “Modified Approach for Cutting Force Measurement in Face Milling Process” IISTE journals 2222-1727 (Paper) ISSN 2222-2871 (Online) Vol 2, No 3.jan 2011.

[3] Khairi Yusuf, Y. Nukman, T. M. Yusof, S. Z. Dawal, H. Qin Yang1, T. M. I. Mahlia and K. F. Tamrin. Effect of cutting parameters on the surface roughness of titanium alloys using end milling process. Scientific Research and Essays, Vol. 5(11), pp. 1284-1293, ISSN 1992-2248, Academic Journals 4 June, 2010.

[4] E. Kuram, B. T. Simsek, B. Ozcelik, E. Demirbas, and S. Askin.“Optimization of the Cutting Fluids and Parameters Using Taguchi and ANOVA in Milling” Proceedings of the World Congress on Engineering Vol II, June 30 - July 2, 2010.

[5] Sanjit Moshat, Saurav Datta, Asish Bandyopadhyay and Pradip Kumar Pal. “Parametric optimization of CNC end milling using entropy measurement technique combined with grey-Taguchi method.” International Journal of Engineering, Science and Technology Vol. 2, No. 2, 2010, pp. 1-12.

[6] R. Noorani1, Y. Farooque2, T. Ioi3. “Improving Surface Roughness of CNC Milling Machined Aluminum Samples Due to Process Parameter Variation” Loyola Marymount University, Los Angeles, USA, Chiba Institute of Technology, Chiba, Japan.

[7] R. Imani Asrai, S. T. Newman & A. Nassehi “A power consumption model for slot generation with a CNC milling machine” University of Bath, BA2 7AY, Bath, UK.

[8] L. De Chiffre, and W. Belluco, “Investigations of cutting fluidperformance using different machining operations,” Lubri. Eng., vol. 58, pp. 22-29, 2002.

[9] Ghani J.A., Choudhury I.A. and Hassan H.H., 2004. Application of Taguchi method in the optimization of end milling parameters, Journal of Material Processing Technology, Vol. 145, No. 1, pp. 84-92.

[10] Nihat Tosun, Determination of optimum parameters for Multi-performance characteristics in drilling by using grey relational analysis, Int J Adv. Manuf Technology, 28(1) 450–455 (2006).

[11] Anirban Bhattacharya, Santanu Das, P. Majumdar, Ajay Batish. Estimation of the effect of cutting parameters on surface finish and power consumption during high speed machining of AISI 1045 steel using Taguchi design and ANOVA. Prod. Eng. Res. Devel.3, 31 (2009).