OPTIMIZATION OF MILLING PROCESS PARAMETERS - A REVIEW

MihirThakorbhai Patel*

Abstract: *In this paper, a comprehensive and in-depth review on optimization of different process parameters were carried out using different optimization tools. Milling machine is superior to other machine as regards accuracy and better surface finish. Every manufacturing industry is trying to achieve the high quality products in a very short period of time with less input. In milling machine, there are many process parameters like spindle speed, feed rate, depth of cut, coolant, tool geometry etc. which affected on required quality parameters. So, selections of process parameters are the important for any quality parameters. But, selected process parameters for required quality parameters are not run at optimal condition. So, process parameters are required to be optimizing for required quality parameters. Taguchi methodology is widely used for single optimization. But, sometime multi objective quality parameters are required to be optimized. For multi objective optimization Utility concept, Grey relation analysis, PCA etc. are widely used. ANOVA analysis is also used to determine which parameters are the most significant effect on the selected quality parameters.*

***Keywords**: ANOVA, Grey relation analysis, Milling Machine, Multi optimization, Process parameters, Taguchi.*

*Lecturer, Department of Mechanical Engineering, B&B Institute of Technology, VallabhVidhyanagar, Gujarat.

INTRODUCTION

CNC milling is one of the most commonly used in industry and machine shops today for machining parts to precise sizes and shapes.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 good surface quality (SanjitMoshatet al., (2012)) Also, it is capable of producing a variety of shapes using milling cutter. In recent times, computer numerically controlled (CNC) machine tools have been used to make the milling process fully automated. It delivers greater enhancements in productivity, increases the quality of the machined parts and minimizes the production cost. 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 milling process is not the last achievement. It is also necessary to optimize the process parameters for required quality parameters(Mihir Patel et al., (2014)). The surface roughness, material removal rate, machining time, power consumption, tool life etc. are some of the quality parameters which required optimizing for the selected process parameters. For the milling machine, the different process parameters are Spindle speed, feed rate, depth of cut, coolant, tool geometry etc. The optimization objective may be single or multiple. For single optimization Taguchi, RSM, GA, etc. are used while for multi objective optimization utility concept, Grey relation analysis, Principle component analysis, etc. are used.

EXPERIMENTAL PROCEDURE

Surface finish and material removal rate are one of the most important quality characteristics in manufacturing industries which influences the performance of mechanical parts as well as cost. In recent times, modern industries are trying to achieve the high quality products in a very short period of time with less input. For that purpose, the computer numerically controlled (CNC) machine tools with automated and flexible manufacturing systems have been implemented. In the manufacturing industries, various machine tools are used to remove the material from the work piece. Out of these, milling machine is the first most common method for metal cutting because of its ability to remove materials faster with a reasonable good surface quality.

In actual practice, there are many factors which affect responding parameters, e.g., cutting conditions, tool variables andwork piece variables. Cutting conditions include spindle speed, feedrate and depth of cut whereas tool variables include tool material,flute angle, helix angle, rake angle, peripheral 2nd relief angle etc. and work piecevariable include material hardness and other mechanicalproperties. However, it is very difficult to control all theparameters at a time. In a milling machine, it isa vital task to select the control parameters properly toachieve the high quality performance.

- Selection of quality parameters for given machine
- Selection of Process parameters & their levels.
- Perform the experiments
- Measure the quality parameters
- Analyzed the data with help of different tools
- Confirmation run
- Implemented the results

LITERATURE REVIEW

Amit Joshi et al. (2012) had taken process parameters like spindle speed, depth of cut, feed rate to investigate to reveal their Impact on surface finish using Taguchi Methodology. They had taken L_9 orthogonal array to perform experiments. They found the optimal setting for selected process parameters and optimal value of surface finish was obtained at first level of factor A, third level of factor B and second level of factor C. From the ANOVA analysis they were found that feed rate is the most dominating factor for surface finish.

Anish Nair et al. (2013)had studied effect of different process parameters on surface roughness on Brass material on CNC milling machine with TiN coated carbide insert tool. They analyzed the results using Taguchi method. PCA has been used to eliminate correlation among the responses and to convert the correlated responses into independent quality indexes; so as to meet the basic requirement of Taguchi method. They found for multi optimization that best combination of the cutting parameters was the set with Depth = 0.25mm, Speed = 2100 rpm, Feed = 550mm/min.

Avinash A. Thakre(2013) had applied Taguchi methodology for optimize the process parameters for surface roughness in CNC milling machine. They have taken Cutting speed, Feed, Depth of cut & Coolant as input parameters. The results showed that coolant flow with the contribution of 60.69% is the most important parameter in controlling the surface roughness, followed by spindle speed. The optimal parameters for surface roughness was obtained as spindle speed of 2500 rpm, feed rate of 800 mm/min, 0.8 mm depth of cut, 30 lit/min coolant flow.

B. Ramesh et al. (2011) had optimized the process parameters levels on conventional Milling of Beryllium Copper Alloy Using end mill. Taguchi analysis was performed for analyze the result data. They selected cutting speed, feed and depth of cut as process parameters and material removal rate, surface roughness and machining time as quality parameters. The experiments were conducted by using L_9 orthogonal array. The results show that the optimal parameter levels for machining a straight groove with both higher material removal rate and lower surface roughness in the plate of beryllium copper alloy using CNC Vertical Machining Centre (VMC) are 6000 rpm spindle speed,

0.85 mm/rev feed and 4 mm depth of cut.

B. Siddaet al. (2011) were performed single optimization for CNC end milling machining on Pre-hardened steel (P20) by using surface response methodology and genetic algorithm. They selected Nose radius (R), Cutting speed (V), feed (f), axial depth of cut (d) and radial depth of cut (rd) as process parameters. The experiments were conducted experiments using Taguchi's L_{50} orthogonal array. The RSM model was interfaced with an effective Genetic algorithm to find the optimum process parameter values. GA has reduced the surface roughness of the initial model significantly. Surface roughness was improved by about 44.22%.

D.Bhanuprakashetet al. (2013) had performed surface response methodology with Genetic algorithm for optimizing the process parameters for CNC milling. The raw materials used in this investigation were Aluminum alloy 6082 and Cemented carbide end mill of 12mm diameter and 30° helix angle was used. They concluded that The Regression analysis was conducted to develop mathematical model. The Regression analysis had shown closeness of 94.4% with experimental data. The optimal surface roughness values estimated by RSM technique was 1.192 µm with the machining parameters of spindle speed = 3000 rpm, feed rate = 1000 mm/min, and depth of cut = 0.2 mm and for GA was 1.195 µm with spindle speed = 2997.64729 rpm, feed rate = 1005.94134 mm/min and depth of cut = 0.20862 mm. They also conclude that RSM found successful technique to perform analysis of surface roughness with respect to various combinations of machining parameters when compared to GA.

Dr. K.G.Durga Prasad et al. (2013) had optimized material removal rate and surface roughness simultaneously; Data Envelopment Analysis was employed along with Taguchi method. The materials used in this investigation were Aluminum and carbide tool was used. They performed experiments using Taguchi L_9 orthogonal array. They concluded that the optimum condition for multi response parameters was meeting at cutting speed (A_3), feed rate (B_1), and depth of cut (C_1).

John D. Kechagiaset al. (2011) had taken process parameters like core diameter, flute angle, rake angle, peripheral 2nd relief angle, cutting speed, feed and depth of cut to investigate to expose their Impact on surface finish using Taguchi Methodology. They had taken L_9 orthogonal array to perform experiments. Eighteen pockets were manufactured having different combination of parameters values according to Taguchi L_{18} orthogonal array. In order to establish a relationship between the performance measures and the process parameters, a set of additive models was produced. The experimental results shown that the cutting speed, the peripheral relief angle 2nd, and the core diameters were the most important parameters that significant effect the surface texture indicators and other rest process parameters negligible effect on the surface texture parameters.Finally, a verification experiment was performed to verify the result.

Milon D. Selvamet al. (2012) had optimized the process parameters levels on Vertical CNC Milling for face milling operation using mild steel material. They have planned experiments using Taguchi L_9 orthogonal array. The processing of the job was done by three zinc coated carbide tools inserted into a face miller of 25 mm diameter. The machining parameters considered were Number of passes, depth of cut, spindle speed and feed rate. The surface roughness evaluated through Taguchi technique was 0.975 µm with 4.308 % error from the predicted value and for genetic algorithm it was 0.88 µm with 4.625 % error from the predicted value.

N. Nareshet al. (2013) were performed single optimization for CNC end milling machining on Glass Fiber Reinforced Plastics by using Taguchi methodology and analysis of variance was also performed to determine which parameters are the significant effect on the quality parameters. They selected Fiber orientation angle(Θ), Helix angle (Φ), Spindle speed (N) and Feed rate (f) as process parameters and surface roughness, machining force, delamination factor were chosen as responding parameters. The experiments were conducted experiments using Taguchi's L_{27} orthogonal array. They found that fiber orientation angle was the most significant parameter and spindle speed was the least significant parameter for milling of GFRP composite with the objective of minimizing surface roughness, machining force and delamination factor. The optimal level of parameters for minimizing surface roughness, machining force and delamination factor were $\Theta_1\Phi_1N_3f_1$, $\Theta_1 \Phi_3 N_3 f_1$ and $\Theta_1 \Phi_1 N_3 f_1$ respectively. Fiber orientation angle was the cutting parameter that presents the highest statistical and physical impact on surface roughness (60.48 %), on machining force (56.34 %) and on delamination factor (51.05 %).

Nitin Agrawal(2012) had studied effect of different process parameters (cutting speed, feed and depth of cut) on surface roughness on Aluminum alloy material on CNC milling machine with HSS milling cutter. They prepared 36 specimens of alloy have been machined on CNC milling machine then SJ 201 surface roughness tester has been used to determine the surface roughness value. They concluded that depth of cut is most significant parameter, followed by feed rate and spindle speed.

Rajesh Kumar et al. (2014) had performed GRA based Taguchi method to investigate the optimized design of the cutting process in end milling for Al 6061 alloy in order to provide better surface finish as well as high material removal rate. The selected cutting parameters were coolant employment (C), spindle speed (S), feed (F), and depth of cut (D). The experiments were conducted on L_{18} ($2^1 \times 3^3$) orthogonal array. GRA has been used to find the best end milling process parameters with multiple performance characteristics. In order to estimate the weighting values corresponding to various quality characteristics, principle component analysis (PCA) has been used so that their relative importance can be objectively described. They also found the optimum conditions for obtaining higher grey relational grade such as $C_1S_2F_3D_2$, (Coolant emp. on, speed 765 rpm, feed 50mm/min, Depth of cut 0.8mm) were obtained.

S. Y. Chavanet al. (2013) have tried to investigate the effect of various process parameters (Cutting speed, Feed, Depth of cut & Coolant) on material removal rate and surface roughness on CNC milling. The L_{18} mixed orthogonal array used to perform experiments. They performed multi objective optimization by using grey-Taguchi method. The optimum milling parameters for multi performance in terms of lower Ra and higher MRR given by grey-Taguchi method was at flooded coolant (C), Cutting speed at 5600 rpm (N_3), depth of cut 2.7 mm (d_3) and feed rate 0.045 mm/rev (f_3).

Sanjeev Kumar Pal et al. (2014) had compared the surface roughness of the two materials (Al 6061 and Al 6463) and to analyze the influence of end milling cutting parameters (number of revolution, feed rate and depth of cut) on the surface roughness for Aluminum alloys. Principal component analysis (PCA) and grey relational analysis were performed to predict the surface roughness in end milling operation to analyze the pre measured test data. They found from ANOVA that the spindle speed is the most significant parameter among the four end milling process parameters investigated in the present work.

SanjitMoshatet al. (2010) had studied, the effects of milling parameters on surface roughness and material removal rate were investigated in end milling of Aluminum alloy with CVD coated carbide tools. The obtained experimental results were analyzed by PCA-based Taguchi method. They had taken Cutting speed, Feed and Depth of cut as control factors. The principal component, imposing highest accountability proportion, has been treated as single objective function for optimization (multi-response performance index). Finally Taguchi method has been adapted to solve this optimization problem.

SurasitRawangwonget al. (2012) had tried to investigate the effect of process parameters on the surface roughness in aluminum 7075-T6 face milling. The results of the research have been applied in the manufacture of automotive components and mold industry. The study was conducted by using CNC milling machine with Φ 63 mm fine type carbide tool with twin cutting edge. The controlled factors were the speed, feed rate and the depth of cut. They used factorial designs and the result showed that the factors affecting the surface roughness were the feed ratio and the speed while the depth did not significant effect the surface roughness. The optimal setting for the selected process parameters was speed at 2930 rpm and the feed rates at 808 mm/min. They also had given mathematical model for surface roughness in term of selected process parameters.

SurasitRawangwong(2012) had tried to investigate the effect of process parameters on the surface roughness on Semi-Solid AA 7075 material using Carbide Tool on CNC milling. The results of the research have been applied in the manufacture of automotive components and mold industry. The study was conducted by using CNC milling machine with Φ 63 mm fine type carbide tool with twin cutting edge. The controlled factors were the speed, feed rate and the depth of cut. They used factorial designs and the result showed that the factors affecting the surface roughness were the feed ratio and the speed while the depth did not significant effect the surface roughness. The optimal setting for the selected process parameters was speed at 3800 rpm and the feed rates at 1000 mm/min. They also had given mathematical model for surface roughness in term of selected process parameters.

T. K. Barman et al. (2009) have conducted experiments based on Taguchi L_{27} orthogonal array to investigate the effect of process parameters such as Cutting speed, Feed and Depth of cut on surface roughness in CNC milling. They selected AISI 1040 steels as work material and CVD coated carbide tools for performing experiments. They concluded that the spindle speed was the most significant factor affecting the fractal dimension. With increase in spindle speed, fractal dimension also increases. An optimum cutting parameter combination was found out for maximum fractal dimension and it may be useful in computer aided process planning.

Table 1 Summary ofdifferent review papers

Sr. No.	Year	Author	Material	Tool	Input Parameters	Output Parameters	Methodology used
1	2012	Amit Joshi & Pradeep	Aluminium cast heat-treatable alloy	HSS	Cutting speed, Feed and Depth of cut	SR	Taguchi, ANOVA
2	2013	Anish Nair & P Govindan	Brass	TiNCoated Carbide Insert Tool	Cutting speed, Feed and Depth of cut	SR	Hybrid Taguchi Method, Principal components analysis
3	2013	Avinash A. Thakre	MS 1040	Carbide Tool	Cutting speed, Feed, Depth of cut & Coolant	SR	Taguchi
4	2011	B. Ramesh, R. Venkatesh, etc.	beryllium copper alloy	Carbide End Mill	Cutting speed, Feed and Depth of cut	MRR, SR and Machining Time	Taguchi, ANOVA, Regression Analysis
5	2011	B. Sidda Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy	Pre-hardened steel (P20)	CVD coated carbide tool inserts (TN 450)	Nose radius, Cutting speed, feed , axial depth of cut and radial depth of cut	SR	RSM and Genetic algorithm

Sr. No.	Year	Author	Material	Tool	Input Parameters	Output Parameters	Methodology used
6	2013	D.Bhanuprakash , G.RamaBalaji , etc.	Aluminum Alloy 6082	Cemented Carbide	Cutting speed, Feed and Depth of cut	SR	RSM and Genetic algorithm
7	2010	Bharat Chandra Routara, SaumyaDarsanMohanty, Sauravdatta, AsishBandyopadhyay And SibaSankar	UNS C34000 medium leaded brass	CVD coated carbide tools	Cutting speed, Feed and Depth of cut	SR	Utility Concept, Taguchi
8	2013	Dr. K.G.Durga Prasad, M.V.Prasad, etc.	Aluminum	Carbide Tool	Cutting speed, Feed and Depth of cut	MRR & SR	DEA based Taguchi method
9	2011	John D. Kechagias, Christos K. Ziogas, etc.	Al Alloy 5083	Carbide Tool	Core Diameter, Flute Angle, Rake Angle, Peripheral 2nd Relief Angle, Cutting Speed, Feed and Depth of Cut	SR	Analysis of mean
10	2012	Milon D. Selvam, Dr.A.K.Shaiketc.	Mild Steel	Zinc Coated Carbide Tools	Number of passes, Cutting speed, Feed and Depth of cut	SR	Taguchi technique and Genetic Algorithm
11	2013	N. Naresh, K. Rajasekhar, P. VijayaBhaskara Reddy	Glass Fiber Reinforced Plastics (GFRP) Composite	Carbide Tool	Fibre Orientation Angle, Helix Angle, Spindle Speed and Feed Rate	SR, Machining Force, Delamination factor	Taguchi, ANOVA, Regression Analysis
12	2012	Nitin Agrawal	Aluminum	HSS Milling Cutter	Cutting speed, Feed and Depth of cut	SR	Multiple regression and t-test
13	2014	Rajesh Kumar, M. K. Pradhan and Rishi Kumar	Aluminum 6061 Alloy	Cobalt Bonded Cemented Carbide Tool	Cutting speed, Feed, Depth of cut & Coolant	MRR & SR	GRA based Taguchi & PCA
14	2013	S. Y. Chavan, V. S. Jadhav	Al-Si7Mg Aluminum Alloy	Solid Carbide with TiCN Coating	Cutting speed, Feed, Depth of cut & Coolant	MRR & SR	GRA
15	2014	Sanjeev Kumar Pal and Rahul Davis	Al 6061 and Al 6463	HSS Cutting Tool	Feed and Depth of cut	SR	PCA, Grey relation analysis,
16	2010	SanjitMoshat, SauravDatta,	Aluminum	CVD Coated	Cutting speed, Feed and Depth	MRR & SR	PCA based Taguchi

Sr. No.	Year	Author	Material	Tool	Input Parameters	Output Parameters	Methodology used
		AsishBandyopadhyay and Pradip Kumar Pal		Carbide Tools	of cut		method
17	2012	SurasitRawangwong, JaknarinChatthong, R. Burapa and W. Boonchouytan	Aluminum 7075-T6	Carbide Tool	Cutting speed, Feed and Depth of cut	SR	Taguchi, ANOVA, Regression Analysis
18	2012	SurasitRawangwong, JaknarinChatthong, RomadornBurapa, and WorapongBoonchouytan	Aluminum Alloy	Carbide Tool	Cutting speed, Feed and Depth of cut	SR	Taguchi, ANOVA, Regression Analysis
19	2009	T. K. Barman, P. Sahoo	AISI 1040	CVD Coated Carbide Tools	Cutting speed, Feed and Depth of cut	SR	Taguchi & ANOVA

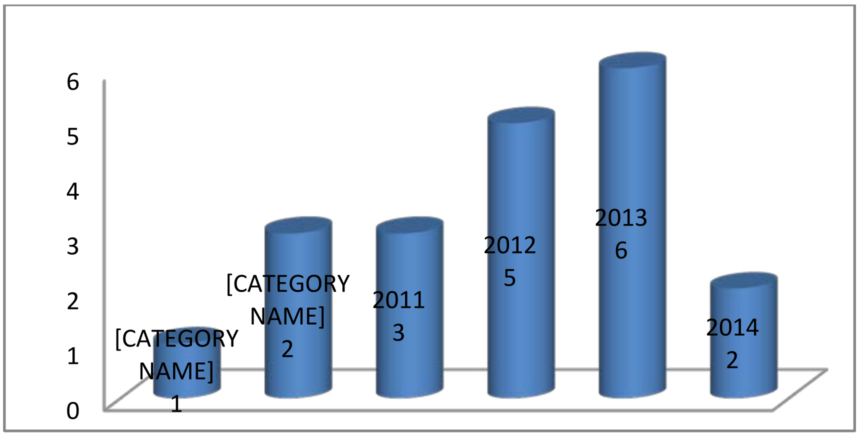

Figure 1.Bar chart of publication year with number of papers

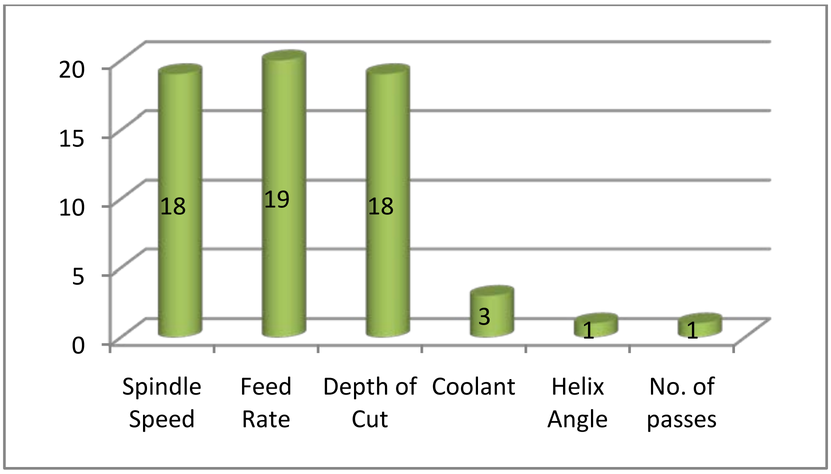

Figure 2. Process Parameters taken in different research paper

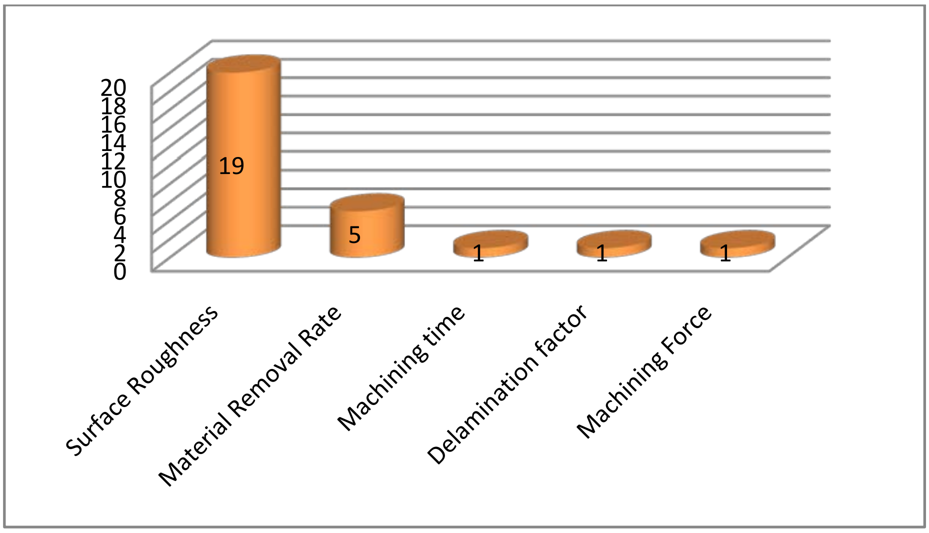

Figure 3. Performance/Quality Parameters taken in different research papers

CONCLUSION

From reviewed different research paper it has been concluded that

- Most of the research people have taken spindle speed, feed rate and depth of cut as input parameters. Spindle speed, feed rate and depth of cut are the important parameters while studying the effects of process parameters on the required responding characteristics.
- For any manufacturing industries the quality is the most important quality parameters. So, most of the research people have taken surface roughness as the quality parameters.

- Every research people tried to optimize the quality/performance characteristics according to problem taken. All performance characteristics are equally important according to industries problem.
- Taguchi combined with ANOVA are good methodologies to analyze the result data. Taguchi helps to determine optimal sequence and ANOVA technique helps to determine which parameters are most significant and their percentage contribution.
- Taguchi methodology widely used for the single optimization.
- Grey Relation analyses, Principle component analysis, utility concept with combined Taguchi methodology arewidely used for multi optimization.

REFERENCES

1. Amit Joshi & Pradeep Kothiyal, “Investigating Effect of Machining Parameters of CNC Milling on Surface Finish by Taguchi Method”, International Journal on Theoretical and Applied Research in Mechanical Engineering, Volume-1, Issue-2, 2012, pp. 60-65.
2. Anish Nair and P Govindan, “Optimization Of CNC End Milling Of Brass Using Hybrid Taguchi Method Using PCA And Grey Relational Analysis”, International Journal of Mechanical and Production Engineering Research and Development, Vol. 3, Issue 1, Mar 2013, pp. 227-240.
3. Avinash A. Thakre, “Optimization of Milling Parameters for Minimizing Surface Roughness Using Taguchi‘s Approach”, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 6, June 2013, pp. 226-230.
4. B. Ramesh, R. Venkatesh, Dr. Jolly Abraham, S. Clement, R. BibeyeJahaziel and Dr. A. Elayaperumal, “Optimization of Process Parameter Levels during Conventional Milling of Beryllium Copper Alloy Using End Mill”, International Journal of Advance Research in Science and Engineering, Vol-1, Issue 2, 2011, pp. 57- 63.
5. B. Sidda Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy, “Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm, International Journal of Engineering, Science and Technology, Vol. 3, No. 8, 2011, pp. 102-109.
6. Bharat Chandra Routara, SaumyaDarsanMohanty, Sauravdatta, AsishBandyopadhyay and SibaSankarMahapatra, “Optimization in CNC end milling of UNS C34000 medium

leaded brass with multiple surface roughness characteristics”, Sadhana, Vol. 35, Part 5, October 2010, pp. 619–629.

7. D.Bhanuprakash , G.RamaBalaji , A.Gopichand, V.Ajaykumar andD.V.N.Prabhaker, “Optimization Of Machining Parameters For Aluminum Alloy 6082 In CNC End Milling”, International Journal of Engineering Research and Applications, Vol. 3, Issue 1, January -February 2013, pp.505-510.
8. Dr. K.G.Durga Prasad, M.V.Prasad, A.Chakradhara Rao and P.V.S.C.Manjusha, “DEA-based Taguchi method for Optimization of CNC End milling Process parameters”, International Journal of Emerging Trends in Engineering and Development, Issue 3, Vol.4 , June-July 2013, pp. 202-211.
9. John D. Kechagias, Christos K. Ziogas, Menelaos K. Pappas and Ioannis E. Ntziatzias, “Parameter Optimization during Finish End Milling of Al Alloy 5083 using Robust Design”, Proceedings of the World Congress on Engineering Vol I, July 6 - 8, 2011.
10. Mihir Patel and Vivek Deshpande, “Application of Taguchi Approach for Optimization Roughness for Boring Operation of E 250 B0 for Standard IS:2062 on CNC TC”, International Journal of Engineering Development and Research, vol. 2, issue 2, 2014, pp. 2528-252537.
11. Milon D. Selvam, Dr.A.K.ShaikDawood and Dr. G. Karuppusami, “Optimization Of Machining Parameters For Face Milling Operation in a Vertical CNC Milling Machine using Genetic Algorithm”, Engineering Science and Technology: An International Journal, Vol.2, No. 4, August 2012, pp. 544-548.
12. N. Naresh, K. Rajasekhar, P. and VijayaBhaskara Reddy, “Parametric analysis of GFRP composites in CNC milling machine using Taguchi method”, IOSR Journal of Mechanical and Civil Engineering, Volume 6, Issue 1, Mar. - Apr. 2013, pp. 102-111.
13. Nitin Agrawal, “Surface roughness Modeling with Machining parameters (Speed, feed and depth of cut) in CNC Milling, “MIT International Journal of Mechanical Engineering, Vol. 2, No. 1, Jan. 2012, pp. 55-61.
14. Rajesh Kumar, M. K. Pradhan and Rishi kumar, “Modeling and optimization of end milling parameters on aluminum 6061 alloy using GRA based Taguchi method coupled with PCA", 5th International & 26th All India Manufacturing Technology,

Design and Research Conference (AIMTDR 2014) December 12th – 14th December 2014, IIT Guwahati, Assam, India, pp. 90-1 to 90-6.

15. S. Y. Chavan and V. S. Jadhav, "Determination of Optimum Cutting Parameters for Multi performance Characteristics in CNC End Milling of Al-Si7Mg Aluminum Alloy", International Journal of Engineering and Technical Research, Volume-1, Issue-6, August 2013, pp. 16-21.
16. Sanjeev Kumar Pal and Rahul Davis, "A Design of Experiment Approach to Compare the Machining Performance of CNC End Milling", International Journal of Mechanical Engineering, Volume 2, Issue 7, July 2014, pp. 34-44.
17. SanjitMoshat, SauravDatta, AsishBandyopadhyay and Pradip Kumar Pal, "Optimization of CNC end milling process parameters using PCA-based Taguchi method", International Journal of Engineering, Science and Technology, Vol. 2, No. 1, 2010, pp. 92-102.
18. SanjitMoshat, SauravDatta, AsishBandyopadhyay 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.
19. SurasitRawangwong, JaknarinChatthong, R. Burapa and W. Boonchouytan, "An investigation of optimum cuttingconditions in face milling aluminum7075-t6 using design of experiment", 4th International Conference on Applied Operational Research, Proceedings, Lecture Notes in Management Science, Vol. 4, 2012. pp. 125–135
20. SurasitRawangwong, JaknarinChatthong, RomadornBurapa, and WorapongBoonchouytan, "An Investigation of Optimum Cutting Conditions in Face Milling Semi-Solid AA 7075 Using Carbide Tool", International Journal of Innovation, Management and Technology, Vol. 3, No. 6, December 2012, pp. 692-696.
21. T. K. Barman and P. Sahoo, "Fractal Dimension Modeling in CNC Milling Using Taguchi Method", Proceedings of the International Conference on Mechanical Engineering 2009 (ICME2009) 26- 28th December 2009, Dhaka, Bangladesh, pp. RT 29 1-6.