A Literature Review On Taguchi Optimization Methodology With CNC Machine

Rajesh A S[1], Dr. M S Prabuswamy[2]
[1, 2] Dept of Mechanical Engineering
[2]Professor, Dept of Mechanical Engineering
[1]GSSSIETW, Mysuru, Karnataka, INDIA.
[2]JSS S&T University, Mysuru, Karnataka, INDIA.

Abstract- *CNC (Computer Numerical Control) machines are widely used to manufacture different parts in different types of materials. It is a highly precise way for manufactures to make sure all their parts are within the set tolerances. CNC is computer controlled whereas in the past it was manually controlled by the operator. CNC Machine is a machine controlled by a computer with command data code numbers, letters and symbols, according to standard ISO. This paper reviews the Taguchi optimization technique with different cutting variables in machining operation with different materials.*

Keywords- Optimization, Taguchi, MRR, SR.

I. INTRODUCTION

The development of computer aided design and manufacturing system is evolving to the phase of integrated manufacturing systems, which is oriented towards the need of 21stcentury. Efforts are made to maintain and improve the vitality of manufacturing system. Keeping it as center stone of all economic activities and ensuring that manufacturing remains an attractive industrial area. Optimization of corporate activities in computer integrated manufacturing (CIM) and CAPP in one of the greatest targets of the system. Since it has been believed that only those industries capable of effective manufacturing would withstand international and global competition. A CNC (Computer Numerical Controlled) machine is controlled by motors by using computers. In the modern machining the challenge is mainly focused on quality in terms of surface finishing. Surface texture is concerned with geometric irregularities. The quality of surface is most significant for any product. The surface roughness is main affecting thing such as for contact causing surface friction, wearing, holding the lubricant etc. There are many factors which affect the surface roughness (SR) and material removal rate (MRR), i.e. tool (material, nose radius, geometry, tool vibration), work piece (hardness, mechanical properties), cutting condition (speed, feed, depth)etc. New products have been generally designed to be produced on three axis CNC machining centers from cubical billets. It is not sufficient to device a feasible procedure for manufacture of desired component. The procedure must be economically justified. Cutting conditions may be established which give satisfactory results.

Machining operations have been the core of the manufacturing industry since the industrial revolution [1]. The existing optimization researches for CNC (computer numerical controlled) turning were either simulated within particular manufacturing circumstances [2-5], or achieved through numerous frequent equipment operations [6,7]. Nevertheless, these are regarded as computing simulations, and the applicability to real world industry is still uncertain. Therefore, a general deduction optimization scheme without equipment operations is deemed to be necessarily developed. The machining process on a CNC lathe is programmed by speed, feed rate, and cutting depth, which are frequently determined based on the job shop experiences. However, the machine performance and the product characteristics are not guaranteed to be acceptable. Therefore, the optimum turning conditions have to be accomplished. It is mentioned that the tool nose run-off will affect the performance of the machining process [8]. Therefore, the tool nose run-off is also selected as one of the control factors in this study.

With all the viewpoints above, this paper considers four parameters (cutting depth, feed rate, speed, tool nose runoff) with three levels (low, medium, high) to optimize the tool wear in CNC finish turning. The fuzzy control rules using triangle membership function with respective to five linguistic grades for tool wear are additionally constructed. The defuzzification is then quantified using center of gravity and moreover introduced to Taguchi experiment as the S/N (signal-to-noise) ratio; therefore, the optimum general deduction parameters can then be received. This paper definitely proposes a fuzzy deduction general optimization approach and satisfactory fuzzy linguistic technique for improving tool wear in CNC turning with profound insight.

II. LITERATURE REVIEW

Prajapati et al. [1]have optimized the machining parameters for SR and MRR in CNC turning.SS 316 (austenite steel) work material of Ø 45 mm and length 35 mm was used in turning in dry environment conditions. In this study, the effect and optimization of machining parameters (cutting speed, feed rate and depth of cut) on SR and MRR is investigated. An L27 Orthogonal array, analysis of variance (ANOVA) and grey relation analysis is used.

Chandrasekaran et al.[2] studied the machine ability of AISI 410 on CNC lathe for SR using Taguchi method. The effect and optimization of machining parameters on SR is investigated. L27 Orthogonal array, analysis of variance (ANOVA) is used in this investigation. The experiment was conducted on FANUC CNC lathe. Work material of Ø 32 mm and length 60 mm was used. Benardos et al. [3] studied a neural network modeling approach for the prediction of surface roughness in CNC face milling. Taguchi design of experiments method is used and MATLAB version 5.3.0.10183 (R11) program was used to create, train and test the ANNs.

Zhang et al. [4] investigated the Taguchi design application to optimize surface quality in a CNC face milling operation. An orthogonal array of L9 was used and ANOVA analyses were carried out to identify the significant factors affecting surface roughness. CNC Mill: Fadal VMC-40 vertical machining centre was used for this experiment and 19.1×38.1×76.2 mm aluminum blocks as a work piece. The experimental results indicate that in this study the effects of spindle speed and feed rate on surface were larger than depth of cut for milling operation.

Gologlu et al. [5] studied about pocket milling which is often encountered in plastic mould manufacture. The implementation and selection of cutting path strategies with appropriate cutting parameters have significant effect on surface roughness. The aim of this study is to investigate optimum cutting characteristics of DIN 1.2738 mould steel using high-speed steel end mills.

Joshi et al.[6] Investigated the SR response on CNC milling by Taguchi technique. Analysis of variance (ANOVA) was used in this investigation. The material used for the experiment is (100 x 34 x 20 mm) 5 blocks of aluminum cast heat-treatable alloy. The output characteristic, surface finish is analyzed by software Minitab 15 and ANOVA is formed, which shows the percentage contribution of each influencing factor on surface roughness.

Kothiyal et al.[7]performing experiment for optimized the parameter for MRR using Taguchi methodology and ANOVA. The L9 Orthogonal array is used in MINITAB 15 which shows the percentage contribution of each influencing factor on MRR. The material used for the experiment is (100 x 34 x 20 mm) blocks of aluminum cast heat-treatable alloy.

Yang et al. [8] studied the surface roughness on end milling with gene expression programming. In this research, a method based on gene expression programming (GEP) has been proposed to construct the prediction model of surface roughness. GEP combines the advantages of the genetic algorithm (GA) and genetic programming.

Reddy et al.[9]optimized the parameters for surface roughness using response surface methodology and genetic algorithm The experiments were conducted using Taguchi's L50 orthogonal array in the design of experiments by considering the machining parameters such as Nose radius, Cutting speed, feed, axial depth of cut and radial depth of cut.

Kromanis et al. [10] studied to develop a technique to predict a surface roughness of part to be machined. 3D surface parameters give more precise picture of the surface; therefore it is possible more precisely to evaluate the surface parameters according to technological parameters. In result of the study, the mathematical model of end-milling is achieved and qualitative analysis is maintained. Achieved model could help technologists to understand more completely the process of forming surface roughness.

Bajic et al.[11] performed the machining process for optimized the parameters for SR in face milling. Test samples made of carbon steel St 52-3 with dimensions 230x100x100 mm were used in experiments. The parameters cutting speed, depth of cut and feed on machined surface roughness in face milling process have been examined. The results of the performed research show that both feed and cutting speed influence on surface roughness but the feed is the most influential factor.

Chockalingam et al.[12]studied the effect of different coolant conditions on milling of AISI 304 stainless steel. Cooling methods used in this investigation were flooding of synthetic oil, water-based emulsion, and compressed cold air. Cutting forces and the surface roughness were studied and tool flank wears observed. In this study, the comparison between different coolants effect to the milling of AISI 304 stainless steel is done.

Routara et al.[13] investigated the optimization of parameters using response surface method. For this research three different materials 6061-T4 aluminum, AISI 1040 steel

and medium leaded brass UNS C34000 were used. For this research he used the ANOVA approach and F test. All experiment conduct on CNC turning and the output parameters are MRR & SR is predicted by ANOVA.

Newman et. al [15] studied the CNC places the most important place in industries. CNC has an efficient role in production.

III. CUTTING PROCESS VARIABLE

Feed rate-The feed of a lathe can be defined as the distance the cutting tool advances along the length of the work for every revolution of the spindle. A finer feed is required for better finishing.

Depth of cut-The measurement (normally in inches or millimeters) of how wide and deep the tool cuts into the work piece.

Cutting speed-The cutting speed is the speed at which the circumference of the work part moves along the cutter and is normally given in mm/min.

Surface Roughness Parameters Surface roughness most commonly refers to the variations in the height of the surface relative to a reference plane. It is measured either along a set of parallel line profiles (surface maps) OR along a single line profile.

Material Removal Rate (MRR) is the factor in turning is the material/metal that is removed per unit time in mm3/sec. On each revolution of the job, a circular shaped layer of material is removed. Material Removal Rate (MRR) = v × f × d mm3/sec Where, v = cutting speed in mm/sec d = depth of cut in mm f = feed in mm/rev.

IV. TAGUCHI METHODOLOGY

Traditionally design methods are too complex and difficult to use. A large number of experimental works has been done when the process parameters are increased with their levels. To solve this problem Taguchi method is used with a design of orthogonal arrays to study the all parameters. Taguchi Method is developed by Dr.Genichi Taguchi, a Japanese quality management consultant. It is an efficient tool for the design of high quality manufacturing system. The main advantage of this method to reduce the experimental time and find out significant factor. Taguchi robust design method is a most powerful tool for the design of a high quality system. He considered three steps in a process's and product's development: system design, parameter design, and tolerance design. In system design, the engineer uses scientific and engineering principles to determine the fundamental configuration. In the parameter design step, the specific values for system parameters are determined. Tolerance design is used to determine the best tolerances for the parameters [17].Taguchi's orthogonal array provides the set of experimental data (less number of experimental runs) and Taguchi's S/N ratio is the logarithmic function of desired output. The objective of using S/N ratio as a performance measurement is to develop products and processes insensitive to noise factors. The steps suggested by Taguchi are:

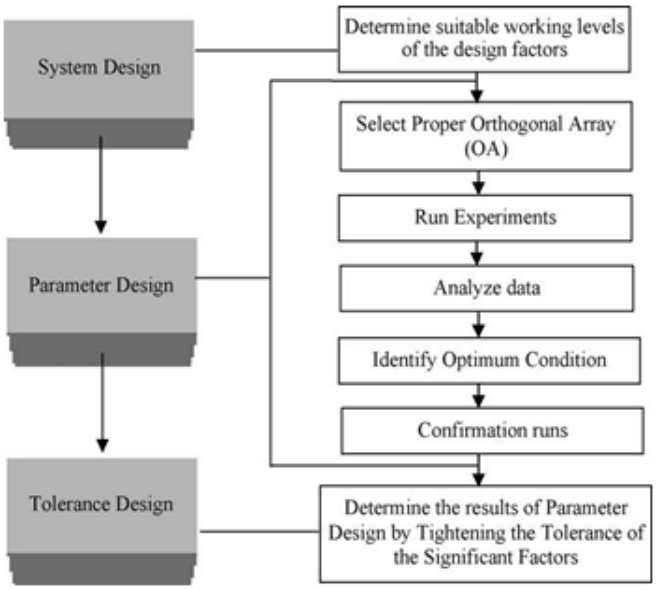

Fig: Graphic representation of Taguchi's method

Material Removal Rate (MRR): Material removal rate (MRR) is defined as the material is removed per unit time. Its unit is mm^3/sec.

MRR = V*f*d mm^3/sec
V = Cutting Speed (in mm/sec)
f = Tool feed (in mm)
d = Depth of cut (in mm)

Surface Roughness: Surface roughness is defined as a group of irregular waves in the surface, measured in micrometers. It is produced by the fluctuations of short wavelengths characterized by asperities (local maxima) and valleys (local minima) of varying amplitudes and spacing. Surface roughness is defined by various characteristics of the surface profile such as center-line average R. peak-to-valley height Hand average roughness depth, but these have limitations. The randomness of the profile is no measured by any of these parameters. The randomness of the surface profile causes the roughness value to vary under the given cutting conditions and is caused by the random nature of the mechanism of formation of the built-up edge, side flow and tool wears. There are

various methods used for the roughness measurement such as stylus profilometry, light sectioning and taper sectioning methods, scanning electron microscopy and transmission electron microscopy etc.

V. CONCLUSION

From the above discussion we found that most of the researchers had taken input parameters (speed, feed, depth of cut) and in some cases other parameters such as nose radius, environment etc. and facing output parameters SR, MRR.

From the literature review it is found that for surface roughness the most significant parameters are speed, feed and nose radius and least significant parameter is DOC and for MRR the most significant parameters are DOC, feed and speed and least significant parameter is nose radius. In this paper, studied the different approaches for the machining parameters with the optimum utilization of these parameters. Now these days these parameters play a very vital role for the machining and utilized in the industries.

VI. ACKNOWLEDGEMENT

I would like to express my sincere gratitude to Review Committee for the insightful comments & Encouragement and my Research Supervisor **Dr. M S Prabuswamy** for the continuous support of my Ph. D study and related research, motivation, and immense knowledge.

REFERENCES

[1] Prajapati, Navneet K. and Patel, S. M.," Optimization of process parameters for surface roughness and material removal rate for SS 316 on CNC turning machine." International Journal of Research in Modern Engineering and Emerging Technology, Vol. 1, Issue: 3, pp.40-47, 2013

[2] Chandrasekaran, K., Marimuthu,P., Raja, K and ManimaranA,"Machinability study on AISI 410 with different layered inserts in CNC turning during dry condition." International Journal of Engineering& Material Science, Vol. 20, pp.398-404, 2013.

[3] Benardos, P.G. and Vosniakos, G.C.,"Prediction of surface roughness in CNC face milling using neural networks and Taguchi's design of experiments." Robotics and computer integrated manufacturing, Vol. 18, pp.343-354, 2002.

[4] Zhang, Julie Z., Chen, Joseph C. and Kirby, E. Daniel," Surface roughness optimization in an end-milling operation using the Taguchi design method."Journal of Materials Processing Technology Vol.184, pp. 233–239, 2007.

[5] Gologlu,Cevdet and Sakarya,Nazim, "The effects of cutter path strategies on surface roughness of pocket milling of 1.2738 steel based on Taguchi method." Journal of materials processing technology Vol.206,pp. 7–15, 2008.

[6] Joshi, Amit and Kothiyal, Pradeep," 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-2, Issue-2, pp. 113-119, 2013.

[7] Joshi, Amit, Kothiyal, Pradeep and Pant, Ruby," Experimental investigation of machining parameters of CNC milling on MRR by taguchi method." International Journal of Applied Engineering Research, Vol.7 No.11, 2012

[8] Yang, Yang, Li, Xinyu, Jiang, Ping and Zhang Liping," Prediction of surface roughness in end milling with gene expression programming."(Proceedings of the 41st International Conference on Computers & Industrial Engineering),2011.

[9] Reddy, B. Sidda, Kumar, J. Suresh and Reddy K. Vijaya Kumar," 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, pp. 102-109, 2011.

[10] Kromanis, A. and Krizbergs, J.,"3d Surface roughness prediction technique in endmilling using regression analysis."(6th International DAAAM Baltic Conference Industrial Engineering),2008.

[11] Bajic, D., Lele,B. and Zivkovic, D.,"Modeling of machined surface roughness and optimization of cutting parameters in face milling." Vol.47, pp.331-334, 2008.

[12] Chockalingam, P.and Wee Lee Hong," Surface Roughness and Tool Wear Study on Milling of AISI 304 Stainless Steel Using Different Cooling Conditions." International Journal of Engineering and Technology Vol. 2, No. 8,pp.1386-1392, 2012.

[13] Routara, B. C., Bandyopadhyay, A.andSahoo, P.," Roughness modeling andoptimization in CNC end milling using response surface method: effect of work piece material variation." International Journal of Advance Manufaturing and Technology,Vol. 40, pp.1166–1180, 2009.

[14] Thakkar, Jitendra and Patel Mitesh I.," A Review on Optimization of Process Parameters for Surface Roughness and Material Removal Rate for SS 410 Material During Turning Operation."International Journal of Engineering Research and Applications,Vol. 4, Issue 2, pp.235-242, 2014.

[15] Newman, S.T. and Nassehi, A.,"Universal Manufacturing Platform for CNC Machining."Annals of the CIRP,Vol. 56, pp. 459-463, 2007.
[16] Ghani, J.A., Choudhury, I.A. and Hassan, H.H.," Application of Taguchi method in the optimization of end milling parameters." Journal of Materials Processing Technology, Vol. 145, pp. 84–92, 2004
[17] Ross Philip J, "Taguchi techniques for quality engineering" (McGraw-Hill book company, New Delhi),2005.