TECHNIQUES USED FOR OPTIMIZATION OF PROCESS PARAMETERS IN MILLING OPERATIONS: LITERATURE REVIEW

Balwant Singh[1], Ravinder Kumar[2] and Raman Kumar[3]

[1]*Research Scholar, LCET, Punjab (India)*

[2]*Assistant Professor, Department of Mechanical Engineering, LCET, Punjab (India)*

[3]*Assistant Professor, Department of Mechanical Engineering, Chandigarh University, Gharuan, Punjab (India)*

ABSTRACT

Machining is the essential activity of a manufacturing organization and milling is one of them. The economy growth rate of a country depends upon the innovation and research in manufacturing sectors. In this paper an attempt has been made to identify the gap in optimization of process parameters in milling operations through extensive literature review. Literature review revealed that researcher were mainly focus on input process parameter such as cutting speed, feed rate and depth of cut and output process parameters such as material removal rate (MRR), surface finish. The Taughi method and response surface method (RSM) were frequently used to optimize the process parameter. It was found that very less work support the process parameter optimization in which different weightage has been assigned to output parameters as per application of machining process. The little work reported in which algorithm and application of multiple criteria decision making approaches such as particle swarm optimization (PSO), teaching learning based optimization (TLBO), Genetic algorithm (GA) was implemented to optimize the parameters. The guidelines were provided for further research in optimization of process parameters.

Keywords: Machining, Milling, Optimization Technique

I. INTRODUCTION

In milling, machining is done with cutter having one or more teeth. In this globalization era milling has become popular due to its characteristics such as maximum production rate, minimum operational cost, and the quality. The efficiency of milling machine is higher than other traditional machining processes such as lathe machine. In Whitney, 1798 first Milling machine was designed for producing muskets and gun parts. Joseph Brown an American Engineer presented universal milling machine at Paris exhibition in 1827. After this invention the applications and use of milling machine are increasing continuously in manufacturing sector. In milling machine three processes such as End milling, Face Milling and Side milling are most commonly used during machining of work-piece. End mill is used for finishing the face and side of work-piece. End mill cutter has sharp cutting edges with large flutes to allow chips discharge from cutter. Face milling is the most common milling operation for machining flat surface and can be performed using a wide range of different tools. Face mills cut with the end of the cutter and have a larger diameter than the width of the work-piece being faced in order to process the

surface in one pass. Side milling is used for making flat vertical surface on the side of work-piece with stability and productivity. It can build into a gang to machine more than one surface in the same plane at the same time [1]. The operation of milling was done basically with two ways such as Up Milling and Down Milling. Up Milling is the operation when the milling tool is rotating in the opposite direction as the feed which means that the teeth of the tool are pulling the chips out. In Up Milling process work-piece is securely fastened because of upward forces act on a work-piece and table. Down Milling is the operation when the tool is rotating in the same direction as the feed which means that the teeth of tool are pushing down on work-piece. In Down Milling work-piece is not securely fastened because of downward forces act on a work-piece and table. The up milling process become popular in medium scale organization only and small scale manufacturing organization are frequently using down milling due to safety criteria [2]. Milling process has been used in a variety of industrial applications such as like complex shaping, removing large amounts of materials with full of accuracy. Now-a-days advancement/ automation in milling such as CNC milling has become popular for increasing the mass production and accuracy [3].

II. LITERATURE REVIEW

Moshat et al, (2010) [4] made an attempt to optimize the CNC end milling process parameters to achieve good surface finish and high removal rate (MRR). The Principal Component Analysis (PCA) based on Taguchi method was used for optimization. It has been found that PCA method makes result more reliable for multi-objective problem as it has characteristics to eliminate multi-correlation. Ghani et al., (2004) [5] performed an experiment on AISI H13 with TiN coated P10 carbide insert tool under semi-finishing and finishing condition of high speed cutting. The three input process parameters such as cutting speed, feed rate and depth of cut were consider and Taugchi approach has been implemented for process parameter optimization. The Analysis of variance (ANOVA) was so employed to get the significance level of experimental values. It was concluded that to achieve the low resultant cutting force and good surface finish the values of cutting speed must be high and value of feed rate as well as depth of cut must be low. Gopalsamy et al., (2009) [6] putted an effort to optimize process parameters for end milling process. The Taguchi method was applied to study the performance characteristics of machining (cutting speed, feed rate, depth of cut and width of cut) with consideration of surface finish and tool life. It result showed that cutting speed was most influencing parameter. Zhang et al., (2006) [7] did experimental work to optimize surface quality in a CNC face milling operation. The two methods such as Taguchi method and Analysis of variance (ANOVA) were carried out to identify the significant factors affecting surface roughness and the optimal cutting combination. It has been observed that Taguchi design was successful in optimizing milling parameters for surface roughness. Camuscu, (2005) [8] used three different tool materials such as coated carbide, coated cermet,alumina (Al_2O_3)based mixed ceramic & cubic boron nitride (CBN) to analyze the response parameters such as tool life and surface finish. The experimental work was done on AISI D3 Cold work tool steel hardened 35HRC. It has found that best cutting performance was obtained with CBN tool. The rest of literature review has been presented in tabular form as shown in Table 1.

Table 1 Literature review focusing on optimization approach in milling operation

S.No	Authors	Optimization approach
1.	Iqbal et al., (2007) [9]	Analysis of Variance (ANOVA)
2.	Wang et al., (2005) [10]	Genetic Algorithm (GA)
3.	Tsao (2009)[11]	Grey-Taguchi method
4.	Sreeram et al., (2006) [12]	GA
5.	Yildiz, (2013) [13]	Cuckoo Algorithm (CA)
6.	Hou et al., (2007) [14]	Response surface methodology (RSM)
7.	Yang et al., (2006) [15]	Grey Relational Analysis Method
8	Oktem et al., (2005) [16]	(RSM)
9.	Lu et al., (2009) [17]	Grey Relational Analysis Method
10.	Zain et al., (2010) [18]	(GA)
11.	Kopac et al., (2007) [19]	Grey-Taguchi method
12.	Lin , (2002) [20]	Taguchi method
13.	Bagci and Aykut, (2006) [21]	Taguchi method
14.	Fratila and Caizar, (2011) [22]	Taguchi method
15.	Savas and Ozay, (2008) [23]	(GA)
16.	Yazdi and Khorram, (2010) [24]	(RSM)
17.	Lee, (2003) [25]	Taguchi method
18.	Razfar et al., (2011) [26]	Neural Network and Harmony Search Algorithm
19.	Ozel and Altan, (2000) [27]	Finite Element Method
20.	Ji et al., (2012) [28]	Taguchi method

III. CONCLUSIONS AND FUTURE SCOPES

Optimization of process parameters helps the organization to get effective result of machining. The number of process parameters selected for particular research work may call many suitable optimization techniques. The use of algorithm and computer language reduces the statistical calculation and hence minimizes the error in result of methodology. The algorithm developed once may apply to other similar type's problem by doing minor changes in algorithm. The results obtained by algorithm should compare with other existing software available and other techniques to makes result more realistic.

Some points are listed below which helps in optimize process parameters research.

1. The use of AHP and entropy method can be used to assign different weightage to output process parameters.
2. Use at least two techniques to optimize the process parameters and compare the results.
3. The use of latest developed algorithm/Matlab code/soft computing techniques such as TLBO.

REFERENCES

[1] Palanisamy, P., Rajendran, I. and Shanmugasundaram, S., "Optimization of machining parameters using genetic algorithm and experimental validation for end-milling operations", International Journal of Advance Manufacturing Technology, 32,2007, 644–655.

[2] Norberto, L., Francisco, J. and Lamikiz, A., "Milling processes.Modern machining technology", 2011,213-303.

[3] Nalbant, M., Gokkaya, H. and Sur, G., " Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning", Materials and Design, 28, 2007, 1379–1385

[4] Moshat, S., Datta, S., Bandyopadhyay, A. and Kumar, P., "Optimization of CNC end milling process parameters using PCA-based Taguchi method", International Journal of Engineering, Science and Technology,2(1), 2010, 92-102.

[5] Ghani, J.A., Choudhury, I.A. And Hassan, H.H., "Application of Taguchi Method in the optimization of end milling parameters", Journal of Material Processing, Elsevier, 143(1), 2004, 84-92.

[6] Gopalsamy, B.M., Mondal, B. and Ghosh, S., "Taguchi method and ANOVA: An approach for process parameters optimization of hard machining while machining hardened steel", Journal of Scientific and Industrial Reseasrch, 68, 2009, 686-695.

[7] Zhang, J.Z., Chen, J.C. and Kirby, E.D., "Surface roughness optimization in an end-milling operation using the Taguchi design method", Journal of materials processing technology, 184(1-3), 2007, 233-239.

[8] Camuscu, N. and Aslan, E., "Comparative study on cutting tool performance in end milling of AISI D3 tool steel", Journal of materials processing technology, 170(1), 2005, 121-126.

[9] Iqbal, A., He, N., Li, L. and Dar, N.U., "A fuzzy expert system for optimizing parameters and predicting performance measures in hard-milling process", Expert Systems with Applications, 32(4), 2007, 1020-1027.

[10] Wang, Z.G., Rahman, M., Wong, Y.S. And Sun, J., "Optimization of multi-pass milling using parallel genetic algorithm and parallel genetic simulated annealing", International Journal of Machine Tools and Manufacture, 45(15), 2005, 1726-1734.

[11] Tsao, C.C., "Grey-Taguchi method to optimize the milling parameters of aluminum alloy", The International Journal of Advanced Manufacturing Technology, 40(1-2), 2009, 41-48.

[12] Sreeeam, S., Kumar, A.S., Rahman M. and Zaman, M.T. "Optimization of cutting parameters in micro end milling operations in dry cutting condition using genetic algorithms", The International Journal of Advanced Manufacturing Technology, 30(11-12), 2006, 1030-1039.

[13] Yildiz, A.R.,"Cuckoo search algorithm for the selection of optimal machining parameters in milling operations", The International Journal of Advanced Manufacturing Technology, 64(1-4), 2013, 55-61.

[14] Hou, T.H., Su, C.H. and Liu, W.L. "Parameters optimization of a nano-particle wet milling process using the Taguchi method, response surface method and genetic algorithm", Powder Technology, 173(3), 2007, 153-162.

[15] Yang, Y.K., Shie, J.R. and Huang, C.H. "Optimization of dry machining parameters for high-purity graphite in end-milling process", Materials and manufacturing processes, 21(8), 2006, 832-837.

[16] Oktem, H., Erzurumlu, T. and Kurtaran, H., "Application of response surface methodology in the optimization of cutting conditions for surface roughness", Journal of Materials Processing Technology, 170(1), 2005, 11-16.

[17] Lu, H.S., Chang, C.K., Hwang, N.C. And Chung, C.T.,"Grey relational analysis coupled with principal component analysis for optimization design of the cutting parameters in high-speed end milling", Journal of materials processing technology, 209(8), 2009, 3808-3817.

[18] Zain, A.M., Haron, H. and Sharif, S., "Application of GA to optimize cutting conditions for minimizing surface roughness in end milling machining process", Expert Systems with Applications, 37(6), 2010, 4650-4659.

[19] Kopac, J. and Krajnik, P., "Robust design of flank milling parameters based on grey-Taguchi method", Journal of Materials Processing Technology, 191(1), 2007, 400-403.

[20] Lin, T.R., "Optimisation technique for face milling stainless steel with multiple performance characteristics", The International Journal of Advanced Manufacturing Technology, 19(5), 2002, 330-335.

[21] Bagci, E. and Aykut, S., "A study of Taguchi optimization method for identifying optimum surface roughness in CNC face milling of cobalt-based alloy (stellite 6)", The International Journal of Advanced Manufacturing Technology,29(9-10), 2006, 940-947.

[22] Fratila, D. and Caizar, C., "Application of Taguchi method to selection of optimal lubrication and cutting conditions in face milling of AlMg", Journal of Cleaner Production, 19(6), 2011, 640-645.

[23] Savas, V. and Ozay, C., "The optimization of the surface roughness in the process of tangential turn-milling using genetic algorithm", The International Journal of Advanced Manufacturing Technology, 37(3-4), 2008, 335-340.

[24] Yazdi M.S. and Khorram, A., "Modeling and Optimization of Milling Process by using RSM and ANN Methods", IACSIT International Journal of Engineering and Technology, 2(5), 2010, 474-480.

[25] Lee, S.H., "Optimisation of cutting parameters for burr minimization in face-milling operations", International journal of production research, 41(3), 2003, 497-511.

[26] Razfar, M.R., Zinati, R.F. and Haghshenas, M., "Optimum surface roughness prediction in face milling by using neural network and harmony search algorithm", The International Journal of Advanced Manufacturing Technology, 52(5-8), 2011, 487-495.

[27] Ozel, T. and Altan, T., "Process simulation using finite element method—prediction of cutting forces, tool stresses and temperatures in high-speed flat end milling", International Journal of Machine Tools and Manufacture, 40(5), 2000, 713-738.

[28] Ji, R., Liu, Y., Zhang, Y. and Wang, F., "Machining Performance Optimization in End ED Milling and Mechanical Grinding Compound Process", Materials and Manufacturing Processes, 27(2), 2012, 221-228.