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REVIEW OF MILLING MACHINE PARAMETER OPTIMIZATION

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This work investigates for milling parameter optimization and to targets work performance system for the control of the surface quality and MRR. The experiment performed on Vertical Milling Machine have been using for cutting Alloy material with end mill tools. To optimize these machining parameters in which the most significant parameters affecting the surface roughness can be identified, grey relation method is used to optimize the responses. This research focused on review on milling operations by optimizing machining parameters.

1. INTRODUCTION

CNC milling machine, the flexibility has been adopted along with versatility in end milling process. It is found that many research works have been done so far on continuous improvement of the performance of end milling process. CNC machine tools have been implemented to realize full automation in milling since they provide greater improvements in productivity, quality of the machined parts with less operator input [1]. The surface finish of the machined surface has been recognized as quality attribute whereas MRR has been treated as performance index directly related to productivity. The productivity of any machine tool and any machined component is determined by the quality of the surface produced by that machine. Hence for the good functional behaviour of any mechanical components achieving good surface quality is of great importance. 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 quantified surface roughness, assortment of controlling parameters is necessary [3]. There have been a great many research developments in modelling surface roughness and optimization of the controlling parameters to obtain a surface finish of desired level since only proper selection of cutting parameters can produce a better surface finish. Thus surface roughness is used as an indicator of quality of any product. In today's manufacturing industries quality is one of the significant factors, the only component to influence the customer to a level of satisfaction. Industrial sector for each quantity, surface quality is detected by the surface roughness of the component [4].

2. LITERATURE REVIEWS

The static stiffness of a machine tool can be increased by using either higher modulus material or more material in the structure of a machine tool. However, it is difficult to increase the dynamic stiffness of a machine tool with these methods because the damping of the machine tool structure cannot be increased by increasing the static stiffness. Often the most economical way of improving a machine tool with high resonance peaks is to increase the damping rather than the static stiffness even though it is not easy to increase the damping of the machine tool structure. Chatter or Self-excited vibrations occurs when the width of cut or cutting speed exceeds the stability limit of the machine tool [3,4]. The chatter is a nuisance to the metal cutting process and can occur on any chip producing tool. The effects of chatter are all adverse, affecting surface finish, dimensional accuracy, tool life and machine life [5]. When the machine tool is operated without any vibration or chatter, the damping of the machine tool plays no important role in machining.

3. REVIEW OF OPTIMIZATION TECHNIQUE

Abbas et al. [1] investigated on Magnesium alloys which are widely used in aerospace vehicles and modern cars, due to their rapid machinability at high cutting speeds. A novel Edgeworth–Pareto optimization of an artificial neural network (ANN) is presented in this paper for surface roughness (*Ra*) prediction of one component in computer numerical control (CNC) turning over minimal machining time (T_m) and at prime machining costs (*C*). Akhyar et al. [2] applied Taguchi optimization method to optimize cutting parameters in turning Ti-6%Al-4%V extra low interstitial with coated and uncoated cemented carbide tools under dry conditions and high cutting speeds for improved surface finish. L27 orthogonal array including four factors such as Cutting speed, feed rate, depth of cut and tool grades with three levels for each factor was used to identify the optimal combination. ANOVA is used to determine the cutting speed and tool grade to be significant factors affecting the surface finish. Chen et al. [3] optimize machining parameters with a reduction in energy consumption and production time for the face milling process. They presented an integrated approach for minimizing the energy footprint and production time by optimizing cutting tools and cutting parameters. Three energy footprint-aware optimization models were used to demonstrate the necessity of the integrated approach. When the energy footprint of each model was compared, the integrated approach achieved the most energy-efficient footprint. Therefore, they found that it is necessary to optimize the cutting tool and cutting parameters in an integrated manner. Ghhani et al. [4] optimized cutting parameters in end milling process while machining hardened steel AISI H13 with TiN coated P10 carbide insert tool under semi-finishing and finishing conditions of high speed cutting. The effect of milling parameters such as cutting speed, feed rate and depth of cut along with their interactions on the process is studied using Taguchi method of experimental design (DOE). The study indicated the suitability of Taguchi method to solve the stated problem with minimum number of trials as compared with a full factorial design.

4. SIGNIFIANT PARAMÈTRES

Goel et al. [5] attempt has been made in this work to determine the optimal setting of slab milling process parameters of HLSA material. Four process parameters, i.e. cutting fluid, cutting speed, feed and depth-of-cut each at three levels except the cutting fluid at two levels, were considered. Further, the results of ANOVA indicated that all four machining parameters significantly affected the multi-performance with maximum contribution from depth-of-cut (33.76%) followed by feed (24.02%), cutting speed (16.29%) and cutting fluid (13.21%). Hamdan et.al [6] presents an optimization method of the machining parameters in high speed machining of stainless steel using coated carbide tool to achieve minimum cutting forces and better surface roughness. The standard orthogonal array of L9 was employed in this research work and the results were analysed for the optimization process using S/N ratio response analysis and ANOVA to identify the most significant parameters affecting the cutting forces and surface roughness. The input parameters include parameters include the lubrication modes, feed rate, cutting speed, and depth of cut. The result showed a reduction of 25.5% in the cutting forces and 41.3% improvement on the surface roughness performance. Ishan et al. [7] discuss on the literature review of optimization of tool life in milling using Design of experiment implemented to model the end milling process that are using solid carbide flat end mill as the cutting tool and stainless steels s.s-304 as material due to predict the resulting of Tool life. Data is collected from CNC milling machines were run by 8 samples of experiments using DOE approach that generate table design in MINITAB packages. Joshi and Kothiyal [8] had taken process parameters like spindle speed, depth of cut, feed rate to investigate to reveal their Impact on surface finish. From the ANOVA analysis they were found that feed rate is the most dominating factor for surface finish. Katta & Chaitanya [9] presented work on the execution of carbide tip tools in machining of titanium (ti-6al-4v) alloys, under turning process, Kopac et al. [10] designed various flank milling parameters for the optimization of the cutting forces, milled surface roughness and the material removal rate (MRR) in the machining of an Al-alloy casting plate for injection moulds. The optimal combination of milling parameters for multiple process responses was determined using Grey-Taguchi method combined the orthogonal array design of experiments with grey-relational analysis (GRA).

5. REVIEW ON RESPONSES

Krishnaraj et.al [11] investigates high speed end milling of titanium alloy (Ti–6% Al–4% V) using carbide insert based end mill cutter. The experiments have been carried out under dry cutting conditions. The cutting speeds selected for the experiments are 120, 150 and180 m/min. The depth of cuts and feed rate were selected to suit finish machining. For conducting the experiments single insert based cutting tool is used. Experiments were conducted based on the Taguchi's design of experiments, in order to analyse the effect of cutting parameters on cutting force, temperature and surface roughness. Kumar et al. [12] works on influenced by the surface quality during their useful life and productivity also plays an important role in the existence of any product in the market. In order to achieve that, the process parameters should be suitably regulated, but both the responses are conflicting in nature as Surface Roughness (Ra) is to be minimized and Material Removal Rate (MRR) is to be maximized. Hence, modeling and optimization of any process are getting attention by researchers. This paper presents an approach for determination of the best cutting parameters leading to minimum Ra and maximum MRR simultaneously by integrating Response Surface Methodology (RSM) with Multi-Objective Genetic Algorithm (MOGA) in face milling of Al-6061 alloy. Thirty experiments have been conducted based on RSM with four parameters, namely Speed (v), Feed (f), Depth of Cut (d) and Coolant Speed (c.s) and three levels each. ANOVA is performed to find the most influential parameters on both MRR and Ra. It is revealed that f and d are the most influential parameters on MRR and c.s is the most influential parameter for Ra, respectively. Later the multi- objective optimization tool GA is used to optimize the responses. A paretooptimal set of 21 solutions is obtained and validated through confirmation test. Lee et al. [13] worked on machining operations is to make specific shapes or surface characteristics for a product. Conditions for machining operations were traditionally selected based on geometry and surface finish requirements. However, nowadays, many researchers are optimizing machining parameters since high-quality products can be produced using more expensive and advanced machines and tools. There are a few methods to optimize the machining process, such as minimizing unit production time or rate or maximizing profit. This research focused on maximizing the profit of computer numerical control (CNC) milling operations by optimizing machining parameters. Cutting speeds and feed are considered as the main process variables to maximize the profit of CNC milling operations as they have the greatest effect on machining operation. In this research, the Nelder–Mead simplex method was used to maximize the profit of CNC milling processes by optimizing machining parameters. The Nelder–Mead simplex method was used to calculate best, worst, and second-worst value based on an initial guess. The possible range of machining parameters was limited by several constraints. Optimization methods that utilize the gradient of an objective function, which are composed of a non-linear system with constraint functions, have difficulty in arriving at an optimum solution efficiently.

Lu et.al [14] investigates optimization design of the cutting parameters for rough cutting processes in highspeed end milling on SKD61 tool steel. The performance measures are tool life and metal removal rate, and the corresponding cutting parameters are milling type, spindle speed, feed per tooth, radial depth of cut, and axial depth of cut. Mahendra et al.[15] has been carried out in the literature by many researchers. A few works are based on simulations and other works are based on many experimental runs, collecting huge amount of data and processing it to achieve the result. Taguchi method is widely adopted in the literature for the improvement of quality and machining economics. Taguchi method uses the orthogonal array concept with small number of experimental runs to investigate the effects of parameters on performance measures reduces the sensitivity due to inherent variations present in the system. Moreover, Taguchi method does not consider the interactive effects of control factors. Research work on Multi response optimization requireattention. Very less work is done on MRPI. Also other methods of optimization should be used. Output parameter such as surface roughness is focused much other parameters such as tool life, toolwear, cutting force, torque, flank angle, approach angle, power generated etc.

Mismiati & Ahmed [16] work focuses on investigating the effect of machined surface inclination angle, axial depth of cut, spindle speed and feed rate for better surface integrity in inclined end milling process utilizing titanium coated carbide ball end mill. Through the analysis, it was found that machined surface inclination angle had great influence on micro hardness and residual stress in the feed direction. As the machined surface inclination angle was increased, the micro hardness also increased. However, residual stress showed the opposite results.

Moshat et al. [17] experiment use of PCA based hybrid Taguchi method has been proposed and adopted for solution of multi-objective optimization, along with a case study, in CNC end milling operation. From the study and analyses, we conclude that this proposed method has been found efficient for solving multi-attribute decision making problem i.e., for multiobjective product as well as process optimization; for continuous quality improvement.

Nguyen [18] works on CNC milling operations generally consists of production rate, production time, and the sale price of a product. The production rate per part is made up of several components, including raw material rate, overhead rate, tool changing rate, machining rate, and setup rate. Setup, material, and overhead rates are not dependent on the selection of machining parameters. Machining rate tends to decrease with increasing cutting speed, while tool changing rate tends to increase with higher cutting speeds. Even though low cutting speeds and feed tend to increase tool life, they will produce a rough surface finish

Pare et al. [19] the paper addresses the effects of cutting speed and feed on the work piece deflection and surface integrity during milling of cantilever shaped Inconel 718 plate under different cutter orientations. He suggest machine bed is selected for the complete analysis for both static and dynamic loads. Then investigation is carried out to reduce the weight of the machine bed without deteriorating its structural rigidity and the accuracy of the machine tool by adding ribs at the suitable locations.

Patel A et.al [20] to studied the effect of machining parameters such as cutting speed, feed rate, depth of cut, no of cutting flute that are influences on responsive output parameters such as Surface Roughness and Material Removal Rate by using optimization philosophy in CNC end milling. This is review paper in this it is find out that there is very few investigator research worked on SS316 stainless steel material so, they want to do work on this material. In this research work we want to investigate influences of input machining parameters like cutting speed, feed rate, depth of cut and no of flute on response parameters like surface roughness and MRR.

Rajmohan & Prabhu [21] evaluates the optimization of Machining Parameters in Electrical Discharge Machining (EDM) of 304 Stainless Steel In this investigation, the effect of electrical discharge machining parameters such as pulse-on time, pulse-off time, voltage and current on material removal rate in 304 stainless steel was studied. The experiments are carried out as per design of experiment approach using L9 orthogonal array. The results are analyzed using ANOVA and response graphs. From this study, it is found that different combinations of EDM process parameters are required to achieve higher MRR for 304SS. S/N ratio and ANOVA is used to analyze the effect of parameters on MRR and also to identify the optimum cutting parameters. The contribution of each cutting parameters towards the MRR is also identified. The result from this study is useful for manufacturing engineers to select appropriate EDM process parameters to machine SS304.

Ribeiro et al. [22] studied on the Taguchi design application to optimize surface quality in a CNC end milling operation, includes parameter feed per tooth, cutting speed and radial depth of cut as control factors. An orthogonal array of L9 was used and the ANOVA analyses were carried out to identify the significant factors affecting the surface roughness. The optimal cutting combination was determined by seeking the best surface roughness (response) and signal-to-noise ratio. The study was carried-out by machining a hardened steel block (steel 1.2738) with tungsten carbide coated tools.

Sadiq et al. [23] Oil Hardened Non Shrinkable (OHNS) steel finding many applications in Manufacturing parts like Shaft, Gears and Tooling due to their excellent Mechanical properties. The continuous development of carbide milling cutter and its coating technology are great concern with manufacturing Environment. Titanium Aluminum Nitrite coating play an important role in milling cutter to produce better surface finish and tool life with minimum cost. In this Experimental investigation of face milling operation of OHNS steel plates with different process parameters like spindle speed, feed rate and depth of cut and to find optimal machining conditions of minimum surface roughness (Ra). The experiments are designed and conducted based on Taguchi's design of experiments using L9 orthogonal array and analyzed by ANOVA.

Selvan and Karuppusami [24] performed on Mild Steel and obtained data has been analyzed using Taguchi technique and Genetic algorithm. It has been observed that, Taguchi's orthogonal array provides a large amount of information in a small amount of experimentation. The surface roughness evaluated through Taguchi technique is 0.975 µm with 4.308 % error from the predicted value and for genetic algorithm it is 0.88 µm with 4.625 % error from the predicted value. Selvam et al. [25] describes the tool life prediction model with end milling EN31 tool steel using P30 Tungsten uncoated carbide tool. The data set from the Taguchi method design is taken. For discussion the effects of cutting speed, feed rate and depth of cut on tool life of P30 are considered. This paper suggests a novel technique for the tool wear measurement based on machine vision. Tool images are captured with cutting operations using a machine vision system for the analysis. The proposed scheme is shown to be effective for the tool wear prediction. The use of the EN31 give the different and optimum parameters. The wear mechanisms of cutting tools made of EN31 were investigated.

Shelar & Shaikh [26] play important role in manufacturing market. In machining operations, achieving desired surface quality features of the machined product, is really a challenging job on CNC machine. Now a day's due to very stiff and cut throat competitive market condition in manufacturing industries. The main objective of industries reveals with producing better quality product at minimum cost and increase productivity. CNC milling is most vital and common operation use for produce machine part with desire surface quality and higher productivity with less time and cost constrain. To obtain main project an attempt is made to understand the effect of machining parameters such as cutting speed (m/min), feed rate (mm/min), depth of cut (mm) that are influences on responsive output parameters such as Surface Roughness, material removal rate, diamentinal accuracy in this the flatness can be measured by using optimization philosophy. In this work three levels and three parameters are considered; and L27 orthogonal array should be carried out by using two different insert coatings. For the experimentation the wet conditions is taken. In this optimization of milling process parameters using Taguchi method in machining of AISI 316 stainless steel is carried out.

Shokrani et.al [27] presents one of the very first studies on cryogenic CNC end milling of the Inconel 718 nickel based alloy using TiAlN coated solid carbide tools. Cutting parameters selected were tool diameter, cutting speed, fees rate, depth of cut and immersion rate whereas response factors selected were surface roughness, tool wear and power consumption. Singh et al [28] CNC machine tool is widely used by manufacturing engineers and production personnel to quickly and effectively set up manufacturing processes for new products. This study discusses an investigation into the use of Taguchi Parameter Design methodology for Parametric Study of CNC milling operation for Surface Roughness and Material Removal Rate as a response variable. The Taguchi parameter design method is an efficient experimental method in which a response variable can be study, using fewer experimental runs than a factorial design method. A confirmation run was used to verify the results, which indicated that this method was both efficient and effective in determining the best milling parameters for the surface roughness & material removal rate.

Suh et al. [29] have used Alloys for the massive slides for CNC milling machine in machining moulds and dies because presence of these massive slides do not allow rapid acceleration and deceleration during the frequent starts/stops encountered in machining moulds and dies. Sukumar et.al [30] used taguchi method to identify the optimal combination of influential factors in the milling process. Milling experiment has been performed on Al 6061 material, according to Taguchi orthogonal array (L16) for various roughness (Ra) was measured and recorded for each experimental run and analyzed using Taguchi S/N ratios and the optimum controllable parameter combination is identified. Thakre [31] had applied Taguchi methodology for optimize the process parameters for surface roughness in CNC milling machine. 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. Wakasawa et al. [32] have improved the damping capacity of machine tool structure by ball packing. In structures closely packed with balls, various damping characteristics appear in correspondence with the ball size and other conditions. The effect of ball size is the most significant factor in these structures. Wang et al. [33] carried out multi-objective optimization considering energy consumption, cost, and surface roughness for a turning process. Also proposed a multi-objective optimization method called RSM in the milling process, which is to evaluate trade-offs between sustainability, production rate, and cutting quality. Yasiret & Ginta [34] investigates the effect of cutting parameters on the surface topography of stainless steel AISI 316L with tungsten carbide tool by using response surface methodology. The experiment is conducted in dry condition. The cutting speeds ranges from 80 m/min to 120 m/min while feed rates ranges from 0.10 mm/rev to 0.14 mm/rev were used. Scanning electron microscope (SEM) and Mitutoyo surface tester were used to study in detail the surface topography of stainless steel AISI 316L. According to the results of analysis of variance (ANOVA), feed rate (f) is the most significant parameter on the surface roughness while cutting speed (Vc) is less significant parameter. Constant cutting speed has no effect on the surface roughness but when feed rate was varied the roughness get altered.

6. CONCLUSION

From the available literature, it can be seen that though some work has been reported on influence of milling parameters on surface roughness and cutting forces measurement of the machined surface, no attempt has so far been made to Alloy material using for increasing the roughness responses. Milling machines are capable of achieving reasonable accuracy and surface finish. Processing time is also very low as compared to some of the conventional machining process. The analysis of mean and variance technique is required to study the significance of each machining parameter on the surface roughness.

REFERENCES

[1]. Abbas A. T., Pimenov D. Y., Erdakov I. N., Taha M. A., Soliman M. S. and Rayes M. M. E., (2018), ANN Surface Roughness Optimization of AZ61 Magnesium Alloy Finish Turning: Minimum Machining Times at Prime Machining Costs, Materials , 11(5), 808-814.

[2]. Akhyar G., Che-Haron C. H., Ghani J. A., (2008), Application of Taguchi Method in the Optimization of Turning Parameters for Surface Roughness, International Journal of Science Engineering and Technology,1(3), 60-66.

[3]. Chen X., Li C., Tang Y., Li L., Du Y., Li L., (2019) Integrated optimization of cutting tool and cutting parameters in face milling for minimizing energy footprint and production time. Energy, 175, 1021–1037

[4]. Ghani J. A., Choudhury I. A., 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.

[5]. Goel P., Khan Z. A, Siddiquee A. N., Shahrul K., & Gupta R. K., (2012). Influence of slab milling process parameters on surface integrity of HSLA: A multi-performance characteristics optimization. International Journal of Advanced manufacturing Technology, International Journal of Advanced Manufacturing Technology 61(9-12):859-871.

[6]. Hamdan A., Ahmed A. D. S., Hamdi M., (2012), “An optimization method of the machining parameters in high-speed machining of stainless steel using coated carbide tool for best surface finish”, International Journal of Advance Manufacturing Technology, 58:81–91.

[7]. Ishan S. B., Gawande K. R., (2012), "Optimization of Cutting Tool Life on CNC Milling Machine through Design of Experiments-A Suitable Approach An overview", International Journal of Engineering and Advanced Technology (IJEAT), 1(4), 208-216.

[8]. Joshi A., & Kothiyal P., (2012), Investigating Effect of Machining Parameters of CNC Milling on Surface Finish by Taguchi Method”, International Journal on Theoretical and Applied Research in Mechanical Engineering. 1, -2, 47-59.

[9]. Katta S., Chaitanya G., (2018), Optimum Technique for Investigations of Machining Parameters in Titanium (Grade5) Alloy Turning the Use of Carbide Tip Tools, American Journal of Mechanical and Industrial Engineering 3(2): 27-33.

[10]. Kopac J. and Krajnik P., (2007), Robust design of flank milling parameters based on grey-Taguchi method, Journal of Material Processing Technology, 191(1-3), pp. 400-403.

[11]. Krishnaraj V., Samsudeensadham S., Sindhumathi R., Kuppan P., (2014),“A study on high speed end milling of titanium alloy”, 12th Global Congress On Manufacturing And Management, GCMM 2014, Procedia Engineering 97, 251 – 257.

[12]. Kumar R, Pradhan M. K., Kumar R., (2014), Modeling and Optimization of Milling Parameters on Al-6061 Alloy Using Multi-Objective Genetic Algorithm, 5 th

International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014), 891-897.

[13]. Lee Y., Resiga A., Yi S., Wern C., (2020), The Optimization of Machining Parameters for Milling Operations by Using the Nelder–Mead Simplex Method, J. Manuf. Mater. Process, 4(66), 1-22.

[14]. Lu H.S., Chang C.K., Hwang N.C., Chung C.T., (2009), "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, 3808–3817.

[15]. Mahendra G., Rathi N., Jakhade A., (2015)"An Optimization of Forging Process Parameters by using Taguchi Method"International Journal of Scientific and Research Publications Volume No 4, Issue 6.

[16]. Masmiati N., Ahmed A.D. S., (2015), "Optimizing cutting parameters in inclined end milling for minimum surface residual stress – Taguchi approach", Measurement 60 267–275, ISSN 0263-2241.

[17]. Moshat S., Datta S., Patel P. K., (2010), Optimization of CNC end milling process parameters using PCA-based Taguchi method. International Journal of Engineering, Science and Technology, 2(1), 16-29.

[18]. Nguyen T., (2019), Prediction and optimization of machining energy, surface roughness, and production rate in SKD61 milling. Measurement 136, 525–544.

[19]. Pare V., Agnihotri G., Krishna C. M., (2011), "Optimization of Cutting Conditions in End Milling Process with the Approach of Particle Swarm Optimization", International Journal of Mechanical and Industrial Engineering (IJMIE), 1(2), 27-32.

[20]. Patel A. R., Prajapati N. K., (2013), "A Review On Optimization Of Machining Parameters For Surface Roughness And Material Removal Rate For SS 316 In CNC End Milling Process", Int. Journal of Engineering Research and Applications, 3(6), pp.1965-1969, ISSN : 2248- 9622.

[21]. Rajmohan T., Prabhu R., (2012), Optimization of Machining Parameters in Electrical Discharge Machining (EDM) of 304 Stainless Steel", Procedia Engineering 38, 1030-1036.

[22]. Ribeiro J., Lopes H., Queijo L., Figueiredo D., (2016), Optimization of Cutting Parameters to Minimize the Surface Roughness in the End Milling Process Using the Taguchi Method, Periodica Polytechnica Mechanical Engineering, 61(1), 30-35.

[23]. Sadiq S. N., Raguraman T. R., Kumar D. T., Rajasekaran R., Kannan T. T. M., (2014), Optimization Of Milling Parameters Of OHNS Steel Using Ti Coated Cutter By Design Of Experiment Technique, Int. J. Mech. Eng. & Rob., 3(1), 97-105, ISSN 2278 – 0149.

[24]. Selvam M. D., & Karuppusami G., (2012), Optimization of machining parameters for face milling using genetic algorithm" , Engineering Science and Technology: An International Journal (ESTIJ), 2(4), 29-38.

[25]. Selvam M. D., ShaikDawood A. K., Karuppusami G., (2012)"Optimization of machining parameters for end milling operation in a vertical CNC milling machine using genetic algorithm", 2(4), 116-121.

[26]. Shelar A.B, Shaikh A. M., (2017), Optimization of CNC Milling Process by using Different Coatings - A Review, International Advanced Research Journal in Science, Engineering and Technology, 4(1), 36-43.

[27]. Shokrani V., Dhokia S.T., Newman R., Asrai I., (2012), "An Initial Study of the Effect of Using Liquid Nitrogen Coolant on the Surface Roughness of Inconel 718 Nickel-Based Alloy in CNC Milling", 45th CIRP Conference on Manufacturing Systems 2012, Procedia CIRP 3, 121 – 125.

[28]. Singh B., Khanna R., Goyal K., Kumar P., (2014), Optimization of Input Process Parameters in CNC Milling Machine of EN24 Steel, IJRMET, 4(1) ISSN : 2249-5762.

[29]. Suh, J.D., Lee, D.G. and Kegg, R. (2002), "Alloy machine tool structures for high speed milling machines". Annals CIRP, 51(1), 285–288.

[30]. Sukumar M. S., Ramaiah P. V., Nagarjuna A., (2014), "Optimization and Prediction of Parameters in Face Milling of Al-6061 Using Taguchi and ANN Approach", 12th Global Congress On Manufacturing And Management,2014, Procedia Engineering 97, 365 – 371.

[31]. Thakre A. A., (2013), Optimization of Milling Parameters for Minimizing Surface Roughness Using Taguchi's Approach, International Journal of Emerging Technology and Advanced Engineering, 3(6), 34-50.

[32]. Wakasawa Y., Masatoshi H. and Etsuo M., (2004), "The damping capacity improvement of machine tool structures by balls packing". Int J Mach Tools Manuf, 44(14), 1527-1536.

[33]. Wang Q., Liu F., Wang X., (2014), Multi-objective optimization of machining parameters considering energy consumption. Int. J. Adv. Manuf. Technol, 71, 1133–1142

[34]. Yasir M., Ginta t. N., (2016), "Effect Of Cutting Speed And Feed Rate On Surface Roughness Of AISI 316L SS Using End-Milling", ARPN Journal of Engineering and Applied Sciences , 11(4), 98-106.