RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation & Analysis of Machining Parameters of CNC End Milling Operation: An Overview

S.T. Warghat[1], N.S.More[2], Dr.T.R.Deshmukh[3]
[1] Assistant Professor,[2] PG Students,
Department of Mechanical Engineering (CAD/CAM),
Dr. Sau. Kamaltai Gawai Institute of Engineering and Technology, Darapur,
Tq:-Daryapur. Dist – Amravati, M.S. , India.
stwarghat@yahoo.co.in, more22nitesh@gmail.com
[3]Professor, Prof. Ram Meghe Institute of Technology And Research, Badnera-Amravati, M.S., India
trdeshmukh@mitra.ac.in

Abstract:
Milling is the mainly common form of machining. It is a material removal process, which can produce a variety of features on a part by cutting away the unnecessary material. The optimization is performed within the practicable region defined by the important constraints .In order to optimize the cutting conditions, the experimental relationships between input and output variables should be time-honored in order to expectthe output. Optimization of these analytical models helpsus to select suitableinput variables for achieving the best productivity performance. In this review paper the study is enclosedconcerning the optimization of dissimilarinput parameters and results areanalyzed.
Particle swarm optimization (PSO) method is used for resulting the best possible set of values of input variables for most material removal rate.
Keywords: End Milling, Particle swarm optimization, Process parameter optimization

I. INTRODUCTION

Milling is the mainly common sort of machining, a material removing procedure, which can produce a collection of feature on a part by cutting away the unnecessary material. Rising productivity is one of uncertainties in the overall competitions so each group attempt to find new approaches for decreasing expenditure and growing quality of the manufacture. Automated manufacturing systems are broadly engaged in machining along with computer numerical control (CNC).Materials are machined in computerized numerical control to get superior surface finish , dimensional accuracy and geometrical shape. In machining significant quantity of material is removed from raw material in the form of chips to get the preferred profile. End milling process is one of the most fundamental and commonly encountered material removal operations in manufacturing industries counting the automobile and aerospace sector where quality is thekey factor on the production of slots, dies. The quality of the surface plays avery important role in the performance of milling as aexcellent quality milled surface drastically improves fatigue strength, corrosion resistance and creep life. Surface roughness also affects numerous functional attributes of parts such as wearing , heat transmission , ability of holding lubricant ,coating .Thus the desired surface finish is frequently specified and suitable processes are selected to reach the required quality.

New research in the material science has been heading towards the development of new light weight engineering materials processing high specific strength and stiffness at hightemperatures and good creep, fatigue and wear resistance. That is because advanced automotive and aerospace technology requires these materials to get better performance.End milling process is known as material removal process. This process and its machine tools are able of producing complex shapes with the help of multi tooth cutting tools. In the end milling process, a multi tooth cutter rotates along withdifferent axes with reference to the workpiece. Milling is the process of cutting away material by feeding a workpiece past a rotating multiple toothcutter. The cutting stroke of the many teeth in the region of the milling cutter delivers a fast method ofmachining.

There are generally two methods of milling, Climb and Conventional.Climb milling, is sometimes known as down milling, where the direction of the cutter rotation isthe same as the feed direction. This method is possibly the most common option on the shop floor andwill normally produce a good surface finish. Conventional milling is also sometimes referred to as up milling where the direction of the cutteropposes the feed direction.The machined surface may be smooth, angular, or curved. The surface may also be milled to any mixture of shapes. The machine for holding the work piece, rotating the cutter, and feeding it is known as the Milling machine.

In recent times, computer numerically controlled (CNC) machine tools have been adopted to make the milling process fully automated. It provides better improvements in productivity, increases the quality of the machined parts and requires less operator input. The effectiveness of milling machine is advanced than other conventional machining processes such as lathe machine. InWhitney, 1798 first Milling machine was designed for producing muskets and gun parts. Joseph Brown anAmerican Engineer presented universal milling machine at Paris exhibition in 1827. After this innovation theapplications and utilization of milling machine isgrowingconstantly in manufacturing area. In milling machinethree processes such as End milling, Face Milling and Side milling are mainly used throughout machiningof work-piece. End mill is used for finishing the face and side of work-piece. Sharp cuttingedges with large flutes to allow chips discharge from cutter are present in end milling cutter

Quality and productivity are two important but differing criteria in every machining operation. Productivity can be interpreted in terms of material removal rate in the machining operation and quality representreasonable defer in terms of product characteristics as preferred by the customers. Increase in productivity consequencesis to reduction in machining time which may effect in quality loss.

Due to the different types of shapes are possible and production rate is high, milling is one of the most creative and broadly used machining operations. The geometric form produced by milling are divided into three major groups:

1. Plane surfaces: The surface is linear in all three dimensions. The simplest and most suitableform of surface.
2. Two-dimensional surfaces: The contour of the surface changes in the path of two of the axes and is linear along the third axis. Examples include cams.
3. Three-dimensional surfaces: The shape of the surface changes in all three directions Examples includes gas turbine blades, propellers, casting patterns, die cavities etc.

The conventional milling machines supplies a primary rotating motion for the cutter held in the spindle, and a linear feed motion for the workpiece, which is fastened onto the worktable. Milling machines for machining of difficultshapes typicallyoffer both a rotating primary motion and a curvilinear feed motion for the cutter in the spindle with a fixed work-piece. A variety of machine designs are available for different milling operations. In this partwe talk about only the for the most popular ones, which are classified into the following types:

1. Column-and-knee milling machines;
2. Bed type milling machines;
3. Machining centers

Particle swarm optimization is a heuristic global optimization method put forward originally by Doctor Kennedy and Eberhart in 1995. While searching for food, the birds are either scattered or go together before they locate the place where they can find the food. PSO is a robust stochastic optimization technique based on the movement and intelligence of swarms. PSO applies the concept of social interaction to problem solving. It was developed in 1995 by James Kennedy (social-psychologist) and Russell Eberhart (electrical engineer). It uses a number of agents (particles) that constitute a swarm moving around in the search space looking for the best solution. Each particle is treated as a point in a N-dimensional space which adjusts its “flying” according to its own flying experience as well as the flying experience of other particles. Particle Swarm Optimization (PSO) incorporates swarming behaviors observed in flocks of birds, schools of fish, or swarms of bees, and even human social behavior, from which the idea is emerged. PSO is a population-based optimization tool, which could be implemented and applied easily to solve various function optimization problems, or the problems that can be transformed to function optimization. While searching for food, the birds are either scattered or go together before they locate the place where they can find the food. While the birds are searching for food from one place to another, there is always a bird that can smell the food very well, that is, the bird is perceptible of the place where the food can be found, having the better food resource information. Because they are transmitting the information, especially the good information at any time while searching the food from one place to another, conducted by the good information, the birds will eventually flock to the place where food can be found.

II. LITERATURE REVIEW

Computer Numerical Control (CNC) machines are broadly used in manufacturing industry. Conventional machines such as vertical millers, centre lathes, shaping machines, etc. operated by a qualified engineer.In many cases, have been replaced by computer control machines. Since the rise of the CNC (Computer Numerical Control) machines introduction in the machining sector, they have been praised for being precise, fast, reliable and flexible. Although CNC machines are not entirely independent, a lot of major industries depend on thesemarvel machines. Common CNC-dependent industries includethe metal industry and the woodworking industry. Productivity as well as quality both has a similar impact on final product. In this research work, milling experiments are carried out on Mild Steel. Full factorial experimentation is adapted for conducting pilot experiments to study the effects of cutting parameters on machining time and roughness. Empirical relations for surface roughness have been developed for the proposed Mild Steel material based on pilot experiments. Then, Particle Swarm Optimization (PSO) technique was implemented for predicting optimum cutting parameters for any desired roughness in minimum machining time. Most of the research work ends up here without validating the optimal cutting parameters. However, most importantly, in this research work, validation experiments are conducted as per the optimized parameters obtained by PSO. The predicted values of machining time and roughness obtained by PSO are compared with experimental results. It is found that the predicted values are in good agreement with the measured machining time and roughness. The findings of the present work infer that the use of the proposed methodology can greatly replace the laborious process of selection of cutting parameters by trial and error method. This will reduce the wastage of resources used for manufacturing. Due to this, production cost and selling cost of the component can be reduced; hence sales and profit for the industries can be improved to a great extent**[4]**.

This paper discuss of the literature review of optimization of milling machining process parameters for composite materials. Machining process has characteristics that describe their performance relative to efficient use of machine tools by setting optimum cutting parameters. The traditional optimization techniques are not suitable because milling machining operation is highly constrained in nature**[8] .**Due to the urgent need for global reductions of environmental impacts, many studies have been carriedout in differentfields. One of the most important sectors is manufacturing, particularly due to the highpower consumption of the production machines of manufacturing plants. This paper focuses on theefficiency of the machining centers and provides an experimental approach to evaluate and optimize theprocess parameters in order to minimize the power consumption in a milling process performed on amodern CNC machine. The parameters evaluated are the cutting speed, the axial and radial depth of cut,and the feed rate**.**Thefirst important result is thatthe idle or basic state constitutes the larger component for thepower consumption of the machine; this result is also demonstrated by many other papers in the literature. This characteristic ofthe machine could be used by machine tool manufacturers todesign more efficient machining processes;first steps could be thereduction of the time during which the machine stays in the readystate, the reduction of the moving mass of the machine**[10].**Manufacturing technologies are currently defined as on basics of adoptability, autonomous production, and level ofautomatization. As we modernize the manufacturing lines, subsequently we are required to update and integrate most modern technologies in order to keep the business competitive. In such way, we can assure cheaper products, shorter manufacturing times, lowering of the production costs. Due to the dynamic processes and increase of the machining parameters optimizing theinformation which is essential for production got significantly harder. For solving such problems, we have to turn our choice onto the intelligent methods, such as Particle swarm optimization or similar type of intelligent optimization. In this paper we present a proposal, how to successfully gain optimal cutting parameters – cutting speed, feedrate and cutting depth for certain requirements such as cutting force, surface finish – roughness and cutting tool life.The presented paper serves us for initial step into optimizing methods and it shows an elementary approach to solving machining optimization parameters. Despite its purpose for certain material, the code could get adopted for broader spectrum of parameter optimization, which means we could eliminate the factor of material in order to gain an optimization algorithm capable of optimizing parameters for different materials**[15]**.Milling is one of the progressive enhancements of miniaturized technologies which has wide range of application in industries and other related areas. Milling like any metal cutting operation is used with an objective of optimizing surface roughness at micro level and economic performance atmacro level. In addition tosurface finish, modern manufacturers do not want any compromise on the achievement of high quality, dimensional accuracy, high production rate, minimum wear on the cutting tools, cost saving and increase of the performance of the product withminimum environmental hazards. In order to optimize the surfacefinish, the empirical relationships between input and output variables should be established in order to predict the output. Optimization of these predictive models helps us to select appropriate input variables for achieving the best output performance. In this paper, four input variables are selected and surface roughness is taken as output variable. Particle swarm optimization technique is used for finding the optimum set of values of input variables and the results are compared with those obtained by GA optimization in theliterature.There is lot of scope for application of particle swarm optimization (PSO) for these kinds of problems by taking more number of input variables. It will beinteresting to see the results for greater number of variables and trying various combinations of variables.As the recent trends in research is in the area of micro manufacturingprocess like micro grinding, micro milling, micro drilling and laser application, application of PSO will help the industrialists to find the optimum values of input variables and work for longer periods without changing the manufacturing set up. The work can also be extended by taking output variables such as, material removal rate (MRR), production cost etc., in addition to surface roughness **[20]**. Machining of thin-walled parts is a key process in aerospace industry. Many components used in the aerospace industry are usually thin-walled structures. Because of their poor stiffness, thin-walled work pieces are very easy to deform under the action of cutting force in the process of cutting. Even in CNC milling, in which the tools are controlled exactly according to the contour of the thin-walled component, the wall will be thicker at the top and thinner at the root. In general, the surface dimensional error is induced mainly by the deflection of the work piece during milling, which does not remove the material as planned. The part deflection caused by the cutting force is difficult to predict and control. The main objective of this work is to achieve the minimum surface dimensional error which decreases the machining time. Therefore, the cutting parameters are to be optimized which enables the minimum possible surface dimensional error. The conditions required to achieve this in high speed milling process imply optimum cutting forces which in turn induce the part deflection. The present work is aimed at predicting cutting forces during machining and obtaining optimum cutting speed and feed rate. An Artificial Neural Network (ANN) predictive model is used to predict cutting forces during machining and Particle Swarm Optimization (PSO) algorithm is used to obtain optimum cutting speed and feed rate**[22]**.In this paper, Particle Swarm Optimization (PSO), which is a recently developed evolutionary technique, is used to efficiently optimize machining parameters simultaneously in high-speed milling processes where multiple conflicting objectives are present. This study has presented multi-objective optimization of end milling process by using neural network modeling and Particle swarm optimization. A neural network model was used to predict cutting forces during machining and particle swarm optimization was used to obtain optimum cutting speed and feed rate.PSO algorithm is used to optimize both feed and speed for a typical case found in industry. Both feed and speed were considered during optimization. The experimental results show that the MRR is improved by 28%. Machining time reductions of up to 20% are observed [25]

V CONCLUSION

Here we have offered the concept of PSO and work conceded out on PSO by different researchers. A thorough literature review is presented which is used toget out the limitations in different method and which gives opportunity for future scope. Future scope identifies as effort to be carried out towards topology of communication, parameter adjustment, initial distribution of particles and methods to dealing with any inactivity.Optimization of process parameters helps the organization to obtain valuable effect of machining. The number of process parameters chosen for exact study work may entitle many appropriate optimization techniques

REFRENCES

[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**]**N.V.MaheshBabuTalupula, NersuRadhikaExperimental Investigation Of Optimal Machining Parameters Of Mild Steel In CNC Milling Using Particle Swarm Optimization IPASJ International Journal of Computer Science (IIJCS)Volume 3, Issue 1, January 2015

[5] Krishna J. Nagallapati, Reddy S. Bathini, Reddy V.K. Kontakka,"Modeling of Machining Parameters in CNC End Milling Using Principal Component Analysis Based Neural Networks", Vol.2, No. 3.

[6] Afzeri, Sujtipto A.G.E, Muhida R, Konneh M, Darmawan, Remote Operation of CNC Milling Through Virtual Simulation and Remote Desktop Interface", World Academy of Science, Engineering and Technology 29 2009.

[7] Bharats Patel,HirenPal,"Optimization of Machining Parameters for Surface Roughness in Milling Operation", International Journal of Applied Engineering Research, Vol. 7 No. 11, 2011.

[8] Sequeira Antony Anil, PrabhuRavikantha, SriramN.S,"Effect of Cutting Parameters on Cutting Force and Surface Roughness of Aluminium Components using Face Milling Process a Taguchi Approach", Vol. 3, Issue 4 (SepOct. 2012),

[8] Neeraj Kumar, Prof. K.K. ChhabraAn Overview of Optimization Techniques for CNC Milling MachineInternational Journal of Engineering, Management & Sciences (IJEMS)ISSN 2348 –3733, Volume-1, Issue-5, May 2014

[9] Liam Cervante, Bing Xue, Mengjie Zhang," Binary Particle Swarm Optimisation for Feature Selection: A Filter Based Approach ", WCCI 2012 IEEE World Congress on Computational Intelligence June, 10-15,2012 - Brisbane, Australia.

[10] Gianni Campatelli*, Lorenzo Lorenzini, Antonio Scippa Optimization of process parameters using a Response Surface Method for minimizing power consumption in the milling of carbon steel Journal of Cleaner Production 66 (2014) 309e316

[11] Milon D. Selvam, Dr.A.K.ShaikDawood& Dr. G. Karuppusami (2012) , "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, pp 544 –548.

[12] JitendraVerma, PankajAgrawa,&LokeshBajpai (2012),"Tturning parameter optimization for surface roughness of astm a242 type-1 alloys steel by taguchi method" , International Journal of Advances in Engineering & Technology , Vol. 3, Issue 1, pp. 255-261.
[13] N. Baskar , P. Asokan , R. Saravanan& G. Prabhaharan (2005) "Optimization of Machining Parameters for Milling Operations Using Non-conventional Methods" , Int J AdvManufTechnol Springer-Verlag London Limited, 25, pp 1078–1088
[14] M. N. Islam & Dong-Woo Cho , "Technical and Economical Optimization of Peripheral End Milling Process".
[15] Hrelja Marko, Klancnik Simon, IrgolicTomaz, PaulicMatej, BalicJoze, BrezocnikMiran Turning Parameters Optimization using Particle Swarm Optimization
[16] Omar OEEK, El-Wardony T, Ng E, Elbestawi MA. An improved cutting force and surface topography prediction model in end milling. Int J Mach Tools Manuf 2007; 47: 1263-1275.
[17] BikramjitPodder, Paul S. Effect of machining environment on machinabiolity of Nimonic 263 during end milling with uncoated carbide tool. Int J Machin& Machinability Mater 2008; 3: 104-119.
[18] VenkataRao R, Pawar PJ. Parameter optimization of a multi-pass milling process using non-traditional optimization algorithms. Adv Soft Comp 2010; 10; 445-456.
[19] Bharathi Raja S, Baskar N. Computational solution for multi-objective optimization problem in CNC milling operation using Particle Swarm Optimization technique. Applied Soft Computing 2010. ISSN: 1568-4946.
[20] Vikas Pare, GeetaAgnihotri& C.M. Krishna Optimization of Cutting Conditions in End Milling Process with the Approach of Particle Swarm Optimization International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 6477,Volume-1, Issue-2, 2011
[20] A. Unler and A. Murat, "A discrete particle swarmoptimization method for feature selection in binary classification problems," European Journal of OperationalResearch, vol. 206, no. 3, pp. 528–539,2010.
[21] Rabab M. Ramadan And Rehab F. Abdel –Kader,"Face Recognition Using Particle Swarm Optimization-Based SelectedFeatures,"International Journal Of Signal Processing, Image Processing And Pattern Recognition,Vol. 2, No. 2, June 2009
[22] Pal Pandian P., Dr. Prabhu Raja V. Sakthimurugan K.Optimization of Cutting Parameters of Thin Ribs in High Speed Machining International Journal of Engineering Inventions e-ISSN: 2278-7461, p-ISSN: 2319-6491 Volume 2, Issue 4 (February 2013) PP: 62-68
[23] M.Janardhan," Multi-objective optimization of cutting parameters for surface roughness and metal removal rate in surface grinding using Response Surface Methodology", IJAET,March 2012, ISSN
[24] PrajinaN. V. ," Multi response optimization of CNC end milling using Response Surface Methodology and desirability function",ISSN0974-3154 volume 6,Number 6,(2013),PP.739-746.
[25] F. Cus a, U. Zuperl , V. Gecevska High speed end-milling optimisation using Particle Swarm Intelligence Journal of Achievements in Materials and Manufacturing Engineering F. Cus, U. Zuperl, V. Gecevska Volume 22 Issue 2 June 2007
[26] K.SundaraMurthy[15]"Optimization of end milling parameters under minimum quantity lubrication using principal component analysis and grey relational analysis "Eng.2012 vol.no3/253.