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Non Traditional Optimization Techniques For Cutting Force Optimization In Milling Process Based On Machining Parameters

M.S.Aezhisai vallavi[1], N.Dhamodharan[2],C. Manivelprabhu[3]
[1]Assistant professor, [2]P.G Scholer
Department of Mechanical Engineering, Kumaraguru college of Technology, Coimbatore

Abstract-Minimum cutting forces are always gives the better results on response parameters. In this paper describes the nontraditional optimization methods to get the optimum cutting force in milling process. The objective function was consider for minimizing cutting force in milling operations. This paper gives the optimization algorithm based on simulated annealing, pattern search method and genetic algorithm. The results are compared between different optimization techniques .
Key words: cutting force, optimization, simulated annealing, pattern search, genetic algorithm.

I. INTRODUCTION

With considering the manufacturing industries the machining process are subjected into major operation to bring the required shape from the raw materials. Milling process are mostly used machining operation in manufacturing sector. End milling process are commonly used operation in automobile, aerospace and other material processing industries. Cutting forces generated during the machining process in milling is one of the most influence parameters, undesirable cutting forces affects the output responses such as surface finish, wear on the tool dimensional accuracy of the workpiece and power fluctuation. To avoid such hysteresis the selection of optimum cutting forces are important. Subramaniam et al [1], the author concluded in his paper by controlling the machining parameters the required cutting force can be obtain and to select the suitable machining parameters the previous knowledge on cutting forces were used. P.S.Sivasakthivel et al [2] discussed about the cutting force, the tool deflection and the vibration of the tool is reduced when the minimum cutting forces are maintained. Ghani.J.A et al [3] this paper discussed about the optimization methodology based on the taguchy method. To analyse the milling parameters an orthogonal array, signal to noise ratio and pareto analysis are used. The low cutting force and good surface finish were obtained at high cutting speed, low feed rate and low depth of cut. Analysing the mean and S/N ratio using the conceptual approach that involves graphing the effects and visualy identifying the factors that appear significant. F. Cus et al [4] Particle swarm optimization is a relatively new technique for continuous non-linear functions. To search the optimal process parameters, neural network model of cutting force was investigated with particle swarm optimizer. this process executes two phases. Kareem Idan fadheel et al [5] One of the methods to analyze data for process optimization is the use of Pareto ANOVA. Pareto ANOVA is a simplified ANOVA method which uses Pareto principles. It is a quick and easy method to analyze results of parameter design. It does not require an ANOVA table and therefo redoes not use F-tests. Vikas Pare et al [6] objective of optimizing surface roughness at micro level and economic performance at macro level. In addition to surface 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 with minimum environmental hazards. In order to optimize the surface finish, 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 the literature. H.S. Lu et al [7] This paper investigates optimization design of the cutting parameters for rough cutting processes in high-speed end milling on SKD61 tool steel. Ramezan Ali Mahdavinejad et al [8] Gives that the Artificial neural network is a powerful tool to model the problems especially those with no authentic governing equation for their behaviors. The model obtained using artificial neural network can learn and mimic the human thinking process. many researchers worked on presenting some rules to make a perfect structure, until now, there is not any definite rule to specify a perfect structure. Sudhakaran R et al [9] GA simulates the survival of the fittest among individuals over consecutive generation for solving a problem. Each generation consists of a population of character. The GA operates on three main operators namely 1) Reproduction 2) Cross over and 3) Mutation. Basker.N et al [10] presents the non-conventional methods such as Genetic Algorithm, Ant Colony Algorithm, Tabu search method and Particle swarm optimization for optimizing machining parameters to maximizing the profit in milling operations. Tandon et al [11] this paper presents about the optimization on feed and speed parameters in CNC end milling process.

II. MATHEMATICAL MODEL

Machining parameters are the most influenced parameter to meet the required output responses in all kinds of machining process. The process parameters such as cutting speed, Feed rate, Depth of cut and Nose radius are considered the most influenced parameters in this optimization process. In this paper the mathematical model obtained by S.Jeyakumar et al [12] is taken for the optimization process.

A. Objective Function

The main aim of this optimization is to minimize the cutting forces in end milling operation. The objective function was formulated from the developed mathematical model with considering the four parameters and three levels. Parameters such as cutting speed(s) in m/min, feed rate(f) in mm/min, depth of cut(d) in mm and nose radius(r) in mm with the levels -1 to +1. Cutting forces in x direction and cutting forces in z direction are considered as the objective function to minimize the cutting forces.

B. Optimization

Optimization is the process of maximizing the required things and minimizing the un wanted things. In this study the minimization of cutting forces is the main aim of optimization. The optimum values of cutting forces are obtained based on the three different optimization techniques such as Genetic algorithm, Simulated annealing and pattern search method. The optimization processes are executed in MATLAB software.

C. Genetic Algorithm(GA)

Genetic algorithm is one of the frequently used optimization methods. GA optimization was done with the constrains of sample size, crossover function, mutation function crossover fraction and so on. The search algorithm based in the mechanics of natural selection and natural genetics is known as Genetic Algorithm(GA). They combined survival of the fittest among the string structures with some of the innovative flair of human search. The Genetic algorithm works with the major three process they are as Reproduction, Crossover, Mutation in addition to this major process the sub process like population chromosomes are helps the fitness test.

The following Constrains are considered for the GA

Population size : 50

Elit count : 2.5

Cross over fraction : 0.9

Mutation function : Adaptive feasible

Cross over function : single point

From the results of GA the optimum values of cutting parameters are obtained and mentioned in the table 1 as coded form. For this objective function optimum cutting forces in x direction was obtained for low cutting speed, depth of cut and high feed rate, nose radius. For y direction cutting force optimum values are obtained for cutting speed, depth of cut and low feed rate, nose radius. Fig. 1, fig. 2 shows the best and mean fitness values.

TABLE 1 OPTIMUM VALUES OF GA.

S.No	Process parameter	Optimum values (x direction)	Optimum values (z direction)

1	Cutting speed	-1	1
2	Feed rate	1	-0.999
3	Depth of cut	-1	0.707
4	Nose radius	1	-1

D. Simulated Annealing

Solving unconstraint and boundary constrain problems for optimization the simulated annealing methods is one of the most suitable optimization methods among the other optimization methods. The new point is randomly generated in simulated annealing algorithm for each iteration. The probability distribution along with the scale proportional on temperature used to find the distance of the new point generated from the current point, the simulated annealing algorithm always lower the objective for all new points but some time they may raise the objective with a certain probability points. The simulated annealing optimization procedure is given in the fig. 3. The constrain for this process are given as follows. Annealing function is fast annealing and reannealing interval is 100.

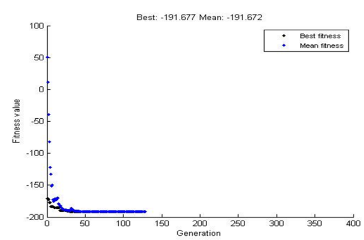

Fig. 1 GA graph for x axis cutting force

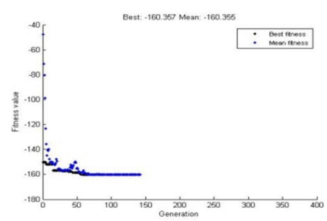

Fig. 2 GA graph for z direction cutting force

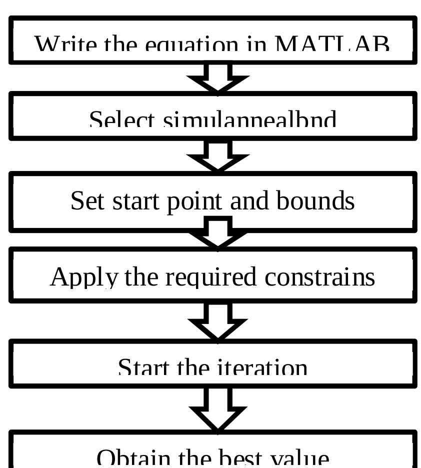

Fig.3 Flow diagram of Simulated annealing

TABLE 2 OPTIMUM VALUES OF SIMULATED ANNEALING.

S.No	Process parameter	Optimum values (x direction)	Optimum values (z direction)
1	Cutting speed	-0.979	0.996
2	Feed rate	0.995	-0.999
3	Depth of cut	-1	0.728
4	Nose radius	1	-1

The results obtained based on the simulated annealing process are given in table. 2. very minute deviations are observed between the GA results and simulated annealing results. Low cutting speed, depth of cut gives the optimal x direction cutting force and high feed rate , nose radius gives optimum z direction cutting force. Fig. 4 and fig. 5 shows the best and mean fitness function of simulated annealing .

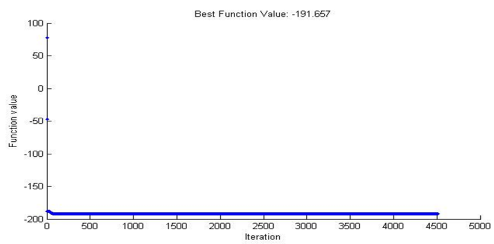

Fig. 4 Results of x direction cutting force

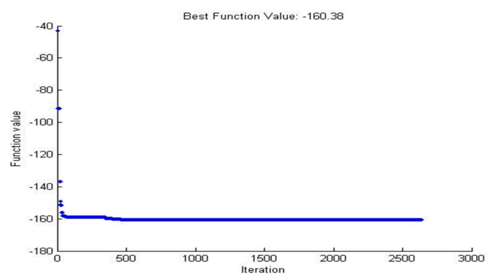

Fig. 5 Results of z direction cutting force

E. Pattern Search Method

Pattern search methods results are given in the table . 3. these results are also similar to that of GA and simulated annealing. Fig. 6 and fig. 7 gives the mean and best value of fitness function. The pattern search procedure are given in the following steps.

TABLE 3 OPTIMUM VALUES OF PATTERN SEARCH METHOD.

S.No	Process parameter	Optimum values (x direction)	Optimum values (z direction)
1	Cutting speed	-1	1
2	Feed rate	1	-1
3	Depth of cut	-1	0.707
4	Nose radius	1	-1

Step 1: write the objective function equation.

Step 2: select the patternsearch silver from the optimization tool.

Step 3: enter the start points and bounds.

Step 4: give the necessary constrains.

Step 5: obtain the results after completion of iteration process.

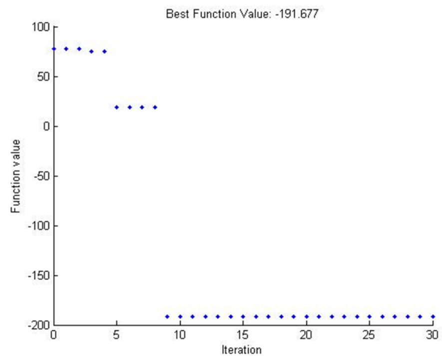

Fig. 6 Results of pattern search for F_x

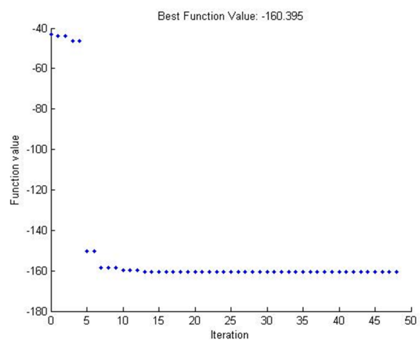

Fig. 7 Results of pattern search for F_z

III. CONCLUSION

Optimization techniques based on non-traditional methods are obtained for the process of optimizing the cutting forces. While comparing genetic algorithm, simulated annealing and pattern search methods, simulated annealing is most time consuming process and number of iteration also high where as other two methods number of iteration are low as compare with simulated annealing. All these three methods results are obtained most similarly. The optimum values of x direction cutting force are obtained for low cutting speed, depth of cut and high feed rate, nose radius. For z direction cutting force optimum values are obtained for high cutting speed, depth of cut and low feed rate , nose radius.

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