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Optimization of End Milling Process Parameters on Mild Steel Grade EN3B using Genetic Algorithm

S.Premkumar[1] ,K.Saravanakumar[2]

[1, 2] *Assistant Professor*
[1]*Department of Mechanical Engineering & KGiSL Institute of Technology, premkumar.s@kgkite.ac.in*
[2]*Department of Production Engineering & PSG College of Technology, ksk.prod@psgtech.ac.in*

***Abstract*— This project aims to reduce the surface roughness and improve the MRR rate of taken mild steel material. Now a day's quality and productivity plays main roles in the market. Optimization should be required for all types of machining process to improve the desired quality of the product. The Main aim of this project is to reduce tool wear, increase tool life, MRR rate and improve surface finish of the product. In the end milling process, it is considered to be three main cutting parameters cutting speed, feed and depth of cut. The optimization of cutting parameters according to the raw material and cutting tool to get higher surface finish. There are various optimization techniques are available in this project Genetic Algorithm is used. Minitab is used for forming regression equations for L27 arrays table values and optimizing the input parameters values by using GA. Mild Steel BS 970 Grade EN3B is the raw material used and the appropriate cutting tool is TIN coated tungsten carbide. The MCV 650 Vertical Machining Centre is used to making end milling process on the work piece and the obtained results shows that the optimized parameters are efficient to machining and give better surface finish.**

Keywords— MRR Rate, End Milling Operation.Genetic Algorithm

I. INTRODUCTION

The selection of optimum cutting parameters like cutting speed, depth of cut, feed rate, plays main role in the every machining process. Main aim of the project is to reduce tool wear, increase tool life and improve surface finish of the product. In this optimisation technique, considering of three input machining parameters cutting speed(X1), feed rate(X2), depth of cut(X3).According to these input parameters the corresponding output parameters surface roughness (Y1) and metal removal rate (Y2) can also be optimized for an economical production. For predicting the optimal setting by using Genetic Algorithm.

II. LITERATURE REVIEW

P.Palani Samy, I.Rajendren et al. [1] Optimization of cutting parameters is valuable in terms of providing high precision and efficient machining. In this work a mathematical model has been developed based on both the material behaviour and the machine dynamics to determine cutting force for milling operations. The technique used for optimization is based on powerful artificial intelligence called genetic algorithms (GA).T srikanth, Dr V.Vimala et al. [2] Surface roughness, an indicator of surface quality is one of the most specified customer requirements in a machining process. So it is necessary to find a suitable optimization method which can find optimum values of cutting parameters for minimizing surface roughness. The process parameter for turning operation to be optimized is highly constrained and nonlinear, so this paper proposes a real coded genetic algorithm (RCGA) to find optimum cutting parameters. Ramon Quizasardinas, marcelino [3] Determination of optimal cutting parameters is one of the most important elements in any process planning of metal parts. This paper describes a multi-objective optimization technique using of genetic algorithm, to optimize the cutting parameters in turning processes: depth of cut, feed rate and speed. Two conflicting objectives, tool life and operation time, are simultaneously optimized. The proposed model uses a micro genetic algorithm in order to obtain the non-dominated points and build the Pareto front graph. Franci cus and joze balic [4] in metal cutting processes, cutting conditions have an influence on reducing the production cost and time and deciding the quality of a final product. This paper presents a new methodology for continual improvement of cutting conditions with GA. It predict the following modification of recommended cutting conditions obtained from a machining data, learning of obtained cutting conditions using neural networks and the substitution of better cutting conditions for those learned previously by a proposed GA. Suresh, Rao et al. [5] The prediction of optimal machining conditions for good surface finish and dimensional accuracy plays a very important role in process planning. It deals with the study and development of a surface roughness prediction model for machining mild steel, using Response Surface Methodology (RSM). A second order mathematical model was derived for the machining parameter surface roughness predicted using RSM. This model gives the factor effects of the individual process parameters. An attempt has also been made to optimize the surface roughness prediction model using Genetic Algorithms (GA) to optimize the objective function.Saravanan, Asokan et al. [6] A genetic algorithm (GA) based optimization procedure has been developed to optimize grinding conditions. The procedure evaluates the production cost and production rate for the optimum grinding condition, for the constraints such as thermal damage, wheel wear parameters, machine tool stiffness and surface finish. New GA procedure is illustrated with an example and optimum results such as production cost, surface finish and metal removal rate are compared with quadratic programming techniques.S.V Bhaskara reddy, M.S shunmugam et al. [7] A new approach for the optimal sub-division of the depth of cut is presented using a genetic algorithm. Minimization of total production-cost is achieved by adding the minimum costs of the individual rough passes and the finish pass. The resulting sub-division of the depth of cut using the proposed methodology gives a cost that is lower than, or equal to, the minimum cost obtained by the commonly-practiced method of using the minimum depth of cut in the finish pass and a number of rough passes of equal size, or using enumerative search techniques based on integer programming and dynamic programming.H.ganesan and G.MohanKumar [8] This paper presents a multi-objective optimization technique, based on genetic algorithms, to optimize the cutting parameters in turning processes: cutting depth, feed and speed. In this paper the three objective functions, minimum operating time and minimum production cost and minimum tool wear are simultaneously optimized. The proposed model uses a genetic algorithm in order to obtain the non dominated sorting genetic algorithm (NSGA-II) and build the Pareto front graph..V.Shai Shanmuga raja and S.P raja gopalan [9] Optimization of Neural Networks improves speed of recall and may also improve the efficiency of training. Here we have used the Ant colony optimization, Particle Swarm Optimization and Genetic Algorithm to optimize the artificial neural networks for applications in medical image processing (extraction and compression). The aim of developing such algorithms is to arrive at near optimum solutions to large-scale optimization problems, for which traditional mathematical techniques may fail. We have compared these algorithms based on processing time, accuracy and time taken to train Neural Networks. The results show that the Genetic Algorithm outperformed the other two algorithms. N.Muthu Krishnan and J.Paulo Davim [10] In the present work, the surface roughness of Al–Sic (20 p) has been studied in this paper by turning the composite bars using coarse grade polycrystalline diamond (PCD) insert under different cutting conditions. Experimental data collected are tested with analysis of variance (ANOVA) and artificial neural network (ANN) techniques. Multilayer perception model has been constructed with back-propagation algorithm using the input parameters of depth of cut, cutting speed and feed.

III. **METHODOLOGY**

Mild steel EN3B material is widely used in pipes, amours, knives, bullets, nuts, bolts, chains and hinges etc. Cost effective machining with generation of good surface finish on the Mild Steel EN3B components by end milling operation is a challenge to the manufacturing industry. Major advantages of high speed machining are high material removal rates, more dissipation of heat, high chip removal rate and better surface finish.

Therefore, by identifying the suitable combinations of input parameters such as cutting speed (X1, m/min), feed rate (X2, mm/rev), and depth of cut (X3, mm), etc., the output parameters like Surface Roughness (Ra)and Material Removal Rate (MRR) can be optimized which would lead to economical production. In order to achieve this several experiments had been conducted on Mild Steel EN3B with different combinations of input parameters and the influence of these input parameters on the output parameters as well as best combinations of input parameters to achieve optimized output parameters have been identified.

Machining process was done in high speed vertical machining Centre (VMC).Several optimization techniques are available for obtaining the best combination of input parameters to get optimized output parameters genetic algorithm has been used in this project.

The chemical composition analysis, hardness test were carried out for mild steel EN3B material. Number of experiments had been conducted with suitable combinations of input parameters. Relationship between material removal rate and input parameters and between surface roughness and input parameters were arrived through Minitab software. These regression equations are solved using genetic algorithm tool called user interface method and the optimum combinations of input parameters for maximization of material removal rate (MRR) and minimization of surface roughness (Ra) had been arrived using genetic algorithm.

From literature survey on more number of journals to study about the project and finally selected mild steel as work piece and TIN coated tungsten carbide as a tool insert. The selected raw material and tool insert using for the end milling process conducted in VMC machine. In this optimization process considering three input parameters Cutting speed (X1), Feed rate(X2) and Depth of cut(X3).The measure of output parameters MRR rate (Y1) using formula and surface roughness (Y2) using surface roughness tester.

The DOE table is formed according to the L27 orthogonal array table and the readings are tabulated for the calculations. GA analysis is carried out to identify the significant characters affecting material removal rate. The predicted optimal setting ensured maximization of MRR. Optimal result was verified through confirmatory test. The final result MRR rate is get increased and surface roughness get reduced it will plotted in the graphical representation using GA. The Flowchart methodology adopted in this project work is shown in the figure.1.

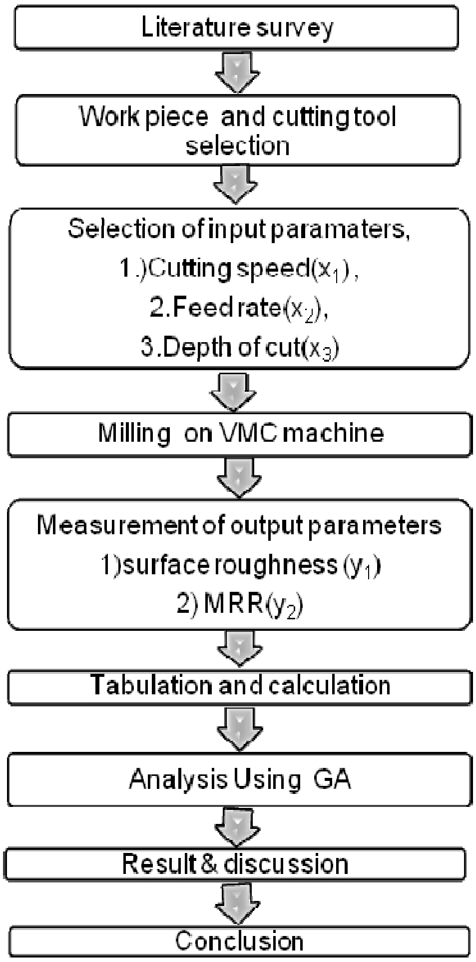

Figure1: Flowchart Methodology

IV. EXPERIMENTAL DETAILS

A. MATERIAL REMOVAL RATE (MRR)

Material removal rate (MRR) has been calculated from the difference of weight of work piece before and after experiment to the density value of the material.

MRR=W1-W2/ Density *Time mm^3/minute

Where,

W1- Initial weight of the specimen in grams.

W2- Final weight of the specimen in grams.

ρ -Density in grams per cubic volume.

(Density of mild steel is 7.8×10-3 g/ mm^3)

t- Time taken for machining the component in seconds.

The weight of the work piece has been measured in a high precision digital balance meter which can measure up to the accuracy of 10-4 g and thus eliminates the possibility of large error while calculating material removal.

B. SURFACE ROUGHNESS(Ra)

For measuring Surface Roughness (Ra) MITUTOYO Surface roughness tester is used

C. CHEMICAL COMPOSITION ANALYSIS

Chemical composition analysis was done in order to check the originality of material at MICRO LAB, Coimbatore. Chemical composition of Mild Steel Grade EN3B shown in table 1.

TABLE.1: CHEMICAL COMPOSITION ANALYSIS

Elements	Symbol	Unit	Specified values	Observed values
Carbon	C	%	0.25 max	0.239
Silicon	Si	%	0.35 max	0.270
Manganese	Mn	%	1.00 max	0.826
Phosphorus	P	%	0.060 max	0.044
Sulphur	S	%	0.060 max	0.042

D. MACHINING PARAMETERS AND THEIR LEVELS

The Machining parameters and their levels values are given in table selected for milling process.

TABLE.2: MACHINING PARAMETERS AND THEIR LEVELS

Factors /level	Level 1	Level 2	Level 3
Cutting speed(m/min) X_1	80	90	100
Feed rate(mm/rev) X_2	0.4	0.3	0.2
Depth of cut(mm) X_3	0.5	0.3	0.2

E. EXPERIMENTAL VALUES

Experiments were conducted under different combinations of input parameters and the details are given below in table 3.The Input parameters are Cutting speed (m/minute) (X_1), Feed rate (mm/revolution) (X_2), and Depth of cut (mm) (X_3).According to these input parameters the corresponding output parameters are Surface Roughness Ra(µm) (Y_2) and Metal Removal Rate (Y_1). t- Time taken for machining the component in seconds.

TABLE 3: EXPERIMENTAL VALUES

Experiment no	X_1	X_2	X_3	t	Y_1	Y_2
1	80	0.4	0.5	55	1.668	1.052
2	80	0.3	0.3	44	1.390	1.599
3	80	0.2	0.2	90	0.510	1.444
4	80	0.4	0.3	35	0.437	1.680
5	80	0.3	0.2	44	0.347	1.548
6	80	0.2	0.5	90	1.019	1.252
7	80	0.4	0.2	35	0.437	1.211
8	80	0.3	0.5	44	2.085	1.265
9	80	0.2	0.3	90	1.188	1.265
10	90	0.4	0.5	27	3.397	1.795
11	90	0.3	0.3	40	1.530	1.737
12	90	0.2	0.2	57	0.804	1.446
13	90	0.4	0.3	32	1.912	1.357
14	90	0.3	0.2	40	0.765	1.276
15	90	0.2	0.5	57	1.609	1.720
16	90	0.4	0.2	32	1.434	1.326
17	90	0.3	0.5	40	2.295	1.063
18	90	0.2	0.3	57	1.072	1.734
19	100	0.4	0.5	29	3.692	0.766
20	100	0.3	0.3	37	2.067	0.845
21	100	0.2	0.2	52	1.176	1.209
22	100	0.4	0.3	29	2.637	1.785
23	100	0.3	0.2	37	0.827	2.598
24	100	0.2	0.5	52	2.059	0.984
25	100	0.4	0.2	29	2.109	1.934
26	100	0.3	0.5	37	2.895	1.067
27	100	0.2	0.3	52	1.176	1.551

V. REGRESSION EQUATIONS

Regression equations were obtained by using Minitab software for Material Removal Rate (Y_1) and Surface Roughness (Y_2) are given in equation (1) and (2).

Material Removal Rate (Y_1) $=-5.8841+0.053094*X_1 +3.9500*X_2 +4.4881*X_3$ ………………………Equation (1)

Surface Roughness (Y_2.) $=1.5535+0.00235* X_1+0.16722* X_2\ 1.16675* X_3$ ………..…………………Equation (2)

VI. RESULTS AND DISCUSSIONS

A. MAXIMIZATION MATERIAL REMOVAL RATE (MRR)

Window given below shows the M-file window entering fitness function equation by adding command as function y=max(x) for maximization of Material Removal Rate. The best fitness for maximization of material removal rate is shown in figure 3 using genetic algorithm tool.

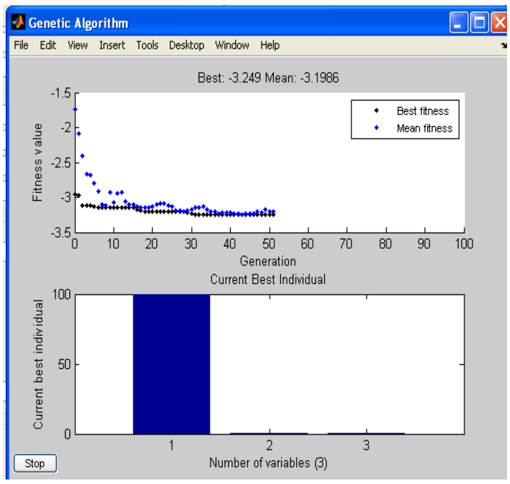

Figure. 3: Optimum MRR rate value using GA Tool Best Fitness Graph
Generation vs. Fitness value and Number of Variables vs. Current Best Individual

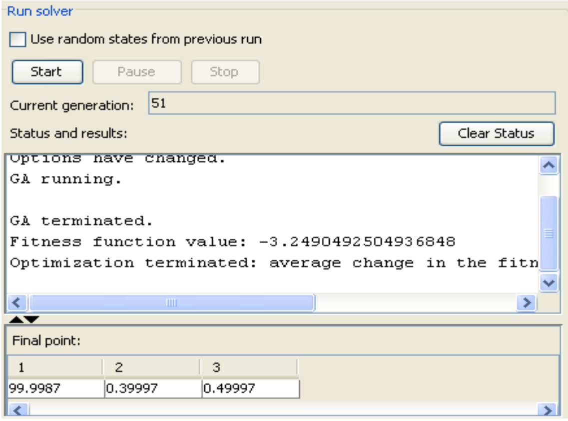

Figure. 4: Optimum Values for input parameters and fitness function value terminated for MRR value using GA Tool

The best combination of input parameters for optimum material removal rate(-3.249 mm3/min) is obtained as cutting speed 99.99m/min, feed rate 0.399mm/rev and a depth of cut of 0.499mm through 52 generations as shown in figure 4.

B. MINIMIZATION OF SURFACE ROUGHNESS (Ra)

Window given below shows the M-file window entering fitness function equation by adding command as function y=mini(x) for minimum surface roughness. The best fitness for minimization of surface roughness Ra is shown in fig 5 using genetic algorithm tool.

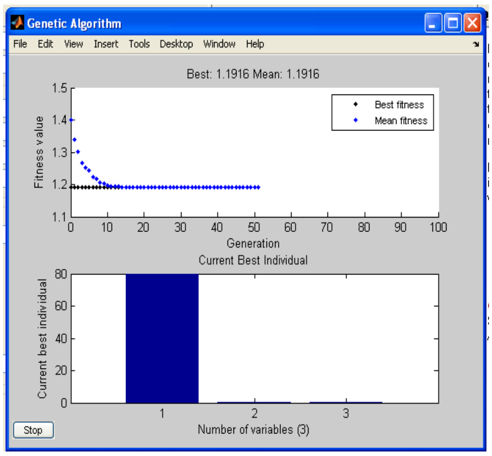

Figure.5: Optimum Surface Roughness Ra Value using GA Tool Best Fitness Graph

Generation vs. Fitness value and Number of Variables vs. Current Best Individual

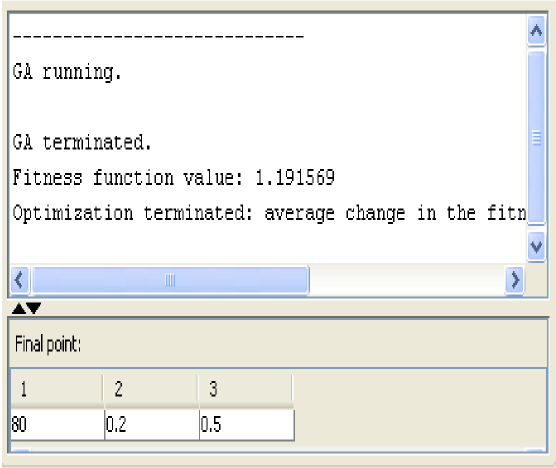

Figure 6: Optimum Values for input parameters and fitness function value terminated for Surface Roughness Ra using GA Tool

The best combination of input parameters for optimum Ra (1.19 µm) is obtained as cutting speed 80 m/min, feed rate 0.2 mm/rev and a depth of cut of 0.5mm through 52 generations as shown in figure 6.

VII. CONCLUSION

The optimum combination of input parameters for maximum material removal rate is found to be cutting speed 99.9987 m/min, feed rate 0.3999 mm/rev, depth of cut 0.4999mm and the best fit value for material removal rate is 3.2490 mm3/min. The optimum combination of input parameters for minimum of surface roughness Ra is found to be cutting speed 80m/min, feed rate 0.2 mm/rev, depth of cut 0.5 mm and the best fit value for surface roughness Ra is 1.1915 µm. Percentage error between experimental value of material removal rate and the optimized material removal rate value given genetic algorithm is 14.8%. Similarly percentage error between experimental value of Ra and the optimized Ra value given genetic algorithm is 18.79%.The analysis predicts that, for maximum material removal rate high cutting speed, high feed rate and low depth of cut are required and for minimum surface roughness Ra high cutting speed, low feed rate and low depth of cut are required during end milling process for mild steel EN3B grade material using Tin coated tungsten carbide as tool insert.

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