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OPTIMIZATION OF MILLING MACHINING PROCESS PARAMETERS: A REVIEW

Dheerendra Sengar*, Dr. A.K Sarathe

*M.E. Student, Mechanical Engineering Department, NITTTR Bhopal-462002, INDIA
Associate Professor, Mechanical Engineering Department, NITTTR Bhopal-462002, INDIA

ABSTRACT

In this competition era, manufacturing and industrial industries are switching to the non conventional machining processes instead to the conventional machining process. Many of the new machining tools available in market like CNC milling, turning etc. each process is affected by some parameter like feed, speed, and depth of cut. Other parameters that is responsible for the affecting the process i.e. MRR, cutting coolant. Possibility of optimize these parameter leads to the great reduction in machining cost. This paper gives the information about the optimization technique used along with different parameter. Some non conventional machining optimization techniques are consist in this paper like fuzzy logic, particle swarm optimization, genetic algorithm, artificial neural network, taguchi, ANOVA, Ant colony optimization, Simulated Annealing (SA) and Scatter search technique (SS)etc. Non conventional machining processes along with respected parameter are being reviewed in this paper. It also include literature of the performance parameter like surface roughness, tool wear rate etc

KEYWORDS: Milling machin

INTRODUCTION

The automation of machine tool industry was come with the development of CNC concept with a revolution in 1949. At present many of conventional machining tool has been replaced by CNC machine tools. Among the metal cutting methods, milling is one of the most widely used manufacturing processes in manufacturing industry in which a multi point cutting tool with multiple cutting edges removes desired material from the surface of a work piece. The workpiece is fed under a rotating cylindrical type multi point cutting tool. In addition to work piece and tool material, cutting speed, feed, and depth of cut are most essential cutting parameters which highly affect the performance parameters. It is compulsory to select the most appropriate cutting parameters and cutting tools to achieve higher cutting efficiency, maximum material removal rate (MRR), minimum surface roughness, and high quality products at low-cost of process and manufacturing. To get optimum milling process parameter, non conventional techniques are required. In present many non conventional optimization techniques are available in which some techniques have been used to perform various operations of CNC milling. This paper brings to the forefront the work done in this area, the techniques used along with the results established.

OPTIMIZATION ISSUES DURING MILLING OPERATION

1.Work Piece Materials- The materials used for the optimization of CNC milling process parameters are Aluminum alloy 6061, AISI 1018 Steel, AISI H13, SKD 61 Tool steel, 6061-T4 aluminum, AISI 1040 Steel, medium leaded brass UNS C34000, Aluminum alloy 5083, Annealed alpha beta titanium alloy, Mould aluminum alloy AA6061-T6 , Soda lime glass, Mild Steel (AISI-1045), Mold Steel AISI P20 and 10150 Leaded Steel etc.

2.Tool Materials- The tool materials that have been used for the optimization of CNC milling machining parameters are Tungsten carbide coated with AlTin, CVD coated carbide tool, HSS end mill tool, CVD coated carbide tool inserts (TN450), an internal CBN grinding tool of 4.5 diameter, versa tool 900 cutting edge and XPNT 160412TN5515 etc.

3.Input Parameters- The input process parameters that have been used for optimization to get response or performance parameters in machining operation are shown in Table no. 1:

Table No. 1 Influence Parameters

Cutting tool	Tool material
	Tool shape
Machining parameters	Feed Rate
	Cutting Speed
	Depth of Cut
	Cutting Fluid
Work-piece properties	Work-piece Material
	Work-piece Dimension
	Work-piece Hardness
	Mechanical Properties
Cutting condition	Cutting Force
	Friction
	Cutting Velocity
	Vibration
	Types of chip formation

4. Performance Parameters - The following performance parameter (surface roughness, Material removal rate, Tool wear rate, cutting time, Tool life, total cost, vibration, and, power consumption) those are depend on independent machining parameter.

DIFFERENT ADVANCED OPTIMIZATION TECHNIQUES

Following are the different advanced optimization techniques which was applied by various researchers are written below:

- Taguchi Method
- Artificial Neural Network (ANN)
- Genetic Algorithm (GA)
- Fuzzy Logic
- Scatter search technique (SS)
- Simulated Annealing
- Particle swarm optimization
- Ant colony optimization
- ANOVA etc.

LITERATURE SURVEY

Aguero E. et. al. [1] has studied on fuzzy model of cutting process on a milling machine. They were performed experiment on a vertical milling machine to optimize cutting processes such as cutting speed, feed rate depth of cut, and tool diameter and workpiece hardness with the help of fuzzy model. The fuzzy model was consisting of a number of IF...THEN rules with fuzzy previous circumstances (antecedents) and consequents. The inputs like cutting speed, feed rate, depth of cut, tool diameter, and workpiece hardness and output from the three-axis force sensing signal, working directly on the machine tool were used to perform fuzzy model. Five fuzzy models as dural or aluminum alloy, steel F110, steel F114, combination of both steels as F110 and F114, and combination of three different materials as Aluminum alloy, Steel F110 and Steel F114, had been generated according to the material type used while output error and the relative output error had been used as performance indices of the fuzzy models.

Joseph C. Chen et. al. [2] Worked on an effective fuzzy-nets training scheme for monitoring tool breakage. They were used fuzzy logic and the neural networks systems to detect the breakage of cutting tools at the time of machining of 6061 aluminum, on the Fadal VMC-40 machining center with four flute (3/400 diameter) high speed steel (HSS) end mill cutter. They were developed a fuzzy-nets training procedure to build the rule banks to meet the dynamic requirements of machining processes like cutting speed, feed and depth of cut. Furthermore, the combination of two fuzzy-nets systems were used as a tool breakage detection system of tool breakage detection for an end milling operation. This system had capability of responding and adapting in "real-time" to either shut down the machine tool when a tool fracture occurs or tune the process parameters "on-line". The major goal of this research was to propose a fuzzy-nets training scheme that provided adaptive control capabilities in machining process control, particularly for a detection system
In the tool breakage.

J.C. Chen et. al. [3] investigated a fuzzy net based multilevel in-process surface recognition system in milling operation. They were performed an experiment on a Fadal VMC-40 vertical machining center with capability of multiple tool change in which machining parameters like spindle speed, depth of cut, feed rate and vibration variables were optimized to predict surface roughness. All machining operations were performed on a workpiece of 6061 aluminium and AISI 1018 steel with HSS tool of 0.5 and 0.75 mm diameter. They were developed a fuzzy-nets training procedure to build the rule banks to meet the dynamic requirements of machining processes. Furthermore, the combination of two fuzzy-nets systems were used as a tool breakage detection system of tool breakage detection for an end milling operation. This system had capability of responding and adapting in "real-time" to either shut down the machine when a tool fracture occurs or tune the process parameters "on-line". The major goal of this research was to propose a fuzzy-nets training scheme that provided adaptive control capabilities in machining process control, particularly for a tool breakage detection system.The neural fuzzy system was used to predict surface roughness with 90% prediction accuracy during a milling operation. Finally, a federal pocket surf stylus profilometer was used offline to measure the surface roughness value of machined samples.

PG Benardos et. al. [4] were carried out prediction of surface roughness in CNC face milling using neural networks and taguchi's design of experiments. They were used a neural network modeling approach to prediction of surface roughness (R_a) in CNC face milling. The data for the training and checking of the networks performance which derived from experiments conducted on a CNC milling machine, were used according to the principles of Taguchi design of experiments. The experimental work were conducted in a Deckel Maho DMU 70V vertical axis CNC milling machine using a 40 mm diameter cutter head with 4 cutter inserts on the workpiece of series 2 Aluminium. The cutter inserts were from WIDIA designated as type XPNT 160412 TN 5515. Cutting speed, feed rate per tooth, depth of cut, are used as input variables for experiment and the engagement and wear of the cutting tool, the use of cutting fluid and the three components of the cutting force are also used as important factors in the experiment. Using feed forward ANN trained with the Levenberg – Marquardt algorithm was able to predict the surface roughness with a mean squared error equal to 1.86% and to be consistent throughout the whole range of values.

V. Susanto et. al. [5] Worked on a fuzzy logic based in-process tool-wear monitoring System in face milling operations. They were performed a face milling operation of in-process tool-wear monitoring on a Fadal VMC-40 vertical milling machine. In this operation, there were used the workpiece of AISI 1018 steel and Versa tool with 90^0 cutting edge. The fuzzy membership function and rule bank were used in face milling operation, based on observations during cutting experiments using artificial tool-wear inserts. Maximum resultant force and cutting parameters such as feed rate and depth of cut, were used as independent variables and the system was verified by using 25 test experimental runs. For monitoring of tool-wear during machining processes, a decision-making method like fuzzy logic (FL) model along with Acoustic emission (AE) sensors was used while a dynamometer was employed to collect cutting force data and a fuzzy logic model was used to make decisions on the basis of signals receiving from the dynamometer and the machine controller. Finally there were concluded that the FL-ITWM system (Fuzzy logic in process tool wear monitoring system) was capable of monitoring tool wear with approximately 91.3% accuracy.

Iqbal A et. al. [6] have discussed on a fuzzy expert system for optimization of high-speed milling process. They were used a fuzzy expert system which containing a knowledge base system with fuzzy reasoning mechanism to optimize parameters in High Speed Milling of hardened steels named as EXHARMIL. Fuzzy CLIPS of expert system shell and strategy of stepwise determination of parameters were used to develop this system. They were performed an experiment on a workpiece of AISI H13 (HSS) with the help of cutting tool as tungsten carbide tool coated with AlTiN. This system provides the optimum value for cutting speed, feed rate, depth of cut, tool-substrate, its coating, tool geometry and tool life prediction, surface integrity prediction and more, according to material of workpiece, planned objective and other inputs provided to it. Finally there were found that the expected tool life is 135 m of cut length, arithmetic transverse surface roughness is 0.9 microns at tool temperature of 500^0C, the optimal cutting speed of 255 m per min, optimal feed rate of 0.1 mm per tooth.

Shibendu Shekhar Roy [7] has done work on an adaptive-network based fuzzy approach for prediction of surface roughness in end milling. He was used an adaptive-network based fuzzy inference system (ANFIS) to predict the surface roughness of work piece after the end milling process and three milling parameters like spindle speed, feed rate and depth of cut were analyzed. He was used a workpiece of 6061 aluminum alloy to perform experiment by using four flutes HSS end milling cutter of 19.05 diameter. Two different memberships' functions such as triangular and bell shaped, were adopted at the time of training process of ANFIS. An adaptive-network based fuzzy inference system can automatically and effectively generate optimal triangular and bell shaped membership functions and corresponding rule base. Finally, the predicted value of surface roughness derived from ANFIS were compared with experimental data and this comparison shows that the adoption of both triangular and bell shaped membership functions in ANFIS achieved very suitable accuracy.

H.-S. Lu et. al. [8] worked on "The optimal cutting parameter design of rough cutting process in side milling".
This paper was focused on the optimal cutting parameters design of rough cutting processes in side milling for SKD61 tool steels by using an application of Taguchi methodology with grey –fuzzy logics, for rough cutting process in side milling operations, tool life and material removal rate (MRR)are selected as indexes to evaluate cutting performance. The experiment includes four cutting parameters such as Spindle speed (V in rpm), Feed rate (F feed per tooth), Depth of cut (Da) and Radial depth of cut (Dr) and each parameter is set to three levels. In this investigation or research, the test work piece was made of SKD61 tool steel and 200 mm×80 mm ×80 mm in size, the hardness of the work piece material was measured to be 53 HRC and the end mill served as cutting tools was made of tungsten carbide and coated with AlTiN under a major specification such as: diameter of 10 mm, 4 flutes, helix angle of 45°, negative radial rake angle of 8°, and radial relief angle of 8°. The overhang length of the tools is fixed at about 45 mm, and radial run-out was maintained at less than 10 μm. The experiments were carried out on a Papers B8 CNC machining center using up milling operation with air blow. The results reveal that the proposed method provides a systematic and efficient methodology for the optimized designation of the cutting parameters. By applying optimized design of the cutting parameters, the improvement of metal removal rate (MRR)and tool life from the initial cutting parameters to the optimal cutting parameters are 54% and 9.7%.Hence, this optimal result can be applied to practical processes to effectively reduce manufacturing cost and greatly enhance manufacturing efficiency.

K Kadirgama et. al. [9] have done experiment on optimization of surface roughness in end milling on mould aluminum alloys (AA6061-T6) using response surface method and radian basis function network. By using Response Surface Method (RSM)and Radian Basis Function Network (RBFN),they were conducted experiment on Haans machining centre with 6-axis with tool of carbide coated inserts in which the machining parameters are such as feed rate, cutting speed, axial and radial depth, optimized to obtain better surface finish on the work piece. After the experiment, the optimum value for surface roughness was 0.4261 μm, which corresponds to design variables as cutting speed (m/min) =100, feed rate (mm/rev) = 0.2, axial depth (mm) = 0.1 and radial depth (mm) = 5.0.

R. Jalili Saffar et. al. [10] has done work on optimization of machining parameters to minimize tool deflection in the end milling operation using genetic algorithm. This study introduces a developed computer algorithm to optimize the cutting parameters to increase tool life and minimize tool deflection and surface roughness for a constant material removal rate. The system is mainly based on a artificial intelligence (AI) tool called genetic algorithms (GA). They performed the milling operation to investigate the effect of machining parameters (such as feed rate, axial depth of cut, radial depth of cut and cutting speed) on Universal milling machine using mild steel AISI 1045 as a workpiece material and two HSS tools (tool diameter-3mm and 6mm, no. of flutes- 4, flute length-11mm, overall length 56mm) as cutting tool. Finally, they were calculated the maximum surface roughness and minimum surface roughness as 6.3 μm and 1.6 μm respectively by using the best possible combination of feed rates and depth of cuts while cutting speed are considered as constantly with the help of Genetic Algorithms.

B. C. Routara et. al. [11] was disbursed "Roughness modeling and optimization in CNC end milling using response surface method: effect of work piece material variation". They describe use and steps of Full factorial design of experiments to search out a specific range and combinations of machining parameters such as feed rate, spindle speed and depth of cut to achieve optimal values of response variables like Roughness parameters (Ra, Rq, Rsk, Rku and Rsm) in machining of three totally different materials like 6061-T4 aluminum, AISI 1040 steel and medium leaded brass UNS C34000 of the specimens of form of 100 mm × 75 mm × 25 mm blocks by CVD coated carbide tools flat end mill cutters (8 mm diameter, 30° helix angle, TiAlN coated solid carbide, parallel shank. The second-order model was postulated in getting the relationship between the surface roughness parameters and the machining variables. The analysis of variance (ANOVA) was used to check the adequacy of the second-order model roughness modeling in milling is specific to the surface roughness parameter of particular Concern as well as to the work piece-tool material combination used within the process.

M.F.F. Ab. Rashid and M.R. Abdul Lani, [12] were administered "Surface Roughness Prediction for CNC milling process using Artificial Neural Network". In this study, the aim for this analysis is to develop mathematical model using multiple correlations and artificial neural network model for artificial intelligent technique. Spindle speed, feed rate, and depth of cut are chosen as predictors so as to predict surface roughness. Twenty seven samples of 400mmX100mmx50mm 6061 aluminum were run with using HSS end mill tool (No. of flute = 4, Dia. D=10mm) carried out on FANUC CNC milling α-T14E. The experiment is executed by using full factorial style. Analysis of variances (ANOVA) shows that the most important parameter is feed rate followed by spindle speed and last depth of cut. After the expected surface roughness has been obtained by using each strategy, average methods error is calculated. The mathematical model developed by victimization (using) multiple correlation technique shows the accuracy of 86.7% that is reliable to be utilized in surface roughness prediction. On the opposite hand, artificial neural network technique shows the accuracy of 93.58% that is possible and applicable in prediction of surface roughness. The result from this analysis is beneficial to be applied in industry to reduce time and cost in surface roughness prediction.

Bharat Chandra Routara et. al. [13] were discussed on "Optimization in CNC end milling of UNS C34000 medium leaded brass with multiple surface roughness's characteristics". The purpose of this study is highlights a multi-objective optimization problem by applying utility concept coupled with Taguchi methodology through a case study in CNC end milling of UNS C34000 medium leaded brass as a work piece material and Coated with TiAlN End mill Cutter (diameter 8 mm, Overall length 108 mm, Fluted length 38 mm, Helix angle 30º). The study aimed toward evaluating the best process environment that could at the same time satisfy multiple requirements of surface roughness quality. In view of the fact, the normal Taguchi methodology cannot solve a multi-objective optimization problem; to overcome this limitation, utility theory has been coupled with Taguchi methodology. Depending on Taguchi's Lower-the- Better (LB) response criteria; individual surface quality characteristics has been reworked into corresponding utility values. Individual utility values have been aggregated finally to calculate overall utility degree that is representative objective function for optimizing using Taguchi methodology. Utility theory has been adopted to convert a multi-response optimization problem into a one response optimization problem; during which overall utility degree serves as the representative single objective function for optimization. The study of Taguchi methodology and combined utility theory are used for predicting optimum setting. Based on Taguchi's Signal-to-Noise ratio (S/N), analysis has been created on the general utility degree and optimum process environment has been designated finally that corresponds to highest S/N Ratio. Optimum result has been verified through confirmatory test. The case study indicates application feasibility of the aforesaid methodology proposed for multi response optimization and off-line control of multiple surface quality characteristics in CNC end milling.

Qiao Yin-hu et. al. [14] conducted an experiment on "Selection of Machining Parameters Using Improved Fuzzy Petri Nets". They performed an experiment on a work piece of hard alloy of aluminum by using Improved Fuzzy

Petri Nets rules and these expert rules are evaluated by the fuzzy set theory. They developed a fuzzy model (system), which uses improved fuzzy petri nets rule, on a PC using MATLAB Fuzzy Logic. This system included many machining parameters such as surface roughness, feed rate, cutting speed, cutting depth, corner radius, vibration, etc. in which feed rate, cutting speed and cutting depth are the input while for milling operation while the outputs are surface roughness, and removal rate and remaining parameters are considered at constant rate at the time of machining. Finally, the comparison of parameters obtained from Fuzzy Petri Nets and traditional design method, Fuzzy Petri Nets were improved surface roughness and metal removal rate (MRR).

U. Deepak [15] worked on Optimization of Milling Operation using Genetic and PSO (Particle Swarm Optimization) Algorithm. He was performed an experiment on milling process (Face milling, Corner milling, Pocket milling, Slot milling) by using Genetic Algorithm and Particle Swarm Optimization Algorithm to optimize machining parameters such as feed rate, cutting speed, and depth of cut. In this experimental work, he was used 10150 leaded steel as a workpiece material, and cutting tool of HSS tool for n=0.15 and carbide tool for n=0.30 where n is tool life exponent. Genetic Algorithms (GA) is a search heuristic which mimics the process of natural evolution. He was used this heuristic as it was routinely used to generate useful solutions to optimization and issues related to search problems, it is belong to the larger group of Evolutionary Algorithms, that generate helpful solutions to optimize problems using technique motivated by natural evolution like mutation, inheritance, selection, and crossover. Particle Swarm Optimization (PSO) Algorithms is an algorithm based computational method that optimize a problem by iteratively trying to enhance a solution of candidate related measure of quality. Such methods are commonly called as metaheuristics as they formulate few or no assumptions about the issue being optimized and can search very large spaces of candidate solutions.

John D. Kechagias et. al [16] were disbursed "Parameter Optimization during Finish End Milling of Al Alloy 5083 using Robust Design". The use and steps of Taguchi design of experiments and orthogonal array L18 were used as to seek out a selected range and combinations of machining parameters like Flute angle (38^o), Core diameter (50%), Rake angle (22^o), Relief angle 1st (22^o), Relief angle 2nd (30^o), Cutting depth (1.5mm), Cutting speed (5000 rpm), Feed (0.08mm/flute). The influence of cutter geometry and cutting parameters throughout end milling on the surface texture of aluminum (Al) alloy 5083 was through the two flutes carbide end mill cutter. Surface texture parameters (R_a, R_y and R_z) were measured on three totally different passes on side surface of pockets and analyzed using statistical techniques. The results reveal that the cutting speed, the peripheral 2nd relief angle, and the core diameter have vital effect in surface texture parameters. Once the relief angle 2nd takes its optimum value (30^o) the surface roughness decreases whereas the cutting speed will increase. This can be accordance with the cutting theory.

Reddy B. Sidda et. al. [17] were carried out "Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm". During this study, reduction of surface roughness has been investigated by desegregation design of experiment (DOE) method, Response surface methodology (RSM) and genetic algorithm. The experiments were performed on AISI P20 mould steel (100x100x10 mm) with CVD coated carbide tool inserts (TN 450) and CNC Vertical milling machine 600 II, KENAMETAL tool holder BT40ER40080M 20 ATC by exploitation (using) Taguchi's L50 orthogonal array within the design of experiments (DOE) .Considering the machining parameters like Cutting speed (V), feed (f), axial depth of cut (d), Nose radius (R) and radial depth of cut (rd). A predictive response surface model for surface roughness is developed using Response Surface Methodology (RSM). The response surface (RS) model is interfaced with the genetic algorithm (GA) to seek out the optimum machining parameter values. To attain the minimum surface roughness, the suitable process parameters are determined. Nose radius, cutting speed, feed rate, axial depth of cut and radial depth of cut are thought of as process parameters GA has reduced the surface roughness of the initial model significantly. Surface roughness is improved by concerning 44.22%.

Vikas Pare et.al. [18] have conducted on optimization of cutting conditions in end milling process with the approach of particle swarm optimization. They were conducted an experiment on the workpiece of annealed alpha beta titanium alloy Ti-6Al-4V (Ti-64) with three types of end mills as uncoated carbide and two TiAlN base coated carbide tools, to optimize surface finish, they were used the experimental relationships between input and output variables to predict the output. Optimizations of these predictive models help to select suitable input variables for achieving the best output performance. In this experiment, four variables (as cutting speed, feed rate, radial rake angle and depth of cut) are selected as input while surface roughness is considered as output variable and 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 (Genetic Algorithms) optimization. Finally, optimized value of surface roughness is 0.32 microns.

Ahmed A. D. et. al. [19] have done an experimental work on a fuzzy logic based model to predict surface roughness of a machined surface in glass milling operation using CBN grinding tool. They were used the CBN grinding tool of 4.5mm diameter for machining of workpiece of soda lime glass (80x50x25 mm in rectangular size) in which input parameters are lubrication pressure, spindle speed, feed rate and depth of cut while surface roughness is considered as output parameters. This experiment was conducted on a Vertical-type Machining Center (Cincinnati Milacron Saber TNC 750 VMC). In this work, fuzzy logic based model were used to predict surface roughness by setting up the relationship between input and output parameters. Four membership functions were allocated to be connected with each input of the model. The predicted results achieved by fuzzy logic model are compared to the experimental result. The result established settlement between the fuzzy model and experimental results with the 93.103% accuracy.

Surasit Rawangwong et. al. [20] have considered an investigation of optimum cutting conditions for quality of surface roughness in face milling mold steel AISI P20 using carbide tool. They were performed a face milling operation on workpiece of mold steel AISI P20 with 50×150 mm in a cross section and 250 mm in a length with using Carbide inserts model Iscar type SEKT 1204AFR-HM as a fine type cutting tool. This experimental work was done on a Semi milling machine of model Obraeci Strojie type FGV 32. They were used four main procedures this experiment in which the first procedure was used as to investigate the sample size for designing the workpiece of mold steel AISI P20 by CNC milling machine, second to study the factors expected to make an effect on surface roughness in the workpiece of mold steel AISI P20 face milling process, third to pilot treatment to observe the best possible surface roughness while the last procedure was used to take the real treatment that confirm the results. Finally, the optimum value of surface roughness is 15.0 µm which was obtained at feed rate (224 mm/min), speed (710 rpm) and depth of cut (1 mm) by surface testing device Mitutoyo Surf Test 301.

Table No. 2 Review of literature survey done by different researchers'

Sr. no.	Name of Researchers	Contribution or Title of performed experiment	Workpiece Material and its Geometry	Tool Material and its Geometry	Process/ Machining Parameters	Machining Performance Parameters
1	Aguero E. et. al.	Fuzzy model of cutting process on a milling machine	Five models of three materials as Dural (Aluminum alloy),Steel F110,SteelF114,Steel F110 + Steel F114, and Dural+ Steel F110 + Steel F114	Cutting tool of different diameter for every model like for Model 1- 10mm dia., Model 2- 12mm dia., Model 3- 14mm dia., Model 4- 16mm dia., and Model 5- 25mm dia.	Cutting speed, feed rate, Depth of cut, tool diameter and hardness	Force sensor signals
2	Joseph C. Chen et. al.	An effective fuzzy-nets training scheme for monitoring tool breakage	Aluminum 6061	High speed steel (HSS) end mill cutter of four flutes and 400 mm diameter	Cutting speed, feed and depth of cut	Detection of tool breakage
3	J.C. Chen et. al.	A fuzzy net based multilevel in-process surface recognition system in milling operation	Different workpiece of 6061 aluminium and AISI 1018 steel	HSS tool of 0.5 and 0.75 mm diameter	Spindle speed, depth of cut, feed rate and vibration variables	Surface roughness

4	PG Benardos et. al.	Prediction of surface roughness in CNC face milling using neural networks and taguchi's design of experiments	Series 2 Aluminium	40 mm diameter cutter head with 4 cutter inserts	Depth of cut, feed rate per tooth, cutting speed	Surface roughness with a mean squared error (MSE)
5	V. Susanto et. al.	A fuzzy logic based in-process tool-wear monitoring System in face milling operations	AISI 1018steel	Versa tool 90 degree cutting edge	Feed rate , depth of cut and maximum resultant force	Flank wear Vb
6	Iqbal A et. al.	Fuzzy expert system for optimization of high-speed milling process	AISI H13	Inserted ball nose end of tungesten carbide coated with AlTin	Cutting speed, feed rate, axial DOC, radial DOC	To maximize tool life and MRR and minimize surface roughness
7	Shibendu Shekhar Roy	An adaptive-network based fuzzy approach for prediction of surface roughness in end milling	6061 aluminum alloy	Four flutes HSS end milling cutter of 19.05 diameter	Spindle speed, feed rate and depth of cut	Surface roughness
8	H.-S. Lu et. al.	The optimal cutting parameter design of rough cutting process in side milling	SKD61 tool steel (200 ×80 × 80) mm	Tungsten carbide coated with AlTiN	Spindle speed, Feed rate, Depth of cut,	Tool life And Material Removal Rate
9	K Kadirgama et. al.	Optimization of surface roughness in end milling on mould aluminum alloys (AA6061-T6) using response surface method and radian basis function network	Mould Aluminium alloys (AA6061-T6)	Carbide coated inserts	Cutting speed, feed rate, axial depth and radial depth	Surface roughness
10	R. Jalili Saffar et. al.	Optimization of machining parameters to minimize tool deflection in the end milling operation using genetic algorithm	Mild steel AISI 1045	Two HSS tools of diameter-3mm and 6mm, no. of flutes- 4, flute length- 11mm, overall length 56mm with helix angle 30°	Cutting speed, feed rate, axial DOC,radial DOC	Tool deflection and surface roughness
11	B. C. Routara et. al.	Roughness modeling and optimization in CNC end milling using response surface method: effect of work piece material variation	6061-T4 aluminum, AISI 1040 steel and medium leaded brass UNS C34000 in the form of 100 mm × 75 mm × 25 mm blocks	CVD helix angle, TiAlN coated solid carbide, parallel shank, four flutes)	Feed rate, spindle speed and depth of cut (Rsm)	Centre line average roughness (Ra), root mean square roughness (Rq), skewness (Rsk), kurtosis (Rku) and mean line peak spacing (Rsm)
12	M.F.F. Ab. Rashid and M.R. Abdul Lani	Surface Roughness Prediction for CNC milling process using Artificial Neural Network	6061-T4 Aluminium	HSS end mill tool, No. of flute = 4, Dia. D=10mm	Spindle speed, feed rate, and depth of cut	Surface finishing
13	Bharat Chandra Routara et. al.	Optimization in CNC end milling of UNS C34000 medium leaded brass with multiple surface roughness's characteristics	UNS C34000 medium leaded brass 100mmX 75mmX 25mm	CVD coated carbide tool with TiAlN, cutter diameter 8 mm, Overall length 108 mm, Fluted length 38 mm, Helix angle 30°	Spindle speed, feed rate, and depth of cut	Multiple surface roughness characteristic like Centre line average roughness (Ra), root mean square roughness (Rq), kurtosis (Rku)

						and mean line peak spacing (Rsm)
13	Qiao Yin-hu et. al.	Selection of Machining Parameters Using Improved Fuzzy Petri Nets	Hard alloy of aluminum	Tool selection from machine catalog	Cutting speed, feed rate, depth, corner radius, vibration	Surface roughness, Metal removal rate
14	U. Deepak	Optimization of Milling Operation using Genetic and Particle Swarm Optimization Algorithm	10150 leaded steel	HSS tool for n=0.15 and carbide tool for n=0.30	Cutting speed, feed rate and depth of cut	Face milling, Corner milling, Pocket milling, Slot milling
15	John D. Kechagias et. al	Parameter Optimization during Finish End Milling of Al Alloy 5083 using Robust Design	Aluminium (Al) alloy 5083	Two flute carbide end mill cutter	Core diameter (50%), Flute angle (38°), Rake angle (22°), Relief angle 1st (22°), Relief angle 2nd (30°), Cutting depth (1.5mm), Cutting speed (5000 rpm), Feed (0.08mm/flute)	Arithmetical roughness (Ra), Maximum peak (Ry) and Ten point mean roughness (Rz)
16	Reddy B. Sidda et. al.	Optimization of surface roughness in CNC end milling using response surface methodology and genetic algorithm	AISI P20 mould steel (100x100x10 mm)	coated carbide tool inserts (TN 450)	Cutting speed (V), feed (f), axial depth of cut (d), Nose radius (R) and radial depth of cut (rd)	Surface roughness
17	Vikas Pare et.al.	Optimization of cutting conditions in end milling process with the approach of particle swarm optimization	Annealed alpha beta titanium alloy Ti-6Al-4V (Ti-64	Three types of end mills as an uncoated carbide and two TiAlN base coated carbide tools	Cutting speed, feed rate, radial rake angle and depth of cut	Surface roughness
18	Ahmed A. D. et. al.	A fuzzy logic based model to predict surface roughness of a machined surface in glass milling operation using CBN grinding tool	Soda lime glass 80x50x25 mm	CBN grinding tool of 4.5mm diameter	Lubrication pressure, spindle speed, feed rate and depth of cut	Surface roughness
19	Surasit Rawangwong et. al.	An investigation of optimum cutting conditions for quality of surface roughness in face milling mold steel AISI P20 using carbide tool	Mold steel AISI P20, 50x150mm in a cross section and 250 mm in length	Carbide tool with 63 millimeter diameter of 5 edges	Speed (rpm),Feed rate (mm/min) and Depth of cut (mm)	Surface roughness Ra
20	V V K Lakshmi et.al.	Modeling and optimization of process parameters during end milling of hardened steel	En24 alloy steel 70x70x30 mm with hardness of 260 BHN	Solid coated carbide end mill cutting tool of 8 mm diameter four flutes	Cutting speed, feed rate and depth of cut	Surface roughness, Metal removal rate

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CONCLUSION

CNC machine is playing a vital role in industrial and manufacturing area. And machining is dependent upon various parameter .if we could able to optimize these parameter it will lead to great reduction in machine related cost. So far, this paper revels to the information related to the various optimization technique used in industrial sector. This paper also concludes the information of the number of parameter that is associated with these techniques. It shows the various detailed information of the non conventional machining optimization technique like fuzzy set technique, genetic algorithm, and neural network that is used along the necessary tool material and set of work material. This paper is also focus the parameter of machining that affects to it like feed, spindle speed, and doc. Various researcher had been work over the AI technique ,so this paper is consists the collective information of the machine performance parameter used with different no. of AI techniques.

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