Optimization of Tools for CNC Machine: An Explication & An Overview

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Abstract— Over the last few decades, the range of engineering materials encountered in machine shops has increased greatly, as has the variety of cutting tools that are capable of machining these materials. Recent advances in computer hardware and software technology have led to research in calculation of efficient cutting parameters and design and development of a tool or combination of tools for a specific operation or set of operations. In this paper an attempt is made to review the literature on optimizing machining parameters and geometric parameters in CNC machine. Various conventional techniques employed for machining optimization include geometric programming, geometric plus linear programming, goal programming, sequential unconstrained minimization technique, dynamic programming etc. The latest techniques for optimization include fuzzy logic, scatter search technique, genetic algorithm, Taguchi technique and response surface methodology. This paper gives the machine tool methodology optimization.

Index Terms— CNC, Machining optimization, goal programming, fuzzy logic, genetic algorithms, Taguchi technique, response surface methodology.

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1 INTRODUCTION

AS the tool life & tool wear is a major problem faced by the industry, it has long been recognized that conditions during cutting, such as feed rate, cutting speedand depth of cut, should be selected to optimize the economics of machining operations, as assessed by productivity, total manufacturing cost per component or some other suitable criterion. Taylor [1] showed that an optimum or economic cutting speed exists which could maximize material removal rate. Manufacturing industries have long depended on the skill and experience of shop-floor machine-tool operators for optimal selection of cutting conditions and cutting tools. Considerable efforts are still in progress on the use of handbook- based conservative cutting conditions and cutting tool selection at the process planning level. The most adverse effect of such a not-very scientific practice is decreased productivity due to suboptimal use of machining capability. The need for selecting and implementing optimal machining conditions and the most suitable cutting tool has been felt over the last few decades. Despite Taylor's early work on establishing optimum cutting speeds in single pass turnings, progress has been slow since all the process parameters need to be optimized. Furthermore, for realistic solutions, the many constraints met in practice, such as low machine tool power, torque, force limits and component surface roughness, must be over come.The non-availability of the required technological performance equation represents a major obstacle to implementation of optimized cutting conditions in practice. This follows since extensive testing is required to establish empirical performance equations for each tool coating–work material combination for a given machining operation, which can be quite expensive when a wide spectrum of machining operations is considered. Further the performance equations have to be updated as new coatings, new work materials and new cutting tools are introduced. While comprehensive sets of equations are found in some Chinese and Russian handbooks [8],[20] as well in the American handbook [3] and Kroneberg's textbook [9] most authors have not included discussions on the more modern tools, new work materials and tool coatings. Difficulties are experienced in locating the empirical performance equations for moderntool designs because these are hidden under computerized databases in proprietary software [18] as noted in recent investigations "[45],[46]".

Recent works are concentrated on design and development of tool, milling operations for determining machining parameters. The optimization strategy for single pass end milling on CNC machine tools, allowing for many practical constraints has been based on minimum production time per component. Different optimization procedures have been developed using new approaches such as genetic algorithm (GA), hill climbing algorithm and memetic algorithm to optimize machining parameters for milling operations.

Modeling and simulation of machining processes is a critical step in the realization of high quality machined parts. To precisely simulate the machining operations, accurate models of cutting tools used in the machining processes are required. In metal cutting industry, an end mill cutter plays an important role for obtaining the desired shape and size of a component. A variety of helical end mill cutters are used in the industry. Helical cylindrical, helical ball, taper helical ball, bull-nosed and special purpose end mills are widely used in aerospace, automotive and die machining industries. The analysis of the geometry of the tool surfaces and cutting flutes along with the cutting forces acting on the end mill plays an important part in the design of the end mill and the quality of the manufacturing process. Traditionally, the geometry of cutting tools has been defined using the principles of projective geometry. The advancements in the domain of Computer Aided Design (CAD) allow a designer to specify the cutting tool surfaces in terms of biparametric surface patches. Using such an

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approach, one may develop the comprehensive three-dimensional (3D) surface based definitions of the cutting tools.

Hu Gong [61] describes an optimized positioning procedure for flank milling ruled surfaces with cylindrical cutter. The proposition that the envelope surface of cylindrical cutter is the offset surface of tool axis trajectory surface is proved using kinematics approach. It is a complement of Bedi's [53] analysis about the envelope surface of cylindrical cutter.

Optimization procedures based on the genetic algorithm, hill climbing algorithm and memetic algorithm were demonstrated for the optimization of machining parameters for milling operation developed by basker et al [62]. They describe development and utilization of an optimization system, which determines optimum machining parameters for milling operations like face milling, corner milling, pocket milling and slot milling.

Sheen et al [63] developed an effective method for identifying machining features. It reliably determines the shapes between top and bottom profiles of workpiece. Most of the isolated, intersecting or 2.5D or 3D features can be recognized. Furthermore, the merging of the slot, step and notch features simplifies the manufacturing sequence and minimizes burr produced by discontinuous machining. Using the information of machining features, the manufacturing sequence can be automatically arranged and different kinds of tool paths can be efficiently generated.

A geometric approach to the problem of multi-patch machining by generating bisectors to partition the region into smaller sub regions, and generates the toolpath by offsetting the sub region boundary by using a special offset function was introduced by Li [64]. The author developed this approach for generating a boundary conformed toolpath for free-form multi-patch surface machining.

Saffar et al. [65] develops a 3D simulation system which is employed in order to predict cutting forces and tool deflection during end-milling operation. In order to verify the accuracy of 3D simulation, results (cutting forces and tool deflection) were compared with those based on the theoretical relationships may be attributed to the followings:

(1) Material properties in the simulations are defined based on the Johnson–Cook theory, i.e. they are a function of strain, strain rate, and workpiece temperature whereas in the theoretical relationships, properties are simply defined using the constant material coefficient.

(2) In simulation, non-linear geometric boundaries such as the free surface of the chip can be represented and used while theoretical relationships are based on linear geometric boundaries.

2 REVIEW OF LITURATURE

2.1 Conventional Optimization Technique

The follwing are some convetional optimization technique suggested by the concern researchers. Gilbert [2] studied the optimization of machining parameters in turning with respect to maximum production rate and minimum production cost as criteria. Armarego & Brown [10] investigated unconstrained machine-parameter optimization using differential calcu-

lus. Brewer & Rueda [6] carried out simplified optimum analysis for non-ferrous materials. For cast iron (CI) and steels, they employed the criterion of reducing the machining cost to a minimum. A number of nomograms were worked out to facilitate the practical determination of the most economic machining conditions. They pointed out that the more-difficult-to-machine materials have a restricted range of parameters over which machining can be carried out and thus any attempt at optimizing their costs is artificial. Brewer [8] suggested the use of Lagrangian multipliers for optimization of the constrained problem of unit cost, with cutting power as the main constraint. Bhattacharya et al [11] optimized the unit cost for turning, subject to the constraints of surface roughness and cutting power by the use of Lagrange's method. Walvekar & Lambert [12] discussed the use of geometric programming to selection of machining variables. They optimized cutting speed and feed rate to yield minimum production cost. Petropoulos [13] investigated optimal selection of machining rate variables, viz. cutting speed and feed rate, by geometric programming. A constrained unit cost problem in turning was optimized by machining SAE 1045 steel with a cemented carbide tool of ISO P-10 grade. Sundaram [16] applied a goal-programming technique in metal cutting for selecting levels of machining parameters in a fine turning operation on AISI 4140 steel using cemented tungsten carbide tools. Ermer & Kromodiharajo [19] developed a multi-step mathematical model to solve a constrained multi-pass machining problem. They concluded that in some cases with certain constant total depths of cut, multi-pass machining was more economical than single-pass machining, if depth of cut for each pass was properly allocated. They used high speed steel (HSS) cutting tools to machine carbon steel. Hinduja et al [21] described a procedure to calculate the optimum cutting conditions for turning operations with minimum cost or maximum production rate as the objective function. For a given combination of tool and work material, the search for the optimum was confined to a feed rate versus depth-of-cut plane defined by the chip-breaking constraint. Some of the other constraints considered include power available, work holding, surface finish and dimensional accuracy. Tsai [25] studied the relationship between the multi-pass machining and single-pass machining. He presented the concept of a break-even point, i.e. there is always a point, a certain value of depth of cut, at which single-pass and double-pass machining are equally effective. When the depth of cut drops below the break-even point, the single-pass is more economical than the double-pass, and when the depth of cut rises above this break-even point, double-pass is better. Carbide tools are used to turn the carbon steel work material. Gopalakrishnan & Khayyal [37] described the design and development of an analytical tool for the selection of machine parameters in turning. Geometric programming was used as the basic methodology to determine values for feed rate and cutting speed that minimize the total cost of machining SAE 1045 steel with cemented carbide tools of ISO P-10 grade. Surface finish and machine power were taken as the constraints while optimizing cutting speed and feed rate for a given depth of cut. Agapiou [38] formulated single-pass and multi-pass machining operations. Production cost and total time were taken

as objectives and a weighting factor was assigned to prioritize the two objectives in the objective function. He optimized the number of passes, depth of cut, cutting speed and feed rate in his model, through a multi-stage solution process called dynamic programming. Several physical constraints were considered and applied in his model. In his solution methodology, every cutting pass is independent of the previous pass, hence the optimality for each pass is not reached simultaneously. Prasad [43] reported the development of an optimization module for determining process parameters for turning operations as part of a PC-based generative CAPP system. The work piece materials considered in their study include steels, cast iron, aluminium, copper and brass. HSS and carbide tool materials are considered in this study. The minimization of production time is taken as the basis for formulating the objective function. The constraints considered in this study include power, surface finish, tolerance, work piece rigidity, range of cutting speed, maximum and minimum depths of cut and total depth of cut. Improved mathematical models are formulated by modifying the tolerance and work piece rigidity constraints for multi-pass turning operations. The formulated models are solved by the combination of geometric and linear programming techniques.

2.2 Current Techniques

The latest techniques for optimization include fuzzy logic, scatter search technique, genetic algorithm, Taguchi technique and response surface methodology.

2.2.1 Fuzzy Logic

Fuzzy logic has great capability to capture human commonsense reasoning, decision-making and other aspects of human cognition. Kosko [42] shows that it overcomes the limitations of classic logical systems, which impose inherent restrictions on representation of imprecise concepts. Vagueness in the coefficients and constraints may be naturally modelled by fuzzy logic. Modelling by fuzzy logic opens up a new way to optimize cutting conditions and also tool selection.

Methodology: As per Klir & Yuan [44] fuzzy logic involves a fuzzy interference engine and a fuzzification-defuzzification module. Fuzzification expresses the input variables in the form of fuzzy membership values based on various membership functions. Governing rules in linguistic form, such as if cutting force is high and machining time is high, then tool wear is high, are formulated on the basis of experimental observations. Based on each rule,inference can be drawn on output grade and membership value. Inferences obtained from various rules are combined to arrive at a final decision. The membership values thus obtained are defuzzified using various techniques to obtain true value, say of flank wear.

2.2.2 Genetic algorithm (GA)

These are the algorithms based on mechanics of natural selection and natural genetics, which are more robust and more likely to locate global optimum. It is because of this feature that GA goes through solution space starting from a group of points and not from a single point. The cutting condi-

tions are encoded as genes by binary encoding to apply GA in optimization of machining parameters. A set of genes is combined together to form chromosomes, used to perform the basic mechanisms in GA, such as crossover and mutation. Crossover is the operation to exchange some part of two chromosomes to generate new offspring, which is important when exploring the whole search space rapidly. Mutation is applied after crossover to provide a small randomness to the new chromosomes. To evaluate each individual or chromosome, the encoded cutting conditions are decoded from the chromosomes and are used to predict machining performance measures. Fitness or objective function is a function needed in the optimization process and selection of next generation in genetic algorithm. Optimum results of cutting conditions are obtained by comparison of values of objective functions among all individuals after a number of iterations. Besides weighting factors and constraints, suitable parameters of GA are required to operate efficiently. GA optimization methodology is based on machining performance predictions models developed from a comprehensive system of theoretical analysis, experimental database and numerical methods. The GA parameters along with relevant objective functions and set of machining performance constraints are imposed on GA optimization methodology to provide optimum cutting conditions.

Implementation of GA: First of all, the variables are encoded as n-bit binary numbers assigned in a row as chromosome strings. To implement constraints in GA, penalties are given to individuals out of constraint. If an individual is out of constraint, its fitness will be assigned as zero. Because individuals are selected to mate according to fitness value, zero fitness individuals will not become parents. Thus most individuals in the next generation are ensured in feasible regions bounded by constraints. The GA is initialized by randomly selecting individuals in the full range of variables. Individuals are selected to be parents of the next generation according to their fitness value. The larger the fitness value, the greater their possibility of being selected as parents. Wang & Jawahir [58] have used this technique for optimization of milling machine parameters. Kuo & Yen [50] have used a genetic algorithm based parameter tuning algorithm for multidimensional motion control of a computer numerical control machine tool.

2.2.3 Scatter Search Technique (SS)

This technique originates from strategies for combining decision rules and surrogate constraints. SS is completely generalized and problem-independent since it has no restrictive assumptions about objective function, parameter set and constraint set. It can be easily modified to optimize machining operation under various economic criteria and numerous practical constraints. It can obtain near-optimal solutions within reasonable execution time on PC. Potentially, it can be extended as an on-line quality control strategy for optimizing machining parameters based on signals from sensors. Chen & Chen [51] have done extensive work on this technique.
Methodology: First of all, machining models are required to determine the optimum machining parameters including cut-

ting speed, feed rate and depth of cut, in order to minimize unit production cost. Unit production cost can be divided into four basic cost elements:

- Cutting cost by actual cut in time
- Machine idle cost due to loading and unloading operation and idling tool motion cost
- Tool replacement cost
- Tool cost

For the optimization of unit production cost, practical constraints which present the state of machining processes need to be considered. The constraints imposed during machining operations are:

- Parameter constraint – Ranges of cutting speed, feed rate and depth of cut
- Tool life constraint – Allowable values of flank wear width and crater wear depth
- Operating constraint – Maximum allowable cutting force, power available on machine tool and surface finish requirement.

An optimization model for multi-pass turning operation can be formulated. The multi-pass turning model is a constrained nonlinear programming problem with multiple variables (machining variables). The initial solution for SS is picked in a random way. The user-specified parameters have to be given. The experimentation can be run on a PC with Pentium800Mhzprocessor. The computational results validate the advantage of SS in terms of solution quality and computational requirement.

2.2.4 Taguchi technique

Genichi Taguchi is a Japanese engineer who has been active in the improvement of Japan's industrial products and processes since the late 1940s. He has developed both the philosophy and methodology for process or product quality improvement that depends heavily on statistical concepts and tools, especially statistically designed experiments. Many Japanese firms have achieved great success by applying his methods. Sullivan [35] reports that Taguchi has received some of Japan's most prestigious awards for quality achievement, including the Deming prize. In 1986, Taguchi received the most prestigious prize from the International Technology Institute – The Willard F. Rockwell Medal for Excellence in Technology. Taguchi's major contribution has involved combining engineering and statistical methods to achieve rapid improvements in cost and quality by optimizing product design and manufacturing processes.

Barker [31] reported that since 1983, after Taguchi's association with the top companies and institutes in USA (AT & T Bell Laboratories, Xerox, Lawrence Institute of Technology (LIT), Ford Motor Company etc.), his methods have been called a radical approach to quality, experimental design and engineering. Sullivan [35] reported that the term "Taguchimethods" (TM) refers to the parameter design, tolerance design, quality loss function, on-line quality control, design of experiments using orthogonal arrays, and methodology applied to evaluate measuring systems.Pignatiello [29] identifies two separate aspects of the Taguchi methods: the strategy of Taguchi and the tactics of Taguchi. Taguchi tactics refer to the col-lection of specific methods and techniques used by Genichi Taguchi, and Taguchi strategy is the conceptual framework or structure for planning a product or process design experiment. Benton [36] reported that Taguchi addresses design and engineering (off-line) as well as manufacturing (on-line) quality. This fundamentally differentiates TM from statistical process control (SPC), which is purely an on-line quality control method. Taguchi's ideas can be distilled into two fundamental concepts:

(a) Quality losses must be defined as deviations from targets, not conformance to arbitrary

specifications [36].

(b) Achieving high system-quality levels economically requires quality to be designed into the product. Quality is designed, not manufactured, into the product "[28],[30]"

Chanin [34] stated that Taguchi methods represent a new philosophy. Quality is measured by the deviation of a functional characteristic from its target value. Noises (uncontrolled variables) can cause such deviations resulting in loss of quality. Taguchi methods seek to remove the effect of noises.

Taguchi [30] described that quality engineering encompasses all stages of product/process development: system design, parameter design, and tolerance design. Byrne & Taguchi [27], however, pointed out that the key element for achieving high quality and low cost is parameter design. Through parameter design, levels of product and process factors are determined, such that the product's functional characteristics are optimized and the effect of noise factors is minimized. Kackar & Shoemaker [23] observed that parameter design reduces performance variation by reducing the influence of the sources of variation rather than by controlling them, it is thus a very cost-effective technique for improving engineering design.

Applications: Chanin [30] remarked that Japanese companies such as Nippon Denso, NEC, and Fugitsu have become world economic competitors by using Taguchi's approach which has potential for saving experimental time and cost on product or process development, as well as quality improvement. Kacker & Shoemaker [23], Phadke [24], pointed out that the methodology advocated by Taguchi has been applied within AT & T to a variety of problems ranging from IC fabrication to response time opti-mization of a UNIX system since Taguchi's first visit to AT & T Bell Laboratories in 1980. Ghosh [32] remarked that Taguchi's ideas are also being used in many others US companies such as Ford and Xerox. There are also many courses on robust parameter design offered by organizations like American Supplier Institute, Rochester Institute of Technology, and the Center for Quality and Productivity Improvement at the University of Wisconsin in Madison. The American Supplier Institute also has an annual symposium where case studies on the application of the Taguchi Methods are presented.

The Casting Division of Ford Motors has been one of the pioneers in training employees in Taguchi's methods since 1983. In a few case studies conducted in the Casting Division of Ford Motors and illustrated the depth and impact on the product quality and productivity that has occurred since the

decision to implement Taguchi's approach was made. Moneymaker & Hubbard [26] have presented a case of the application of loss function concept to the quality improvement program at the Rockwell International Steel Foundry at Atchison, Kansas. Lin & Kackar [22] have shown how a 36-run orthogonal array design was used to improve a wave soldering process by studying 17 variables simultaneously. Kamat & Rao [41] have presented a case study of Taguchi optimization related to manufacturing processes for die-cast components. The use of optimal parame-ter combinations obtained from the analysis reduced the rejection of die-cast components by 90%. Tsui [25] presented robust design optimization for multiple characteristic problems. Robust design improves product or manufacturing process design by making the output response insensitive (robust) to difficult-to-control variations. The multivariate quality loss function considered by Pignatiello [40] has been extended to include the smaller and the larger-the-better type characteristics. Under various assumptions, appropriate two-step procedures were developed that minimize the average multivariate loss. The proposed two-step procedure substantially reduces the dimension of the design optimization problem and allows for future changes of response target values without re-optimization. The proposed procedure was illustrated with a polysilicon deposition example. Singh & Kumar [52] have applied Taguchi's technique for optimizing surface finish, tool wear, cutting force and power consumed in turning operations for machining En24 steel with titanium carbide-coated tungsten carbide inserts. The success of many applications has demonstrated the power of Taguchi's overall approach. It is also worth mentioning that many of the specific statistical techniques he has proposed for implementing robust parameter design have generated a great deal of controversy. However, most commentators agree that Taguchi's loss function concept represents a solid contribution. Furthermore, there is general agreement that off-line experiments during the product or process design stage are of great value and the methodology is based on solid engineering principles. Reducing quality loss by designing the products and processes to be insensitive to variations in noise variables is a novel concept to statisticians and quality engineers.

2.2.5 Response surface methodology (RSM)

Experimentation and making inferences are the twin features of general scientific methodol-ogy. Statistics as a scientific discipline is mainly designed to achieve these objectives. Planning of experiments is particularly very useful in deriving clear and accurate conclusions from the experimental observations, on the basis of which inferences can be made in the best possible manner. The methodology for making inferences has three main aspects. First, it establishes methods for drawing inferences from observations when these are not exact but subject to variation, because inferences are not exact but probabilistic in nature. Second, it specifies methods for collection of data appropriately, so that assumptions for the application of appropriate statistical methods to them are satisfied. Lastly, techniques for proper interpretation of results are devised.

The advantages of design of experiments as reported by Adler [15] and Johnston [7] are as follows.

(1) Numbers of trials are reduced.
(2) Optimum values of parameters can be determined.
(3) Assessment of experimental error can be made.
(4) Qualitative estimation of parameters can be made.
(5) Inference regarding the effect of parameters on the chacteristics of the process can be made.

Cochran & Cox [5] quoted Box [4] as having proposed response surface methodology for the optimization of experiments. In many experimental situations, it is possible to represent independent factors in quantitative form. Then these factors can be thought of as having a functional relationship or response:

$$Y = \varphi(X1, X2, \ldots, X_k) \pm e_r,$$

between the response Y and X1, X2, . . . X_k of k quantitative factors. The function φ is called response surface or response function. The residual e_r measures the experimental error. For a given set of independent variables, a characteristic surface responds. When the mathematical form of φ is not known, it can be approximated satisfactorily within the experimental region by a polynomial. The higher the degree of the polynomial the better is the correlation, though at the same time the costs of experimentation become higher. The methodology may be applied for developing the mathematical models in the form of multiple regression equations correlating the dependent parameters such as cutting force, power consumption, surface roughness, tool life etc. with three independent parameters, viz. cutting speed, feed rate and depth of cut, in a turning process. In applying the response surface methodology, the dependent parameter is viewed as a surface to which a mathematical model is fitted. For the development of regression equations related to various quality characteristics of turned parts, the second-order response surface may be assumed as:

$$Y = b_o + \sum_{i=1}^{k} b_i X_i + \sum_{i=1}^{k} b_{ii} X_i^2 + \sum_{i<j=2}^{k} b_{ij} X_i X_j \pm e_r. \qquad (1)$$

This assumed surface Y contains linear, squared and cross-product terms of variables Xi 's. In order to estimate the regression coefficients a number of experimental design techniques are available. Box & Hunter [4] have proposed that the scheme based on central composite rotatable design fits the second-order response surfaces very accurately. Lambert & Taraman [14] developed an adequate mathematical model for the cutting force acting on a carbide tool while machining SAE 1018 cold-rolled steel in a turning operation and then utilized the model in the selection of the levels of the machining variables of cutting speed, feed rate, and depth of cut, such that the rate of metal-removal could be at the highest possible value without violating some given force restriction. By using response surface methodology the three independent variables (cutting speed, feed rate and depth of cut) could be investigated simultaneously to study their effects on the cutting force, resulting in considerable saving in time and money over traditional methods of analysis. Taraman [14] investigated multi-machining output multi-independent variable

turning research by response surface methodology. The purpose of this research was to develop a methodology that would allow determination of the cutting conditions (cutting speed, feed rate and depth of cut) such that the specified criterion for each of several machining-dependent parameters (surface finish, tool force and tool life) could be achieved simultaneously. To accomplish this, first mathematical models were developed representing the relationship between the dependent and independent variables of the process. A central composite design was used to develop the models in order to minimize the amount of experimentation. The models were represented by response surfaces and contours of these surfaces were obtained at different levels of each of the independent variables in planes of the other independent variables. By superimposing the contours, a proper combination of the cutting speed, feed rate and depth of cut can be selected to satisfy some specified criteria. Disposable inserts of tungsten carbide were used to turn SAE1018 cold-rolled steel. Hassan & Suliman [33] presented mathematical models for the prediction of surface roughness, tool vibration, power consumption and cutting time, when turning medium carbon steel using tungsten carbide tools under dry conditions. The functional relationships of these variables and the machining-independent variables (cutting speed, feed rate and depth of cut) were established by a second-order polynomial multi-regression analysis. The surface roughness model developed was used as an objective function to establish the optimum cutting conditions while the tool vibration level, power consumption and cutting time were considered the functional constraints. El Baradie [39] presented a study of the development of a surface roughness model for turning grey cast iron (154 BHN) using tipped carbide tools under dry conditions and for a constant depth of cut (d = 1.00 mm). The mathematical model utilizing the response surface methodology was developed in terms of cutting speed, feed rate and nose radius of the cutting tool. These variables were investigated using design of experiments and utilization of the response surface methodology. The turning operation was performed on a 10 h.p. lathe. The work pieces were cast in the form of cylindrical bars 200 mm in diameter and approximately 500 mm in length. The cutting tests were carried out using a tungsten carbide insert (grade K10). Surface roughness measurements were made using a Taylor–Hobson Surtronic surface roughness measuring instrument. A first-order model covering the cutting speed range of 110–350 m/min and a second-order model covering the cutting speed range of 80–495 m/min are presented in this study. Contours of the surface roughness outputs were obtained in planes containing two of the independent variables. These contours were further developed to select the proper combination of the cutting speed and feed rate to increase the metal removal rate without sacrificing the quality of the surface roughness produced.

Table 1 summarizes the traditional and latest optimization techniques discussed in 2.1 and 2.2 for the optimization of process variables in metal machining.

TABLE 1
SUMMARY OF OPTIMIZATION TECHNIQUES.

Technique	Tool used	References	Remarks
Lan-grange,s method	Langrange's multiplier	Brewer [8],Bhatacharya [11]	Used for constrained optimization
Geometric programming	Theory based on the arithmetic inequality	Walve-kar & Lam-bert,pet ropou-luos ,Gopalk rishnan & khayyal	Opimization technique developed for solving a class of nonlinear optimization problem found in engineering design and manufacturing
Goal programming	Goal programming combines the logic of optimization in mathematical programming with the decision maker's desire to satisfy several goals	Sundaram	Form of multi-objective optimization
Form of multi-objective optimization	A collection of algorithms used to compute optimal policies given a perfect model of environment	Agapiou	Solving sequential or multi-stage decision problems by solving a series of single variable problems
Fuzzy logic	Fuzzy interface engine & fuzzification–defuzzification module	Kosko (1997); Klir & Yuan (1998)	Based on a machining model which works on human common-sense reasoning, decisionmaking and other concepts of human cognition
Genetic algorithm	A CGI (common gateway interface) program	Kuo (2002); Wang (2004)	Based on a machining model developed from theoretical analysis, experimental database and numerical methods
Taguchi technique	Design of experiments, Orthogonal arrays, ANOVA,MINITAB.15	Pignatiello (1993); Tsui (1999); Singh & Kumar (2003, 2004, 2005)	Based on actual experimental work and determination of optimum conditions using statistical tools
Response surface methodology	Design expert software (DX6)	Taraman (1974); Hassan & Suliman (1990); Baradie (1993); Noordin (2004)	Based on a machining model developed by mathematical and statistical techniques

3 METHODOLOGY

The main effort are taken as the study of machining parameter like speed, depth of cut and feed rate etc. Also the tool geometry (Rake angle) and design a milling tool for rough milling operation. Development of a relational model to predict the tool life based on machining and geometric parameter by Buckingham's π-theorem. Design of experiment is perform with help of Taguchi method and combination of selected parameters using analysis of variance. Experimental reading are taken form a VMC milling machine. The analysis of theoretical and experimental is perform for the effect of tool life estimation. Before The figure 1 showing method applied to optimize the milling tool of a CNC machine.
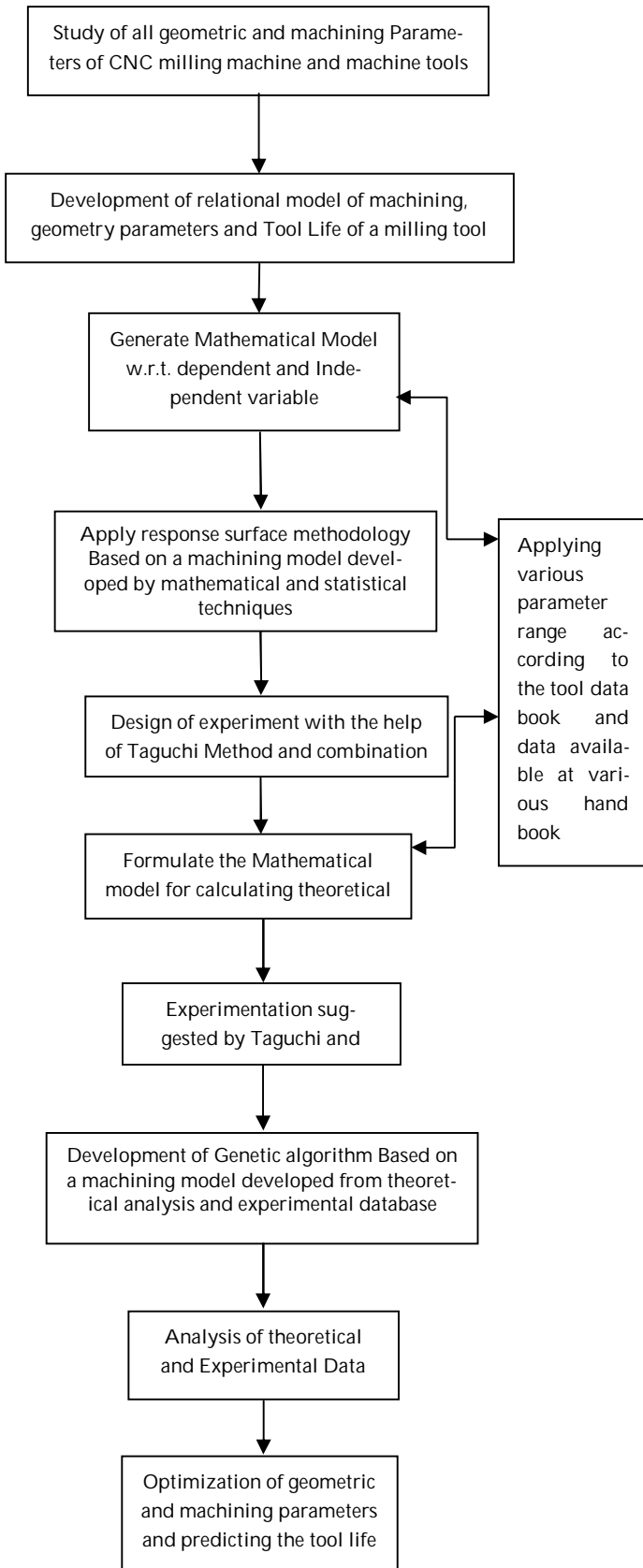
Fig 1. Flowchart Showing Methodology

4 CONCLUSION

The critical review of the literature suggested that inadequate work is done w. r. t. operation time, accuracy, tool life, tool path planning etc. Many researchers are engaged in the study of the shape change, feed rate control and optimize cutting speed in terms of the tool life, tool path generation algorithm of the milling operations. The Maximum effects of the insert run out errors and variation of the feed rate on the surface roughness and dimensional accuracy in face milling operations using surface roughness model, where the optimal feed rate and maximum metal removal rate are determined. Based on the above literature survey the proposed study is focus to design, development & performance optimization of tool for milling operation in CNC.

As the tool life & tool wear is a major problem faced by the industry, it is therefore proposed in the present study that, it gives the direction of development of unified representation schemes that can provide direct 3D models for downstream technological applications and this work not only improves the profit rate but also the production cost and production time.

Generation of algorithm for tool path planning helps to improve the critical shape milling operations and solves the problem of positioning of the work piece. This generalized tool safety software helps to increase the tool life. Also this work may lead to improvement of quality of tool and the tool path planning for milling CNC.

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