# Surface Roughness Optimization Techniques of CNC Turning: A Review

**A.Sathyavathi, M.R.Rajaraman, B.Kumaragurubaran, P.Gopal**

***ABSTRACT-Surface Roughness are generally used as a guide to find out the surface finish for unbroken upgrading of surface quality. A great number of publications by a variety of authors reproduce the significance in this parameters. Reviews of literature on surface roughness optimization have been done in the past by a most of the authors. However, considering the assistance in the recent times, a special review is attempted here. In this paper, the authors have reviewed the literature in a way that would facilitate researchers, academicians and industrials to take an earlier look at the growth, development and applicability of this technique. The authors have reported various papers and have proposed a different scheme of sorting. In count, positive gaps that would offer hints for further research in this playing field have been identified.***

***Keywords: Computer numerial control, Surface Roughness, Optimization, Tool***

## I. INTRODUCTION

Machining operations have been the core of the manufacturing industry since the industrial revolution [1]. The existing optimization researches for computer numerical controlled (CNC) turning were either simulated within particular manufacturing circumstances [2–5] or achieved through numerous frequent equipment operations [6, 7]. Nevertheless, these are regarded as computing simulations, and the applicability to real-world industry is still uncertain. Therefore, a general deduction optimization scheme without equipment operations is deemed to be necessarily developed. The machining process on a CNC lathe is programmed by speed, feed rate, and cutting depth, which are frequently determined based on the job shop experiences. However, the machine performance and the product characteristics are not guaranteed to be acceptable. Therefore, the optimum turning conditions have to be accomplished. It is mentioned that the tool nose runoff will affect the performance of the machining process [8]. Therefore, the tool nose runoff is also selected as one of the control factors in this study.

Manufacturing enterprises presently have to deal with growing demands for improved product quality, greater product unpredictability, shorter product life-cycles, cheap cost, and global struggle . In the field of machining, manufacturers are turning increasingly more often to automation as an effective way to meet these demands. A solution issue for an unattended and automated machining system is the development of reliable and robust monitoring systems. Turning is the removal of metal from the outer diameter of a rotating cylindrical workpiece.

**Manuscript received on June, 2013.**

**A.Sathyavathi**, BIT Campus, University College of Engineering, Tiruchirappalli,620024, TN India.

**M.R.Rajaraman**, BIT Campus, University College of Engineering, Tiruchirappalli,620024, TN India

**B.Kumaragurubaran**, BIT Campus, University College of Engineering, Tiruchirappalli,620024, TN India.

**P.Gopal**, BIT Campus, University College of Engineering, Tiruchirappalli,620024, TN India.

Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. With all the viewpoints above, this paper considers three cutting parameters are cutting depth, feed rate, speed with coated and uncoated tool, the response is to optimize surface roughness in CNC finish turning. In this case, dry machining of aluminium alloy, the machining condition which affect the quality of the generated surface. According to previous works , the various types of surface roughness depend on the nature of the tool, the workpiece material, the cutting conditions and the machining operation. Physical and chemical vapour deposited coatings offer today a powerful alternative to improve further the cutting performance of the cutting materials. The flexibility of coating processes especially of the physical vapour deposition (PVD) method, well supported by the superior and controllable properties of modern coatings are responsible for the almost exclusive world wide application of coated tools . The few of the experimental works was performed finish turning, PVD coated carbide insert at high cutting speed.

To achieve the general optimization, it is necessary to first describe the dynamic behavior of the system to be controlled. Because of the number, complexity, and unclear, vague nature of the variables of the dynamic systems that may influence the decision maker's decision, fuzzy set theory is the most suitable solution [13, 14]. Fuzzy linguistic models permit the translation of verbal expressions into numerical ones [15]. Therefore, the input-output relationship of the process can be described by the collection of fuzzy control rules involving linguistic variables rather than a complicated dynamic mathematical model.

With all the viewpoints above, this paper considers four parameters (cutting depth, feed rate, speed, and tool nose runoff) with three levels (low, medium, and high) to optimize surface roughness in CNC finish turning. The fuzzy control rules using triangle membership function with respective to five linguistic grades for surface roughness are additionally constructed. The defuzzification is then quantified using center of gravity and introduced to Taguchi experiment. Thus, the optimum fuzzy linguistic parameters can then be received. This paper definitely proposes a general deduction optimization approach and satisfactory fuzzy linguistic technique for improving surface roughness in CNC turning with profound insight.

In the next step, the paper outlines the possible methods that can be employed to select or extract which will be used for modelling the machining process. Then, the common design of experiments carried out in the literature to acquire data for modeling purposes is reviewed, and a universal methodology to conduct the experimentation with a minimal number of runs is described. Finally, the last section discusses the GA techniques applied in optimization of machining parameter systems and their advantages and drawbacks as regards facilitating their selection according to the optimization purpose.

## II. METHODOGY

Surface finish is one of the most important quality characteristics in manufacturing industries which influences the performance of mechanical parts as well as production cost. In recent times, modern industries are trying to achieve the high quality products in a very short time with less operator input. For that purpose, the computer numerically controlled (CNC) machine tools with automated and flexible manufacturing systems have been implemented. In the manufacturing industries, various manufacturing processes are adopted to remove the material from the work piece. Out of these, turning is the first most common method for metal cutting because of its ability to remove materials faster with a reasonable good surface quality.

In actual practice, there are many factors which affect surface roughness, e.g., cutting conditions, tool variables and workpiece variables. Cutting conditions include speed, feed and depth of cut where as tool variables include tool material, nose radius, rake angle, cutting edge geometry, tool vibration, tool overhang, tool point angle etc. and workpiece variable include material hardness and other mechanical properties. However, it is very difficult to control all the parameters at a time that affect the surface roughness for a particular manufacturing process. In a turning operation, it is a vital task to select the cutting parameters properly to achieve the high quality performance.

- ***Methodology***
  - Selection of work piece and tool
  - Choosing of suitable parameters
  - Conduct the experiments
  - Model the process
  - Optimization of process parameter
  - Valediction of result

## III. LITREAURE SURVEY

In the field of machining, manufacturers are turning increasingly more often to automation as an effective way to meet these demands.A key issue for an unattended and automated machining system is the development of reliable and robust monitoring systems[1].

It was not possible to carry out the process with it when a high volume of chip per time had to be removed. MQL, however, provide good lubrication for the process and allowed it to be carried out for SR [2].

The machining of aluminium is most important process on industry. Minimal lubrication machining of aluminium alloys is identified and optimization of cutting parameters [3].

Nouari et al proved, The use of diamond as coating material allowed to extend the tool life. The combination of the optimised tool geometry and the cutting conditions entails a high surface quality [4].

Carrilero et al found, The results obtained in this study have allowed the establishment of a first hypothesis about the differences between the mechanisms of BUL and BUE formation [5].

Schneider et al showed,the depth of cut is a significant influence to the tool life. Cutting speed of 60 m/min, feed rate of 0.2 mm/rev, and depth of cut of 0.3 mm are the optimum parameters [6].

Torres et al found, the obtained from the ANFIS model were compared with experimental values. It is found that the predicted values of the responses are in good agreement with the experimental values [7].

Astrand et al showed,the coating layouts and cutting tool edge geometry can significantly affect heat distribution into the cutting tool. The paper clearly shows the role and potential benefits of applying different top coats on the rake and flank faces with regards contact phenomenon, impact on thermal shielding and tool wear [8].

Dong et al investigated, An appropriate coating layout selection is crucial in controlling tool wear, especially in high-speed machining with aid of coated and uncoated tool [9].

Iqbal et al estimated, the SR decreases at low rubbing Speeds and then becomes approximately constant for high rubbing speeds. At these low rubbing Speeds, the estimated values show a dependence on the feed [10].

Grzesik et al found that method of elementary balances multilayer coated cutting tools performamce is better than uncoated tool [11].

Bouzakis et al pointed, Titanium alloy machining performance can be increased byselecting improved cutting tool materials and coated tools [12].

Corduan et al found, PVD coated tool performance is better than the CVD [13].

Özel et al found, the Predicted forces and tool wear contours are compared with experiments. The temperature distributions and tool wear contours demonstrate some advantages of coated insert designs [14].

Vosniakos et al investiagated, optimum condition of machine limitation were identified [15].

Kovacic et al determined that The CNC cutting device should be able to optimise paths autonomously between cutting trajectories, determined by the product's CAD model. An evolutionary GA was used for this purpose [16].

Chao et al formulated that an optimization model for turned parts with continuous forms. Also, a stochastic optimization method based on the simulated annealing algorithm and the pattern search is applied to solving this machining optimization problem. Finally, the applications of the developed machining model and the proposed optimization algorithm are established through the numerical examples [17].

Lin et al proposed that The proposed algorithm is proved to be robust and effective in generating precision tool paths due to its adaptive error correction mechanism. This makes the proposed algorithm suited to serve as an add-on adaptive mechanism to conventional CNC tool path generators [18].

Davim et al found that The chromosomes represent cutting conditions defined according to a temporal scale and are composed by random keys. The merit functions are established based on multicriteria and evaluated using the experimental values obtained for the machining forces, the surface finish and the tool wear. The evolution of the solutions is based on an elitist strategy [19].

Lin et al indicated that the feed had the significance factor affect the surface roughness followed by cutting speed [20].

Meng et al resulted that The approach used should greatly reduce the experimental work needed in collecting tool life data as it allows variations in work material properties and tool geometry to be allowed for independently of experiments [21].

Dhavlikar et al determined, This paper applied combined Taguchi and dual response methodology to determine robust condition for minimization of out of roundness error of workpieces for centerless grinding operation. From the confirmation runs, it was observed that this approach led to successful identification of optimum process parameter values [22].

Kim et al pointed, The results of this work show no apparent relationship between the physical properties and tribological performance of a brake lining [23].

Gen studied that the GA for Engineering design [24].

Saravanan et al proved, The machining performance is measured by the production cost. In this paper the optimal machining parameters for continuous profile machining are determined with respect to the minimum production cost, subject to a set of practical con-straints [25].

Krishnakumar et al approached, Unlike traditional non-linear optimization Methods for fixture optimization reported in the literature, the GA approach is particularly suited for problems where there does not exist a well-defined mathematical relationship between The objective function and the design variables [23].

Vuuren wrote, the GA based heuristic can always give the best results in a short time on workstation [21].

Jindal et al proved, The superior performance of the TiAlN coated tools, which was even greater at higher speeds, is related to the coating's higher resistance to abrasive and crater wear. These characteristics are a result of the higher hot hardness and oxidation resistance of TiAlN at the temperatures normally encountered at the tool tip during machining operations.

Yazid proved that In machining Inconel 718 with PVD TiAlN coated carbide tool, the MQL conditions enhanced the tool life when compared with that of DRY condition.

Bouzakis et al examined, the cutting the speed most influence factor among the machining condition [10].

Bouzakis et al focused that The cutting process is simulated by means of a Finite Elements Method (FEM) parametric model and the stress results illustrate a fatigue prediction that fits to the experimental ones. Data required for the FEM simulation, such as material properties, cutting forces, chip compression ratio etc. are determined experimentally.

## IV.OBJECTIVE

To select or extract which will be used for modelling the machining process. Then, the common design of experiments carried out in the literature to acquire data for modeling purposes is reviewed, and a universal methodology to conduct the experimentation with a minimal number of runs is described. Finally, the last section discusses the GA techniques applied in optimization of machining parameter systems and their advantages and drawbacks as regards facilitating their selection according to the optimization purpose.

## V. CONCLUSIONS

From the literature reviewed. The most of researchers are interested in optimization of machining condition with corresponding surface roughness. In past reviewed found, none of researcher involved for TiBN coated cemented carbide tool. In this paper uncoated carbide tool and PVD (TiBN) coated carbide tool involved for performance of quality of surface and optimization of cutting parameter with aid of DOE and GA.

## REFERENCE

1. S. Y. Liang, R. L. Hecker, and R. G. Landers, "Machining process monitoring and control: The state-of-the-art," Trans. of ASME, J. of Manufacturing Science and Engineering, 126-2, pp. 297-310, 2004.
2. D U Braga, A E Diniz, G.W.A. Miranda, N.L. Coppini, Using a minimum quantity of lubricant (MQL) and a diamond coated tool in the drilling of aluminum-silicon alloys Journal of Materials Processing Technology. 2002, Vol. 122, pg. 127-138.
3. Kelly JF, Cotterell MG (2002) Minimal lubrication machining of aluminium alloys. J Mater Process Technol 120:327–334
4. M. Nouari, G. List, F. Girot, D. Coupard; Experimental analysis and optimisation of tool wear in dry machining of aluminium alloys. Wear, 255 (2003), pp. 1359–1368.
5. MS Carrilero, JMS Sola, JM Sanchez, M. Alvarez, J. Gonzalez, M. Macros; A SEM and EDS insight into the BUL and BUE differences in the turning process of AA2024 Al–Cu Alloy. International Journal of Machine Tools and Manufacture, 42 (2002), pp. 215–220
6. D. Larrouquere, S. Dominiak, D. Dudzinski, Cutting forces and wear in dry machining of Inconel 718 with coated carbide tools , Wear, 2007, http://dx.doi.org/10.1016/j.wear.2006.10.009,
7. Torres CD, Heaney PJ, Sumant AV, Hamilton MA, Carpick RW, Pfefferkorn FE (2009) Analyzing the performance of diamond coated micro end mills. Int J Mach Tool Manuf 49:599–612
8. Astrand M, Selinder TI, Fietzke F, Klostermann H, PVDAl2O3-coated cemented carbide cutting tools, Surf Coat Tech, 2004
9. Dong HY, Huang PJ, Bi YB, Study on the orthogonal cutting process of Al7050T7451 with uncoated and coated Tools, Key Eng Mat, 2009.
10. Iqbal S, Mativenga PT, Sheikh MA, Characterization of machining of AISI 1045 steel over a wide range of cutting speeds. Part 1: investigation of contact phenomena., J Eng Manuf, 2007
11. Grzesik W, Luttervelt CA, Analytical models based on composite layer for computation of tool-chip interface temperatures in machining steels with multilayer coated cutting tools., Ann CIRP Manuf Technol, 2005
12. Bouzakis, K.D., et al., Application in milling of coated tools with rounded cutting edges after the film deposition., CIRP Annals - Manufacturing Technology, 2009.
13. Corduan, N., et al. Wear Mechanisms of New Tool Materials for Ti-6AI-4V High Performance Machining, CIRP Annals – Manufacturing Technology, 2003.
14. Özel, T., et al, Investigations on the effects of multi-layered coated inserts in machining Ti–6Al–4V alloy with experiments and finite element simulations., CIRP Annals - Manufacturing Technology,2010
15. G. Vosniakos, An intelligent software system for the automatic generation of NC programs from wireframe models of 2-1/2D mechanical parts, Comput. Integr. Manufact. Syst., 1998
16. M. Kovacic, J. Balic, Evolutionary programming of a CNC cutting machine, Int. J. Adv. Manufact. Technol. (2002)
17. S. Chao-Ton, C. Mu-Chen, Computer-aided optimization of multi-pass turning operations for continuous forms on CNC lathes, IIE Trans.1999.
18. Y. Lin, An adaptive tool path generation algorithm for precision surface machining, Comput. Aided Des. 1999.
19. J P Davim, C.A. C. Ant´onio, optimization of cutting conditions in the machining of aluminium matrix composites using a numerical and experimental model, Journal of Materials Processing Technology, 2001.
20. W S Lin, B.Y. Lee, C. L. Wu, Modeling the surface roughness and cutting force for turning, Journal of Materials Processing Technology,2001.
21. Q. Meng, JA Arsecularatne, P. Mathew. Calculation of optimum cutting conditions for turning operations using a machining theory, International Journal of Machine Tools and Manufacture, 2000
22. M. N. Dhavlikar, M. S. Kulkarni, V. Mariappan, Combined Taguchi and dual response method for optimization of a centerless grinding operation, Journal of Materials Processing Technology, 2003.
23. S J Kim, K.S. Kim, H. Jang, Optimization of manufacturing parameters for a brake lining using Taguchi method, Journal of Materials Processing Technology,2003.
24. M. Gen, R. Cheng, Genetic Algorithms and Engineering Design, Wiley, Canada, 1997.
25. R. Saravanan, P. Asokan, K. Vijayakumar, Machining parameters optimisation for turning cylindrical stock into a continuous finished

profile using genetic algorithm and simulated annealing, International Journal of Advance Manufacturing Technology, 2003
26. K. Krishnakumar, S.N. Melkote, Machining fixture layout optimization using the genetic algorithm, International Journal of Machine Tools and Manufacture (2000)

A.Sathyavathi M.E (Manufacturing Engg.)Final Year in Anna University College of Engg. , Tiruchirapalli. She received her B.Sc (Chemistry) in the year 1997, completed B.Tech (Production Technology) in the year 2001, is having 5 years of Teaching Experience, is working as Engineering Executive with M/s Classic Industries, Tanjore- Vendor to M/s BHEL, Trichy for Boiler Components Fabrication.

M.R.Rajaraman M.E (Manufacturing Engg.)Final Year in Anna University College of Engg. , Tiruchirapalli. He received his B.E (Mech) in the year 2000, completed M.B.A in the year 2004, is having 13 years of experience in various Engineering Execution Activities, is working as Senior Executive with M/s RSR FABRICATORS, Trichy- Vendor to M/s BHEL, Trichy for Boiler Components Fabrication.

B.Kumaragurubaran is working as an Asst. Professor in in Anna University College of Engineering, Tiruchirappalli. He received his BE from University Of Madras in the year 2003and did his ME from Annamalai University, Chidambaram2005. He is pursuing Ph.D in engineering material. He is having 7 years of experience in the field of teaching. He has attended 18 conferencesand he has published 7 national and international journals. He is life member in Indian Welding Society from 2004.

P.Gopal, B.E.(Mech), M.E.(Auto) is working as an Asst. Professor in Anna University College of Engineering, Tiruchirappalli. He is having 13 years of experience in the field of teaching. He has attended 24 National and international conferences and he has published 8 national and international journals.