A REVIEW ON PARAMETRIC ANALYSIS OF DRY AND WET TURNING ON CNC LATHE USING DESIGN OF EXPERIMENT

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***Abstract*: In recent years, by the progresses in manufacturing industry, great changes have especially been observed in machining of metals. All cutting parameters have already been investigated in order to advancing the properties of cutting tools and machine tools. These researches have improved material removals rate, decreased manufacturing time, improve surface roughness and resulted minimum cutting forces. The effects of dry and wet cuttings have widely been examined on metal machining. In this study, the effects of cutting fluid and dry cutting on surface roughness and cutting force have been examined in CNC turning of EN9 (AISI1055) medium carbon steel material and tungsten carbide P20 grade tool. This paper reviews the research work carried out from the inception to the development of CNC Turning within the past decade. It reports on the CNC Turning research relating to improving performance measures, monitoring and control of process, optimizing the process variables. The paper also discusses the future trend of research work in the same area.**
***Keywords:* CNC turning, Surface Roughness, Cutting Force, Optimization.**

I. INTRODUCTION

In 1947 was the year in which Numerical control was born. In 1949 was the year, the U.S. Air Material command realized that parts for its planes and missiles were becoming more complex. In 1951, the MIT took over the complete job and in 1952; a prototype of NC machine was successfully demonstrated. The term "Numerical Control" was coined at MIT. In 1955 seven companies had tape controlled machines. In 1960, there were 100 NC machines at the machine tool shown in Chicago and a majority of them were relatively simple point to point application. Today there are several hundred sizes and varieties of machines, many options and many varieties of control system available. [1]
There are no. of CNC machines to control through computer programming. CNC lathes are rapidly replacing the older production lathes (multi spindle, etc.) due to their ease of setting, operation, repeatability and accuracy. They are designed to use modern processes. The machine is controlled electronically via a computer menu style interface; the program may be modified and displayed at the machine, along with a simulated view of the process. The operator needs a high level skill to perform the process, however the knowledge base is broader compared to the older production machines where intimate knowledge of each machine was considered essential.

II. TURNING PROCESS

Metal cutting is one of the most extensively used manufacturing processes, and its technology continues to advance in parallel with the developments in material from surface of a work-piece to achieve the desired product. The most common types of cutting process are turning, milling and drilling [1]. Turning is the process of removing material from the outer diameter of the work-piece. In the turning process, the single point cutting tool is moving with a certain velocity while the work-piece is rotating. It is used mainly to produces work-pieces with conical, curved or grooved shapes. The turning process is illustrated in Figure 1.

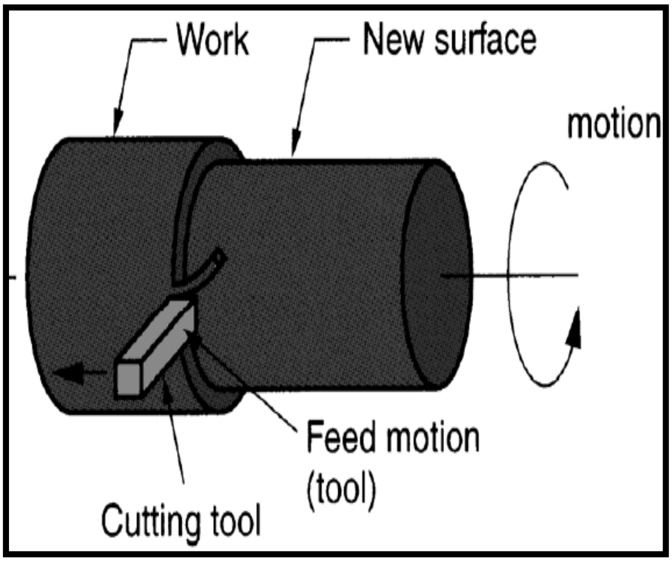

Fig.1. Turning Process.

The turning processes are carried out on a lathe machine and the automatic turning process is performed by the CNC (Computer Numerical Control) lathe machine. The typical cutting tool used in the CNC machine has a replaceable cutting edge (tool insert) [2].

Dry and Wet Turning:
Dry machining means that no cutting fluid is used during process. For economic as well as environmental reasons machining process is carried out without any cutting fluid but dry machining has some disadvantages. During dry machining process, temperature of the cutting tool is very high and this induces excessive tool wear thus decreasing tool life. Also the chips generated at machining cannot wash away and these chips cause deterioration on the machined surface. The problems of cutting fluid contamination and disposal are not seen in dry machining. Dry machining does not induce the pollution of atmosphere or water resources. Contrary to dry machining in wet machining (machining with cutting fluids by any means flooding and MQL), environment, water source and soil become polluted during disposal of the cutting fluid. Application of machining with dry will also diminish the manufacturing costs. [3]

III. TURNING PARAMETERS

A. Input Parameters

The three primary factors in any basic turning operation are speed, feed, and depth of cut. Other factors such as kind of material, type of tool and tool geometry have a large influence, of course, but these four are the ones the operator can change by adjusting the controls, right at the machine.

B. Output Parameters

During the turning process, there is no. of input parameters affecting to the surface roughness, cutting force, tool wear, MRR etc.

IV. LITERATURE REVIEW

A.S.Varadarajan, P.K.Philip (*2000) has investigated on hard turning with minimal cutting fluid application (HTMF) and its comparison with dry and wet turning under parameters of speed, feed and Depth of cut. Research work carried out, the overall performance during minimal cutting fluid application is found to be superior to that during dry turning and conventional wet turning on the basis of cutting force, tool life, surface finish, cutting ratio, cutting temperature and tool–chip contact length by using combination of AISI 4340 steel material and SNMG 120408 with a P30 tool material. [4]

Chrong-Jyh-Tzeng,Yu-Hsin Lin,Ming-Chang Jeng (*2009) has investigated the optimization of CNC turning operation parameters like speed, feed and depth of cut for SKD11 (JIS) using the Taguchi and Grey relational analysis method. The cutting tool is made of carbide and coated with titanium nitride (TiN) and Water-soluble cutting fluids are mixed with water at different ratios depending on the machining operation. The depth of cut was identified to be the most influence on the roughness average and the cutting speed is the most influential factor to the roughness maximum and the roundness. [8]

B.Dilip Jerold and M.Pradip Kumar (*2012) has investigate the performance and influence of cryogenic coolants such as CO2 (carbon dioxide) and LN2 (liquid nitrogen) on cutting temperature, cutting force, tool wear, surface finish and chip morphology in machining of AISI 1045 steel compared to wet machining. Cutting inserts were fixed in PCLNR 2020 K 12 tool holder to carry out the machining process. They have taken process parameters like Cutting velocity, feed and depth of cut. The result was examined by SEM (Scanning Electron Microscope). The results proved that the application of cryogenic coolants reduced the cutting temperature drastically which resulted in appreciable improvement in surface finish of the product and reduced tool wear. [5]

O.Cakir, M.Kiyank, E.Altan (*2004) has investigate the effect of cutting fluid, some gases applications and dry cutting on cutting forces, thrust forces, surface roughness, friction coefficient and shear angle have been examined in turning of AISI1040 steel material. Dry machining, wet machining and machining with oxygen, nitrogen and carbon dioxide gases were carried out under constant cutting speed, three level of feed and depth of cut. The chosen cutting tools were P20 grade TPUN160312 type uncoated inserts and the tool holder was CTGPR2020. It was clear that gas application produced finer surface finish in high feed, although wet machining produced higher surface quality in low feeds. The highest surface roughness was obtained by dry machining. The application of gases produced lower cutting force comparing to dry and wet cutting. Gases applications in turning provided higher shear angle value than dry and wet cutting. [6]

J.M.Zhou, V.Bushlya, J.E.Stahl (*2012) has investigated of surface damage produced by whisker-reinforced ceramic cutting tools in the finish turning of Inconel 718 (nickel-based super alloy). The aim of the present investigation was to study the effects of the cutting parameters (cutting speed, depth of cut and feed), tool wear and Coolant conditions on the surface damage to it occurring during dry and wet turning. In the wet cut, the cutting fluid used was Sitala D 201-03 (Shell) containing 5% of semi-synthetic emulsion in solution The surface generated by machining was examined by use of both a scanning electron microscope (SEM) and a high resolution scanning electron microscope (HRSEM). Cutting with the presence of a coolant generally results in a lesser degree of surface damage than under dry-cut conditions. [7]

Chintan Kayastha, Jaivesh Gandhi (*2013) has optimized Process Parameter in Turning of Copper by Combination of Taguchi and Principal Component Analysis Method. After those different level parameters (combination of feed, spindle speed, depth of cut and side rack angle) was set and turning operation to be carried out. The correlation between MRR and Ra is 0.251. [9]

Gaurav Bartarya, S.K.Choudhary (*2012) has an attempt to develop a force prediction model during finish machining of EN31 steel (equivalent to AISI52100 steel) hardened to 60±2 HRC using hone edge uncoated CBN tool and to analyze the combination of the machining parameters for better performance within a selected range of machining parameters like feed, spindle speed and depth of cut. A full factorial design of experiments procedure was used to develop the force and surface roughness regression models, within the range of parameters selected. The response surface analysis showed that forces first decreased and then increased with increase in cutting speed. [13]

Vishal Francis, Ravi. S .Singh, Nikita Singh, Ali. R. Rizvi, Santosh Kumar (*2013) has optimized Process Parameter for MMR and surface roughness in turning operation by Combination of Taguchi and ANOVA Method. The Experiment was performed by high speed steel tool and mild steel work-piece in dry cutting condition. Spindle peed was found to be most significant parameter for MRR. [11]

Ilhan Asilturk, Harun Akkus (*2011) has optimizing turning parameters based on the Taguchi method to minimize surface roughness (Ra and Rz). Work piece made of AISI 4140 grade (DIN 42CrMo4) steel was used. The tool holder used was model MWLNR 2525M-0.8W. Al2O3 and TiC-coated (WNMA 080408) inserts were used as the cutting tool material. According to the ANOVA analysis, the feed rate has an effect on Ra and Rz. [12]

Mr.Ballal Yuvraj, Dr.Inamdar K.H. and Mr.Patil P.V (*2011) has described use and steps of Taguchi design of experiments and orthogonal array to find a specific range and combinations of turning parameters like cutting speed, feed rate and depth of cut constant (2mm) to achieve optimal values of response variables like surface finish, tool wear, material removal rate by using ANOVA in turning of Brake drum of FG 260 gray cast iron Material. The tool material was Carbide inserts K10 series uncoated and TiCN and TiAlN coated type and tool geometry (CNMA). [14]

H.M.Somashekara and Dr.N.Lakshmanaswamy(*2012) has obtained an optimal setting of Turning parameters Cutting speed in rpm, Feed in mm/re and Depth of Cut in mm which results in an optimal value of and ANOVA analysis were also performed to obtain significant factors influencing Surface Roughness. Surface Roughness while machining Al 6351-T6 alloy with Uncoated Carbide Inserts (TNMG 160408). Several statistical modeling techniques have been used to predict Surface Roughness using Regression Technique. Also an attempt has been made to optimize the process parameters using Taguchi Technique S/N ratio. [15]

W.H.Yang, Y.S.Tarng(*1997) has investigated from the Taguchi method to design optimization for quality, is used to find the optimal cutting parameters for turning operations like Cutting speed, feed and Depth of Cut . An orthogonal array, the signal-to-noise (S: N) ratio, and the analysis of variance (ANOVA) are employed to investigate the cutting characteristics of S45C steel bars using tungsten carbide cutting tools. The improvement of tool life and surface roughness from the initial cutting parameters to the optimal cutting parameters were about 250%. [16]

Hyun Wook Lee and Won Tae Kwon (*2010) has investigated from the Taguchi method to determine the rough region first, followed by RSM technique to determine the exact optimum value for turning parameters like Cutting speed in m/min, Feed in mm/rev and Depth of Cut in mm. Commercial inserts of P20 (tungsten carbide insert) and AB30 (Ceramic insert) with the specification of SNGN120408 were used for turning the work materials, SM45C (AISI45) and SCM440. To achieve the goal, the result from the Taguchi method has been fed to train the artificial neural network (ANN). In a separated experiment, it has been shown that the obtained cutting condition from RSM gives a better result than that from the Taguchi method. [17]

M. Nalbant, H. Gokkaya and G.Sur (*2006) has investigated from the Taguchi method to find the optimal cutting parameters for surface roughness in turning. The analysis of variance has been employed to study the performance characteristics in turning operations of AISI 1030 steel bars using TiN coated tools (inserts were TNMG160404-MA, TNMG160408-MA and TNMG160412-MA). Three cutting parameters namely, insert radius, feed rate, and depth of cut, has been optimized with considerations of surface roughness. In turning, use of greater insert radius has been recommended to obtain better surface roughness for the specific test range. The improvement of surface roughness form initial cutting parameters to the optimal cutting parameters was about 335%. [18]

M. Seeman, G. Ganesan, R. Karthikeyan and A. Velayudham (*2009) has attempted made to model the mach inability evaluation through the response surface methodology and regression analysis. The LM 25 aluminum alloy reinforced with green-bonded silicon carbide particles of size 25μm with 20% volume fraction manufactured through stir-casting route was used for experimentation. The ISO specification of the tool used for the turning operation was WIDAX tool holder PT GNR 2525 M16. The insert used was uncoated carbide tool insert (K10) with the following specifications: TNMG 160404 IC 428. The combined effects of four machining parameters including cutting speed in m/min, feed rate in mm/rev, depth of cut in mm and machining time in min on the basis of two performance characteristics of flank wear (VB max) and surface roughness (Ra) were investigated. The process parameters are optimized using desirability-based approach response surface methodology. The surface roughness was significantly affected by BUE formation at low speeds. The surface increases the increase in surface roughness. 4. The optimal machining parametric combination has been obtained using desirability function. [10].

V. FUTURE DIRECTION OF CNC TURNING RESEARCH

The major research areas in CNC Turning are discussed in previous sections. Researchers have contributed in different directions but due to complex nature of the process a lot of works are still required to be done. The CNC Turning process is a suitable machining option in meeting the demands of today's modern applications. It is the basic operation of CNC lathe machine. All the researchers concentrated on the surface roughness and MRR by using basic main three parameters like speed, feed rate and depth of cut. Researchers have work done either dry turning or wet turning only. Some researchers has work done both dry and wet turning but they was examined the surface roughness, tool wear, chip formation by using a scanning electron microscope (SEM) or a high resolution scanning electron microscope (HRSEM). Few researchers were used optimization method to optimize the turning parameters. No literature available so far for side rake angle parameter and more work is required to be done in this area.

VI. CONCLUSION

The objective of this study is to obtain optimal turning parameters (Constant cutting speed, feed rate, depth of cut and side rake angle) for minimum surface roughness and cutting force in dry turning and wet turning process, while turning EN9(AISI1055) medium carbon steel material and tungsten carbide P20 grade tool. A full factorial design of experiments procedure was used to develop the surface roughness and cutting force regression models, within the range of parameters selected. The regression models developed show that the dependence of the surface roughness and cutting force on machining parameters is significant, hence they could be used for making prediction and analyses of variance (ANOVA) are employed to investigate the cutting characteristics.

REFERENCES

[1] S. Kalpakjian and S. R. Schmid. Manufacturing Engineering and Technology 5th ed. Upper Saddle River, NJ: Prentice Hall, 2006.
[2] S. Kalpakjian. Manufacturing process for engineering material, 3rd ed. Menlo Park, CA: Addison-Wesley Longman, 1997.
[3] E.O. Ezugwu. "Key improvements in the machining of difficult-to-cut aerospace superalloys." International Journal of Machine Tools and Manufacture, vol.45 (12-13), pp. 1353-1367, Oct 2005.
[4] A .S. Varadarajan, P.K.Philip, B.Ramamoorthy," Investigations on hard turning with minimal cutting fluid application (HTMF) & its comparison with dry & wet turning." International Journal of Machine Tools & Manufacture 42 (2002) 193–200.
[5] B. Dilip Jerold, M. Pradeep Kumar," Experimental comparison of carbon-dioxide and liquid nitrogen cryogenic coolants in turning of AISI 1045 steel." Cryogenics 52 (2012) 569–574.
[6] O. Çakır a, M. Kıyak b, E. Altan b," Comparison of gases applications to wet and dry cuttings in turning." Journal of Materials Processing Technology 153–154 (2004) 35–41.
[7] J.M. Zhou, V. Bushlya, J.E. Stahl," An investigation of surface damage in the high speed turning of Inconel 718 with use of whisker reinforced ceramic tools." Journal of Materials Processing Technology 212 (2012) 372– 384.
[8] Chorng-Jyh Tzenga, Yu-Hsin Linb, Yung-Kuang Yanga,, Ming-Chang Jengc," Optimization of turning operations with multiple performance characteristics using the Taguchi method and Grey relational analysis ." journal of materials processing technology 2 0 9- 2753–2759.
[9] Chintan Kayastha, Jaivesh Gandhi," Optimization of Process Parameters in Turning of Copper by Combination of Taguchi and Principal Component Analysis Method." International Journal of Scientific and Publications, Volume 3, Issue 6, June 2013 ISSN 2250-3153
[10] M. Seeman & G. Ganesan & R. Karthikeyan & A. Velayudham," Study on tool wear and surface roughness in machining of particulate aluminum metal matrix composite-response surface methodology approach." Int J Adv Manuf Technol (2010) 48:613–624.
[11] Vishal Francis, Ravi. S. Singh, Nikita Singh, Ali .R. Rizvi, Santosh Kumar," Application of Taguchi method And ANOVA Optimization of Cutting Parameters for Material Removal Rate and Surface Roughness in Turning Operation. "International Journal of Mechanical Egg. And Technology.
[12] Ilhan Asilturk, Harun Akkus," Determination the effect of cutting parameters on surface roughness in hard turning using the Taguchi method." Measurement 44- (1697-1704)
[13] Gaurav Bartarya, S.K.Choudhary," Effect of cutting parameters on cutting force & surface roughness during finish hard turning AISI 52100 grade steel." Procedia CIRP 1 (2012) 651-656.
[14] Mr. Ballal Yuvaraj P, Dr. Inamdar K.H, Mr. Patil P.V," Application of taguchi method for design of experiments in turning gray cast iron." International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 2, Issue 3, pp.1391-1397.
[15] H.M.Somashekara, Dr.N.Lakshmana Swamy," Optimization surface roughness in turning operation using taguchi technique and ANOVA." International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462, Vol.4.
[16] W.H. Yang, Y.S. Tarng," Design optimization of cutting parameters for turning operations based on the Taguchi method." Journal of Materials Processing Technology 84 (1998) 122–129.
[17] Hyun Wook Lee and Won Tae Kwon," Determination of the minute range for RSM to select the optimum cutting conditions during turning on CNC lathe." Journal of Mechanical Science and Technology 24 (8) (2010) 1637-1645.
[18] M. Nalbant, H. Go kkaya, G. Sur," Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning." Material and Design 28 (2007) 1379-1385.

