A Review: Effect of various parameters in metal cutting

Kulbir Singh
Kulbir.gjgi@gmail.com
Department of Mechanical Engg.
Govt. Polytechnic College Bathinda

ABSTRACT- ***This paper describes a review of basic terms and visualizations of the major components of the cutting tool geometry in orthogonal turning process. The parameters like rake angle, depth of cut, feed rate, temperature and cutting speed are taken in to account so as to predict their effects on tool life. Their influences on cutting forces and tool geometry have also been referred***

***KEYWORDS*:** Rake angle, depth of cut, cutting speed, residual stresses and tool wear.

1. INTRODUCTION

In metal turning process, all cutting tools remove a certain layer of material and impart the required shape, size and surface quality to the work piece. Variety of cutting tools has been developed to satisfy the requirements of production for its smooth running. All dimensions and shapes are determined either analytically or graphically during design of cutting tools. For effective production, many researches were carried out in the past and many are continuing for the purpose of decreasing production cost and manufacturing parameters without reducing product quality. In this paper mainly orthogonal metal cutting process is considered. In this process cutting is done at exactly 90 degrees. The various cutting parameters mainly described are:

- Rake angle
- Depth of cut
- Feed rate
- Cutting speed

Rake angle have a great affect on the cutting forces. Increasing and decreasing or keeping the rake angle negative and positive the cutting force and power thereby increases and decreases respectively. When the back rake angle increases, the cutting force decreases, because of small shear strain. When the negative rake angle is used, the shear strain is more, but for practical range, the negative rake angle has higher cutting force than positive rake angles. Rake angle is a parameter used in various cutting and machining processes, describing the angle of the cutting face relative to the work. The two rake angles, namely the back rake angle and side rake angle, both of which help to guide chip flow. There are three types of rake angles: positive, negative, and zero.

Generally, positive rake angles:

Make the tool more sharp and pointed. This reduces the strength of the tool, as the small included angle in the tip may cause it to chip away.

Reduce cutting forces and power requirements.

Helps in the formation of continuous chips in ductile materials.

Can help avoid the formation of a built-up edge.

Negative rake angles, by contrast:

Make the tool more blunt, increasing the strength of the cutting edge.

Increase the cutting forces.

An increase friction, resulting in higher temperatures.

Can improve surface finish.

A zero rake angle is the easiest to manufacture, but has a larger crater wear when compared to positive rake angle as the chip slides over the rake face.

Depth of cut: Cutting speed and feed rate come together with depth of cut to determine the material removal rate, which is the volume of work piece material that can be removed per unit time

Feed rate: Feed rate is the velocity at which the tool is fed, that is, advancement of cutting tool against the work piece. It is expressed in units of distance per revolution for turning.

Cutting speed: Cutting speed (surface speed or simply speed) may be defined as the relative speed between the cutting tool and the surface of the work piece.

All these above mentioned parameters have some effect on the cutting tool during cutting. A schematic diagram of tool and work piece is as drawn:

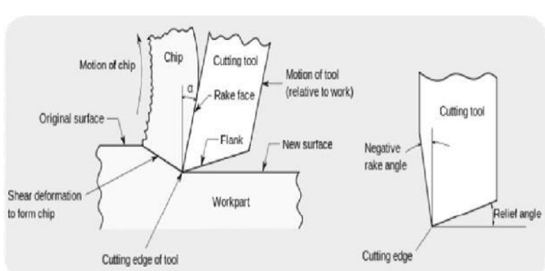

Figure 1: Schematic diagram of tool and work piece.

2. AIMS AND OBJECTIVES OF WORK

Rake angle is a parameter used in various cutting and machining processes, describing the angle of the cutting face relative to the work. Realistically, the rake angle is not an independent variable in the process of tool geometry selection because the effect of the rake angle depends upon other parameters of the cutting tool geometry and the cutting process. The aims and objectives of the present study are as follows:-

- To study the influence of rake angle on metal turning process
- To evaluate the cutting forces.
- To evaluate tool wear and to minimize it.
- To minimize residual stresses.

3. LITERATURE REVIEW

Many surveys have been done considering different rake angles. Researchers have long investigated its effect on cutting forces, temperature and tool life etc. The works of various authors from various fields have been referred from 2000 onwards. In this paper, previous research and important findings in the orthogonal machining process is critically reviewed.

Peng Lo 2000[1] worked on the elastic plastic finite element method so as to investigate the effect of the tool rake angle on the chip formed and the machined work piece in precision cutting process. In this regard cutting simulations were performed under various tool rake angles in order to find the effect on cutting force, the geometric shapes of the chip, equivalent stress distribution, residual stress and the work surface. The results indicates that with increase in rake angle cutting force, maximum equivalent strain on the section decreases and top of the chip contour becomes smoother.

Axinte et al. 2001 [2] in turning process, they proposed a methodology of evaluating those uncertainty components of a single cutting force measurement that are related to the contributions of the dynamometer calibration and the cutting process itself. On the basis of empirical model including errors from both the sources, the uncertainty for a single measurement of cutting force, and expressions for the uncertainty vs. cutting parameters are presented. For defined range of cutting parameters approach gives the possibility of evaluating cutting force uncertainty components, on the basis of few experiments.

McClain et al. 2002 [3] focused on the shear and normal stress distribution in orthogonal metal cutting by the help of FEM (Finite Element Model).

Sikdar and Chen 2002 [4] focused on the relationship between flank wear area and cutting forces for turning operations on a CNC lathe without coolant. Flank wear surface area was measured by Talysurf TM series using a software package whereas cutting forces by Kistler TM piezo-electric dynamometer. The experimental results shows that cutting forces increase with the increase of the flank wear surface area, greater the flank wear area, the higher will be the friction between the tool and the work piece resulting in high heat generation, this ultimately raises the value of cutting forces.

Shi et al. 2002 [5] studied the orthogonal cutting with finite element method under plane strain conditions. The effect of friction on thermo mechanical quantities in an orthogonal metal cutting process is presented. Using modified Coulomb friction law a series of finite element simulations have been performed in which tool rake angle from 15◦ up to 30◦ and a friction coefficient from 0.0 to 0.6 is taken in to consideration and finally found that general purpose finite element code ABAQUS can be used to simulate the orthogonal metal cutting process and further chip formation, the shear angle of primary shear zone, raise in temperature and required cutting force, and all depend strongly on the coefficient of friction and on the rake angle.

Fang and Jawahir 2002 [6] predicted three important machining parameters, i.e. the cutting force ratio, chip thickness, and chip back-flow angle, on the basis of: the universal slip-line model, a maximum value principle in order to determine the state of stresses in the plastic region in restricted contact machining, Dewhurst and Collins' matrix technique and Powell's algorithm for non-linear optimizations and by correct implementation of these techniques it is found that the parameters cutting force, chip thickness, chip back-flow angle can easily be determined.

F**ang** 2002 [7] proposed a slip-line model in favor of the tool–chip contact on the tool secondary rake face. Chip curl in machining was also taken in to account. This model Powell's algorithm of nonlinear optimization and Dewhurst and Collins's matrix technique for numerically solving slip-line problems was employed in the mathematical formulation of the model.

Again Fang 2002 [8] discussed and analyzed the forces, chip thickness, and natural tool–chip contact length in machining with a double-rake-angled tool and demonstrated that double-rake-angled tool increases the thrust forces in comparison with single rake angled tool. It is found that tool–chip friction on the tool secondary rake face plays an important role in machining than the tool–chip friction on the tool primary rake face. They developed a interrelationships among the resultant force, the chip thickness, and the natural tool–chip contact length which further provided a new and effective method to estimate the tool–chip contact length by implementing the resultant force.

Similarly, **Shet and Deng** 2003 [9] presented a finite element method to simulate and to analyze the orthogonal metal cutting process under plane strain conditions, with main attention on the residual stress and strain fields in the finished work piece. Various modeling options have been employed. Considering material properties, range of tool rake angle and friction coefficient values it has been found that thermal cooling increases the residual stress level whereas effects of the rake angle and the friction coefficient are nonlinear and the observed residual stress results were finally compared with experimental results.

Tool chip length is one of the important parameter in orthogonal cutting. **Toropov and Lim Ko** 2003[10] they proposed a new formula for tool chip contact length as a result there is same correspondence between theoretical and experimental results. This research could also be helpful for the analysis of, temperature phenomena, tool strength and wear problems.

Huang and Liang 2003 [11] focused on the finish turning in which the applied feed rate and depth of cut are usually very small. They initially predicted the chip formation forces by transforming the 3-D cutting geometry into an equivalent 2-D cutting geometry and after that calculated the total 2-D cutting forces by ploughing effect mechanistic model and finally then 3-D cutting forces are estimated by a geometric transformation.

Dahlman et al. 2004 [12] showed that rake inclination had the strongest influence on the residual stresses in turning. The residual stresses were measured by using the X-ray diffraction method in both speed and feed direction and concluded that greater negative rake angle gives higher compressive stresses and cutting depth does not affect residual stresses. Further it has been shown that compressive stresses become greater with increased feed rate.

Yen et al. 2004 [13] focused the effects of edge preparation of the cutting tool (round and chamfer edge) on chip formation, cutting forces, and process variables like temperature, stress, and strain etc. in orthogonal cutting. With finite element method (FEM) simulations a fundamental understanding of the process mechanics with realistic cutting tool edges were provided, also it is possible to estimate the values of process variables that are very difficult to measure by experiment not measurable for cutting. On the basis of results carried out from the cutting simulation model, an analysis of tool wear is also possible as it is directly related to cutting temperature, stresses and chip sliding velocity.

Gunay and Aslan 2005 [14] presented an experimental study of the influence of tool rake angle on the main cutting force for machining rotational parts by sharp cutting tools on well-known material, AISI 1040 .A force measuring dynamometer was used for this purpose. Depending upon eight different rake angles ranging from negative to positive and five cutting speeds main cutting force (*F*c) was measured while keeping depth of cut and feed rate constant. Based on this study main cutting force was reduced by increasing rake angle in positive and was increased by increasing rake angle in negative values. The results finally obtained are presented below

In view of the induced cutting forces **Topal and Cogun** 2005 **[**15] focused to compensate the cutting force induced dimensional work piece errors in CNC turning operations. Cutting forces were measured and recorded by a computer for standard specimens and a strain gauge based cutting force dynamometer was used. The Chi Square test results holds good to reduce the cutting forces induced work piece diameter error by 90% approximately.

Again Fang 2005 [16] dependent upon Lee and Shaffer's physical slip-line model, the researcher presented mechanism to investigate that how negative tool rake angle and the cutting speed can affect the tool-chip friction, and how the tool-chip friction further affects machining performances, like chip thickness ratio, the ratio of the cutting force to the thrust force, geometry of shear zone etc. It is also shown that with increase in the cutting speed the size of the stagnation zone decreases.

Majumdar et al.2005 [17] focused on the influences of the heat generation during metal cutting processes and its effects on cutting forces and tool wear. For this purpose they developed a finite element based computational model in order to determine the temperature distribution in a metal cutting process on high-speed carbon steel. Results shows that as cutting speed increases from 29.6 m/min to 155.4 m/min maximum temperature in the tool will also increase from 709.36 K to 1320 K. The model also describes significant effect of conduction and convection losses in heat dissipation and temperature rise in the tool.

Sutter 2005 [18] in orthogonal turning process at very high speeds investigated the chip geometries formed during cutting by the help of high speed numerical camera with a very short time aperture.

Dogu et al. 2006 [19] in this paper they concentrated on the temperature distribution in orthogonal metal cutting using finite elements method. By assuming that all the work required for cutting is converted to the sensible heat energy amount of heat generation is then calculated. The model accurately predicts temperature field over the entire cutting zone (primary, secondary and sliding frictional zone). They showed that during cutting the convective heat transfer coefficient is very high for forced flow and it is of the order of 10–500 and 100–15,000 W/ (m2 ◦C) for forced air and water flows, respectively whereas on the other hand, if coolant is not used during the cutting process, the free convective heat transfer coefficient is small ranging from 5–25 W/ (m2 ◦C).The thermal aspects of orthogonal metal cutting were discussed.

One of the problems usually seen in turning processes is the elastic deformation of the work piece due to the cutting forces resulting in the actual depth of cut being different than the required one in regard of this **Benardos et al.** 2006[20] suggested two approaches: firstly, the analytical model which requires input about the mechanical properties of the material, cutting force values and the detailed geometry of the work piece. Secondly, use of Artificial Neural Networks (ANNs) to develop a model that can predict the dimensional deviation of the final product by relating the cutting parameters and certain work piece geometrical characteristics with the deviations of the depth of cut. The deviations were calculated with precision micrometers or on a CMM (Coordinate Measuring Machine).

Son et al. 2006 [21] showed that because of large rake angle there is unstable cutting process without continuous chip. In this investigation, they applied vibration cutting method for the possibility to reduce the minimum cutting thickness by changing the friction coefficient between tool and work piece. The vibration cutting method is applied to increase the friction coefficient. On the basis of theoretical investigation and experimental verification results show that the cutting technology is efficient by decreasing the minimum cutting thickness and increasing the friction coefficient. Depending upon materials and vibration conditions the minimum cutting thickness was considerably reduced by 0.02–0.04 mm.

Saglam et al. 2006 [22] worked on the measurement of cutting forces and tool tip temperature and also evaluated the effects of feed rate, cutting tool geometry, rake angles and approaching angles on these cutting forces.

Abukhshim et al. 2006 [23] reviewed the previous research on heat generation, heat dissipation and temperature measurement techniques in the orthogonal metal cutting process. They also focused on new temperature measurements results recorded by a thermal imaging camera in high speed cutting.

Boud 2007 [24] analyzed the tool wear in metal turning. In all experiments the factors such as cutting speeds, feed rate and depth of cut were constant and the tests was performed on the same bar except the varying the bar diameter and concluded that bar diameter has an influence on tool temperature.

Fang and Fang 2007 [25] worked on the theoretical and experimental results in finish machining with a rounded edge tool. The analytical results concludes that with increase in cutting speed and feed rate the tool-chip friction along tool rake face and the round tool edge decreases on the other hand the FE (Finite Element) shows that near the round tool edge high temperature exists there.

Maity and Swain 2008 [26] investigated the tool life a function of feed, cutting speed, depth of cut and temperature. The experiment was carried out for hot-machining of high manganese steel. Carbide tool was used for analysis. Finally it has been found out that tool life is influenced by cutting speed, depth of cut and temperature and also the chip-reduction coefficient decreases with increase in temperature.

Lalwani et al. 2008 [27] investigated the influence of certain parameters like feed rate, cutting speed and depth of cut on cutting forces in finish hard turning.

Yanda et al. 2010 [28] focused on the effectiveness of rake angle. They found that cutting force decreases by increasing rake angle in positive side whereas cutting force increases by increasing rake angle in negative side.

Asilturk and Akkus 2011 [29] surveyed on optimizing turning parameters based on the Taguchi method to minimize the surface roughness. They carried dry turning tests on hardened AISI 4140 (51 HRC) with coated carbide cutting tools. To ensure accurate readings of the surface roughness each experiment is repeated three times. They applied statistical methods of signal to noise ratio (SNR) and the analysis of variance (ANOVA) to investigate effects of cutting speed, feed rate and depth of cut on surface roughness. They concluded that the feed rate has the most significant effect on Ra and Rz. The model they developed can be helpful in the metal machining industries in order to find out the optimum cutting parameters for minimum surface roughness.

Totis and Sortino 2011 [30] worked on the measurement of cutting forces in turning by specifically designed an innovative dynamometer for tri axial cutting on modern CNC lathes. The measured cutting forces were finally compared with theoretical values obtained from mathematical modeling.

Dogra et al. 2011 [31] focused on the effect of cutting tool geometry (tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry) on tool wear, surface roughness and surface integrity of the machined surface in turning. Results of this paper shows that an increase of chamfer angle will increase the tool life up to certain value and after that the tool life decreases, size of tool edge radius affects the mechanics of cutting, tool nose radius affects the surface roughness, residual stresses of machined surfaces and with increase in absolute value of negative tool rake angle and cutting speed the tool-chip friction τ/k decreases.

Kosaraju et al. 2011[32] presented the effects of rake angle and feed rate on cutting forces in orthogonal metal cutting process. On the basis of results they found that with increase in feed rate and rake angle cutting force increases and decreases respectively.

Jana and Mandal 2011 [33] focused on the tool setting and cutting tool angle so as to get better results in the form of good quality product (work piece) and hence to achieve accuracy.

Neseli et al. 2011 [34] in this paper they worked on the investigation that how surface finish can be effected by tool geometry in metal turning process. The results show that tool nose radius, rake angle and approach angle are the significant factors that affect surface finish.

Szabo and Kundrak 2011 [35] investigated the effect of rake angle on chip removal in turning. They by changing the values of rake angles found its effect on residual stresses also.

Navas et al. 2012 [36] in AISI 4340 steel they studied the effect on the final surface stress. The surface residual stresses have been measured by the help of X-ray diffraction, on different cutting speeds (between 200 and 300 m/min), cutting feeds (between 0.075 and 0.200 mm/rev), two different nose radius (0.4 and 0.8 mm), two different surface states one coated with CVD and the other without coating and two different geometries of the chip breaker. It has been found that residual stresses are more tensile due to an increase in cutting temperature with increase in feed. Residual stresses tend to be less tensile at speeds 200 and 300 m/min as the cutting speed increases. Further it has been shown that final stress state generated in the part is affected by the geometry of the tool chip breaker. with HSS (high speed steel). The main purpose was to save energy and useful production time during regrinding and re-sharpening of tools and energy is being wasted due to regrinding or re-sharpening of tools when cutting tools got worn or blunt. The rake angle which can give the longest tool life was then selected and observed that rake angle having value of [illegible] as well as the best surface finish and yielded continuous chips formation.

Bartarya and Choudhury 2012 [38] reviewed some of the basic aspects like cutting parameters, cutting tool geometry and tool material and their effects on tool forces.

4. DISCUSSION

From the literature review it has been found that the cutting parameters (rake angle, depth of cut, feed rate, temperature and cutting speed) have considerable effects on the tool life. With the increased in positive rake angle, the cutting forces are decreased which means that less force/power is required. The results also suggest that the rake angles and the approaching angles influence the temperature on the tool and the chip interface. Because chip flow is directed by both the angles, hence by the optimum designs of both angles, not only the cutting forces are controlled but also the tool tip temperature as well.

5. CONCLUSION

The topics of this study focus on the reviews of experimental influence of cutting depth and tool rake angle on the main cutting force during the turning process. The results obtained from the literature survey it is found that:

- The cutting force decreases as the tool rake angle increases.
- With increase in feed rate, this tends increase in cutting force.
- The increase in absolute value of negative tool rake angle and cutting speed these results in the decrement of tool chip friction.
- The tool tip temperature increases with an increase in cutting speed.

The results of this review suggests that rake angle and approaching angle have a considerable effect on cutting forces and the tool tip temperature. As chip flow is directed by both the angles, hence with the optimum design of these two angles, not only the cutting forces, but also tool tip temperature can be controlled.

REFRENCES

[1.] Ship-Peng Lo, "An analysis of cutting under different rake angles using the finite element method" Journal of Materials Processing Technology, 105; 43-151, 2000.

[2.] D.A. Axinte, W. Belluco, L. De Chiffre ,"Evaluation of cutting force uncertainty components in Turning" International Journal of Machine Tools & Manufacture 41,pp. 719–730, 2001.

[3.] Ben McClain, Stephen A. Batzer, G. Ivan Maldonado, "A numeric investigation of the rake face stress distribution in orthogonal machining" Journal of Materials Processing Technology 123,pp. 114-119, 2002.

[4.] Sumit Kanti Sikdar, Mingyuan Chen, "Relationship between tool flank wear area and component forces in single point turning" Journal of Materials Processing Technology 128,pp.210–215, 2002.

[5.] Guoqin Shi, Xiaomin Deng, Chandrakanth Shet, "A finite element study of the effect of friction in orthogonal metal cutting" Finite Elements in Analysis and Design 38,pp. 863–883, 2002.

[6.] N. Fang a, I.S. Jawahir, "Analytical predictions and experimental validation of cutting force ratio, chip thickness, and chip back-flow angle in restricted contact machining using the universal slip-line model" International Journal of Machine Tools & Manufacture 42,pp. 681–694, 2002.

[7.] N. Fang, "Machining with tool–chip contact on the tool secondary rake face—Part I: a new slip-line model" International Journal of Mechanical Sciences 44,pp. 2337–2354, 2002.

[8.] N. Fang, "Machining with tool–chip contact on the tool secondary rake face—Part II: analysis and discussion" International Journal of Mechanical Sciences 44,pp. 2355–2368, 2002.

[9.] C. Shet, X. Deng, "Residual stresses and strains in orthogonal metal cutting" International Journal of Machine Tools & Manufacture 43,pp. 573–587, 2003.

[10.] Andrey Toropov, Sung-Lim Ko, "Prediction of tool-chip contact length using a new slip-line solution for orthogonal cutting" International Journal of Machine Tools & Manufacture 43,pp. 1209–1215, 2003.

[11.] Yong Huang, Steven Y. Liang, "Force modeling in shallow cuts with large negative rake angle and large nose radius tools—application to hard turning" Int J Adv Manuf Technol 22 ,pp. 626–632, 2003.

[12.] Patrik Dahlman, Fredrik Gunnberg, Michael Jacobson, "The influence of rake angle, cutting feed and cutting depth on residual stresses in hard turning" Journal of Materials Processing Technology 147,pp. 181–184, 2004.

[13.] Yung-Chang Yen, Anurag Jain, Taylan Altan , "A finite element analysis of orthogonal machining using different tool edge geometries" Journal of Materials Processing Technology 146,pp. 72–81, 2004.

[14.] Mustafa Gunay, Ihsan Korkut, Ersan Aslan, Ulvi Seker, "Experimental investigation of the effect of cutting tool rake angle on main cutting force" Journal of Materials Processing Technology 166 ,pp. 44–49, 2005.

[15.] Eyup Sabri Topal , Can Cogun, "A cutting force induced error elimination method for turning operations" Journal of Materials Processing Technology 170 ,pp. 192–203, 2005.

[16.] N. Fang, "Tool-chip friction in machining with a large negative rake angle tool" Wear 258,pp. 890–897, 2005.

[17.] Pradip Majumdar, R. Jayaramachandran, S. Ganesan, "Finite element analysis of temperature rise in metal cutting Processes" Applied Thermal Engineering 25, pp. 2152–2168, 2005.

[18.] G. Sutter, "Chip geometries during high-speed machining for orthogonal cutting conditions" International Journal of Machine Tools & Manufacture 45, pp. 719–726, 2005.

[19.] Yahya Dogu, Ersan Aslan, Necip Camuscu, "A numerical model to determine temperature distribution in orthogonal metal cutting" Journal of Materials Processing Technology 171,pp. 1–9, 2006.

[20.] P.G. Benardos, S. Mosialos, G.-C. Vosniakos, "Prediction of workpiece elastic deflections under cutting forces in turning" Robotics and Computer-Integrated Manufacturing 22,pp. 505–514, 2006.

[21.] SeongMin Son, HanSeok Lima, JungHwan Ahn, "The effect of vibration cutting on minimum cutting thickness" International Journal of Machine Tools & Manufacture 46,pp. 2066–2072, 2006.

[22.] Haci Saglam, Faruk Unsacar, Suleyman Yaldiz, "Investigation of the effect of rake angle and approaching angle on main cutting force and tool tip temperature" International Journal of Machine Tools & Manufacture 46,pp. 132–141, 2006.

[23.] N.A. Abukhshim, P.T. Mativenga, M.A. Sheikh (2006) "Heat generation and temperature prediction in metal cutting: A review and implications for high speed machining" International Journal of Machine Tools & Manufacture 46,pp.782–800.

[24.] F. Boud, "Bar diameter as an influencing factor on temperature in turning" International Journal of Machine Tools & Manufacture 47,pp. 223–228, 2007.

[25.] N. Fang , G. Fang, "Theoretical and experimental investigations of finish machining with a rounded edge tool" Journal of Materials Processing Technology 191,pp. 331–334, 2007.

[26.] K.P. Maity, P.K. Swain, "An experimental investigation of hot-machining to predict tool life" journal of materials processing technology 1 9 8,pp.344–349, 2008.

[27.] D.I. Lalwani, N.K. Mehta, P.K. Jain, "Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel" journal of materials processing technology 2 0 6,pp.167–179, 2008.

[28.] Hendri Yanda, Jaharah A. Ghani & Che Hassan Che Haron, "Effect of Rake Angle on Stress, Strain and Temperature on the Edge of Carbide Cutting Tool in Orthogonal Cutting Using FEM Simulation" ITB J. Eng. Sci., Vol. 42,pp.179-194, 2010.

[29.] Ilhan Asilturk, Harun Akkus, "Determining the effect of cutting parameters on surface roughness in hard turning using the Taguchi method" Measurement 44,pp.1697–1704, 2011.

[30.] G. Totis n, M. Sortino, "Development of a modular dynamometer for triaxial cutting force measurement in turning" International Journal of Machine Tools & Manufacture 51,pp. 34–42, 2011.

[31.] M. Dogra,V. S. Sharma, J. Dureja, "Effect of tool geometry variation on finish turning – A Review" Journal of Engineering Science and Technology Review 4 (1) ,pp.1-13, 2011.

[32.] Satyanarayana Kosaraju, Venu Gopal. Anne and Venkateswara Rao.Ghanta, "Effect of Rake Angle and Feed Rate on Cutting Forces in an Orthogonal Turning Process" International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE'2011) Bangkok Dec., 2011.

[33.] Dipak Ranjan Jana, and Tarni Mandal, "Mathematical Calculation of Effects on Tool Setting on Tool Cutting Angle" Proceedings of the International MultiConference of Engineers and Computer Scientists 2008 Vol II,pp. 19-21, Hong Kong,2011.

[34.] Suleyman Neseli, Suleyman Yaldız, Erol Turkes, "Optimization of tool geometry parameters for turning operations based on the response surface methodology" Measurement 44,pp. 580–587,2011.

[35.] G. Szabo, J. Kundark, "Investigation of coherences between residual stresses and tool geometry by hard turning" Hungarian journal of industrial chemistry Veszprem vol. 39(2),pp.289-294, 2011.

[36.] Virginia Garcia Navas, Oscar Gonzalo, Ion Bengoetxea, "Effect of cutting parameters in the surface residual stresses generated by turning in

AISI 4340 steel" International Journal of Machine Tools & Manufacture 61,pp.48– 57, 2012.

[37.] Engr. Kaisan Muhammad Usman, "Effects of Tool Rake Angle on Tool Life in Turning Tools" International Journal of Scientific & Engineering Research Volume 3,pp. 2229-5518,2012.

[38.] Gaurav Bartarya , S.K. Choudhury, "State of the art in hard turning" International Journal of Machine Tools & Manufacture 53,pp.1–14,2012.