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A Review on Experimental Investigation of cutting parameters for HARDOX500 in Hard Turning

Devangkumar V. Fumakiya[1], Prof. D. R. Shah[2]

[1]*ME (CAD/CAM) student, Mechanical department, L.D.College of engineering, Ahmedabad, Gujarat.*
[2]*Assistant professor, Mechanical department, L.D.College of engineering, Ahmedabad, Gujarat.*

Abstract - *In today's era new materials, which have better properties compare to conventional materials are very important. With arriving of new materials difficulties to machine them is also arrive. The ability to predict and evaluate the machining performance quickly and realistically is extremely valuable. HARDOX500 is one kind of new alloy steel which has hardness around 51 HRC and it has good property of abrasion resistant.*

Keywords – *HARDOX500, Hard turning, CNC, cutting power, tool temperature*

I. INTRODUCTION

A. Turning

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the workpiece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear. The majority of turning operations involve the use of simple single-point cutting tools, with the geometry of a typical right-hand cutting tool. The various angles in a single-point cutting tool have important functions in machining operations. These angles are measured in a coordinate system consisting of the three major axes of the tool shank. Note, however, that these angles may be different, with respect to the workpiece, after the tool is installed in the tool holder.

B. Hard turning

In recent days, hard turning is being often preferred over the grinding operation as it consumes less time, cost, and energy. Advanced cutting inserts like carbide, cermet, ceramic, cubic boron nitride (CBN), polycrystalline cubic boron nitride (PCBN), and polycrystalline diamond (PCD) are suggested for use in hard machining in dry condition for attaining higher productivity.

Machining of workpiece material having hardness up to 45 HRC is known as soft machining. On the other hand, machining of the workpiece having a hardness in between 45 and 70 HRC comes under the category of hard machining. Use of cutting fluids in machining often results in occupational hazards. Hence, it has motivated many researchers to investigate in different machinability aspects under dry conditions. In addition, there is a significant economic benefit as a result of non-usage of coolants. Machining of hard material in a dry environment is often recommended to be done at comparatively higher cutting speed because it results in a higher tool tip temperature, thereby softening the work piece material.

C. HARDOX 500

Hardox steels are ultra-high strength steels with excellent abrasive resistance produced by Swedish company SSAB. The main application fields of these steels are heavy machines in mining or civil engineering industry. Hardox steels are resistant against sliding, impact and squeezing wear. Steels need high hardness and strength to achieve the condition of high wear resistance. Due to very high surface hardness, and therefore to high wear of used tool, the cutting edge made by cemented carbide must be used to mill the Hardox steels. Various Hardox steels with different hardness scales are offered by the producer. Higher hardness scale also means higher wear resistance. Hardox 500 steel is bendable and weldable abrasion resistant steel which is used in applications that demand higher wear resistance. The Hardox 500 steel has tempered martensitic structure without clear grain orders of the previous austenite. It has hardness around 51 HRC.

II. LITERATURE REVIEW

N. Satheesh Kumar et al.[14] investigates the effect of process parameters on CNC turning. The parameters namely the spindle speed and feed rate are varied to study their effect on surface roughness. The experiments are conducted using one factor at a time approach. The five different carbon alloy steels used for turning are SAE8620, EN8, EN19, EN24 and EN47. The study reveals that the surface roughness is directly influenced by the spindle speed and feed rate. It is observed that the surface roughness increases with increased feed rate and is higher at lower speeds and vice versa for all feed rates.

D. Manivel et al.[2] employed taguchi method with L18 array for four parameters, where one parameter has 2 level and other three parameters have 3 level. The cutting parameters are optimized in hard turning of ADI using carbide inserts based on taguchi method. The cutting speed is the most dominant factor affecting the surface roughness and tool wear. In optimum cutting condition, the confirmation tests are carried out. The optimum cutting condition results are predicted using signal to noise ratio and regression analysis. The predicted and experimental values for surface roughness and tool wear adhere closer to 9.27 % and 1.05 % of deviations respectively.

Richard geo et al.[16] studied the effect of machining parameters (cutting speed, feed rate, depth of cut) on power consumption of the tool during turning of EN-24 alloy steel was studied. Tools considered in this experimental work are HSS and tungsten carbide tool. Comparison of power consumed by the tools was done. Mathematical models for power consumption of the tools were created by using SPSS software from the experimentally measured power readings. The power consumed by both tools is measured by measuring the forces acting on the cutting tool using a lathe tool dynamometer with a digital display for measuring the forces acting on three axes. From the model it was found that cutting speed is the most important factor that influences power consumed by the tool and feed rate has less influence.

I. Hanafi et al.[5] work on optimization of multiple characteristics in CNC turning of reinforced Poly Ether Ether Ketone (PEEK CF30) with TiN coated tools under dry comdition. The considered criteria included specific cutting pressure, machining force and cutting power. Three controllable factors of the turning process consisting of cutting speed, depth of cut and feed rate were incorporated.

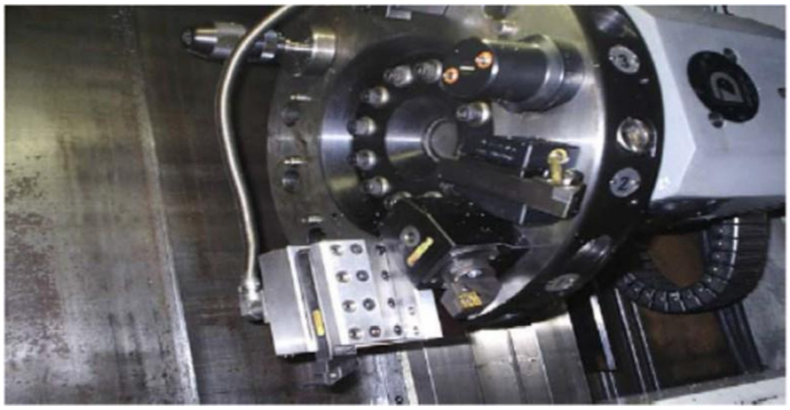

Figure 1. Kistler piezoelectric dynamometer used to measure cutting force

The three components of turning force (radial force – F_p, cutting force – F_c and feed force – F_a) were recorded with a KISTLER piezoelectric dynamometer model 9121 connected to a load amplifier and data acquisition board (Figure 1). They conclude that non-linear relationships are exist between the criteria machining and the cutting conditions and hence justifying the use of RSM based second order mathematical model with reduced number of experiments.

Hamza Bensouilah et al.[4] compare performance of coated and uncoated ceramic tools in their paper *Performance of coated and uncoated mixed ceramic tools in hard turning process*. The focus is made on the effect of the pre-cited cutting parameters on the evolution of surface roughness and cutting force components during hard turning of AISI D3 cold work tool steel with CC6050 and CC650 ceramic inserts. As a result of experimental trials performed using taguchi OA, it was found that the surface roughness is minimal at higher values of cutting speed and lower feed rate in case of CC650 and CC6050 inserts machining. In general, coated ceramic insert CC6050 has the better performance compared with uncoated ceramic insert CC650, in particular the surface roughness of the workpiece. CC650 uncoated ceramic insert is useful in minimizing the cutting force components. Flank and crater wear of both cutting tools shown in figure 2.

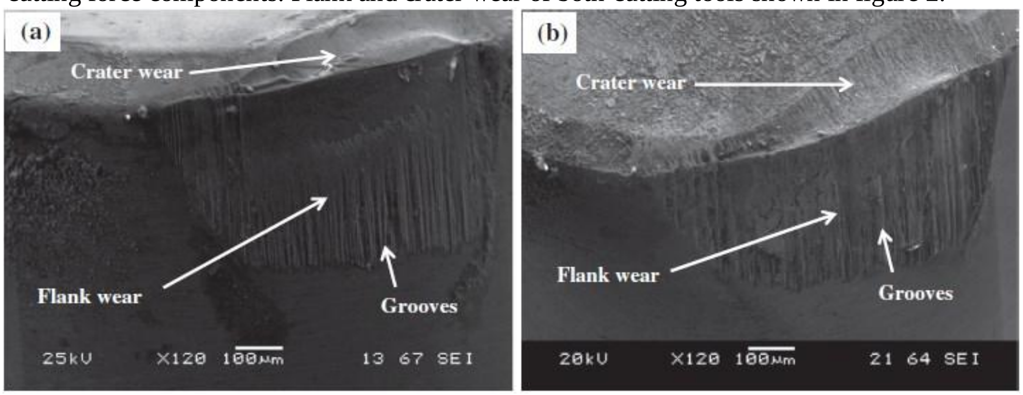

Figure 2. SEM micrograph of the flank and crater wears of (a) CC6050 and (b) CC650 cutting tools for V_c = 150 m/min, a_p = 0.20 mm and f = 0.08 mm/rev

Jenn-Tsong Horng et al.[7] conduct series of tests in order to investigate the machinability evaluation of Hadfield steel in the hard turning. The combined effects of four machining parameters, including cutting speed, feed rate, depth of cut and tool corner radius, on the basis of two performance characteristics—flank wear (VB_{max}) and surface roughness (R_a), were investigated and the centered central composite design (CCD) and the analysis of variance (ANOVA) were employed. The quadratic model of RSM associated with the sequential approximation optimization (SAO) method was used to find optimum values of machining parameters. They conclude that the flank wear (VB_{max}) is influenced principally by the cutting speed factor and the interaction effect of feed rate with corner radius of tool with contribution of 43.08% and12.84%, respectively. The cutting speed and tool corner radius with the contribution of 29.67% and 43.18% have statistic significance on the surface roughness (R_a).
Haci Saglam et al.[3] **, N. fang**[13] and **Mustafa Gunay et al.**[12] all of these researchers worked on the effect of rake angle on the cutting force with tool tip temperature, tool chip friction and main cutting force respectively.
Jozef Majerik et al.[8] done experimental investigation on the impact of the various applied values of cutting speeds while hard machining the material Hardox 500. The cutting speeds 55.7 $m.min^{-1}$, 78.5 $m.min^{-1}$ and 111 $m.min^{-1}$ are investigated with variable parameters, whereas the cutting depth and feed rate are constant parameters. Achieved results of tool wear and achieved tool life are reported in the resulting graph, VB = f (time).
M. Belmonte et al.[10] analyses the effect of the cutting speed (*v*), feed (*f*) and depth of cut (*d*) in the cutting forces and found a clear relationship between tool forces, tool wear and workpiece surface finishing. The cutting forces evolution is investigated during the dry turning of sintered hardmetal (WC-25 wt.%Co) with chemical vapour deposition (CVD) diamond brazed tools. Flank tool wear, besides cratering on the rake tool face and hardmetal deposition on the tool surface, are the main damage modes of the cutting tools.
M. Cemal Cakir et al.[11] examines the effects of cutting parameters (cutting speed, feed rate and depth of cut) onto the surface roughness through the mathematical model developed by using the data gathered from a series of turning experiments. The workpiece material machined was cold-work tool steel AISI P20. Of the two types of inserts employed; Insert 1 possesses a coating consisting of a TiCN underlayer, an intermediate layer of Al2O3 and a TiN outlayer, all deposited by CVD; Insert 2 is PVD coated with a thin TiAlN layer. The total average error of the model was determined to be 4.2% and 5.2% for Insert 1 and Insert 2, respectively; which proves the reliability of the equations established.
Anshuman Das et al.[1]compares the performances of uncoated carbide and coated cermet inserts. All the three input variables cutting speed, feed and depth of cut were ascertained to possess influence over workpiece surface temperature, feed, and radial force in case of uncoated carbide and cermet. Cermets exceeded the performance of carbides for flank wear, cutting force, and workpiece surface temperature, although carbides outperformed cermets concerning feed and radial force. The depth of cut was found to be the most vital, once feed and cutting forces were involved, whereas it had been true for radial force using carbides. Coated cermets experienced a lower cutting force, lower flank wear and lower workpiece surface temperature but higher radial force compared to uncoated carbides. Used inserts and their tool holders are shown in figure 3 and figure 4.

Figure 3. Uncoated carbide with designated tool holder

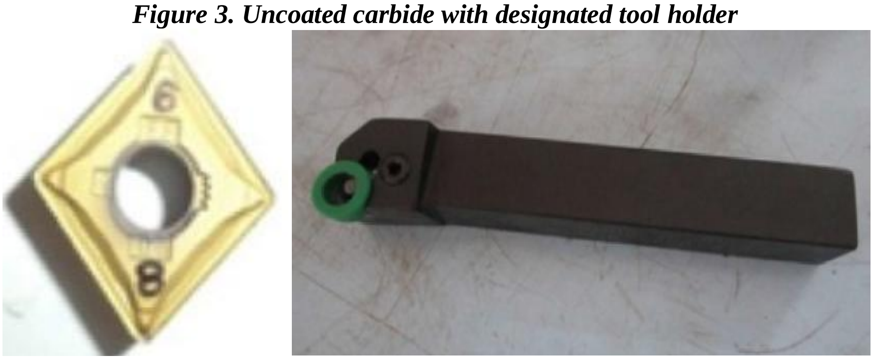

Figure 4. Cermet insert and its tool holder

W. Grzesik[18]**, L. B. Abhang et al.**[9] and **Ismail Lazoglu et al.**[6] all have same subject of research. They all have carried out research on the tool-chip interface temperature with respect to different cutting parameters.
R. M'Saoubi et al.[15] find that temperature of tool is reducing when going away from tip. And at a distance of approximately 2 mm from tip tool temperature drop about 400/450 °C compare to tool-chip interface temperature.

III. CONCLUSIONS

Most of research is carry out on alloy steels of different kind i.e. carbon steel, aluminum steel, hadfield steel. Research works for HARDOX500 is available for milling machine but very few research works are carried out for CNC turning machine.
Process parameters which are mostly used as input parameters are cutting speed, feed rate, depth of cut and noise radius. For Hard turning rake angle is very crucial. Negative rake angle is used for hard materials. Rake angle is not used much as input parameter in optimization modeling of hard turning.
Surface roughness used as an optimized parameter by most of researchers. Cutting force, Tool wear and MRR also considered as optimized parameter by many researchers. Temperature of cutting tool is taken as optimized parameter by very few researchers. Cutting power measured with the help of cutting force, it doesn't measured directly with watt meter by many researchers. Taguchi orthogonal array is used as design of experiment by most of researchers so they can use input parameters at more levels with less number of experimental run. Full Factorial method is very easy and can give perfect result.

IV. REFERENCES

[1] Anshuman Das, A.M., S. K. Patel, B. B. Biswal, Comparative assessment on machinability aspects of AISI 4340 alloy steel using uncoated carbide and coated cermet inserts during hard turning. Arabian Journal for Science and Engineering, vol. 41, pp. 4531-4552, 2016.
[2] D. Manivel, R. Gandhinathan, Optimization of surface roughness and tool wear in hard turning of austempered ductile iron (grade 3) using Taguchi method, Measurement, vol. 93, pp. 108-116, 2016.
[3] Haci Saglam, Faruk Unsacar, Suleyman Yaldiz, Investigation of the effect of rake angle and approaching angle on main cutting force and tool tip temperature, Machine tools and Manufacture, vol. 46, pp. 132-141, 2006.
[4] Hamza Bensouilah, H.A., Ikhlas Meddour, Mohamed Athemane Yallese, Tarek Mabrouki, Francois Girardin, Performance of coated and uncoated mixed ceramic tools in hard turning process. Measurement, vol. 82, pp. 1-18, 2016.
[5] I. Hanafi, F.M.C., F. Dimane, J. Tejero Manzanares, Application of particle swarm optimization for optimizing the process parameters in turning of PEEK CF30 composites. Procedia Technology, vol. 22, pp. 195-202, 2015.
[6] Ismail Lazoglu, Yusuf Altintas, Prediction of tool and chip temperature in continuous and interrupted machining, Machine tools and Manufacture, vol. 42, pp. 1011-1022**,** 2002.
[7] Jenn-Tsong horng, N.-M.L., Ko-To Chiang, Investigate the machinability evaluation of hadfield steel in the hard turning with Al2O3/TiC mixed ceramic tool based on the response surface methodology. Journal of materials processing technology, vol. 208, pp. 532-541, 2008.
[8] Jozef Majerik, Igor Barenyi, Experimental investigation into tool wear of cemented carbide cutting inserts when machining wear resistant steel HARDOX 500. Scintific Journals of Croatia, vol. 36, pp. 167-174, 2016.
[9] L. B. Abhang and M. Hameedullah, Chip-Tool Interface Temperature Prediction Model for Turning Process, International Journal of Engineering Science and Technology, vol. 3, pp. 382-393, 2010.
[10] M. Belmonte, F.J. Oliveira, J. Sacramento, A. J. S. Fernandes, R. F. Silva, Cutting forces evolution with tool wear in sintered hardmetal turning with CVD diamond, Diamond and related materials, vol. 13, pp. 843-847, 2004.
[11] M. Cemal Cakir, Cihat Ensarioglu, Ilker Dermirayak, Mathematical modeling of surface roughness for evaluating the effects of cutting parameters and coating material, Materials processing technology, vol. 209, pp. 102-109, 2009.
[12] 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, vol. 166, pp. 44-49, 2005.
[13] N. Fang, Tool-chip friction in machining with a large negative rake angle tool, Wear, vol. 258, pp. 890-897, 2005.
[14] N. Satheesh Kumar, A.S., Ashay Shetty, Ananth K, Harsha Shetty, Effect of spindle speed and feed rate on surface roughness of carbon steels in CNC turning. Procedia Engineering, vol. 38, pp. 691-697, 2012.
[15] R. M'Saoubi, H. Chandrasekaran, Investigation of the effects of tool micro-geometry and coating on tool temperature during orthogonal turning of quenched and tempered steel.Machine tools & Manufacture, vol. 44, pp. 213-224, 2004.
[16] Richard Geo, Jose Sheril D'cotha, Effect of Turning Parameters on Power Consumption in EN 24 Alloy Steel using Different Cutting Tools, International Journal of Engineering Research and General Science, vol. 2, pp. 691-702, 2014.
[17] Serope Kalpakjian, S.R.S., Manufacturing Engineering and Technology. SIXTH ed. 2009: Pearson. pp. 553-555, 568-574, 615-619.
[18] W. Grzesik, Experimental investigation of the cutting temperature when turning with coated indexable inserts, Machine tools and Manufacture, vol. 39, pp. 355-369, 1999.
[19] http://www.esteelsuppliers.com/new/shop/structure-steel/hardox-500/
[20] https://www.ssab.com/products/brands/hardox/produ-cts/hardox-500/

