International Journal of Analytical, Experimental and Finite Element Analysis (IJAEFEA), Issue. 3, Vol. 2, Sept 2015.
e-ISSN: 2394-5141, p-ISSN: 2394-5133, pp 119-121

Cutting Forces during Hard Turning for CBN Inserts: A Review

Bharatesh Akkiwad[1], N. V. Nanjundaradhya[1], Ramesh. S. Sharma[1], M. Rajanish[2]
prof.m.rajanish@gmail.com

Department of Mechanical Engineering,
[1]R.V.College of Engineering
Bangalore-560059

[2]Dayananda Sagar Academy of Tech & Mgmt-560082

***Abstract* - Tool life and machining surface roughness during hard turning are major components for industries because of the technical competitive world. Many researchers have worked to increase the life of the cutting tools and reduce the surface roughness of the workpiece only by experimental methods. But, the experimental techniques are of time consuming and destructive process. Hence there is a more scope for numerical investigations on hard turning. The objective of this work is to review the works carried out by different researchers both in experimental and numerical methods. Both experimental and numerical analysis work carried out for different combinations of varying cutting speed, feed rate and depth of cut for measuring the cutting forces.**

I. INTRODUCTION

Turning is the process for generating the external surface in which single point cutting tool is moved parallel to the axis of rotating workpiece. Turning of hard materials above 45 HRC is known as hard turning but usually the metals which are hard turned are in the range of 58 – 62 HRC. The cutting tools used for hard turning are mainly made of Cubic Boron Nitride (CBN), Ceramic and Cermet. The use of tool depends upon type of requirement like production quantity and type of surface finish required. Ceramic tool inserts can be used when batch production is to be done but CBN tool inserts are used when mass production is to be done. The selection of the tool depends upon the performance characteristics like tool wear, surface roughness, cutting forces, material removal rate and cost of the tool. Parameters like cutting speed, feed rate, and depth of cut influences a lot the performance of the tool which are need to be studied precisely for the selection of tool for the particular applications. Fig 1 shows the geometry of turning process [1].

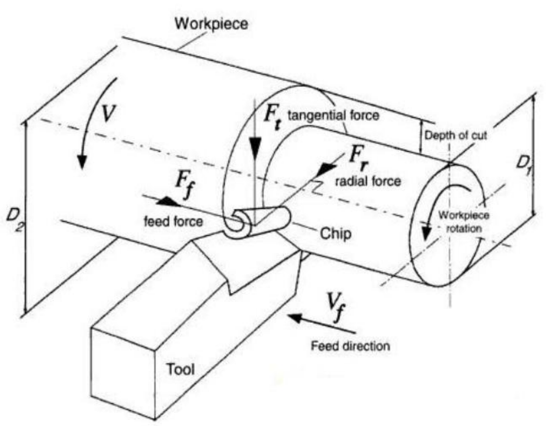

Fig 1. Geometry of turning process

The objective of this work is to review the works carried out by different researchers to understand the performance of the cutting tools by experimental and theoretical methods.

II. REVIEW OF LITERATURES

Khaider Bouacha et al. [2] conducted experimental study on hard turning of AISI 52100 bearing steel with CBN tool on performance characteristics like tool wear, surface roughness, cutting forces, and metal volume removed by changing the parameters like cutting speed, feed rate, depth of cut. They stated that the depth of cut exhibits maximum influence on cutting forces as compared to the other process parameters. Gaurav Bartarya et al. [3] investigated the effect of cutting parameters on cutting force and surface roughness for hard turning of AISI 52100 Steel with CBN tool. They developed prediction models by using ANOVA and compared with the measured force and surface roughness. Hamdi Aouici et al. [4] experimentally studied the effect of cutting speed, feed rate, workpiece hardness and depth of cut on surface roughness and cutting force components for AISI H11 steel using Cubic Boron Nitride insert. They observed that the feed force and cutting force are strongly influenced by the depth of cut. H.M.Lin et al. [5] found that tool life rises with increases of cutting speed until the optimum limit reached where it starts to decrease. Vitor Augusto et al. [6] found that CBN tools exhibits a much better performance with respect to both tool life and workpiece surface roughness for both continuous and interrupted turning. J.P.Costes et al. [7] came with the result of a low CBN content with a ceramic binders and small grains gives the best results. W.Grzesik et al. [8] studied the cutting forces, cutting temperature and surface roughness for turning of pearlitic ferritic nodular iron with L-CBN tools using both orthogonal and semi orthogonal cutting conditions. They stated that the components of forces decrease when machining with higher cutting speeds for orthogonal cutting conditions. M.Kumara Swamy et al. [9] studied the metal cutting process and analyzed it with FEM model for 3D simulation of turning process with solid single point cutting tool and the simulation of the chip formation, development of temperature distributions as well as predictions of stress distributions and strain distribution in the chip on the machined surface are successfully achieved. Riaz Muhammad et al. [10] conducted the finite element modelling of conventional and Hybrid oblique turning process for titanium alloy for different cutting conditions and the results obtained are compared to elucidate main deformation mechanisms responsible for the observed changes in the materials responses to various cutting techniques. Christian Walterb et al. [11] utilized a picoseconds laser to ablate regular micro patterns into the surface of CBN grinding tools aiming to reduce grinding force and improve grinding efficiency. They concluded that 25 to 50% lower forces and significantly improve force stability in long term grinding operation in structured tools. Hongtao Ding et al. [12] compared simulation results with the experimental data at various cutting conditions and proved that the proposed model can accurately predict the phase composition, grain size, micro hardness and residual stress during hard turning. V.Kryzhanivskyy et al. [13] conducted both experimental and modelling investigation of cutting temperature for rough hard turning with PCBN tools. The developed temperature field was reconstructed from the experimental readings and the temperature was modelled for the case of new tools as well as for the case of its development in the course of tool wear. The heat transfer coefficients were solved by the developed parametric representation of FE model. Rajiv Kumar Yadav et al. [14] estimated flank wear and material removal rate in turning of Inconel 718 using simulation approach. From the results it is found that simulation results are in good agreement with experimental results. Girinon Mathieu et al. [15] developed a 3D finite element model for simulating a turning operation in the thermal and mechanical steady state and studied the temperature distribution in the chip, mechanical part, the tool and tool holder is based on Eulerian formation. Fig 2 and Fig 3 show the 3D finite element model of chip and the tool respectively.

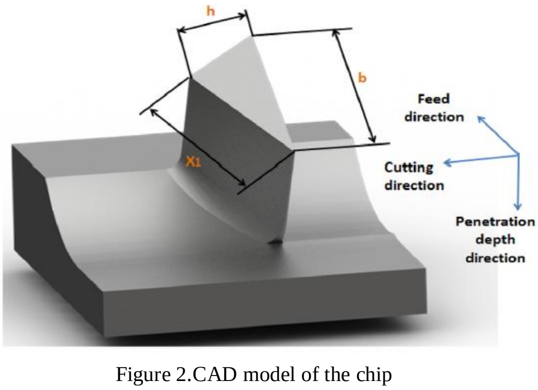

Figure 2.CAD model of the chip

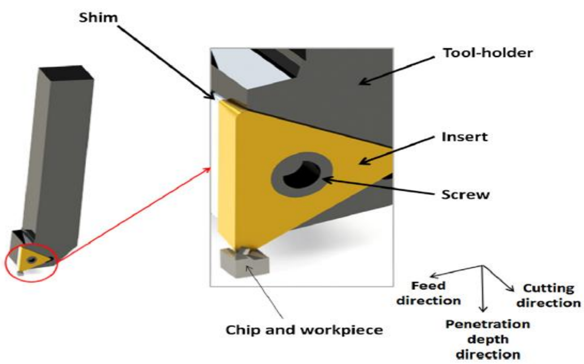

Figure 3.The Tool 3D CAD model

D.I.Lalwani et al. [16] conducted the experiments to investigate the cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel with coated ceramic tool. They found that cutting forces and surface roughness do not vary much with cutting speed in the range of 55 to 93 m/min. Mohamed Athmane Yallese et al. [17] conducted the experimental study on hard turning of 100Cr6 steel to establish the behavior of a CBN tool and they suggested that the hard turning may be presented as a real alternative to substitute grinding in view of roughness measurement. Y. Sahin [18] compares the tool life between ceramic and cubic boron nitride (CBN) cutting tools for machining of hardened steels using the Taguchi method. From the results he showed that cutting speed was found to be a dominant factor on tool life followed by the hardness of cutting tool and CBN cutting tool showed the best performance than that of ceramic based cutting tool. A.Srithar et al. [19] investigated the surface roughness on hard turning of AISI D2 steel using Coated Carbide Insert. The results specify that the increase of cutting speed decreases the surface roughness. Fig 4 show the experimental set up and fig 5 shows the roughness meter used for the purpose.

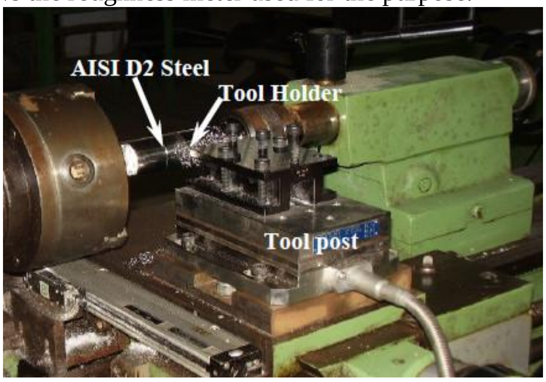

Figure 4.Experimental Setup

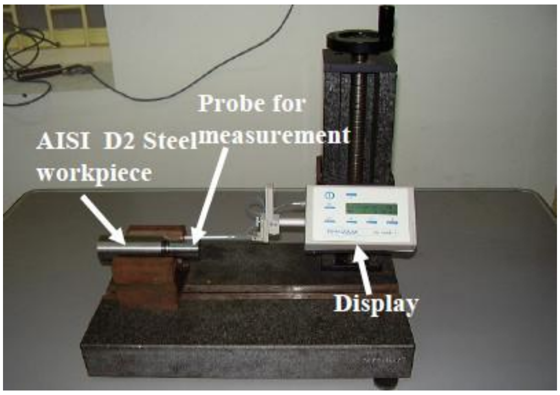

Figure 5.Surface Roughness measurement using roughness meter

Mehdi Remadna et al. [20] conducted the experimental analysis of cutting characteristics for machining a hard material with a cubic boron nitride tool to determine the evolution of descriptive parameters. From experimental results they showed that the geometry of the cut evolves considerably relative to the lifetime of a CBN tool. Anupam Agrawal et al. [21] predicted the surface roughness during hard turning of AISI 4340 steel with CBN insert and also showed that the random forest model is a superior choice over multiple regressions for prediction of surface roughness during machining of AISI 4340 steel having 69 HRC hardness. E. Uhlmann et al. [22] conducted the experiments on machining of high performance workpiece materials with CBN coated cutting tools and results describes regarding the tool life, resultant cutting force components and workpiece surface roughness. They finally compared the experimental results with common used tool coatings for the hard machining. Y. Huang et al. [23] compared model prediction to the published experimental data of hard turning AISI H13 of 52 HRC hardness using low & high CBN content tools. They states that the proposed model and FEM both predict lower thrust and tangential cutting forces and higher tool chip interface temperature when the lower CBN content is used, but the model predicts a temperature higher than that of the FEM. Khaider Bouacha et al. [24] investigated tool wear and forces behavior evolution versus variations of workpiece hardness and cutting speed, and the relationship between cutting parameters. They found that depth of cut exhibits maximum influence on cutting forces as compared to the feed rate and cutting speed. C. J. Rao et al. [25] studies the significance of influence of speed, feed and depth of cut on cutting force and surface roughness. They showed that feed rate has significant influence both on cutting force as well as surface roughness.

III. CONCLUSION

From the literatures available the machining parameters influences a lot the surface roughness. Parameters like speed, feed, depth of cut and cutting forces decides the surface roughness of the machined surfaces. Many researchers have worked to increase the life of the cutting tools and reduce the surface roughness of the workpiece only by experimental methods. The experimental techniques are of time consuming and destructive process. Hence there is a more scope for numerical investigations on hard turning.

REFERENCES

[1] Manjot Singh Cheema “Investigation of effects of process parameters and insert geometry on hard turning of steels” Thesis submitted to Thapar University, Patiala.
[2] Khaider Bouacha et al. “Analysis and optimization of hard turning operation using cubic boron nitride tool” Int. Journal of Refractory Metals and Hard Materials 45 (2014) 160-178.
[3] Gaurav Bartarya et al. “Effect of cutting parameters on cutting force and surface roughness during finish hard turning AISI52100 grade steel” Procedia CIRP 1 (2012) 651 – 656.
[4] Hamdi Aouici et al. “Analysis of surface roughness and cutting force components in hard turning with CBN tool: Prediction model and cutting conditions optimization” Measurement 45 (2012) 344-353.
[5] H.M. Lin et al. “Wear behavior in turning high hardness alloy steel by CBN tool” Wear 264 (2008) 679–684.
[6] Vitor Augusto A. et al. “Turning of interrupted and continuous hardened steel surfaces using ceramic and CBN cutting tools” Journal of Materials Processing Technology 211 (2011) 1014–1025.
[7] J.P. Costes et al. “Tool-life and wear mechanisms of CBN tools in machining of Inconel 718” International Journal of Machine Tools & Manufacture 47 (2007) 1081–1087.
[8] W. Grzesik et al. “Machining of nodular cast iron (PF-NCI) using CBN tools” Procedia CIRP 1 (2012) 483 – 487.
[9] M.Kumara Swamy et al. “Modeling and Simulation of Turning Operation” ISSN: 2278-1684 Volume 3, Issue 6 (Nov-Dec. 2012), PP 19-26.
[10] Riaz Muhammad et al. “Finite Element Modelling of Conventional and Hybrid Oblique Turning Processes of Titanium Alloy” Procedia CIRP 8 (2013) 510 – 515.
[11] Christian Walter et al. “Structuring of CBN grinding tools by ultrashort pulse laser ablation” Procedia CIRP 14 (2014) 31–36.
[12] Hongtao Ding et al. “Multi-physics modeling and simulations of surface microstructure alteration in hard turning” Journal of Materials Processing Technology 213 (2013) 877– 886.
[13] V. Kryzhanivskyy et al. “Modelling and Experimental Investigation of Cutting Temperature when Rough Turning Hardened Tool Steel with PCBN Tools” Procedia CIRP 31 (2015) 489 – 495.
[14] Rajiv Kumar Yadav et al. “A simulation approach for estimating flank wear and material removal rate in turning of Inconel 718” Simulation Modelling Practice and Theory 52 (2015) 1–14.
[15] Girinon Mathieu et al. “3D stationary simulation of a turning operation with an Eulerian approach” Applied Thermal Engineering 76 (2015) 134-146.
[16] D.I.Lalwani et al. “Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel” journal of materials processing technology 206 (2008) 167–179.
[17] Mohamed Athmane Yallese et al. “Hard machining of hardened bearing steel using cubic boron nitride tool” Journal of materials processing technology 209 (2009) 1092–1104.
[18] Y. Sahin “Comparison of tool life between ceramic and cubic boron nitride (CBN) cutting tools when machining hardened steels” Journal of materials processing technology 209 (2009) 3478–3489.
[19] A.Srithar et al. “Experimental Investigation and Surface roughness Analysis on Hard turning of AISI D2 Steel using Coated Carbide Insert” Procedia Engineering 97 (2014) 72 – 77.
[20] Mehdi Remadna et al. “Evolution during time of tool wear and cutting forces in the case of hard turning with CBN inserts” Journal of Materials Processing Technology 178 (2006) 67–75.
[21] Anupam Agrawal et al. “Prediction of surface roughness during hard turning of AISI 4340 steel (69 HRC)” Applied Soft Computing 30 (2015) 279–286.
[22] E. Uhlmann et al. “Machining of high performance workpiece materials with CBN coated cutting tools” Thin Solid Films 518 (2009) 1451–1454.
[23] Y. Huang et al. “Cutting forces modeling considering the effect of tool thermal property-application to CBN hard turning” International Journal of Machine Tools & Manufacture 43 (2003) 307–315.
[24] Khaider Bouacha et al. “Statistical analysis of surface roughness and cutting forces using response surface methodology in hard turning of AISI 52100 bearing steel with CBN tool” Int. Journal of Refractory Metals & Hard Materials 28 (2010) 349–361.
[25] Dr. C. J. Rao et al. “Influence of cutting parameters on cutting force and surface finish in turning operation” Procedia Engineering 64 (2013) 1405 – 1415.