A REVIEW OF EFFECT OF INSERT IN HARD TURNING OF ALLOY STEEL REVIEW ARTICLE

Mayur G. Jain[1], Chirag P. Patel[2]
[1]M.Tech Student, [2]Associate Professor
Department of Mechanical Engineering
U.V. Patel College of Engineering
Ganpat University, Kherva
Gujrat, India.

Abstract: Hard turning is applied to work pieces that are 45 RC and higher. In practice, hard-turned work is typically found in the 58 to 68 RC range. Before the development of hard turning, grinding was necessary to cut work pieces in a hardened state. Hard turning as another process arrow in your quiver. When applied correctly, it can produce machining results akin to grinding without the need to grind and at speeds significantly faster than grinding. When grinding must be done, hard turning can serve as an efficient pre-grind process that removes the majority of stock so the grinder only needs to finish the part to size.
Application of inserts in machining has proved to be a feasible alternative to if it can be applied properly. The main objectives of this study investigate and evaluate the effect of tool geometry with different cutting parameters (cutting speed, feed rate and depth of cut) on surface roughness, tool life, material removal rate and tool-tip temperature during hard turning of AISI 4140 material by coated carbide insert of different geometry.
Keywords: Hard turning, Inserts, Tool Geometry.

I. INTRODUCTION

During the past few years unprecedented progress has been made in the hard turning. Hard turning is a process in which materials in the hardened state are machined with the single point cutting tools. It is most commonly used in industry because of its ability to have faster metal removal giving reasonably good surface quality. the hard turning process provides many technological challenges due to the high level of stresses and hardness variations that are created in a small layer below the work surface. Part integrity, tool performance, and productivity are of particular concern, thereby warranting the attention of tooling, fixture, measurements, and process modelling and optimization methodology to ensure satisfactory process capability. The objective of this Technology Assessment is to survey the current technology in these areas, primarily within the past three years. The implications of these technology developments on future research directions are also reviewed and summarized. Their hardness and chemical stability enable them to withstand the high thermal and mechanical loads. The greatest advantage of using hard turning is the reduced machining time and complexity required to manufacture metal parts.

Before few years problem associated with the hard turning was the generation of high temperature in cutting zone. This adversely affects the quality of the products produced. Inserts have been the conventional choice to deal with this problem. Inserts employed in machining operations can help to remove the heat generated during cutting, to improve the tribological processes, to prevent the formation of built-up edge, to facilitate the transportation of chips, and to achieve better tool life, surface finish and dimensional tolerances.

A. METAL CUTTING PROCESS-HARD TURNING

Hard turning is a turning done on materials with Rockwell C hardness greater than 45. This operation is one of the most basic machining processes in which the part is rotated while a single point cutting tool is moved parallel to the axis of rotation. Hard turning can be done on the external surface of the part as well as internally (boring).The process is intended to replace or limit traditional operations. Hard turning rather than grinding it offers many advantages like.

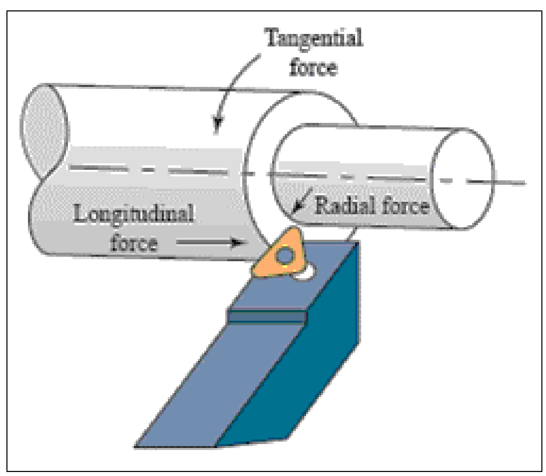

Figure 1: Turning Operations

1. Surface generation can easily accomplish complex contours.

2. Hard turning permits machining of multiple operations with just one set-up.
3. The result is excellent positional accuracy, reduced part handling and risk of part damage.
4. All in all, hard turning reduces machine tool cost and gives better production control and higher quality.

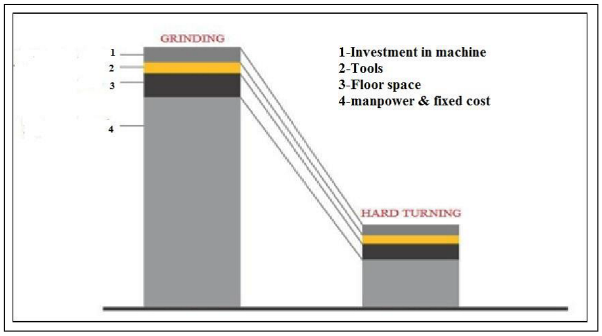

Figure 2: Grinding V/S Hard turning

B. CUTTING TOOL

Cutting tool (or cutter) is any tool that is used to remove material from the work piece by means of shear deformation. Cutting may be accomplished by single point or multipoint tools. Single-point tools are used in turning, shaping, planning and similar operations, and remove material by means of one cutting edge. Milling and drilling tools are often multipoint tools. Grinding tools are also multipoint tools. Various cutting tool materials have been used in the industry for different kind of applications. The important characteristics expected in cutting tool materials are :

1. Higher hardness then work piece material.
2. Hot hardness where the tool should be able to retain hardness at elevated temperature.
3. Wear resistance with high abrasion resistance to improve the effective life of the tool
4. Toughness to withstand the impacts load at the beginning of the cut and force fluctuation.
5. Low friction would allow lower wear rates and improved chip flow.
6. Thermal characteristic where the material tool should have higher thermal conductivity to dissipate heat in the shortest time.

B..1 CUTTING TOOL INSERTS

Cutting tool inserts are replaceable attachments for cutting tools that typically contain the actual cutting edge. Cutting tool inserts applications include turning, boring, construction, cut-off and parting, drilling, grooving, hobbing, milling, mining, sawing, shearing and cutting, tapping, threading, and brake rotor turning. Cutting tool inserts have much different geometry.

B..2 TYPE OF INSERTS USED IN TURNING OPERATION

Inserts are available in several thicknesses and a variety of sizes and shapes. The basic shapes are round, square, triangle, and diamond. Many other shapes, including the parallelogram, hexagon, and pentagon, are also used to meet specific machining requirements. Each shape has its advantages and limitations since the operational, as well as the economical factors must be considered in tooling selection.

1. **THE ROUND INSERT**
   Round or button inserts give a good finish at heavy feeds, and they are also ideal for forming inside corner radii. Their shape provides the greatest geometric strength, and they offer the maximum number of indexes when perform the light cuts. However, round inserts have their limitations since the large nose radius thins the chips and increases the forces between the tool and work piece for a given size cut. This usually produces very high radial forces as compared with normal cutting which particularly at normal feed rates. Chatter and deflection often occur, especially when machining long chip materials. For this reason, button inserts are generally applied with greater success on cast iron and the other short-chip, low-strength materials, although heavy feed rates will often improve the cutting action on ductile materials.
2. **THE SQUARE INSERT**
   Square inserts provide four or eight cutting edges, depending on the design of the tool holder. Positive rakes mean that relief angles must be ground on the insert, which eliminating the use of one side. Square inserts are preferred for most machining jobs, where the work piece and tool design relationships allow their use. Their shape provides strength close to the round insert, but with the economy of four or eight cutting edges. It permits a reduction in the side cutting edge angle and the problem related to the chip-thinning. The most common insert shapes are shown in Figure. 3.

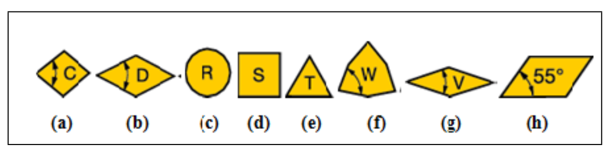

Figure 3: Inserts with different shape (a) C shape insert (b) D shape insert (c) Round insert (d) square insert (e) Triangular insert (f) Trigon insert (g) V shape insert (h) K shape insert

3. **THE TRIANGLE INSERT**
   The triangle provides three or six cutting edges, depending on whether relief angles are required on the insert for use in a positive rake holder. The 60° included angle is not as strong as the 90 degree of the square, or the radius of the button, but many machining operations are performed satisfactorily with triangular inserts. Turning to a

shoulder, plunging and contouring, and numerous other operations require a generous end cutting edge angle which the triangle can provide. The 60 degree included angle is also suitable for threading operations.

4. **THE PENTAGON INSERT**
A pentagon or 5 sided insert providing one or two more cutting edges per insert. There is an extra advantage compare to the square and triangle insert in its 108 degree included angle. The pentagonal shape sets up in certain design and application limitations compare to the square insert. The tool must always cut with a side cutting edge angle which can thins the chip and also improve a tool life. However, the side cutting edge angle can't be performed on a finished part's shape because the increased of radial forces can cause chatter and deflection of the work piece.

5. **THE DIAMOND INSERT**
The diamond insert was developed specifically for tracing operations. The industry's standard marking system includes designations for diamond inserts with included angles of 86, 80, 55, and 35 degrees. By far the most popular size is the 55 degree included angle diamond. This geometry apparently meets the requirements of most tracing operations. Diamond tracer inserts are made in regular and elongated shapes. The elongated diamond provides greater resistance to the twisting action set up by the cutting forces. The selection of a tool for a tracing operation should begin with an analysis of the requirements of the contouring operations. The tool selected should be the one which provides the strongest geometric shape and still meets the contouring requirements.

6. **THE HEXAGONAL INSERT**
Hexagonal shaped insert is a versatile tool where all turning, facing, and chamfering processes can be done from a number of positions. Its shape provides strong cutting edges as in the case of the pentagon, but it also need cutting with considerable side cutting edge angle. The number of usable cutting edges in this design makes it a most economical insert where it can be applied.

Almost all high-performance cutting tools use indexable inserts. There are several reasons for this. First of all, at the very high cutting speeds and feeds supported by these materials, the cutting tip can reach temperatures high enough to melt the brazing material holding it to the shank. Economics are also important; inserts are made symmetrically so that when the first cutting edge is dull they can be rotated, presenting a fresh cutting edge. Some inserts are even made so that they can be flipped over, giving as many as 16 cutting edges per insert. There are many types of inserts: some for roughing, some for finishing. Others are made for specialized jobs like cutting threads or grooves. The industry employs standardized nomenclature to describe inserts by shape, material, coating material, and size.

The Inscribed Circle (I.C.), or the diameter of the circle that fits entirely within the insert geometry generally categorizes insert size. This is used for most indexable inserts, except for rectangular and some parallelogram inserts, where length and width are used. Important specifications for cutting tool inserts include thickness, radius if applicable, and chamfer angle if applicable. Common features for Cutting tool inserts include un ground, indexable, chip breaker, and dished. Insert attachment can be screw-on or no hole.

Cutting tool inserts are commonly constructed of carbide, micro grain carbide, CBN, ceramic, cermet, cobalt, diamond PCD, high-speed steel, and silicon nitride. Coatings for cutting tool inserts include titanium nitride, titanium carbon nitride, titanium aluminum nitride, aluminum titanium nitride, aluminum oxide, chromium nitride, zirconium nitride, and diamond.

II. REVIEW WORK CARRIED OUT

M. Dogra [1] The effect of cutting tool geometry has long been an issue in understanding mechanics of turning, author investigated Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. This article presents a survey on variation in tool geometry i.e. tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry and curvilinear edge tools and their effect on tool wear, surface roughness and surface integrity of the machined surface. Further modelling and simulation approaches on tool geometry including one approach developed in a recent study, on variable micro-geometry tools, is discussed in brief.

The objective of this paper is to review the research progresses on tool geometry variations in turning i.e. edge geometry variations, groove on the rake face, edge radius variations and rake angle variations, further their affect on overall performance of the turning process Author investigated the effect of turning parameters on residual stress in finish turning with focus on the depth of residual stress. The material used was case carburized steel with hardness in the range of 58-62HRc. Author also investigate tool edge , Variable Micro geometry tools experimental and modelling aspects, Tool nose radius variations, Grooved tools, Rake angle variation, Modelling techniques with tool geometry. During finish hard turning increase in the rake angle or the chamfer angle as well as the hone cutting edge radius allowed an increase in the compressive residual stress in the subsurface. [1]

Nikunj Patel [2] The effect of cutting tool insert geometry has significant role for surface finish in turning operation. There are many different types of tool inserts with different tool insert geometry are used in turning operation. This paper present a logical procedure to select best tool insert from alternative tool inserts for better surface finish in turning operation.

The procedure based on three well known Multiple Attribute Decision Making (MADM) methods such as Analytical Hierarchy Process (AHP), Revised Analytical Hierarchy Process (RAHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). A tool insert selection index is proposed that evaluates and ranks of tool insert for good surface finish in turning operation.

Author used 5 different type insert with different tool geometry like Nose radius(mm), Approach angle(degree), Rack angle (degree), Angle of inclination (degree) and Clearance angle (degree) and suggest how to select the insert for Hard turning. The proposed MADM method, the AHP, RAHP and TOPSIS applied for selection of a suitable tool insert from number of alternatives [2].

Zahari Taha [3] Surface roughness is important parameter in ensuring that dimension of geometry within the permitted tolerance. The ideal surface roughness is determined by feed rate and geometry of tool. Author study to compare measured surface roughness (from experiment) with theoretical surface roughness (from theoretical calculation) of two type of insert, 'C' type and 'T' type and the focuses on the turning process. Author also observed that are large deviation between measured and theoretical surface roughness at low feed rates (0.05mm/rev) for both inserts because work material AISI D2 in which curly chips are created that scratch the work piece surfaces when feed rate 0.05 mm/rev is applied.

The work materials factor of AISI D2 affecting the character is presumably the case of this phenomenon. Author used for study two types inserts CNMG 120408 representing the type 'C', rhombus shape with 80° angle and TPMR 160308 representing the type 'T', triangle shape with 60° angle. The surface quality resulting from two types of insert geometry, TPMR and CNMG are similar feed rates of 0.05 mm/rev and 0.02 mm/rev, but significantly different high feed rate. By using the CNMG insert, the surface quality at a high feed rate as 40% better than when using a TPMR inserts and after author also suggest that different materials and cutting tools may give different results of the surface roughness [3].

Gaurav Bartarya [4] Researchers have worked upon several aspects related to hard turning. The present work is an effort to review some of these works and to understand the key issues related to process performance. The review shows that the type of tool material, cutting edge geometry and cutting parameters affect the process efficiencies in terms of tool forces, surface integrities integrity, and white layer. The present work finally lists down certain areas that can be taken up for further research in hard turning. Author tried to investigate the effects of different shapes of inserts, tool materials and coatings on the process performance during turning of hardened steels while many of them have ventured to characterize the wear phenomenon during hard turning and performed to understand the effect of process parameters on force, surface integrity, residual stress and white layer formation through experiments while as modelling. Author used for experiment work piece material like AISI 52100, AISI 4340,D2,D13 Steel etc(60 HRC) and tool material used CBN(low and high content), coated CBN, ceramics, coated ceramics, ceramics and carbide are also used in some case with use parameter for cutting like cutting speed, feed and depth of cut. Author also done tool wear and tool life in hard turning ,forces and temperature and white layer in hard turning [4].

J Guddat [5] Author have investigated the effect of wiper PCBN inserts geometry (nose radius, edge radius, chamfer angle) on surface integrity and cutting forces in finishing by hard turning of through hardened AISI 52100(100Cr6) (58-62 HRC). They have taken wiper new, worn inserts and conventional new, worn inserts. Wiper inserts produces smoother surfaces within the range of experiments conducted and are more stable when it comes to change in feed and nose radius. While the surfaces roughness becomes greater when a worn wiper inserts is used, a worn conventional inserts produces superior roughness then a new conventional [5].

Radu Pavel [6] Author work in paper related to surface quality for a case of interrupted and Continuous hard turning and finding concerning the evolution of common surface roughness parameters as well as the evolution of surface topography with the increase of tool wear are presented. The study employs two work piece materials that were less considered for hard turning investigations to the authors best knowledge. A good correlation between flank wear aspect and machined surface was observed and he used 1117 steel material for experiment and also used TNMA432T inserts and MTJNLS-16-D tool holder. The main cutting angles after the PCBN inserts were clamped in the tool holder were: rake angle -25°, relief angle 5° and side cutting edge angle -3°. The cutting edge had the same preparation consisting in a chamfer at 20° over 0.15mm and an edge hone of 0.025mm radius. The tool nose radius was 0.8 mm. author also determine four type wear behaviour and wear mechanism of the cutting tool [6].

F. Klocke [7] Author suggested in paper impact of PcBN tool edge geometry is investigated based on a modelling as well as an experimental approach. The hard turning process is described by means of a 3D simulation of the tool engagement based on the Finite Element Method and also suggest that the use of proposed new edge tool geometry is an effective way to significantly increased tool performance with respect to tool life ,material removal rate and part surface quality in high precision had turning [7].

Suleyman Neseli [8] Author have found out of the influence of tool geometry (nose radius, approach angle and rack angle) on the surface finish obtained in turning of AISI 1040 lathe machine by using AL2O3 coated tool inserts CNMG 120404-BF, CNMG 120408-BF,120412-BF for finishing operation. They have done experimental design by using L27 Taguchi standard orthogonal array and get results of surface roughness and analysis done with help of ANOVA. They have conclude that the rake angle has the highest effect of in reducing surface roughness and effect of tool nose radius and approach angle increases with increases surface roughness [8].

M Aruna [9] In this study finish turning of Inconel718 is carried out with cermets tools. Cutting parameters are designed using Taguchi's DOE and the experiments are conducted for the designed parameters. The cutting parameters, including tool and coating materials choice, tool geometry, machining strategy, cutting speed, feed rate, depth-of-cut. Taguchi's Design Of Experiment (DOE) method incorporate Orthogonal Arrays (OA) to minimize the number of experiments required to determine the effect of process factors upon performance characteristics. Taguchi experiment can be accomplished in a timely manner and at a reduced cost with results comparable to a full factorial experiment [Philip(1989)]. The adequacy of the developed mathematical model is proved by ANOVA. The findings of this study show new results and the second order model was quite adequate. They have also finding findings of an experimental investigation of the effect of feed rate, cutting speed and depth of cut on the surface roughness when turning Inconel 71 [9].

E.D. Derakhshan [10] Author find that to test the empirical feasibility of using this new method instead of grinding in many industrial applications, and to determine the effects of independent parameters such as hardness of parts and cutting speeds on the surface quality and tool wear in hard turning operation. Work piece made of AISI 4140 alloyed steel are exposed to different thermal treatments to achieve different hardness rates in the range of hard turning operations and also author done experiment on AISI 4140 with different cutting speed and different HRC and conclude best surface roughness is better in higher cutting speed and high HRC [10].

III. CONCLUSION

From the above literature review it is conclude that there are many factors affect on surface roughness of work piece such as cutting speed, feed, and depth of cut, tool geometry, and tool material. So far no work has been done on hard turning by Inserts. That's why in present work hard turning of AISI 4140 will carry out in presence of different inserts.

IV. ACKNOWLEDGMENT

It is a privilege for me to have been associated with Mr. C. P. Patel, Associate Professor of Mechanical Engineering Department at U.V Patel College of Engineering, Kherva. During this paper work. I have been greatly benefited by his valuable suggestions and ideas. It is with great pleasure that I express my deep sense of gratitude to him for his valuable guidance and constant encouragement throughout this work.

References

[1] M. Dogra, V. S. Sharmab, and J. Durejac. Effect of tool geometry variation on finish turning - A Review. *Journal of Engineering Science and Technology Review*, 4(1):1–11, 2011.

[2] Nikunj Patel, Prof. R.K.Patel, and Prof. U.J.Patel. Insert Selection for Turning Operation on CNC Turning Centre using MADM Methods. *International Journal of Latest Trends in Engineering and Technology (IJLTET)*.

[3] Zahari Taha, Hani Kurniati Lelana, Hideki Aoyama, Raja Ariffin, Julirose Gonzales, Novita sakundarini, Sugoro Bhakti. Effect of Insert Geometry on surface roughness in the hard turning process AISI D2. *The 11th Asia Pacific Industrial Engineering and Management system conference, The 14 th Aisa Pacific Regional meeting of International foundation for Production Research*.

[4] Gaurav Bartaryaa, and S.K. Choudhuryb. State of the art in hard turning. *International Journal of Machine Tools and Manufacture*, 53:1–14, 2012.

[5] J Guddata B, R.Ma Saoubia, P. Alma, and D. Mayerb. Hard turning of AISI 52100 using PCBN wiper geometry inserts and the resulting surface integrity. *Procedia Engineering*, 19:118–124, 2011.

[6] Radu Pavel A, Ioan Marinescu A, Mick Deis B, Jim Pillar B. Effect of tool wear on surface finish for a case of continuousand interrupted hard turning. *Journal of Materials Processing Technology*, 170:341–349, 2005.

[7] F. Klocke1, and H. Kratz. Advanced Tool Edge Geometry for High Precision Hard Turning. *Laboratory for Machine Tools and Production Engineering, Chair of Manufacturing Technology - Aachen University*.

[8] Suleyman Neselia, Suleyman Yaldiz A, and Erol Turkes B. Optimization of tool geometry parameters for turning operations based on the response surface methodology. *Measurement*, 44:580–587, 2011.

[9] M Aruna, and Dr.V.Dhanalaxmi. RESPONSE SURFACE METHODOLOGY IN FINISH TURNING INCONEL 718. *International Journal of Engineering Science and Technology*, 2(9):4292–4297, 2010.

[10] E.D. Derakhshan, and A.A. Akbari. ExperimentalInvestigation on the Effect of Work piece Hardness and Cutting Speed on Surface Roughness in Hard Turning With CBN Tools. *Proceedings of the World Congress on Engineering*, 2, 2009.

