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Effect of Tool Geometry Variation of Nano Scale Multilayer Coated Cutting Tool in Machining A Review

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Abstract — In this paper an attempt is made to review the literature on the machining parameters in turning processes by using Carbide inserts. The effects of cutting speed, feed rate, and depth of cut on components in the hard turning were experimentally investigated .To analysis the progress of tool wear of crater wear and Flank wear of the cutting tool insert in machining of mild steel in turning process. The effect of cutting tool geometry has long been an issue in understanding mechanics of turning. Tool geometry has significant Influence on, 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, rake face, variable edge geometry, and their effect on tool wear, surface roughness and surface integrity of the machined surface. Scanning electron microscope (SEM) test are conducted to observe the tool wear surface of carbide insert.

Intex terms: Machining Operation, CNC, Tool Coating, Tool Wear, Tool Geometry.

I.INTRODUCTION

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal [13.20]. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. These demands require major improvements in the design of cutting tools: new substrates, new coatings, cutting tool geometry and materials etc. [12, 20]. The objective of this research is to study the effect of cutting speed, feed, and depth of cut, machining time on metal removal rate, specific energy, surface roughness, volume Fraction and flank wear. Thus the Figure 1.1 is Process parameters in turning operation is given by,

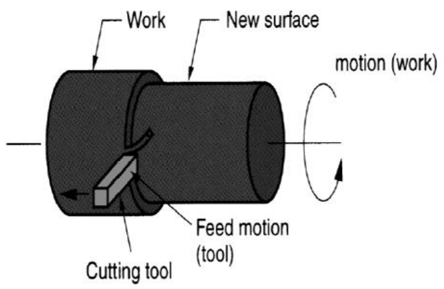

Figure1.1. Process parameters in turning operation

In PCBN cutting tools, several types of edge preparation can be made for hard turning operations, including sharp edge (with no additional edge processing to strengthen edge),chamfers, hones, and chamfers plus edge hones [20].

The tool wears out in several ways such as flank wear, crater wear, and nose wear etc. Flank wear is the more significant type of tool wear because of its impact and influence of tool life as well the ease of measurement. The width of the flank wear land is a suitable tool wear measure and a predetermined value of flank wear is regarded as a good tool-life criterion. Progressive flank wear is measured at the end of each cut using tool maker's microscope [1].

The need for selecting and implementing optimal machining conditions and most suitable cutting tool has been felt over the last few decades. Despite Taylor's early work on establishing optimum cutting speeds in machining, progress has been slow since all the process parameters need to be optimized[18,31]. Thus the Figure 1.2. 3 Axial CNC Machine is given by,

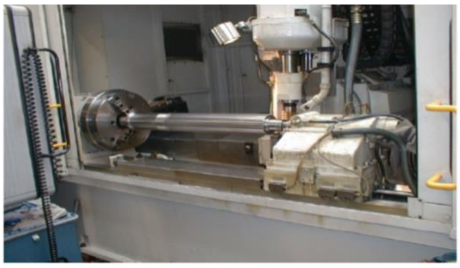

Figure1.2. 3 Axial CNC Machine

Mild Steel is one of the most common of all metals and one of the least expensive steels used. It is to be found in almost every product created from metal. It is weld able, very durable (although it rusts), it is relatively hard and is easily annealed [32, 26].

EN8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. EN8 is suitable for the manufacture of parts such as general-purpose axles and shafts, gears, bolts and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance [32,33].

The coated carbide turning tool has a high elastic modulus. This leads to the more efficient turning of work material as compared to the tool material [4].

The coatings of TiN + AlTiN, TiN + AlTiN + MoS_2, and CrN + CrN:C + C were applied by PVD techniques on WC-Co inserts developing nanostructured layers. Coatings surface qualification included SEM observation with EDS analysis, ball erosion test, Nano indentation, and scratch test [6].Advanced coating technology has significantly improved the tool life expectancy. Titanium Nitride (TiN), Titanium Carbo-Nitride (TiCN), Titanium Aluminum Nitride (TiAlN or AlTiN), Chromium Nitride (CrN), and Diamond coatings can increase overall tool life, decrease cycle time, and promoted better surface finish.[10]Properties of cutting tool materials [29].

Red Hardness or Hot Hardness – It is the ability of a material to retain its hardness at high temperature. Toughness – It relates to the ability of a material to resist shock or impact loads associated with interrupted cuts. Wear Resistance – It enables the cutting tool to retain its shape and cutting efficiency. Other properties are thermal conductivity, specific heat, Hardenability etc [29].

PVD method deposits thin films on the cutting tools through physical techniques, mainly sputtering and evaporation .PVD coatings, with deposition temperatures of 400-600°C, are gaining greater acceptance in the market place. Over the last decade, they have been successfully applied to carbide metal cutting inserts [22].

CVD method deposits thin films on the cutting tools through various chemical reactions. CVD coated cemented carbides have been a huge success since their introduction in the late 1960‘s. Since then, chemical vapour deposition technologies have advanced from single layer to multilayer versions combining TiN, TiCN, TiC and Al_2O_3. Modern CVD coatings combine high temperature and medium temperature processes in complex cycles that produce excellent wear resistant coatings with a total thickness of 4-20 μm [12,20].

Factors Affecting the Tool Wear on whenever two machined surfaces come in contact with one another the quality of the Mating parts play an important role in the performance and wear of the mating parts [15]. The height, shape, arrangement and direction of these surface irregularities on the work piece depend upon a number of factors such as, The machining variables which include Cutting speed, Feed, and Depth of cut. The tool geometry some geometric factors which affect achieved Surface finish includes Nose radius, Rake angle, Side cutting edge angle, Cutting edge. Work piece and tool material combination and their mechanical properties [20].

Tool wear in machining is defined as the amount of volume loss of tool material on the contact surface due to the interactions between the tool and work piece. Specifically, tool wear is described by wear rate (volume loss per unit area per unit time) and is strongly determined by temperature, stresses, and relative sliding velocity generated at the contact interface [15,25].Mechanical wear is resulted by abrasion and adhesion. The flank wear formation is a serious problem in machining of materials irrespective of their condition [44,46]. The flank wear formation is not a gradual wear. It can happen rapidly at the start or delayed. The wear condition depends upon the work material properties and qualities, their alloying elements, condition at which it is being machined (soft or hard condition), operating parameters, types of tool and machine stabilities [22,24].

Tool wear rate is the rate at which the cutting edge of a tool wears away during machining [29,34]. Surface Finish is the degree of smoothness of a part's surface after it has been manufactured. Surface finish is the result of the surface roughness, waviness, and flaws remaining on the part [29].Cutting tool wear is the result of load, friction, and high temperature between the cutting edge and the work piece. Several wear mechanisms can occur during metal cutting: adhesive wear, abrasive wear, diffusion wear, oxidation wear, and fatigue wear [12].The tool wear is a result of mechanical and chemical interactions of the tool with the work piece and can be written as ,

$$\text{Total wear} = W\ \text{mechanical} + W\ \text{chemical}.$$

It occurs on the tool flank as a result of friction between the machined surface of the work piece and the tool flank. Flank wear appears in the form of so-called wear land and is measured by the width of this wear land, VB, Flank wear affects to the great extend the mechanics of cutting [24].It consists of a concave section on the tool face formed by the action of the chip sliding on the surface. Crater wear affects the mechanics of the process increasing the actual rake angle of the cutting tool and consequently, making cutting easier. At the same time, the crater wear weakens the tool wedge and increases the possibility for tool breakage [26].

Tool life is the most important practical consideration during selecting the cutting tools and cutting condition. Tool which wear slowly have a low per part cost and produce predicable tolerances and surface finishes. An Understanding of tool life required an understanding of the ways in which tool fail [16,12].

II.LITERATURE REVIEW

A. WORK PIECE

The turning operation is selected with the various work material and tool combination while machining En-9 steels with coated carbide insert as the cutting tool. More precisely, it is the flank wear in the cutting tool, which is concentrated upon in this research work as it is one of the most significant parameter in analysing the effects of condition monitoring [1].

The cutting forces in a turning process of EN 8 steel to estimate the tool wear effect. Tool wear effect is obtained by monitoring the variation in the cutting forces. The work pieces were EN 8 steel bars with a nominal diameter of Φ30mm and 100mm cutting length [9].

This steel can be hardened and tempered to provide a greater strength and wear resistance in comparison in low carbon steels. Chemical composition Of EN8 Material. [12,45]

The investigation into the effects of cutting speed, feed rate, depth of cut, nose radius and cutting environment in Lathe turning of mild steel tool. Design of experiment techniques, i.e. response surface methodology (RSM) has been used [13].

The optimization and evaluation of machining parameters for turning on EN8 steel on Lathe machine. This study investigates the use of tool materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics [16].

The work piece material selected for investigation is EN 8 steel. En 8 finds wide varieties of application not only for forging, casting, axel shaft, crank shaft and connecting rods but also used for low cost die material in tool and die making industries [17].

B. TOOL MATERIAL& GEOMETRY

Figure1.3. Carbide Insert

Coated carbide inserts are used for machining purposes to obtain good surface finish [1].The coated carbide tool single point cutting tool is used of make SANDVIK. This selection of tool bit depends on many factors like work piece hardness and tool life required and the operating condition etc[4,26,31].Thus the Figure 1.3.and 1.4, Carbide insert, tool nomenclature is given by,

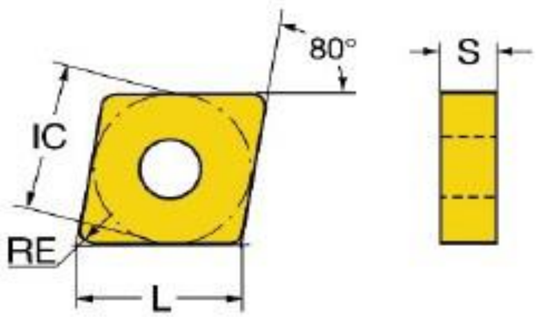

Figure1.4. Tool Nomenclature

Where,

L-Cutting Edge Length

RE-Corner Radius

IC-Inscribed Circle Diameter

S-Insert Thickness

The tool material used for experimental investigation is carbide insert having three pieces of specification CNMG120404 [12,27].

The shear zone, where the main plastic deformation takes place due to shear energy. This heat raises the temperature of the chip. Part of this heat is carried away by the chip when it moves upward along the tool. Considering a continuous type chip, as the cutting speed increases for a given rate of feed, the chip thickness decreases and less shear energy is required for chip deformation so the chip is heated less from this deformation [14].

The chip-tool interface zone, where secondary plastic deformation due to friction between the heated chip and tool takes place. This causes a further rise in the temperature of the chip. This chip-tool interface contributes 15-20% of heat generated [14].

The work-tool interface zone 3, at flanks where frictional rubbing occurs. This area contributes 1-3% of heat generated. As the portion of heat that flows into the tool cause very high temperature in vicinity of tool tip which in turn decrease the hardness of the tool material and in extreme case may even cause melting [14].

Tool wear on the tool-chip and tool-work piece interfaces (i.e. flank wear and crater wear) is strongly influenced by the cutting parameters, cutting temperature, tool geometry, tool material, work piece material, etc [15].

The materials used for this study were Stainless steel, Mild steel iron and Aluminium cast obtained from a scrap yard in Benin City, Nigeria. Cutting tool used was High Speed Steel (HSS) [28]. Thus the Figure 1.5 Tool Geometry is given by,

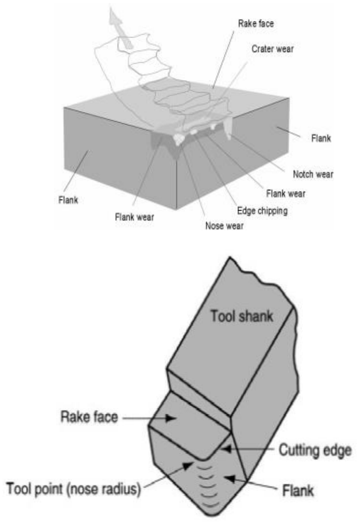

Figure: 1.5.Tool Geometry

The effect of cutting tool geometry has long been an issue in understanding mechanics of turning. 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 [20]. Thus the Figure 1.6 Tool geometry variation is given by,

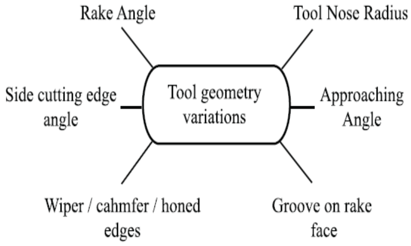

Figure 1.6.Tool Geometry Variation

Among various machining parameters, tool nose radius has a significant contribution to the cutting dynamics and the stability of a machining process. Nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces smoother surface at lower feed rates and a higher cutting speed. Large nose radius tools have, along the whole cutting period, slightly better surface finish than small nose radius tools [20,47]. Thus the Figure 1.7. Schematic sketch for turning indicating various angles is given by,

The lack of information on cutting tool geometry and its influence on the outcomes of machining operation can be explained as follows. Many great findings on the tool geometry were published a long time ago when CNC grinding machines capable of reproducing any kind of tool geometry were not available and computers to calculate parameters of such geometry were not common; it was therefore extremely difficult to reproduce proper tool geometries using manual machines [32,34].

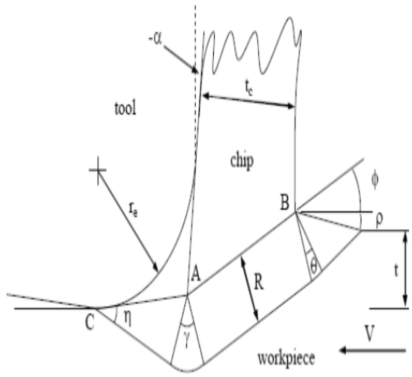

Figure 1.7. Schematic Sketch For Turning Indicating Various Angles

The cutting tool geometry is of prime importance because it directly affects:

1. Chip control.

The tool geometry defines the direction of chip flow. This direction is important to control chip breakage and evacuation.

2. Productivity of machining.

The cutting feed per revolution is considered the major resource in increasing productivity. This feed can be significantly increased by adjusting the tool cutting edge angle.

3. Tool life.

The geometry of the cutting tool directly affects tool life as this geometry defines the magnitude and direction of the cutting force and its components, the sliding velocity at the tool–chip interface, the distribution of the thermal energy released in machining, the temperature distribution in the cutting wedge *etc*.

4. The direction and magnitude of the cutting force and thus its components.

Four components of the cutting tool geometry, namely, the rake Tools(Geometry and Material) and the tool cutting edge angle, the tool minor cutting edge angle and the inclination angle, define the magnitudes of the orthogonal components of the cutting force.

5. Quality (surface integrity and machining residual stress) of machining.

The correlation between tool geometry and the theoretical topography of the machined surface is common knowledge. The influence of the cutting geometry on the machining residual stress is easily realized if one recalls that this geometry defines to a great extent the state of stress in the deformation zone, *i.e.*, around the tool [32,34]. Thus the Figure 1.8. is**.** Uniform Vs variable micro-geometry design given by,

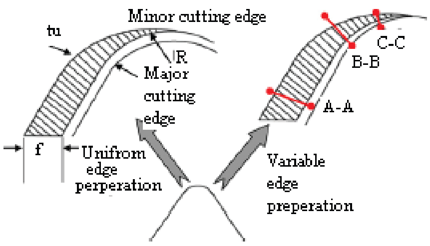

Figure 1.8. Uniform Vs variable micro-geometry design

As mentioned in Figure 4 for variable micro-geometry tool edge radius at point A-A is greater than that of at point B-B and C-C (rA > rB > rC). Author studied the turning of annealed and hardened AISI 4340 steel (40 HRc) using PCBN inserts (50% CBN + 40% TiC + 6% WC) with four different micro geometries (uniform chamfer with 0.1mm chamfer height and 20º angle, uniform hone with 50 µm (and 40 µm) edge radius, waterfall (WF) hone with re = 30:60 mm radii, variable hone edge with rA = 50 µm, rB = 10 µm radii).[12,20]

The passive forces (Fp) in the passive direction are higher than the primary cutting forces (Fc) in cutting direction and increase more rapidly with the increase in chamfer angle.

In finish hard turning there is an optimum value of chamfer angle where the tool life is maximum. The Results indicated that tool life reaches to its maximum up to 15º-chamfer angle and after that it reduces drastically. The tool life was measured up to the value of 0.2 mm flank wear, in order to avoid excessive white layer induced on the work piece surface due to the higher temperature under the large flank wear. As per FE analysis the cutting edge with 15° chamfer angle has the smallest value of flank wear as compared to other cutting tools.[20]

Turning tests were performed on nickel-based alloy, INCONEL- 718 TM, with,Al_2O_3-based, Al_2O_3-based + SiC and PCBN inserts having modified edges. A uniform edge micro-geometry along the corner radius of the insert creates a very low edge radius to uncut chip thickness at the minor cutting edge. This causes more ploughing than shearing at the minor cutting edge resulting in excessive heat built-up and rapid wear. A variable edge micro-geometry along the corner radius of the insert has the potential to reduce this heat built-up at the cutting edge enabling hard turning at higher cutting speeds and feeds with less tool wear [32,20].

Variable edge preparation is not limited to honed micro-geometry inserts. Chamfered and waterfall type micro-geometry inserts can also have variable edge preparation. The purpose of continuously changing the chamfer angle along the corner radius is to alter the locations of high temperature zones and reduce the possibility of a crater wear formation.

Among various machining parameters, tool nose radius has a significant contribution to the cutting dynamics and the stability of a machining process. Nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. Large nose radius tools have, along the Whole cutting period, slightly better surface finish than small nose radius tools [20].

Nose radius is a major factor that affects surface roughness. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. However, a larger nose radius reduces damping at higher cutting speeds, thereby contributing to a rougher surface. The effect of the nose radius on the residual stress distribution decreases greatly with the increase of the tool wear [12,20].

The large tool nose radii only give finer surface finish, but comparable tool wear With small nose radius tools. Specific cutting energy slightly increases with tool nose radius. Tool life based on flank wear increases with increase in nose radius. However, reaches a Constant at nose radius greater than 0.4 mm. On the other hand, tool life based on surface finish shows a local maximum at 0.8 mm nose radius. It was suggested that large nose radii result in severe groove wear, and therefore, poor surface finish [24].

The beneficial effect of controlled contact cutting with respect to energy reduction became more pronounced with an increase in feed rate and depth of cut. During the turning of C45 carbon steel, chromium alloy steel and austenitic steel with coated index able inserts of TNMG having four different chip groove geometries, results reveal that specific cutting energy seems to be governed remarkably by the contact length. Chip breaking increases steadily at higher feed rates and saving in cutting power consumption can be achieved by controlling the contact length at higher feed and depth of cut [20].

To obtain an optimum tool performance for providing good chip-breakability and tool life, it appears that the contact length should be in the range of 55-65% of the natural contact Length. The back rake angle affects the ability of the tool to shear the work material and form the chip. It can be positive or negative. Positive rake angles reduce the cutting forces resulting in smaller deflections of the work piece, tool holder, and machine. If the back rake angle is too large, the strength of the tool is reduced as well as its capacity to conduct heat. In Machining hard work materials, the back rake angle must be small, even negative for carbide, PCBN and diamond tools [14]. In the use of variable micro-geometry design if the focus is given to ratio of uncut chip thickness to edge radius process performance can be enhanced. As with decreasing uncut chip thickness to edge radius ratio friction factor increases. Further the effect of variable micro-geometry design should be explored with respect to surface integrity i.e. its impact on residual stresses, white layer formation and micro-hardness variation beneath the machined surface [20,22].

In tests, single layer (TiAlN) PVD Coated insert has been employed for experimentation. In this insert top layer is TiN which has a certain characteristic such as tendency to reduce built up edge, a higher coefficient of friction and thermal conductivity. These characteristics results in less thermal cracks and improves surface finish [6].

Titanium nitride,TiN is gold-coloured coating offers excellent wear resistance with a wide range of materials, and allows the use of higher feeds and speeds. Forming operations can expect a decrease in galling and welding of work piece material with a corresponding improvement in the surface finish of the formed part [29].

Titanium carbon nitride, TiN(C,N) Bronze-coloured Ti(C,N) offers improved wear resistance with abrasive, adhesive or difficult-to-machine materials such as cast iron, alloys, tool steels, copper and its alloys, Inconel and titanium alloys [29].

Titanium aluminium nitride,(Ti,Al)N Purple/black in colour, (Ti,Al)N is a high-performance coating which excels at machining of abrasive and difficult-to-machine materials such as cast iron, aluminium alloys, tool steels and nickel alloys [29].

Chromium nitride,CrN Silver in colour, CrN offers high thermal stability, which in turn helps in the aluminium die casting and deep-draw applications. It can also reduce edge build-up commonly associated with machining titanium alloys with Ti-based coatings [28,29].

Carbide tool is the most common tool material for machining castings and alloy steels. It has high toughness, but poor wear characteristics compared to advanced tool materials. In order to improve the hardness and surface integrity, carbide tools are coated with hard materials such as TiN, TiAlN, and TiCN by physical vapour deposition (PVD) and chemical vapour deposition (CVD) [20,12].

C.TOOL COATING

Mostly carbide tools are processed by physical vapour deposition (PVD) and chemical vapour deposition (CVD) so as to from a coating of material with properties like higher wear resistance and thermal shocks. Titanium based hard thin films are mostly used due to higher wear resistance, thermal shocks and corrosion property and also impart lubricity at the chip tool interface to reduce friction [6,48].

Titanium nitride (TiN) has been used in the coating of tool steels since the mid-sixties. The reasons to coat cutting tools in a production situation are to increase tool life, to improve the surface quality of the product, and to increase the production rate. The advantages of TiN coating include high hardness, good ductility, excellent lubricity, high chemical stability and tough resistance to wear, corrosion and temperature [10].

The influence of machining parameters under the surface roughness in dry turning of hardened AISI 4340 steel with CVD ($TiN/TiCN/Al_2O_3/ZrCN$) multilayer coated carbide tool and determine the optimal levels of machining parameters for optimizing the surface roughness (Ra) by employing Taguchi's orthogonal array design and utilizing analysis of variance (ANOVA) [11,49].

CVD (chemical vapour deposition) and PVD (physical vapour deposition) technologies are employed to obtain a thin (about 3–12_m) but hard coatings. Each of these two technologies provides different qualities for the tools resulting from their process temperatures and process flexibility different from each other [21].

III. MACHINING

The turning operation is selected with the various work material and tool combination while machining En-9 steels with uncoated carbide insert as the cutting tool .During the turning operation the flank wear, tool vibration acceleration, time and number of cuts is measured [1].

Machining operations are used to produce a desired shape and size by removing excess stock from a blank in the form of chips. New surfaces are generated through a process of plastic deformation and crack propagation [2].

The machining experiments were conducted on all geared lathe using coated cement tool inserts with two levels of factors. The factors considered were cutting speed, work piece fibre orientation angle, depth of cut and feed rate [3].

The selection of the cutting parameters and design array needs very much attention in any experimental research work [4, 43]. The cutting parameters selected are as:

Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed. But the important feature for a particular turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool [12].

Feed always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev [12].

Depth of cut is practically self-explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though, that diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work [12].

The cutting force was measured by Kistler dynamometer (model no 9857B) and charge amplifier model was 5070A. Flank wear was increasing with the increase in cutting speed, this is because higher cutting speed increases cutting temperature and this softens the tool cutting edge. Cutting force was increasing with the increase in feed rate and depth of cut [5].

Turning is a very important machining process in which a single-point cutting tool removes material from the surface of a rotating cylindrical work piece. The cutting tool is feed linearly in a direction parallel to the axis of rotation. Turning is carried out on a lathe that provides the power to turn the work piece at a given rotational speed and to feed the cutting tool at a specified rate and depth of cut [13,35].

Now-a-days 80% of all machining operations are performed with coated carbide cutting tools. Turning is a widely used material removal process. The use of CNC turning machine has a proven record of better surface quality, precise accuracy, less machining times and high production rate in comparison to the conventional lathe machines. The ANOVA i.e. Analysis of Variance table is commonly used to summarize the tests performed [6].

Taguchi, ANOVA, response surface method and FEA analysis are useful tools to develop relationships between various variables [7].

In machining operations, achieving desired surface quality features of the machined product, is really a challenging job on CNC machine. Because, these quality features are highly correlated and are expected to be influenced directly or indirectly by the direct effect of process parameters [8].

It has been made to evaluate the performance of multilayer coated carbide inserts during dry turning of hardened AISI 4340 steel (47 HRC). The effect of machining parameters (depth of cut, feed and cutting speed) on surface roughness (Ra) was investigated by applying ANOVA [11,50].

Taguchi method is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize design for performance, quality and cost. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions [17, 19].

When the chips moving on the rake face with heat moves slowly and forms crater. The heat at tool tip interface is enough to soften the tool edge and loose its cutting strength. As the process is continuously performed, more crater wear occurred [22].

IV.CONCLUSION

1. Large edge hone tools produce statistically higher forces in the axial (feed) and radial (thrust) directions than small edge hone tools. Further large edge hone tools produce higher surface roughness values than small edge hone tools. However, feed dominates surface roughness. The chamfer angle has a great influence on the cutting force and tool stress. All cutting force components increase with an increase in the chamfer angle, especially the level of passive force. Further an increase of chamfer angle will increase tool life up to certain value, after that the tool life decreases. This increase of tool life is due to the increase in wedge strength of the PCBN tool. Also higher value of chamfer angle produces low surface roughness at higher cutting speed.

2. 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. Further the increased radius of a cutting tool will produce larger compressive residual stress beneath the machined surface. Further large edge hone tools promote continuous white layer formation at feeds above 0.05 mm/rev (0.002 in/rev). While small edge hone tools cause over-tempered regions at feeds above 0.05 mm/rev (0.002 in/rev).

3. Variable edge preparation inserts perform better than uniform edge preparation, Tool wear is decreased with the use of a variable micro-geometry inserts. As this variable micro-geometry tool design reduces the heat generation along the tool cutting edge. Further this edge induces less plastic strain on the machined work piece in comparison to uniform edge.

4. Size of tool edge radius is an important factor and it affects the mechanics of cutting. Edge radius must be selected according to cutting conditions. Large edge radius is not suitable for Machining low uncut chip thickness. The ratio of uncut chip thickness to edge radius, which is app. equal to three, seems to be an appropriate ratio for edge preparations used in the cutting tests.

In finish hard turning white layer depth decreases with increasing nose radius.

V. FUTURE WORK

From the above conclusion one can use the ANOVA approach for optimizing the turning process parameters like speed, feed, and depth of cut, nose radius, and type of tool, materials of tool and work piece and cutting fluids etc. For minimizing Tool wear and maximize the tool life by experimental setup.

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