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Turning of Hard Material (62-64 HRC): Research Overview

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Abstract
The hard turning is a modern technology. It involves machining of hard materials by modern machine tools. The hard machining has challenges such as selection of tool insert with improved tool life with high-precision machining. The turning of hardened materials by single-point cutting tool has got considerable interest among manufacturers of cutting tool, ball bearings, automotive, gear, and die industry. The hard turning has a number of benefits over traditional grinding process including lower equipment costs, shorter setup time, and fewer process steps which in turn offers high flexibility and ability to cut intricate geometries. The hard turning process is generally carried out without cutting fluid so the problem of storage, handling, and disposal of cutting fluid is eliminated. It is favors the health of operators.This review paper offering an overview of the past research hard turning by hard turning tools such as PCBN, CBN, Ceramics, Carbide, etc. The main hard turning cutting materials and influence of hard turning process parameters on cutting forces, heat generation during cutting, surface finish, and tool wear have been discussed in light of the outcomes of the past research.

Index terms: hard turning; high-precision machining, hard tool materials

1. INTRODUCTION

The high hardness materials include numerous hardened alloy steels, tool steels, case-hardened steels, super alloys, nitrided steels, hard chrome coated steels, and heat-treated powder metallurgical components. The finishing of hardened steel, (e.g. through hardened AISI 52100 steel for bearing applications, and case hardened steel 16MnCr5 for automotive gears and shafts) by hard turning by super hard cutting tools (PCBN,CBN, Ceramics, and Carbide) was early recognized by the automotive industry as a suggests that of producing of precisely finished transmission elements (Davim, 2011).If hard turning is applied to the manufacture of complicated components, manufacturing prices will be reduced up to half-hour, and US industries exploited the benefits of hard turning for an annual gain of up to $6 billion (Huang, Chou, & Liang, 2007).A qualitative comparison of the capabilities of hard turning and grinding processes in terms of workpiece quality, process flexibility, dimension and shape accuracy, etc. has been made by M'Saoubi, Outeiro, Chandrasekaran, Dillon, and Jawahir (2008).

In the past, many studies have been carried out to explore completely different aspects of the hard turning of steel. Thiele and Melkote (1999) studied the influence s of tool edge geometry of CBN tools and piece of work hardness (45, 52, and 60 HRC) on the surface roughness and cutting forces in the finish hard turning of AISI 52100 steel. Their investigation showed that large edge hone lead to higher forces in the axial, radial, and tangential directions as compared to those tools with small edge hone. Further, the influence of workpiece hardness on the axial and radial elements of force was found to be important, particularly for massive edge hone. Ramesh, Melkote, Allard, Riester, and Watkins (2005) examined the differences in structure and properties of white layers formed throughout machining of hardened AISI 52100 steel (62 HRC) at totally different cutting speeds. Their outcomes indicated that the grain sizes of white layers formed were significantly smaller than the grain sizes of the bulk. They also determined that white layers generated at higher machining speeds are coarser than those generated at lower speeds.

2. MAJOR HARD TURNING CUTTING TOOL MATERIALS

The major hard turning materials are discussed in the following section:

2.1. Sintered carbide (hard metal)

Sintered carbide tools, also known as hard metal tools or cemented carbide tools, are created by a mixture of tungsten carbide micro grains with cobalt at high temperature and pressure. Tantalum, titanium, or vanadium carbides can additionally be mixed in small proportions. This type of material in the straight grade or in the coated grades is generally utilized nowadays for hard machining and high-speed machining.

A sintered tungsten carbide additionally includes tic (carbide with hardness 3200 HV) and in some cases TiCN, but they usually have a nickel–chrome binder. New grades with TaNbC and MoC increase the tool-edge strength against the cyclic impacts which finds typical application in milling. Tungsten carbide is stable with regard to chemical and thermal aspects of machining and is very hard as well. In most cases, cemented carbide degradation starts from the cobalt binder and the tungsten carbide–cobalt cohesion (Davim, 2011).

Aslan (2005) studied the wear behavior of various cutting tools like TiCN coated tungsten carbide, TiCN + TiAlN coated tungsten carbide, TiAlN coated cermet, mixed ceramic with Al2O3 + TiCN, and CBN, in end milling of X210 Cr12 cold-work tool steel hardened to 62 HRC. The outcomes of his investigations indicated that the TiAlN coated carbide and cermet tools perform slightly better than TiCN coated carbide tool which will be attributed to better high-temperature properties of TiAlN compared to TiCN. Further, he also found that CBN tool exhibits the best cutting performance in terms of both flank wear and surface finish and therefore the highest volume of metal removal is obtained with CBN tool. Arsecularatne, Zhang, and Montross (2006) studied wear and tool life for tungsten carbide WC cutting tool throughout machining of AISI 4142 steel and AISI 1045 steel, and also for PCBN cutting tool throughout machining of AISI 52100 with 2 totally different hardness values of 60HRC and 62HRC. It was concluded from their investigation that the most dominant tool wear mechanism for WC is diffusion and for PCBN is chemical wear. Lima, Avila, and Abrao (2007) performed an investigation which is involved with the continuous turning of AISI 4340 steel hardened from 250 up to 525 HV by coated carbide tools. They assessed machining forces, tool life, and wear mechanisms. The outcomes of their investigation indicated that the machining force components increase with the work material hardness, however, the cutting force components decrease slightly as the work hardness increase from 250 up to 345 HV. Further, tool wear was lower when machining the work with a hardness value of 345 HV as compared to machining of the work possessing the hardness of 250 HV steel. Finally, it was observed that the abrasion is that the principal wear mechanism and catastrophic failure takes place once making an attempt to machine the 525 HV steel. Chowdhury and Dhar

(2011) studied the tool wear and surface roughness for varying cutting parameters under dry and minimum quantity Lubrication (MQL) environment whereas turning hardened medium carbon steel by coated carbide insert. The outcomes of their investigation indicated that the application of MQL technique significantly helps to get higher performance of coated carbide insert compared to a dry condition. Hwang and Lee (2010) studied the influence of cutting parameters (nozzle diameter, cutting speed, feed rate, and depth of cut) on cutting forces and surface roughness of carbon steel AISI 1045 by coated carbide inserts under MQL and wet turning conditions. They found that cutting speed and depth of cut show opposite influence s on the cutting force and therefore, they suggested that cutting conditions ought to be set a clear standard because the best combination of cutting parameters may be totally different depending on machinability. Also, cutting speed and depth of cut showed opposite influence on surface roughness in MQL turning and it produced better surface roughness compared to wet turning. They also determined that the MQL turning provides additional benefits than wet turning.

2.2. Ceramics

The ceramics are very hard and refractory materials, withstanding more than 1500 °C with-out chemical decomposition. These features suggest them to be utilized for the machining of metals at high cutting speeds and in dry machining conditions. Ceramic tools are based mostly primarily on aluminum oxide (Al2O3), silicon nitride (Si3N4), and Sialon (a combination of Si, Al, O, and N). Alumina tools will contain titanium, magnesium, chromium, or zirconium oxides distributed homogeneously into the aluminum oxide matrix to improve toughness (Davim, 2011) Several sorts of analysis are done to investigation the influence of hard turning on differing kinds of ceramics tools. Luo, Liao and Tsai (1999) within their analysis revealed the wear behavior of ceramic and CBN tools in the turning of AISI 4340 hardened alloy sheets of steel. It was found from their investigation that the most wear mechanism for the CBN tools is the abrasion of the binder material by the hard carbide particles of the work and for the ceramic tools it's adhesive wear and abrasive wear. They also found that there is a protecting layer formed on the chip–tool interface that plays a vital role in wear behavior of CBN and ceramics tools. Kumar, Durai, and Sornakumar (2003) studied the machinability of EN 24 steel (HRC 40 and HRC 45) by two types of ceramic cutting tool materials particularly, Ti[C, N] mixed aluminum oxide ceramic cutting tool and zirconium oxide toughened alumina ceramic cutting tool. It was found from their investigation that the performance of ceramic cutting tools is nice in the machining of hardened steel and Ti[C, N] mixed alumina ceramic cutting tool produces the best surface finish. Gaitonde, Karnik, Figueira, and Davim (2009b) analyzed the influence s of depth of cut and machining time on machinability aspects such as machining force, power, specific cutting force, surface roughness, and tool wear, with the use of second-order mathematical models during turning of high chromium AISI D2 cold work alloy steel with CC650, CC650WG, and GC6050WH ceramic inserts. From their analysis, it was revealed that the CC650WG wiper insert performs better with respect to surface roughness and tool wear, while the CC650 standard insert is helpful in reducing the machining force, power, and specific cutting force. Elmunafi (2012) evaluated the performance of wiper coated ceramic tool when turning ASSAB DF-3 grade hardened steel with hardness 55 HRC. Their investigation showed that the influence s of cutting speed and feed rate on the tool life is statistically important. They also found that the influence s of cutting speed and feed rate on the surface roughness is statistically important, specifically, at high cutting speed and low feed rate. Accordingly, wiper inserts were able to turn out the higher surface finish.

2.3. Extra-hard materials

The PCD and PCBN are extra hard materials. There are many grades in the PCD and PCBN groups. The PCD is suitable for tools force employed on machining abrasive non-ferrous metals, plastics, and composites. PCBN finds applications in the machining of hardened tool steels and hard cast irons. PCD plates are obtained by a high temperature and pressure process where artificial diamond grains are sintered with cobalt. The CBN is a polymorph boron-nitride-based material. It possesses high mechanical properties due to its crystalline structure and it's covalent link. It has been industrially produced since 1957, starting from hexagonal boron nitride put under high pressures (8Gpa) and temperatures (1500 °C).With a lower hardness (4500 HV) than diamond (9000 HV), CBN is the second-hardest synthetic material. The CBN grains are sintered together with a binder to make a composite, PCBN. The size, shape, and ratio of CBN/binder define the different PCBN grade (Davim, 2011).

The literature reveals that many researchers have recommended an influence of hard turning on CBN and PCBN cutting tools (Chowdhury and Dhar 2011; Diniz et al., 2005; Elmunafi 2012; Lima et al., 2007). In addition, many studies have been conducted to research the performance of CBN and PCBN tool in machining of various hard materials. Oliveira, Diniz, and Ursolino (2009) studied the performance of PCBN and alumina-based ceramic reinforced with silicon carbide tools throughout turning of AISI 4340 steel with 56 HRC under continuous and interrupted cutting. The outcomes of their investigation indicated that the longest tool life is achieved by PCBN in continuous turning, but similar tool longevity is attained in interrupted turning by each PCBN and ceramic. Also, the roughness values were lower for both continuous and interrupted surfaces once PCBN tools were utilized. Sahin (2009) compared the tool life of mixed alumina ceramic with that of Al2O3 (70%): tic (30%) matrix and CBN cutting tools throughout machining of AISI 52100 steel. They showed that the CBN cutting tool has the best performance than that of the ceramic-based cutting tool. Poulachon, Moisan, and Jawahir (2001) studied various modes of wear and damage of PCBN cutter under different loading conditions throughout turning of AISI 52100 steel in order to determine a reliable wear model. Their outcomes led to the conclusion that the main wear mechanism of the PCBN tools is abrasion and it depends not solely on the chemical composition of the PCBN, and the nature of the binder phase however also on the hardness value and particularly on the microstructure of the machining work material. They also found that use of TiN coated PCBN improves the tool wear and hence the tool life by reducing the diffusion wear between work and tool rake face. Diniz, Ferreira, and Filho (2003) studied the influence of cutting speed under three cutting conditions: dry cutting, wet cutting, and minimum volume of oil i.e. MVO (oil flow of 10 ml/h) on CBN tool wear in turning of AISI 52100 hardened steel. Their outcomes revealed that dry and MVO cuttings produce most of the time, similar values of flank wear which is always smaller than the values obtained throughout wet cutting. They also determined that highest cutting speed for three cutting conditions provides the smallest value of surface roughness.

3. INFLUENCE OF PROCESS PARAMETERS IN HARD TURNING:

The hard turning influences many response factors such as cutting forces, vibrations, surface finish, and tool wear etc. The following section discusses various response factors which are investigated by previous investigator.

3.1. Studies on cutting forces

The forces acting on the tool are the vital aspect of machining. The knowledge of the cutting forces is required for the estimation of power needs, the adequately rigid design of machine tool components, tool-holders, and fixtures, for vibration free operations. The many force measuring devices like dynamometers have been developed that are capable of measuring tool forces with increasing accuracy. The power consumed in metal cutting is largely converted into heat close to the cutting edge of the tool, and many of the economic and technical issues of machining are utilized directly or indirectly by this heating action (Sharma, Dhiman, Sehgal, & Sharma, 2008). By measuring the cutting forces, one is able to understand the cutting mechanism like the influences of cutting variables on the cutting force, the machinability of the workpiece, the process of chip formation, chatter, and tool wear. It has been observed that engineering calculations utilized for getting the force values provide some errors when compared to experimental measurements of the forces. The cutting force in even unsteady state conditions is affected by many parameters and therefore the variation of cutting force with time has a typical characteristic. The cutting forces can be resolved into three parts i.e. the radial thrust force (F_X), feed force (F_Y), and tangential cutting force (F_Z).Usually, the tangential cutting force is the largest of the three components, though in finish turning the radial thrust force is typically larger, while the feed force is lowest. The findings of some of the research studies concerning the influence of cutting parameters on cutting forces are presented below. The cutting forces increase drastically when machining materials with hardness higher than about 45 HRC (Davim, 2011). Kurt and Seker (2005) studied the influences of chamfer angle on the cutting forces and the stresses on the PCBN cutting tools in finishing hard turning of AISI 52100 bearing steel. They found that the chamfer angles (20° and 30°) have a great influence on the passive cutting forces and Von Misses tool stresses distribution. Lee (2011) developed a theoretical model to predict cutting forces for machining AISI 4140-hardened materials (45 HRC) that contain more than 0.58% carbon. His predicted values of cutting forces from the model were found to be in good agreement with those measured from an experiment of hard machining of AISI 4140 steel heat-treated. Panzera, Souza, Rubio, Abrao, and Mansur (2012) studied the influence of the cutting parameters (cutting speed, feed rate, and depth of cut) on the cutting force components throughout dry turning AISI 4340 steel by coated carbide inserts. The outcomes of their investigation indicated that the three components of the turning force decrease slightly as cutting speed will increase and also they increase linearly with feed rate and depth of cut. Further, the outcomes of analysis of variance (ANOVA) revealed that the three parts of the force aren't significantly affected by cutting speed however they're significantly affected by feed rate and depth of cut. Aouici, Yallese, Fnides, and Mabrouki (2010) studied the influence of the cutting parameters (cutting speed, feed rate, and depth of cut) on cutting force components, surface roughness, temperature in the cutting zone, and tool life during turning of AISI H11 steel treated at 50 HRC by CBN tool (57% CBN and 35% Ti (C, N)). Their outcomes indicated that (i) tangential cutting force is very sensitive to the variation in cutting depth, (ii) thrust force is dominating compared to both others cutting forces, (iii) surface roughness is very sensitive to the variation of the feed rate, and (iv) the temperature is greatly influenced by the cutting speed.

3.2. Studies on heat generation and cutting temperature

The most of the energy in the cutting process is converted into heat. This heat is generated by plastic deformation and friction at the tool–chip and the tool–workpiece interfaces. The generation of the heat during machining increases the temperature within the cutting zone that affects the strength, hardness, wear resistance, and life of the cutting tool and causes difficulty in controlling the dimensional accuracy and surface integrity. The temperature also causes thermal harm to the work and affects its properties and service life.

The temperature in the cutting zone is affected by the cutting parameters. In addition, it also depends on the properties of the work material, as well as on the physical properties of the tool. Therefore, considerable attention has been paid to the measure and prediction of the temperatures at the tool, chip, and workpiece in the metal cutting (Aouici et al., 2010; Özel, 2009). The cutting tools that are employed for machining should possess adequate hot hardness to withstand elevated temperatures generated at the high-speed condition. Under these conditions, most tool materials generally lose their hardness resulting in the weakening of the interparticle bond strength and consequently, tool wear gets accelerated as reported by Ezugwu, Bonney, and Yamane (2003). Amritkar, Prakash, and Kulkarni (2012) performed machining of SAE 8620 material at the various cutting speed and feed rate by uncoated tungsten carbide tool. They designed and developed a simple and economical technique of temperature measure i.e. tool-work thermocouple setup for the measure of the cutting temperature for that they calibrated the setup so as to determine a relationship between obtained e.m.f. during machining and the cutting temperature. They employed regression analysis for establishing the link between temperature and the generated voltage.

They evaluated the performance of the setup for the different material like EN19, EN31, mild steel, SS 304, and SAE 8620 by uncoated tungsten carbide tool. Their obtained outcomes confirmed that the setup is having better accuracy and good repeatability. Further, they observed that the tool-work thermocouple technique is the best technique for measure the average chip–tool interface temperature throughout metal cutting. Sutter, Faure, Molinari, Ranc, and Pina (2003) studied the influence s of the cutting speed and depth of cut on the temperature profile at the chip during an orthogonal machining of 42 CrMo 4 steel by standard carbide tools TiCN coated. They performed the machining with a gas gun. It was found from their outcomes that the temperature at the chip increases with the rise in both cutting speeds as well as the depth of cut. Ren, Yang, James, and Wang (2004) determined the cutting temperatures during hard turning of high chromium hard facing materials by PCBN tools. They found that the average cutting temperatures ranged from 600 to 700 °C which raised with higher cutting speed and feed rate. Abukhshim, Mativenga, and Sheikh (2005) employed FEA to estimate the quantity of heat flowing into the cutting tool in the high-speed turning of AISI 4140 high strength steel by uncoated cemented carbide. Their outcomes showed that the maximum temperature at the tool–chip contact will increase with cutting speed however not linearly and this might be attributed to the trend of the heat fraction flowing into the tool. Sutter and Ranc (2007) measured the temperature during machining of two sheets of steel i.e. C15 and 42CrMo4 for a range of cutting speed around 15–65 m/s. Their outcomes showed that the increase in cutting speed from 10 to 65 m/s maximizes temperature at the chip continuously. List, Sutter, and Bouthiche (2012) predicted the interface cutting temperature and its relation with the crater wear mechanism. Their work was employed on the domain of the high-speed machining higher than 20 m/s. They analyzed the mechanical and thermal parameters that influenced the temperature distribution at the tool rake face.

3.3. Studies on surface finish and surface integrity

The surface integrity of a machined surface is defined in terms of residual stresses, surface roughness, micro hardness, etc. Surface roughness and dimensional accuracy play an important role in the performance of a machined component. High cutting forces and high localized temperatures may dramatically affect the surface integrity, often resulting in the development of high tensile residual stresses in the machined surfaces. Residual stress on the machined surface and the subsurface is known to influence the service quality of a component, such as fatigue life, tribological properties, and distortion. Therefore, it is essential to predict and control it for enhanced performance as suggested by several researchers (Adesta et al., 2009; Aouici et al., 2010; Benga & Abrao, 2003; Chowdhury & Dhar, 2011; Diniz et al., 2003; Elmunafi, 2012; Fnides et al., 2009; Gaitonde et al., 2009; Godoy & Diniz, 2011; Kumar et al., 2003; More et al., 2006; Poulachon et al., 2001; Ramesh et al., 2005; Sharma et al., 2008; Thamizhmanii & Hasan, 2010; Thiele & Melkote, 1999; Yallese et al., 2009; Zawada-Tomkiewicz, 2011). In addition to the research studies cited above, Hua et al. (2005) analyzed the influence s of cutting edge geometry, workpiece hardness, and cutting parameters, such as cutting speed and feed rate on subsurface residual stress in hard turning of AISI 52100 bearing steel. It was revealed from their analysis that hones edge plus chamfer cutting edge and aggressive feed rate help to increase both compressive residual stress and penetration depth. Also, by medium hone radius (0.02–0.05 mm) plus chamfer was good for keeping tool temperature and cutting force low, while obtaining desired residual stress profile. Rech et al. (2008) provided a comprehensive characterization of residual stresses that were developed in the dry turning of a hardened AISI 52100 bearing steel by PCBN tools. For a better understanding of the experimental outcomes, they studied the generated residual stresses in hard turning or in 'hard turning + belt finishing' by two complementary ways: an experimental X-ray diffraction characterization after each step of the process, and a finite element model of the belt finishing operation. Additionally, they explored the sensitivity of some parameters such as the lubrication and the indentation force during belt finishing. They observed that the belt finishing process improves the surface integrity by the induction of strong compressive residual stresses in the external layer and by a great improvement of the surface roughness. In addition, they also found that among the process parameters of the belt finishing technique, the lubrication is a key parameter to get compressive stresses. Caruso, Umbrello, Outeiro, Filice, and Micari (2011) examined the influence s of the tool cutting-edge geometry, workpiece hardness, cutting speed, and microstructural changes (white and dark layers) on the residual stresses in dry orthogonal hard machining of AISI 52100 steel by PCBN tool inserts. Their outcomes showed that tool geometry, workpiece hardness, and cutting parameters significantly affect the surface residual stress, maximum compressive residual stress below the machined surface, and its location. Also, the microstructural analysis showed that thermally-induced phase transformations have a significant impact on the magnitude and location of this maximum compressive residual stress peak.

On the other hand, a number of investigations have been carried out in the past to assess the surface roughness that could be achieved with hard turning in comparison to grinding. Asilturk and Akkus (2011) studied the influence s of cutting speed, feed rate, and depth of cut on surface roughness during dry turning of AISI 4140 (51 HRC) with coated carbide cutting tools. Their outcomes indicated that the feed rate has the most significant influence on the surface roughness. In addition, the influence s of two-factor interactions of the feed rate-cutting speed and depth of cut-cutting speed appear to be important. Aouici, Yallese, Chaoui, and Mabrouki (2012) studied the influence s of cutting speed, feed rate, workpiece hardness, and depth of cut on surface roughness in the hard turning of AISI H11 steel (hardened to (40; 45; and 50) HRC) by CBN which is essentially made of 57% CBN and 35% TiCN. Their outcomes showed that both the feed rate and workpiece hardness have statistically significant influence on the surface roughness. Further, the best surface roughness was achieved at the lower feed rate and the highest cutting speed. Umbrello et al. (2011) studied the influence s of cryogenic coolant on surface integrity in orthogonal machining of hardened AISI 52100 bearing steel by chamfered CBN tool inserts. The outcomes of their investigation showed that the use of cryogenic coolant significantly affects the surface integrity and improves product's functional performance. Grzesik, Żak, Prażmowski, Storch, and Pałka (2012) explored the influence of cryogenic cooling on the surface integrity produced in hard turning of low alloy 41Cr4 steel with a hardness of 57 ± 2 HRC by low content CBN tools containing about 60% CBN. They confirmed that hard machining produces surfaces with acceptable surface roughness and, in some cases, with attractive service properties. They also observed that cryogenic hard cutting operations can partly eliminate grinding operations in cases when the white layer is not produced.

3.4. Studies on the tool wear

During machining, the cutting tools are subjected to severe forces and temperature which may cause tool wear and therefore, it is necessary to investigation and predict the tool wear during machining for the influences design of cutting tools and determination of cutting conditions that will lead to the formulation of the tool change strategies. Intensive research studies pertaining to the tool wear have been carried out in the past century which has contributed greatly to the understanding of the factors responsible for the tool wear and also the tool wear mechanisms. Many researchers employed their studies on the prediction of the tool wear during hard turning (Adesta et al., 2009; Arsecularatne et al., 2006, Arsecularatne et al., 2006; Aslan, 2005; Chowdhury & Dhar, 2011; Diniz et al., 2003; Elmunafi, 2012; Fnides et al., 2009; Gaitonde et al., 2009; Galoppi et al., 2006; Godoy and Diniz, 2011; Huang et al., 2007; Kumar et al., 2003; Lima et al., 2007; Lin et al., 2008; Luo et al., 1999; Meyer et al., 2012; More et al., 2006; Oliveira et al., 2009; Özel, 2009; Poulachon et al., 2001, 2003, 2004; Remadna & Rigal, 2006; Sahin, 2009; Suresh et al., 2012; Thamizhmanii & Hasan, 2010; Yallese et al., 2009; Zawada-Tomkiewicz, 2011; Zhao et al., 2010). In addition to the references cited before for the tool wear investigation, Grzesik and Zalisz (2008) studied the wear phenomenon of the mixed ceramic tips during dry hard turning of AISI 5140 steel (60 HRC). They performed finishing cuts under varying feed rate, the constant cutting speed of 100 m/min and small depth of cut of 0.2 mm. It was observed from their outcomes that depending on the mechanical and thermal conditions generated on the wear zones, the wear mechanisms involve abrasion, fracture, plastic flow, material transfer, and tribochemical. El Hakim, Abad, Abdelhameed, Shalaby, and Veldhuis (2011) studied the performance of different tool materials, PCBN (CBN + TiN), TiN coated PCBN (CBN + TiN), mixed alumina ceramic (Al_2O_3 + TiC), coated tungsten carbide (TiN coated over a multilayer coating (TiC/TiCN/Al_2O_3)) in the machining of medium hardened steel AISI T15 HSS. Their outcomes indicated that the mixed alumina ceramic and coated carbide tool materials have longer tool life than PCBN tools when they machined the selected workpiece material. Chinchanikar and Choudhury (2013) studied the influence of workpiece hardness, cutting parameters, and type of coating for coated cemented carbide inserts on flank wear during turning of hardened AISI 4340 steel at different levels of hardness. The outcomes of their investigation revealed that flank wear is dominant wear form for CVD coated tool and crater wear is dominant wear form for PVD coated tool. Further, they found that abrasion and adhesion are the main causes for wear of CVD coated tool and abrasion, adhesion and diffusion lead to the wear of PVD coated tool. Gaitonde et al. (2009) studied the relationships between the cutting parameters (cutting speed, feed rate, and machining time) on tool wear. They employed RSM to analyze the influence s of process parameters on machinability during turning of high chromium AISI D2 cold work tool steel by CC650WG wiper ceramic inserts. They found that the maximum tool wear occurs at a cutting speed of 150 m/min for all values of feed rate and the tool wear increases with the increase in machining time. Dogra, Sharma, Sachdeva, Suri, and Dureja (2011) made the comparison between the performance of CBN inserts with coated carbide and cryogenically treated coated/uncoated carbide inserts in terms of flank wear during finish turning of hardened AISI H11 steel (48–49 HRC). They indicated that the flank wear of CBN is lower than that of other inserts.

CONCLUSION

The review has been structured in terms of the role of machining parameters on machining of hard steel, cutting force, heat generation, and temperature evolution during machining, surface integrity, and tool wear during exhausting machining, etc. The information presented is immensely helpful to the researchers in characteristic solutions to the many machining issues to say some:

(i) To identify ways with regard to tool edge geometry, cutting parameters, etc. for specific work material hardness so as to acquire higher surface integrity and surface finish.

(ii)To identify prevalent wear mechanisms and applicable tool material for specified machining situations.

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