IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 04, Issue 05 (May. 2014), ||V2|| PP 06-14

Improving Wear Resistance of Cutting Tool by coating

M.Narasimha[1], D.Tewodros[2], R.Rejikumar[3]
Department of Mechanical Engineering, WolaitaSodoUniversity WolaitaSodo, Ethiopia.
School of Mechanical and Industrial Engineering, Bahir Dar University, Bahir Dar, Ethiopia.

Abstract: - As we know the cutting tool is an important basic tool required in metal removal operations for producing the components. It not only produces component but also maintains the dimensional accuracies, geometrical tolerances and desired surface finish of the machined part. Machining is important in metal manufacturing process to achieve near-net shape, also for the aesthetic requirements. The latest machining process and using the CNC machine tools the cutting tool play a vital role. The manufacturers of these components expect to improve their productivity, quality of the components and longer life of the cutting tools. The longer life of the cutting tool depends on various factors like machine tools used for the machining operation, cutting conditions, work piece material hardness and tool wear etc. In order to meet all these tasks the cutting tool manufacturers in the process of producing quality tools to withstand for higher cutting forces, thermal resistivity with more wear resistance. Many reputed cutting tool manufacturing organisations globally with their rich experience of research and development, invented different ways of enhancing the life of cutting tool in order to optimize the rate of production and to reduce the cost of production, which is highly accepted by the manufacturing industry. The continuous inventions in developing cutting tool materials and coatings on these materials in improving the wear resistance of the cutting tool is in progress day by day.
One of the main pre-requisites for successful industrial production is the use of quality coated cutting tools with defined mechanical and technological properties. Therefore, for the development and introduction of new coated cutting tool (new combination of cutting material and hard coatings), it is necessary to carry out a number of studies with the purpose to optimize the coatings composition and processing procedures, and also to test new tools in working conditions.The requirement from the manufacturing industry is produce faster, better, safety and more ecologically, force us to develop new effective tools and innovative technologies. This provides a technological challenge to the scientists and engineers and increases the importance of knowing several scientific disciplines
In this paper the analysis is made for the performance of various coated carbide cutting tools in machining the steel AISI 1018. In this review, the machining performance of coated tungsten based cemented carbides, were investigated during finish turning of AISI 1018 steel under dry conditions.

***Keyword**: - Coated carbide insert, coating Materials and Steel AISI 1018.*

I. INTRODUCTION

The factors that lead to tool wear are mechanical, thermal, chemical, and abrasive [1-3]. Owing to chip formation a significant amount of heat is generated. Owing to the cyclic nature of the cutting operation these thermal loads pulsate leading to thermal fatigue of the cutting tool. As a result of load factors exerted on the cutting tool edge, a few basic mechanisms dominate metal machining. These mechanisms include:

1. Abrasive wear – affected by the hardness of the tool and is controlled by the carbide content of the cuttingtool material.
2. Diffusion wear – affected by chemical loading on the tool and is controlled by the metallurgicalcomposition of the tool and coating material.
3. Oxidation wear – causes gaps to occur in coated films and results in a loss of the coating at elevated temperatures.
4. Adhesion wear – occurs at low machining temperatures on the chip face of the tool and leads to the formationof a built-up-edge, and the continual breakdown of the built-up edge and the tool edge itself
5. Fatigue wear (static or dynamic) – this is a thermo-mechanical effect and leads to the breakdown of the edges of the cutting tool.

The manufacturing industry is constantly striving to decrease its cutting costs and increase the quality of the machined parts as the demand for high tolerance manufactured goods is rapidly increasing. The increasing need to boost productivity, to machine more difficult materials and to improve quality in high volume by the manufacturing industry has been the driving force behind the development of cutting tool materials [4].

Numerous cutting tools have been developed continuously since the first cutting tool material suitable for use in metal cutting, carbon steel, was developed a century ago [5].

Cemented carbides are the most popular and most common high production tool materials available today [6]. The productivity enhancement of manufacturing processes is the acceleration of improved cutting tools with respect to the achievement of a superior tribological attainment and wear-resistance [7]. This resulted in developing hard coating for cutting tools; these hard coatings are thin films of one layer to hundreds of layers. The majority of carbide cutting tools in use today employ chemical vapour deposition (CVD) or physical vapour deposition (PVD) hard coatings. The high hardness, wear resistance and chemical stability of these coatings offer proven benefits in terms of tool life and machining performance [8-9]. The use of coolant to increase tool life has been an issue with different views [10]. The inherent brittleness of carbides makes them susceptible to severe damage by cracking if sudden loads of thermal gradients are applied to their edge [11]. Conventional machining uses 300-4000 l/h of coolants during machining. Environmental considerations mandate use of minimal coolant in the range of 6-70 ml/h. This is termed dry machining [12].

Dry machining is desirable to avoid the extra costs and environmental problems associated to cutting fluids. High speed machining of hardened steel has the potential of giving sufficiently high quality of the machined surface to make finishing operations such as grinding and polishing unnecessary [13].

II. LITERATURE REVIEW

In order to achieve the objectives of this research a literature review was conducted. The literature included information on carbide cutting tools used in turning, coating materials for cutting tools, wear observed during turning operations and surface finish of the machined work piece. This information served as a guideline in the course of this study. The boost in wear resistance gave room for a significant increase in cutting speed and thereby improved productivity at the machine shop floor. And today, 70% of the cemented carbide tools used in the industry is coated [14]. Coating composites are designed to specifically improve tribological and chemical functions. It is thus natural to select the bulk of a component to meet the demands for stiffness, strength, toughness, formability, cost, etc. and then modify or add another material as a thin surface layer. Application of coatings on tools and machine elements is, therefore, a very efficient way of improving their friction and wear resistance properties [15]. The combined substrate-coating properties ultimately determine the important properties such as wear, abrasion resistance and adhesion strength of a coating.

2.1. Wear

The prediction and control of wear is one of the most essential problems emerging in the design of cutting operations [16]. A useful definition for a worn out tool is: “A tool is considered to be worn out when the replacement cost is less than the cost for not replacing the tool” [17]. Tool failure is said to occur when the tool no longer performs the desired function whereas total failure (ultimate failure) is defined as the complete removal of the cutting edge, a condition obtaining when catastrophic failure occurs [18]. Therefore, in machining operations, tools are considered to be worn out and are changed long before total failures to avoid incurring high costs associated with such catastrophic failures. Some of the tool life rejection criteria presented in ISO 3685 is listed below [19]:

1. Average flank wear = 0.4 mm
2. Maximum flank wear = 0.6 mm
3. Notching = 1.0 mm
4. Nose wear = 0.5 mm
5. Surface roughness (Ra) = 6.0 μm.

Machining of metals is a complex process. The cutting tool environment features high-localized temperatures (~1000 ºC) and high stress (~700 MPa). The tool may experience repeated impact loads during interrupted cuts, and the work piece chips may chemically interact with the tool materials. The useful life of a cutting tool may be limited by a variety of wear processes such as crater wear, flank wear or abrasive wear, built up edge, depth of cut notching and nose wear [12]. The wear zones are characterized by the type of wear that occurs on the tip of the tool and around the cutting edge. The main types of wear on a carbide-cutting tool are shown in Figure 2-1.

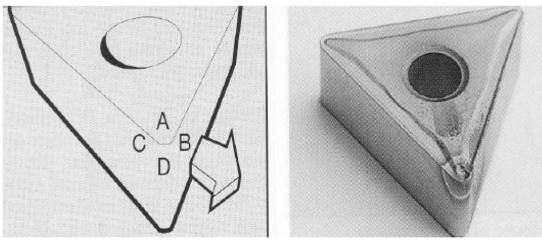


Fig. 2-1. Wear zones on the cutting tool caused by chip formation

Flank wear is observed on the flank or clearance face of a metal cutting insert and is caused mainly by abrasion of the flank face by the hard constituents of the work piece [20]. This failure mechanism is commonly observed during machining of cast irons and steels where the abrasive particles are mainly Fe_3C and non-metallic inclusions [12].

Crater wear is observed on the rake face of cutting tools and is caused by chemical interactions between the rake face of a metal cutting insert and the hot metal chip flowing over the tool. Depth of cut notching is attributed to the oxidation of the tool material. Nose wear or tool tip blunting results from insufficient deformation resistance of the tool material [12].

Fracture is the least desirable mode of tool failure because it is unpredictable and catastrophic. When machining using carbides under typical cutting conditions, the gradual wear of the flank and rake faces is the main process by which a cutting tool fails [10]. However, flank wear is the preferred mode because it progresses gradually and can easily be monitored [12]. Most tool material development work is focused on minimizing flank wear and preventing unwanted tool failure modes such as catastrophic fracture, gross plastic deformation, built up edge and crater wear.

Severe abrasion occurs at the flank face because of the lower temperature, the more rigid work piece relatively to the chip, and the constraint in the movement of the work piece and tool [23]. The intimate contact between the flank of the tool and work piece, high compressive and shear contact stresses acting on the flank of the tool and cutting temperature of around 850oC can encourage atomic dissolution-diffusion wear [24].

In many previous studies, a very smooth surface at the worn flank face possessing voids between carbide grain boundaries was observed on a carbide insert. This smoothly worn surface topography is a characteristic of dissolution/diffusion wear. Inter-diffusion between cobalt in the tool and iron in the steel and decarburization of the tool has been reported as the major diffusion reactions that occur [26, 27].

According to Jiang and Xu [28], the tool wear process can be divided into five stages: initial stage of wear, regular stage of wear, micro breakage stage, and fast wear stage and tool breakage. Other studies have divided the tool wear process into three stages in which rapid flank wear occurred at the beginning of machining at cutting speeds of 200250 m/min, followed by a gradual and steady wear growth, and finally by an accelerated wear towards the point of tool rejection [29].

2.2 Coating

The machining of hard and chemically reactive materials at higher speeds is improved by depositing single and multi-layer coatings on conventional tool materials to combine the beneficial properties of ceramics and traditional tool materials.[23].

Schintlmeister et al [30].had summarized the effect of coatings in the following statements:

1. Reduction in friction, in generation heat, and in cutting forces
2. Reduction in the diffusion between the chip and the surface of the tool, especially at higher speeds (the coating acts as a diffusion barrier)
3. Prevention of galling, especially at lower cutting speeds

2.3. Types of Coating Technology

Surface coating of tribological applications is associated with deposition temperatures ranging from room temperature to over 1000°C as shown in Figure 2-2. The coating thickness ranges from microns to several millimetres. Typically, the atomistic methods produce the thinnest coatings. Some methods involve high deposition temperatures that may give undesired phase transformations, softening or shape changes of the coated component.[13].

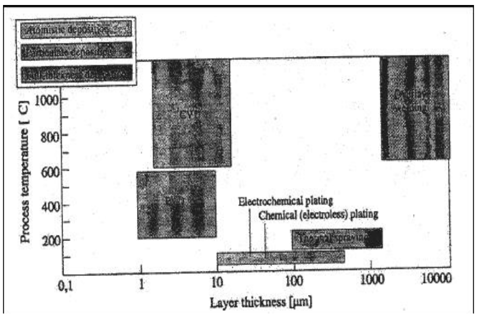


Figure 2- 2 Typical value of coating thickness and process temperature of today's tribological coating methods.[15].

CVD coated cemented carbides have been a huge success since their introduction in the late 1960's.[31]. Since then, chemical vapour deposition technologies have advanced from single layer to multi-layer 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.[32].

PVD process chain includes pre-PVD processes and post PVD-processes. Pre-treatment processes such as plasma etching and chemical etching influence adhesion, grain growth, stress at substrate surface and coating structure, whereas post-PVD processes influence smoothness of coating surface and better chip flow[33].

Modern design of coated cutting tools place such high demands on the materials specified that they can very often only be met by tailoring composite materials for these specific applications. In particular, the requirements for substrate (bulk) properties, on the one hand, and tool surface properties, on the other hand, differ so much that the surfaces have to be specially treated and modified to meet the particular demands. [34].. It is increasingly apparent that thermo-physical properties of the coatings have a substantial effect on their performance and operating parameters. The quality of coated cutting tools often depends on three main parameters, which are shown in Fig. 2-3

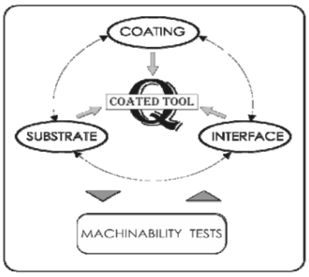


Fig. 2-3 The interaction of main parameters on the quality of coated cutting tools

2.4.Materials Used in Coatings

The majority of inserts presently used in various metal cutting operations are cemented carbide tools coated with a material consisting of nitrides (TiN, CrN, etc.), carbides (TiC, CrC, W2C, WC/C, etc.), oxides (e.g. alumina) or combinations of these [13,23]. Coating cemented carbide with TiC, TiN and Al2O3 dramatically reduces the rate of flank wear [22]. High hardness is beneficial in resisting the abrasive wear. Retention of hardness even at higher temperatures is very important since the tool bit experiences a temperature in the range of 300-1000°C depending on the machining parameters and the materials to be machined [12]. Micro hardness values of different coatings measured at different temperatures are shown in Figure 2-2. They all exhibit a decrease with an increase of temperature, and the decrease of hardness was much more pronounced in the case of TiC. Interestingly, the micro hardness of Al_2O_3 was significantly lower than TiC at room temperature but retained almost 40 % of its room temperature hardness at 1000 °C.

Coating with three layers of TiC-Al_2O_3-TiN as seen from the substrate are widely used for machining of many types of steels [13]. This type of coating improves the wear resistance of the tool by combining the properties of the three materials. The ranking of the solubility products and limits of TiC, TiN and Al_2O_3 in iron, compared to the carbide substrate, is in the order TiC>TiN> Al_2O_3 [22]. Another reason for having the TiN as an outer layer, as opposed to inner layer, is that at higher temperatures of oxidation, the growth of TiO2 (rutile) under layer may affect the performance of the protective alumina over layer of the oxide [14].

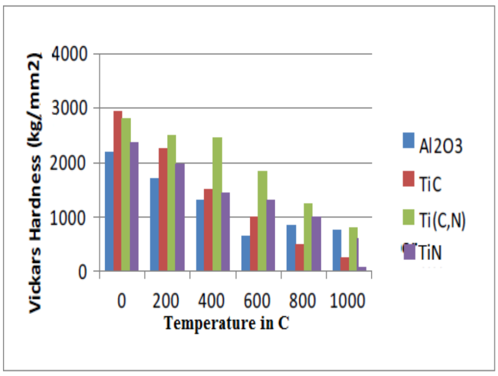
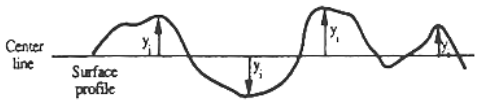


Figure 2- 4 Temperature dependence of micro hardness [20, 35].

2.5. Surface Finish

Surface roughness and tolerance are among the most critical quality measures in many mechanical products. As competition grows closer, customers now have increasingly high demands on quality, making surface roughness become one of the most competitive dimensions in today's manufacturing industry [36]. .

There are several measurements that describe the roughness of a machined surface. One of the most common is the arithmetic average (AA) value usually known as Ra. [37]. The AA value is obtained by measuring the height and depth of the valleys on a surface with respect to an average centreline. The higher the AA value is, the rougher the machined surface. Figure 2-5 shows a magnified cross section of a typical machined surface.



$$\text{Arithmetic Average (AA) Value} = \frac{\sum_{i=1}^{n} y_i}{n}$$

Figure 2-5 Illustration of surface roughness [30]

Many factors influence the formation of surface roughness in the turning process. These factors include chip deformation and side flow, vibration of the machine-tool fixture work piece system, geometrical contribution of the feed and tool nose radius. Classical surface roughness related equations calculate geometrical contribution:

$h \approx f^2/ 8R$, , $hCLA \approx f^2/ 18\sqrt{3}R$

Where h is the peak to valley height, hCLA the centre line average roughness, f the feed and R the nose radius. This show that surface roughness is primarily dependent on feed rate and tool nose radius. However, the above equations give ideal surface finish values under satisfactory cutting conditions [38].

The tool wear influences the surface roughness of the work piece and the value of surface roughness is one of the main parameters used to establish the moment to change the tool in finish turning [39]. Carbide tool wear may occur by the mechanical detachment of relatively large fragments of tool material (attrition wear). This causes the surface roughness to increase significantly and promote the formation of ridges [22, 25].

The geometry of tool wear also causes a change in surface roughness as machining time elapses. Flank wear is along with groove wear are the types of wear that most influence this change in surface roughness [40]. Some studies have claimed that the change in surface roughness is primarily caused by cutting-tool flank wear [37].

Many authors have studied the relationship between surface roughness and flankwear. Sundaram and Lambert [40] studied turning of steel with uncoated carbide tools.The results are shown in Figure 2-6. The graph shows increased amplitude of thesurface roughness at the beginning of cut, a decreased tendency in the middle and again an increased tendency at the end of wear.

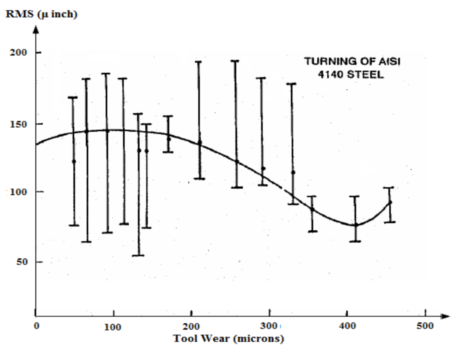


Figure 2-6 Surface roughness's vs tools wear [34]

III. RESULTS AND ANALYSIS

The results for the machining performance of the four different coated cutting tools and the uncoated cutting tool in turning AISI 1018 steel. The results for the flank wear of the uncoated tool and the surface roughness of the machined.

AISI 1018 work-piece are first presented. The results of the other coated tools are then shown and are compared to those obtained using the uncoated tool in order to obtain the effectiveness of the different coatings on the flank wear and the surface roughness.

The flank-wear and the obtained surface roughness results for each of the coated tools are then compared in order to confirm the machining performance rankings of the different coatings considered.

3.1 Wear of TiN Coated vs. Uncoated Tool

To compare the performance of the TiN coating, the flank wear of the TiN coated tool was compared with the flank wear of the uncoated tool. Table 3-1 shows the SAS output for the regression of flank-wear on the number of cuts for both TiN coated and the uncoated tools. A null hypothesis (Ho) that the TiN coating has no effect on the flank wear and an alternative hypothesis (Ha) that the TiN coating has an effect on flank-wear were used. Again using a a-value of 0.05, the null hypothesis is rejected in favor of the alternative hypothesis since the P value for this regression is <0.0001. And so it can be concluded that the TiN coating has a significant effect on tool flank wear for the TiN coated tool.

Table 3- 1Regression of flank wear on the type of coating for TiN and uncoated.

The SAS system The REG procedure Dependant variable: wear					
Analysis of variance					
Source	DF	Sum of square	Mean Square	F value	Pr>F
Model	2	0.21497	0.10749	128.58	<0.0001
Error	37	0.03093	0.00083597		
Corrected total	39	0.24591			
Root MSE	0.02891				
Dependant mean	0.33069	Root square	0.8742		
Coeff. Variant	8.74340	Adj. R. Sq.	0.8674		

The flank wear for the five different types of cutting tools tested are shown in Figure 2-4. The uncoated tool exhibited the largest wear within the 60 cuts machined in the test. All the coated tools were observed to have better wear resistance than the uncoated tool as expected.

The TiN coated tool showed a slight improvement compared to the uncoated tool. The TiN/Al_2O_3 had the third highest flank wear. The improvement of the wear resistance compared to the TiN coating was due to the addition of the Al_2O_3 layer. This layer protected the TiN coating.

However, the Al_2O_3 coating had the second highest flank wear resistance and showed an improvement in wear resistance as compared to TiN/Al_2O_3. Hence, using one layer of Al_2O_3 appears to have better wear resistance to flank wear as compared to using 2 layers of coating with TiN interlayer and Al_2O_3 outer layer. The TiC/Al_2O_3/TiN coated tool appeared to have the best wear resistance under the testing conditions used. This was as expected since the combination of TiC with high abrasive resistance, chemically stable Al_2O_3 with low thermal conductivity and the added wear resistance of the TiN coating improved the overall wear resistance of the cutting tool.

The photographs of the flank face for each of the machined tools are shown in Figure3-1. The flank-wear on the uncoated and TiN coated tool can be easily seen. The lower flank-wear on the TiN/Al_2O_3, Al_2O_3 and TiC/Al_2O_3/TiN coated tools displays their higher wear resistance performance.

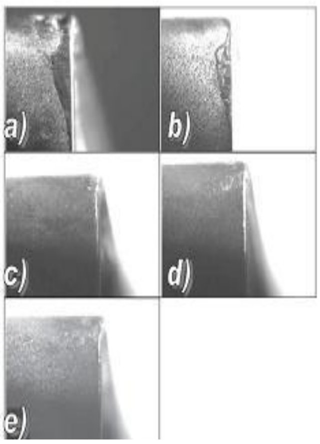


Figure 3-1Photographs of the final flank wear for a) uncoated tool, b) TiN coated tool, c) iN/Al_2O_3 coated tool, d) Al_2O_3 coated tool and e) TiC/Al_2O_3/TiN coated tool

IV. CONCLUSIONS

The machining performance of five cutting tool inserts in turning AISI 1018 steel, Uncoated, TiN coated, TiN/Al2O3 coated, Al2O3 coated and TiC/Al2O3/TiN coated tools were examined and their flank wear and the resultant machined work piece surface finish were analysed. The tool coatings were found to improve upon the wear resistance of the cutting tool. This was shown by the decrease in wear on the flank face of the coated tools compared to that of the uncoated tool. The wear of the TiN coated tool was around 12% lower than the wear observed on the uncoated tool. TiN/Al2O3 coated tool showed a decrease of around 65% compared to the uncoated tool. The Al2O3 coated tool showed a decrease of around 92% compared to the uncoated tool. The TiC/Al2O3/TiN coated tool appeared to have the lowest wear of all the tools tested, and showed a decrease of around 96% in wear compared to the uncoated tool. In the case of the machined surface roughness, all the coated tools produced lower surface roughness than that produced by the uncoated tool except for the TiN/Al2O3 coated tool. This was believed to be due to factors other than the coating material and mainly the different chip breaker geometry on the tool which produced longer chips that got in contact with the work piece material and increased its surface roughness.

The surface roughness increased while oscillating for all the cutting tools used except for the TiN coated tool in which surface roughness oscillated around a constant value and produced more consistent surface roughness that was not affected by the flank wear of the tool. Table 4-1 shows surface roughness and Figure 4-2 shows flank wear vs number of cuts.

The SAS system The REG procedure Dependant variable:roughness					
Analysis of variance					
Source	DF	Sum of square	Mean Square	F value	Pr>F
Model	2	14.23162	7.11581	22.85	<.0001
Error	114	35.50296	0.31143		
Corrected total	116	49.73458			
Root MSE	0.55806	Root square	**0.2862**		
Dependant mean	2.93090	Adj. R. Sq	0.2736		
Coeff. Varient	19.04054				

Table 4- 1 Regression of surface roughness on tool type for Al_2O_3 and $TiC/Al_2O_3/TiN$.

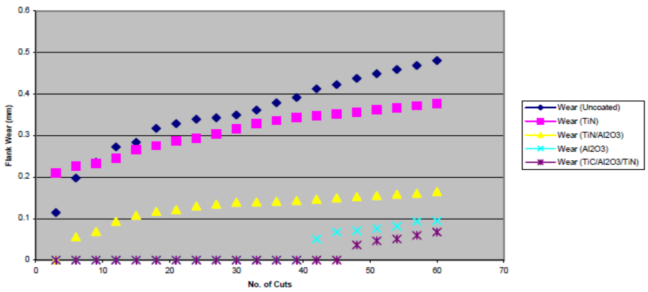


Figure 4- 2 Flank wear vs. number of cuts for different cutting tools.

This research may be extended to study the effects of multi-layer coatings on cutting tool performance. Multi layers are composed of alternating layers of two different materials that can vary in number from few up to tens of thousands. Multi layers are believed to offer very high strength, hardness, heat resistance, and many new properties that could greatly enhance the performance of the cutting tools.

REFERENCES

[1] M.C. Shaw, Metal Cutting Principles – Second Edition, Oxford Series on Advanced Manufacturing, Oxford University Press 2005, 15-38.

[2] G. Boothroyd, W.A. Knight, Fundamentals of Machining and Machine Tools, Marcel Dekker, (1989), 73-108.

[3] 'ASM Metals Handbook – Machining', Volume 16, p.p. 874-878 – Machining of Uranium, 9th Edition, 1989, ASM International, ISBN0-87170-007-7.

[4] Wallbank, J., Development in tool materials, Proceedings of the Second International Conference on Behaviour of Materials in Machining, York, UK, November 14-15, 1991.

[5] Smith, G. T., Advanced Machining: The Handbook of Cutting Technology, IFS Publications, 1989.

[6] Metals Handbook, Machining, Vol. 7, 9th Edition, ASM, USA, 1980, pp. 773-783.

[7] Bouzakis, K. D., Michailidis, N., Vidakis, N., Eftathiou, K., Kompogiannis, S., Erkens, G., Interpretation of PVD Coated Inserts Wear Phenomena in Turning, Annals of the CIRP 49 (2000) 65-68.

[8 Lux, B., Columbier, C., Atena, H., Stemberg, K., Preparation of Alumina Coatings by Chemical Vapor Deposition, Thin Solid Films 138 (1986) 49-64.

[9] Prengel, H. G., Pfouts, W. R., Santhanam, A. T., State of the art in hard coatings for carbide cutting tools, Surface &Coatings Technology 102 (1998) 183-190.

[10] Haron, C. H., Ginting, A., Goh, J. H., Wear of coated and uncoated carbides in turning tool steel, Journal of materialsprocessing technology 116 (2001) 49-54.

[11] Wright, P. K., Bagchi, A., Horne, J. G., Identification of the dominant wear mechanism in specific tool-work systems, Proceedings of the International Conference on Cutting Tool Materials, Ohio, 1980 pp. 7-23.

[12] PalDey, S., Deevi, S. C., Single layer and multilayer wear resistant coatings of (Ti,Al)N: A review, Materials Science and Engineering 342 (2003) 58-79.

[13] Armarego, E. J. A., Verezub, S., Samaranayake, P., The effect of coatings on the cutting process, friction, forces and predictive cutting models in machining operations, Proceedings of the Institution of Mechanical Engineers, Part B:Journal of Engineering Manufacture 216 (2002) 347-356.

[14] Abdullah, A., Machining of aluminium based metal matrix composite (MMC) ,Ph.D. Thesis, University of Warwick, Warwick, UK, 1996.

[15] Hogmark, S., Jacobson, S., Larsson, M., Design and evaluation of tribological coatings, Wear 246 (2000) 20-33.

[16] Holmberg, K., Matthews, A., Ronkainen, H., Coatings tribology - contact mechanisms and surface design, Tribology International 31 (1998) 107-120.

[17] Carlsson, T. E., Strand, F., Lindstrom, B., Statistical model for prediction of tool life as a basis for economical optimization of the cutting process, CIRP Annals 41 (1992) 79-82.

[18] Armarego, E. J. A., Brown, R. H., The machining of metals, Prentice-Hall Inc., 1965.

[19] ISO, ISO 3685 – Tool life testing with single point turning tools, 2nd Edition (1993).

[20] Santhanam, A. T., Quinto, D. T., ASM Handbook, Surface Engineering, vol. 5, ASM International, Materials Park, OH, 1994, pp. 900-908.

[21] Chubb, J. P., Billingham, J., Coated cutting tools – a study of wear mechanism in high speed machining, Wear 61 (1980) 283-293.

[22] Dearnley, P. A., Rake and flank wear mechanisms of coated and uncoated cemented carbides, Journal of Engineering Materials and Technology, 107 (1985)68-82.

[23] Cho, S. S., Komvopoulos, K., Wear Mechanisms of Multi-Layer Coated Cemented Carbide Cutting Tools, Journal of Tribology 119 (1997) 8-17.

[24] Dearnley, P. A., Trent, E. M., Wear mechanisms of coated carbide tools, Metals Technology 9 (1982) 60-75.

[25] Trent, E. M., Cutting steel and iron with cemented carbide tools, Journal of the Iron and Steel Institute 201 (1963) 847-855.

[26] Naerheim, Y., Trent, E. M., Diffusion wear of cemented carbide tools when cutting steel at high speeds, Metals Technology 4 (1977) 548-556.

[27] Narutaki, N., Yamane, Y., Wear mechanism of carbide tool based on the reaction between tool and work material, Bulletin of the Japan Society of Precision Engineering 10 (1976) 95-100.

[28] Jiang, Y. C., Xu, J. H., In-process monitoring of tool wear stage by the frequency band energy method, CIRP Annals 36 (1987) 45-48.

[29] Ezugwu, E. O., Olajire, K. A., Jawaid, A., Wear Performance of multiplayer coated carbide tools, Machining Science and Technology 5(1) (2001) 115-129.

[30] Schintlmeister, W., Wallgram, W., Kanz, J., Gigl, K., Cutting tool materials coated by chemical vapor deposition, Wear 100 (1989) 153-169.

[31] Venkatesh, V. C., Ye, C. T., Quinto, D. T., Hoy, De. E. P., Performance studies ofuncoated, CVD coated and PVD coated carbides in turning and milling, CIRPAnnals 40 (1991) 545-551.

[32] Prengel, H. G., Heinrich, W., Roder, G., Wendt, K. H., CVD coatings based onmedium temperature CVD K- and α-Al2O3, Surface & Coatings Technology68/69 (1994) 217-220.

[33] Prengel, H. G., Jindal, P. C., Wendt, K. H., Santhanam, A. T., Hegde, P. L.,Penich, R. M., A new class of high performance PVD coatings for carbide cuttingtools, Surface & Coatings Technology 139 (2001) 25-34.

[34] K.N. Strafford, R.St.C. Smart, I. Sare, Ch. Subramanian, Surface engineering – Processes and applications, Technomic Publishing AG, Basel, Switzerland, 1995.

[35] Jindal, P. C., Santhanam, A. T., Schleinkofer, U., Shuster, A. F., Performance of PVD TiN, TiC, and TiAlN coated cemented carbide tools in turning, International Journal of Refractory Metals & Hard Materials 17 (1999) 163-170.

[36] Feng, C. X., An experimental study of the impact of turning parameters on surface roughness, Proceedings of the 2001 Industrial Engineering Research Conference, Paper No. 2036.

[37] DeGarmo, E. P., Black , J. T., Kohser, R. A., Materials and Processes in Manufacturing, Macmillan Publishing Co., New York, 1988.

[38] Noordin, M. Y., Venkatesh, V. C., Chan, C. L, Abdullah, A., Performance Evaluation of Cemented Carbide Tools in Turning AISI 1010 steel, Journal of Materials Processing Technology 116 (2001) 16-21.

[39] Bonifacio, M. E. R., Diniz, A. E., Correlating tool weartool life, surfaceroughness and tool vibration in finish turning with coated carbide tools, Wear 173(1994) 137-144.

[40] Luk, W. K., Scrutton, R. F., The origin of groove wear in the turning operation, International Journal of Production Research 6 (1968) 197-206.

Authors Biography

M.NarasimhareceivedhisB.Tech. Degree in Mechanical Engineering from JNTU, HYDERABAD. He received M.E. Degree from VMU, TAMILNADU. He has worked in Major Industries like HMT, Praga Tools, Automobile Industries and Allwyn Watches in India in senior positions for around 25 years. Currently working as Associate Professor in the Department of Mechanical Engineering, WolaitaSodo University, WolaitaSodo, **Ethiopia**.

TewodrosDerese received Bsc degree in Mechanical Engineering from Bahirdar University. Currently working as Assistance Lecturer in Department of Mechanical Engineering, Wolaitasodo University, Ethiopia.

R.RejikumarreceivedhisB.E., Degree in Mechanical Engineering from Anna University;Chennai. Hereceived M.E. Degree from ANNA University, Thiruchirapalli. Currently working as Teaching Faculty in the School of Mechanical and Industrial Engineering, Institute of Technology, Bahir Dar, University, Bahir Dar, **Ethiopia**