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EXPERIMENTAL INVESTIGATION OF COATING ON HIGH SPEED STEEL CUTTING TOOL

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ABSTRACT

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. In this paper, the principles, advantages and limitations of various TiN coating processes are summarized. With the growing popularity of TiN-coated tools and new development of coating process, this paper deals with the study of the performance of coated tools in machining hardening steel under dry conditions. This paper involves of machining hardened steel using Titanium nitride (TiN), coated carbide tools is studied using full factorial experiments. Many parameters influence the quality of the products in turning process. The objective of this study is on the effect of coating on tool to determine its various parameters such as temperature, cutting velocity, feed and depth of cut in machining hardened steel. Machining of hardened steels has become an important manufacturing process, particularly in the automotive and bearing industries.

Key words — Titanium nitride (TiN), Coating of tool, Turning, Coated tool, hardened steel

I. INTRODUCTION

Sodium chloride structured TiN is a golden yellow refractory compound of low density (5.22 g/cm3) and high melting point (2930°C). Titanium nitride as a coating for tool steels has been available widely since the last decade and is enjoying increasing attention and application in tool industries. The reasons are simple yet important the advantages of TiN coatings of tool steels include a noble appearance, excellent adhesion to substrates, high chemical inertness, resistance to elevated temperatures, hard surfaces (2400HV) to reduce abrasive wear, a low coefficient of friction with most work piece materials which increases lubricity and results in excellent surface finish and decrease of horsepower requirements, improved ability to hold tolerances and high temperature stability and low maintenance cost and high productivity. In practice, the degree of extended tool life and increased productivity attained with coated tools depends primarily on the tool and its application, the work piece material and the operating parameters. Keeping all these conditions equivalent, tool life improvement can be evaluated by comparing the increase in number of work pieces machined by a TiN-coated tool with the number of work pieces machined by an uncoated tool while the cost of coating is usually 20 to 30% of the base price of the tool, or as little as a 15% rise in the total price.

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A. Review Stage

It is found by F Akbar in 2008 [P T Mativenga et al. [1], Weiguang Zhu [2]]. that the use of TiN-coated tools causes a reduction in heat partition into the cutting tool compared with the uncoated tool about 17 percent at conventional cutting speed and 60 percent in the HSM region. It may be concluded that, compared with uncoated carbide tools, TiN coatings significantly improve the tribological phenomena by reducing the tool chip contact area, providing a lower thermal conductivity for the tooling systems, and ultimately reducing heat partition into the cutting tool. Seshadri.R et al.[3]. Titanium Nitride (Tin) coating improves the tool wear by increasing the wear resistance, thereby protecting the tool. Initial Flank wear is observed after machining the material continuously for 250 seconds. Specific power consumption is low at higher cutting speeds which supports that this material posses good machinability. Hardness of the material is more, hence machining at high speed is recommended.

S. PalDey [4] In this paper, deposition of (Ti,Al)N coatings using different PVD techniques have been reviewed. The effects of deposition variables on coating microstructure and film properties were analyzed. (Ti,Al) N exhibited superior performance in many applications as compared with the other commercially available Ti based coatings. Based on a simple TiN coating, various strategies were developed in order to improve or adapt hard coatings. Cem Karacal et al. [5] 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. K. Aslantas et al. [6] in coated mixed ceramic tool, the thermal conductivity value of TiN coating material increases with increases in temperature. Therefore, the heat flow to the cutting tool increases and the temperature at the tool–chip interface decreases. The temperature difference between the upper and lower sides of the chip decreases and the chip up-curl radius increases. J. Nickel et al.[7] The nature and the underlying wear mechanisms of TiN-coated tools and the role of TiN in improving wear resistance and increasing tool life have been the subject of many investigations. For example, the wear modes of TiN-coated HSS, from the results of sliding pin-on-disc wear tests, were found to include adhesive and abrasive wear of the coating w12,13x. TiN-coating fragments were found to be the dominant wear mechanisms in actual machining tests w8x. The latter wear mechanism was attributed to insufficient adhesion. Abdul Kareem Jaleel et al. [8] Hard coating such as TiN, TiC and AL2O3 have been used. High-speed machining is constantly increasing in importance. These new techniques can be applied in place of conventional machining methods for manufacturing of various components at low cost or even making entirely new type products, e. g. machined from brittle materials. B. RAMAMOORTHY et al.[9] The sputter deposition conditions for DLC/TiN/ Ti/Cu/Ni multilayer coatings are identified to achieve improved quality with particular reference to adhesion and surface finish. Y. BIROL et al.[10] The stable and protective oxide surface layer on AlTiN and AlTiON coatings provide an enhanced resistance to high temperature wear. M.A. Kamely et al. [11] Force difference is observed when using the same type of tools, but with different thermal properties. For example, under the same cutting condition there is force difference between using low CBN content tools coated with TiAIN and CBN-Low coated with TiN/AI2O3/TiCN. This was the case when turning with uncoated CBN-High and CBN-High coated with TiN/AI2O3/TiCN. Y. C. Chim1 et al. [12] TiN, CrN, TiAlN and CrAlN coatings were deposited by vacuum arc. Their thermal stability and oxidation resistance were investigated after annealing in air at different temperatures (500°C-1000°C). TiAlN and CrAlN showed better oxidation resistance than their binary counter parts TiN and CrN. Cr-based coatings exhibited much better oxidation resistance than Ti-based coatings. K. Subramanyam et al. [13]. In the present work the performance of coated tools in machining hardening steel under dry conditions is studied. The experimental results showed with increase in feed the surface roughness is observed is very poor. The effect of cutting velocity on surface roughness is relatively low when compared to feed rate. With increase in depth of cut the surface roughness is increased. Here experimental results shows by selecting the proper cutting parameters the coated tools are suitable to produce fine surface finished componentsStan Veprek et al.[14]. Hard coatings, such as TiN, TiC, TiCN, Al2O3 deposited by thermal chemical vapour deposition (CVD) on machining tools have been used since 1960 in order to increase their life time. However, because of the requirements of the uniform high plasma density, complex reaction kinetics and mechanism and gas transport within the reactor, plasma CVD is difficult to scale up. MUBARAK and PARVEZ AKHTER Pakistan Council of Renewable Energy Technologies (PCRET), 12 November 2007 [A. Mubarak et al. [15]].Titanium nitride (TiN) widely used as hard coating material, was coated on tool steels, namely on high-speed steel (HSS) and D2 tool steel by physical vapor deposition method. The study concentrated on Cathodic arc physical vapor deposition (CAPVD), a technique used for the deposition of hard coatings for tooling applications, and which has many advantages. It is used to analyze and quantify the following properties and parameters surface morphology, thickness, hardness, adhesion, and coefficient of friction (COF) of the deposited coatings. Surface morphology revealed that the MDs produced during the etching stage, protruded through the TiN film, resulting in film with deteriorated surface features. The coatings deposited on HSS exhibit better adhesion compared to those on D2 tool steel. Audy J et al. [16]. Nowadays, the use of coated tools has advanced to the stage when surface coatings of increasing complexity are being routinely deposited on HSS tools. It is generally accepted by industry that popular TiN and Ti(C, N) coatings are now under increasing competition from TiAlN, TiAlCrN and more complex coatings based on TiN/TiAlN and or TiAlCrYN. These coatings are claimed firstly to increase the tool life due to improved tool wear resistance, and secondly to reduce the forces, power and tool temperature due to improved tool surface roughness and its resistance to built-up-edge formation and reduced friction at the tool-chip interface. L.B.ABHANG and M. HAMEEDULLAH [L.B.Abhang et al. [17]] International Journal of Engineering Science and Technology Vol. 2(4), 2010, 382-393 research has been undertaken into measuring the temperatures generated during cutting operations. The main techniques used to evaluate the cutting temperature during machining are tool-chip thermocouple, embedded thermocouple, and thermal radiation method. Tool-work thermocouple has become a popular tool to be used in temperature measurements during metal cutting. In this paper the tool-work thermo couple technique was used to measure the chip-tool interface temperature during machining of EN-31 steel alloy. J.D. Bressan et al. [18] A comparison of the lost mass rate for HSS, HSS coated with TiCN (HSS\TiCN) and WC pins are plotted as functions of the sliding distance. The benefit of the TiCN coating is very clear. The wear resistance comparison between HSS\TiCN and the hard metal WC H. Wang et al. [19]. We investigated mechanical properties of TiN as a function of microstructure varying from nano crystalline to single crystal TiN films deposited on (100) silicon substrates. By varying the substrate temperature from 25 to 700 °C during pulsed laser deposition, hardness of TiN films decreased with decreasing grain size. This behavior was modeled recently involving grain boundary sliding, which is particularly relevant in the case of hard materials such as TiN. R. Marumo at el. [20] found that temperature influences cutting action in several ways, such as altering properties of the machined surface, decreasing dimensional accuracy and affecting the strength, hardness and wear resistance of the cutting tool. During the experiment of metal cutting (mild steel and aluminum) the Infra–red Camera showed the difference of temperature at a cutting point and through the tip.

Rogério Fernandes Brito et al. [21] In this model, the thermal properties of three layers of titanium carbide, (TiC), aluminum oxide (Al_2O_3), and titanium nitride (TiN) were analyzed, both individually and in group, considering a layer with equivalent thermal properties. Coated and uncoated cutting tools, titanium aluminum nitride (TiAlN) and aluminum chromium nitride (AlCrN), were used in the turning of AISI 4340 steel. The simulations performed indicated that the temperature on the tool-chip interface was approximately 800 (°C) in the absence of flank wear, regardless of the coating. The objective of the present work is to perform a numerical analysis of the thermal influence of the coating in cutting tools during the cutting process. Shivdev Singh et al. [22]. Researchers used different methods to reduce tool wear and cutting forces so as to increase productivity. Earlier, heat treatment was used to improve the wear resistance of cutting tools. Now-a-days hard coating is generally used for this purpose. Some researchers have reported the effect of the coating on the performance of cutting tools, the wear behavior of coated and uncoated carbide tools in turning cutting steel under dry and wet conditions. They found that in terms of flank wear, the performance of coated tools was found to be better than uncoated. Coated carbide tools showed better results under wet conditions than dry. The results showed that high aluminium content improves oxidation and wear resistance. It increased tool life and provided wide range of cutting speeds as compared to Ti –based coating. Tool performance was evaluated with respect to tool wear, surface finish produced and cutting forces generated during turning. The coating acts as a heat barrier owing to the lower thermal conductivity compared with that of the substrate. Thus the proportion of frictional heat which dissipates into the substrate is reduced which, in turn, lowers the substrate temperature. In case of coated and cryogenic treated, the lowest cutting force was achieved with coating TiN as compared to AlCrN coating and uncoated tools T. Cselle et al. [23] summarizes the most important material components and their influence on the features of the coatings. Carbon strengthens the lattices of the basic coating TiN, increases the internal stress level and therefore the hardness, reduces the friction coefficient, but only up to 400°C. The TiCN coating is still the most popular coating for taps but is not adequate for dry and high-speed cutting. Due tothe excellent heat insulation between chips and tools, the TiAlN or AlTiN coatings are the most used coatings for modern high performance cutting.

II. CONCLUSION

In the present work the performance of coated tools in machining hardening steel under dry conditions is studied. The results shows that the Tin coated tool perform better as compared to uncoated cutting tool. The effect of cutting is to reduce wear and tear of tool tip point as well as more heat dissipation to surrounding hence the increase in tool life and surface finish of the product to be machine. With increase in depth of cut the surface roughness is increased. Here experimental results shows by selecting the proper cutting parameters the coated tools are suitable to produce fine surface finished components

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This paper deal with the various concepts of High Speed Steel Single Point Cutting Tool mainly the temperature distribution along the length of tool when tool is turning the work piece and removing the material from the work piece. Author would like to thank to Meenakshi Ramasamy Engineering College for support and motivation.

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