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Functioning and Assessment of Uncoated and PVD Coated Carbide Tool and its Vibration Analysis

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*Abstract— **In today's manufacturing industries there is an always demand and requirement of high rate of production, accurate dimensions, decrease in the cutting rate, increase in the quality of manufacturing machined part and machining of hard materials. In this experimentation work the machining and performance of uncoated carbide cutting tool and PVD Tin coated cutting carbide tool is experimented. The hard turning is done on hard material AISI 1045H and soft material pure aluminum under various parameters cutting speed, rate of feed and depth of cut. The machining is done under dry condition. The affect of various parameters of cutting tool and work material has been tested in experimentation work. The tool chatter vibration, surface roughness, tool wear is tested. The tool chatter vibration is measured by using Digital Vibration Meter (VM-8200) for both uncoated and PVD tin coated cutting tool in running conditions. The surface finish for tool material is measured by using Taylor Hobson roughness meter. In the last tool wear is measured by Scanning Electron Microscope (SEM) for both uncoated and PVD tin coated cutting tool. It has been found that hard turning on hard material at high speed, low rate of feed and high depth of cut is improved by using PVD Tin coated cutting tool and uncoated cutting too is good for soft material. The tool chatter vibration is very critical factor that's affect on rate of production, dimensions, tool life, efficiency of machine, and etc. The high tool chatter vibration can break cutting tool that's result on loss of material, decrease the rate of production, money loss, time loss. It is very essential to reduce tool chatter vibration, the various researches has been done on this factor but no researches exits that completely exit this factor. In this experimentation work the PVD TiN multilayer coating is used for minimization of tool chatter vibration that meets to the demands and requirements of today's manufacturing world. The tool chatter vibration on uncoated cutting tool is high at high speed, low rate of feed and high depth of cut, whereas the tool chatter vibration on PVD Tin coated tool at same conditions is low. PVD Tin coated cutting tool give better performance as compared to uncoated tool. The surface roughness is also a very crucial factor that's affect on the dimensions of the machined material and its quality. It is very necessary to achieve better surface finish. The PVD Tin coated cutting tool gives good surface finish as compared to uncoated tool. It also increases the life of tool that's affect on performance and the demands and requirement of today's manufacturing industries.***

*Index Terms—**Dry machining, PVD Tin coated, SEM, Tool chatter vibration.***

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I. INTRODUCTION

In today's manufacturing world corrosion, fatigue and wear has become a important factor for tool life and that affect on the machining process as well as on the engineering component or material which is manufacturing in that process.

These important factors create loss of material in machining process that's affects on the dimensions of the component. These factors in today's manufacturing world create very critical affect on heavy engineering system or small engineering system. This leads to decrease in the rate of productivity, increases in the clearance between the moving parts and which results in high vibration, high noise and reduced efficiency. The scope of the industries is to achieve high production rate, accurate dimensions, decrease in the cutting rate, increase in the quality of manufacturing machined part and machining of hard materials. The efficiency of machine can be improved by increase in cutting speed, low vibration, less clearance on the machine moving parts. The quality of a machined material can be improved by using better cutting tool which creates better surface roughness of a machined material and also create less vibration which can affect on the machined material as well as on the machine. The high speed machines increases the production rate. In today's manufacturing industries the rate of production is very demandable for fulfillment of the requirements in the world. The cutting of hard materials like high graded steels, cast iron and alloys by lathe machine is very challenging in today's manufacturing process which can be improved by better cutting tool. The hard turning process of hard materials like high graded steels and alloys is very challenging to achieve by low vibration on cutting tool, better surface roughness on machined material and without breaking of the cutting tool which affects on material loss. This can be achieved by better coated cutting tool which can give better surface roughness, low vibrations and also affect on the machined material during manufacturing process. This process is very beneficial and advantageous because it improves the quality of machined material, it's also improves its efficiency, decrease the cost and also improves production rate. Hard turning is adorable because this process can be possible in dry cutting conditions. This process can be done without using of lubricants or cutting fluid. Hard turning in dry condition is very advantageous because it exterminates the cost of cutting lubricant and also exterminates the high cost of lubricant ejection. The rising needs of manufacturing world to mounting the production rate, to machining the different types of difficult materials, and also improve in the quality of materials in very large amount.

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For achieving good machining efficiency the selection of suitable type of hard coating on the cutting tool is very important factor. Machining of ferrous materials like steel and alloys it is very important the coated tool to have excellent high temperature, and mechanical properties. The machining of hard and chemically reactive materials can be enhanced by putting single layer coating to multilayer coating according to the material that is to be manufactured. In today's manufacturing process the two types of coating is to be done on the cutting tool. Chemical vapour deposition (CVD) or physical vapour deposition (PVD) hard coatings. Due to good mechanical and chemical properties of these coatings they have good hardness, wear resistant and chemical constancy due to which it's advantageous affects on tool life and manufacturing process. Metal cutting is the metal removing process from the work piece in the types of chips for getting preferred geometry, shape, size and surface finish. Metal cutting process became very valuable in industrial design industries and mechanical industries now these days. The manufacturing sectors like railways, sail, vizag steel power plant, aircraft, ship building, automobiles, military vehicles, appliances, etc has great extend use of metal cutting process to manufacture large amount of products on daily basis. These all sectors are focused to improve quality of a product and production rate in less cost.

1.2 Surface finishing

Surface finish depends upon these factors given below:- Cutting speed, Feed rate, Depth of cut

1.2.1 Cutting speed

The surface roughness of the machined material depends upon the cutting speed and cutting tool behavior, low cutting speed produce better surface finish but as the cutting speed increases there will be change in its roughness.

1.2.2 Feed rate

Higher feed rates affect on surface finish of the work material.

1.2.3 Depth of cut

Low depth of cut produce better surface finish and as depth of cut increase the surface finish also increases. At the higher speed when machining high graded steel, ferrous, material or alloys high vibration takes place which affect on cutting tool as well as on work material it can be prevented by using suitable coating on cutting tool.

1.3 Tool chatter vibration

The tool chatter vibration is the relative, movement between the machining material and the cutting tool. It is the self excited vibrations that affects to the performance of the machining. It is very necessary to reduce this major factor of the machine which results in poor surface roughness, damage to the cutting tool and frustrating noise which affects on rate of production, dimensions, economy of machine, money loss, material loss, and time loss. The tool chatter vibration is very difficult to control because the operator of the machine stops the machine for applying some changes in feed rate and depth of cut. The tool chatter vibration becomes high on hard material machining. The main cause of tool chatters vibration is the dynamic interaction between the machining material and the cutting tool. During machining the cutting speed force is produced between the machining material and cutting tool which proceed at an angle to the surface of machining material and cutting tool. The disturbance in the machining process because of hardness of the work material will produce deflection on the structure which creates irregular shape of chips. To make increased potential of modern machining process the modern tool cutting edges, tool material, coatings, stable machine tool, tool holder, and cutting tools are required. The shape and dimension accuracy of machined material is influenced by machine tool behavior, thermal stiffness of machine cutting tool. The internal parts of aircraft, cars, military vehicles, etc are required specialized cutting tool.

II. LITERATURE REVIEW

The demand and requirement of high rate of production and increase in the quality of manufacturing machined part and machining of hard materials are the challenges of today's manufacturing world. This literature contains information of machining of hard material, soft material. The hard turning operations are done on these materials by using uncoated and PVD TiN coated carbide cutting tool at different cutting parameters. The velocity vibration is measured in running condition on both types of cutting carbide tool then surface finish is measured on the machined material and in the last tool wear is measured on both types of cutting carbide tools. The effort is done to increase rate of production, accurate dimensions, surface finishing, tool life and etc. The use of coated cutting tool is not new in the manufacturing industries they are in the use from 1960s; the several researches have been done on this concept.

Yong Huang et al [1] have investigated performance of tool in provisions of tool life based on the flank wear criterion as a function of cutting conditions like, cutting speed, feed, and depth of cut. He shown that cutting speed plays a crucial role in defining the tool performance in terms of tool life, trailed by feed and depth of cut, and others factors.

J. Rech [10] presented that various coatings deposited on a carbide insert has exposed the sliding properties of the TiN and (Ti, Al) N+MoS_2 coatings, match up with uncoated tools in the situation of high speed dry turning of steels. TiN and (Ti, Al)N+MoS_2 coatings lower the tool chip contact area, the thickness of the secondary shear zone and the temperature at this interface, which lower the heat flux diffused to the cutting tool.

Renato Franc oso de A vila et al [4] evaluated the implementation of uncoated and coated carbide tools (ISO grade K10) with a 3 mm thick monolayer of TiN (produced by PA PVD) when hard turning AISI 8620 steel. His results shows that two distinct crater wear rates are shown when machining by using coated cutting tools, whereas a higher and single rate of wear was recognized for the uncoated inserts.

Noordin, M.Y et al [9] initiated hard turning to produce parts manufactured from hardened steels. TiAlN coated carbide tool was taken for finishing machined hardened steel.

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Performing hard dry turning at different cutting conditions, like, cutting speed and feed rate, exposed that better tool life and surface finish that meet up the harsh range of finish machining were achieved when finish machining hardened steel of 47–48 HRC hardness.

R.F. Avila et al [5] evaluated cutting tool life used for cemented carbide tools is the depth of the crater (KT) situated on the rake face, given as a role of the feed rate. The results bring a new loom and confirm the significance of the coating on the crater wear resistance, yet if the coating has previously been presented on the rake face.

P. Roy et al [3] introduced the compatibility of cutting materials in machining of Aluminum and Al–Si alloys in dry conditions. They have presented that chemical dullness of diamond towards aluminum was principally reliable for outperforming an uncoated tool with other tools coated with hard coatings like TiC, TiN, TiB_2, Al_2O_3 and AlON.

*M.A. El Hakim et al [8]*They have evaluated the accomplishment of four kinds cutting tool in the machining of medium hardened HSS: polycrystallinec-cBN (c-BN-TiN), TiN-coated polycrystallinec-cBN (c-BN-TiN), ceramic mixed alumina (Al_2O_3-TiC), and coated tungsten carbide (TiN coated over a multilayer coating (TiC/TiCN/ Al_2O_3) and have got that the high chemical and thermal stability of Al_2O_3 tribofilms protects the tool substrate because it prelude the heat generation on the tool/chip from inflowing the tool core.

Recep Yigit et al [10] have done an experimentation work on the affect of cutting speed in turning nodular cast iron with uncoated and coated cutting tools. The results show that uncoated WC/Co tool was the nastiest performing tool with respect to tool wear and the nastiest with respect to surface finish. The multilayer TiCN+TiC+TiCN+Al_2O_3 +TiN-coated carbide tool with extra TiN layer is the most suitable for turning nodular cast iron, especially on high cutting speeds.

2.2 Objectives of the project

1. To fulfill the demands and requirements of today's manufacturing world.
2. Study of change in tool chatter vibration at different parameters in running conditions which affect the performance.
3. Study of surface roughness by different kinds of cutting tool on different materials at different parameters.
4. Study about the behavior of cutting tools.
5. To study about different types of wear on carbide cutting tools.

III. EXPERIMENTAL INVESTIGATION

The experimentation work was carried out in two parts, the first part, turning of AISI 1045H steel with uncoated cutting tool and multifilm TiN coated carbide cutting tool with extra layer of TiN. In the second experimental part turning of soft material Aluminum was done with uncoated cutting tool and multifilm TiN coated carbide cutting tool with extra layer of TiN.

A. Machining of hard material (AISI 1045H Steel)

AISI 1045H steel is high graded steel in hardness and widely used in manufacturing industries. It is very crucial material in automobile engineering, aeronautical engineering, military heavy vehicles and others sectors of mechanical engineering.

TABLE I

CHEMICAL COMPOSITION OF AISI 1045H steel

Element	Weight %
Carbon	0.42-0.51
Manganese	0.50-1.00
Phosphorus	0.04
Sulfur	0.05
Silicon	0.15-0.30

B. Machined soft material Aluminum

The pure aluminum cylindrical solid rod have taken of length 80mm and diameter 35mm was machined with uncoated cutting tool and multilayer TiN coated carbide cutting tool.

C. Cutting insert

Types of cutting insert are available in the market. The cutting insert were uncoated and second was coated multifilm TiCN+TiC+TiCN+ Al_2O_3 +TiN coated carbide cutting tool. This cutting tool is suitable for machining high graded steel, alloys and ferrous material at high cutting speed.

D. Machine Tool

The experimentation work was done on capstan lathe machine in dry conditions.

E. Cutting conditions

Eight experiments with combination of different cutting parameters were done for AISI 1045H Steel. Different levels of speeds, rate of feed and depth of cuts were done.

TABLE II

THE LEVELS AND PARAMETERS FOR AISI 1045H

S.No.	Speed	*f* (mm/rev)	*d*(mm)
1	500	0.05	0.2
2	500	0.08	0.3
3	500	0.14	0.4
4	775	0.05	0.2
5	775	0.08	0.4
6	775	0.14	0.6
7	1200	0.05	0.2
8	1200	0.08	0.5
9	1200	0.14	0.8

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TABLE III

THE LEVELS AND PARAMETERS FOR ALUMINIUM

S. No.	Speed	*f*	*d* (mm)
1	500	20	0.2
2	500	35	0.3
3	500	55	0.4
4	1200	20	0.4
5	1200	35	0.6
6	1200	55	0.8

F. Tool chatter Vibration measurement

The measurement of average vibration velocity on the cutting tool was measured with the use of Digital Vibration Meter (VM-8200). The average vibration velocity is taken at different parameters.

G. Surface Roughness Measurement

The roughness of the surface of work material is measured by using Taylor Hobson roughness meter it gives accurate reading of the roughness. This meter can be used freestanding, vertically or horizontally. It is very reliable can use be used very easily.

H. Tool wear measurement

To identify wear on cutting tool Scanning Electron Microscope (SEM) test is to be done which microscopic view and condition of the cutting tool. SEM gives clear result about the wear on tool.

I. Experimentation procedure

The experimentation work of turning for AISI 1045H Steel was done on capstan lathe speed of cutting were 500, 775 and 1200 min/rev and Feed rates were 0.05, 0.08,0.14mm/rev *(f)* and depth of cut *(d)* was 0.2, 0.3, 0.4 for 500 RPM,0.2, 0.4, 0.6 mm for 775 RPM and 0.2,0.5,0.8 for 1200 RPM. Secondly hard turning experimentation work was done for soft material (Aluminum) at 1200 RPM and Feed rates were 20, 35, 55mm/min *(f)* and depth of cut *(d)* was 0.4,0.6,0.8 mm. The conditions of cutting were taken same for PVD coated and uncoated carbide tool.

IV. RESULTS AND DISCUSSION

A. Tool chatter Vibration measurement

The vibration velocity of cutting tool is measured with vibration meter on different cutting speed, feed rate, and depth of cut. The velocity parameter is used to measure vibration on cutting tool. The results are given below in tables and figures given below.

Table (A) Average vibration velocity for uncoated tool in running condition on AISI 1045H Steel.

S. No.	Speed (RPM)	*f* (mm/rev)	*d* (mm)	Average Vibration velocity (m/s)
1	500	0.05	0.2	11.45
2	500	0.08	0.3	17.34
3	500	0.14	0.4	27.36
4	775	0.05	0.2	20.58
5	775	0.08	0.4	29.38
6	775	0.14	0.6	36.34
7	1200	0.05	0.2	33.45
8	1200	0.08	0.5	41.83
9	1200	0.14	0.8	48.64

Table (B) Average vibration velocity for PVD TiN coated cutting tool in running condition on AISI 1045H Steel.

S. No.	Speed (RPM)	*f* (mm/rev)	*d* (mm)	Average Vibration velocity (m/s)
1	500	0.05	0.2	5.96
2	500	0.08	0.3	8.66
3	500	0.14	0.4	12.32
4	775	0.05	0.2	9.73
5	775	0.08	0.4	12.76
6	775	0.14	0.6	16.68
7	1200	0.05	0.2	16.39
8	1200	0.08	0.5	21.57
9	1200	0.14	0.8	25.31

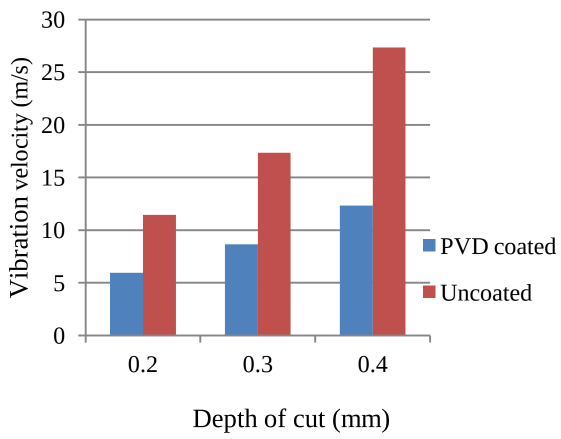

Fig. I Vibration velocity PVD vs. Uncoated cutting tool for AISI 1045H Steel at 500 RPM

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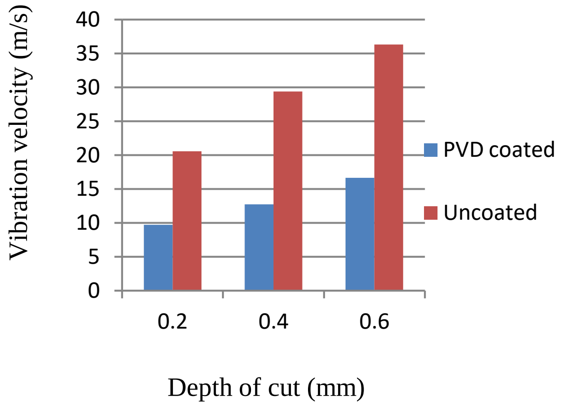

Fig. II Vibration velocity PVD vs. Uncoated cutting tool for AISI 1045H Steel at 775 RPM

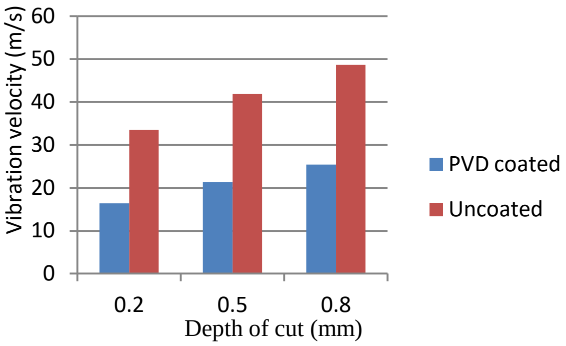

Fig. III Vibration velocity PVD vs. Uncoated cutting tool for AISI 1045H Steel at 1200 RPM

Results of tool chatter vibration on cutting tool are presented in terms of tables and graphs. In table A,B and in fig. I, II, III shows the graphical representation of vibration velocity of PVD coated cutting tool Vs Uncoated cutting tool at cutting speeds of 500, 775, 1200 RPM with feed rates of 0.05, 0.08, 0.14 mm/rev and depth of cut of 0.2,0.3,0.4, 0.5, 0.6, 0.8 mm for AISI 1045H Steel. It was seen that the vibration velocity for uncoated carbide tool is increased with the increase in cutting speed and at high cutting speed the vibrations increased very highly and vibration velocity for PVD coated tool at different level of depth of cut it gives low vibration reading. The PVD coated tool vibration velocity give best performance as compared to uncoated tool it means that PVD coated carbide cutting tool is very efficient for the life of tool and as well as for work material. It can increase the product quality, rate of production and give accurate dimensions. PVD TiN coated is very useful in various engineering sectors.

B. Surface roughness measurement

Surface roughness is influenced by many factors in this project like turning speed, rate of feed, depth of cut and velocity vibration on cutting tool. The simple parameter for roughness R_a as an average roughness value is taken out in the results. The surface roughness in the table I.II,III and also in term of graph fig. a, b, c, d, e, f, g the representation of graphs shows the results of surface roughness vs. feed rates, surface roughness vs. depth of cut. It is shown that surface roughness for hard material by uncoated tool increases with increases in feed, and depth of cut. At the higher depth of cut and speed, surface roughness for uncoated tool is high whereas using PVD coated tool it gives better surface roughness. Surface roughness for soft ductile material like Aluminum from PVD coated is high and for uncoated carbide tool surface roughness is low.

Table I Surface roughness of Aluminum for PVD coated tool

S. No.	Speed (RPM)	*f* (mm/min)	*d* (mm)	Ra(µ)
1	500	20	0.2	1.23
2	500	35	0.3	1.54
3	500	55	0.4	1.91
4	1200	20	0.4	1.94
5	1200	35	0.6	2.06
6	1200	55	0.8	2.26

Table II Surface roughness of Aluminum for Uncoated tool

	Speed (RPM)	*f* (mm/min)	*d* (mm)	Ra (µ)
1	500	20	0.2	0.45
2	500	35	0.3	0.84
3	500	55	0.4	0.93
4	1200	20	0.4	0.04
5	1200	35	0.6	0.06
6	1200	55	0.8	0.07

Table III Surface roughness of AISI 1045H for uncoated tool

S. No.	Speed (RPM)	*f* (mm/rev)	*d* (mm)	Ra (µ)
1	500	0.05	0.2	0.38
2	500	0.08	0.3	0.52
3	500	0.14	0.4	0.72
4	775	0.05	0.2	2.34
5	775	0.08	0.4	2.97
6	775	0.14	0.6	4.52
7	1200	0.05	0.2	2.23
8	1200	0.08	0.5	3.39
9	1200	0.14	0.8	4.66

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Table 3.14 Surface roughness of AISI 1045H for PVD coated tool

S. No.	Speed (RPM)	*f* (mm/rev)	*d* (mm)	Ra (µ)
1	500	0.05	0.2	0.04
2	500	0.08	0.3	0.06
3	500	0.14	0.4	0.08
4	775	0.05	0.2	0.2
5	775	0.08	0.4	0.5
6	775	0.14	0.6	0.8
7	1200	0.05	0.2	0.5
8	1200	0.08	0.5	0.7
9	1200	0.14	0.8	0.9

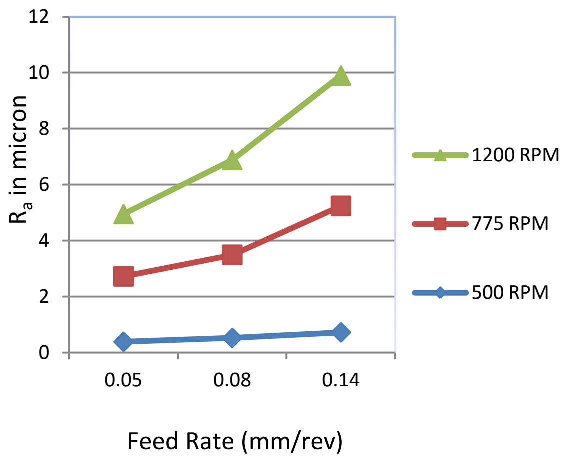

Fig (a) Surface roughness vs. Feed rate of uncoated carbide tool on AISI 1045H

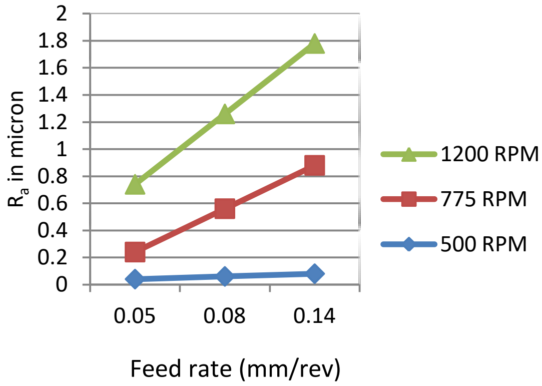

Fig. (b) Surface roughness vs. Feed rate of PVD TiN Coated carbide tool on AISI 1045H.

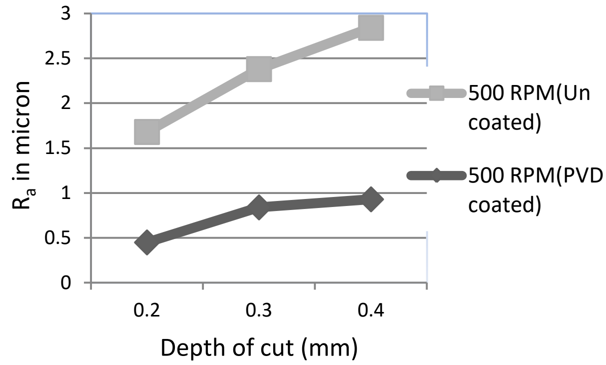

Fig. (c) Surface roughness PVD vs. Uncoated of Aluminum at 500 RPM

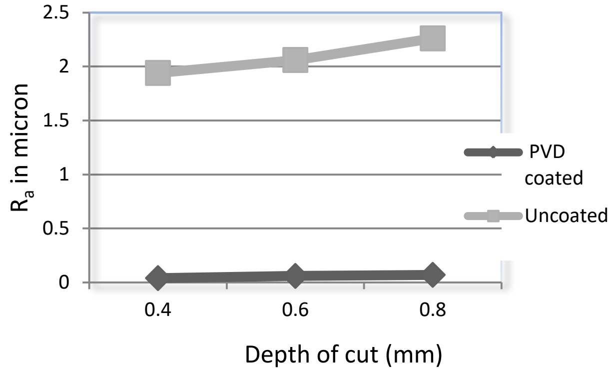

Fig. (d) Surface roughness PVD vs. Uncoated of Aluminum at 1200 RPM

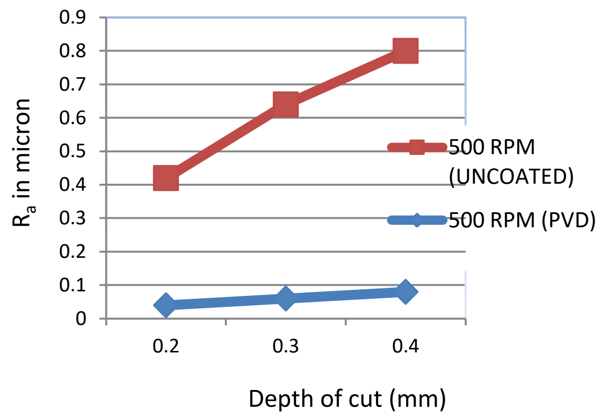

Fig. (e) Surface roughness PVD vs. Uncoated of AISI 1045H at 500 RPM

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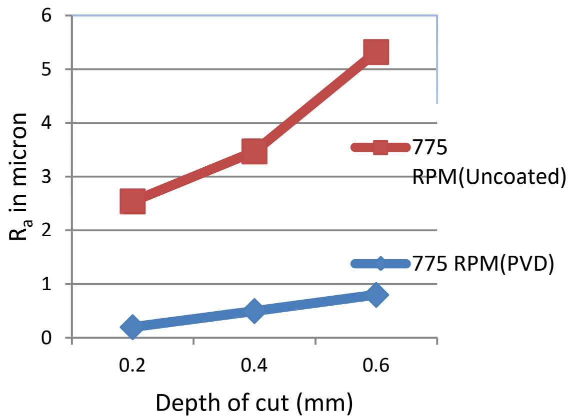

Fig. (f) Surface roughness PVD vs. Uncoated of AISI 1045H at 775 RPM

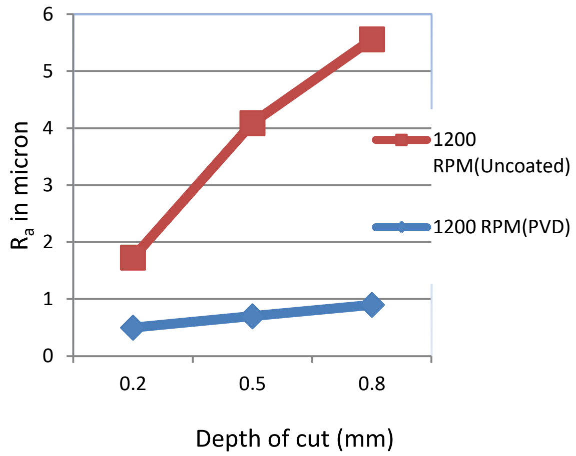

Fig. (g) Surface roughness PVD vs. Uncoated of AISI 1045H at 1200 RPM

C. Tool wear measurement

Fig (a) and (b) shows the SEM pictures of uncoated and PVD TiN coated carbide cutting tool. The worn surface of uncoated carbide cutting tool is more in the image. The tool nose and tip is destructed by more wear on it and due to plastic deformation or abrasion which caused by high too chatter vibration on cutting carbide tool. In fig. (a) It is shown that there is critical wear on the tool nose and its tip. When the uncoated tool is subjected to low depth of cut and at low speed the tool chatter vibration on the cutting tool is less but when it is subjected to high speed and high depth of cut the deformation takes place to mechanical affect and chemical affect the cutting edge is destroyed due to high hardness and temperature and wear. The SEM picture of PVD TiN coated carbide cutting tool shows that the protective coating of TiN on the tool surface gives best performance under high speed and depth of cut. When the hard material AISI 1045H was machined by coated tool it gives high protection to the cutting tool, less vibrations and less wear on the cutting.

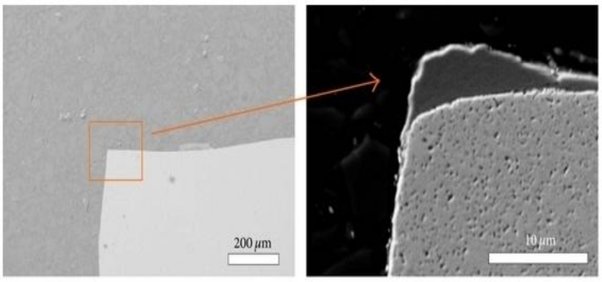

Fig. (a) SEM Pictures of Uncoated Carbide Cutting tool

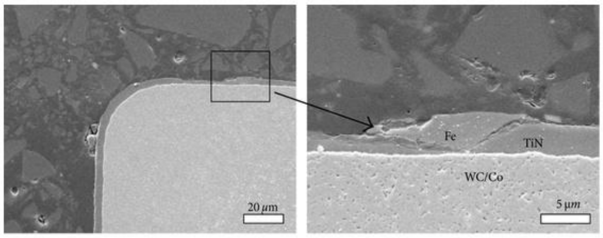

Fig. (b) SEM Pictures of PVD TiN Carbide Cutting tool

In TiN coated carbide cutting tool due to its protective coating and strong microstructure bonding between tool surfaces and coating it gives best performance. The edge, nose and tip of the PVD TiN coated cutting carbide tool are protected by its TiN coating.

V. CONCLUSION

(1) The vibration velocity on cutting tool at higher speed and higher depth of cut for uncoated tool is high but vibration velocity on PVD TiN coated tool is very low at high speed and depth of cut.

(2) Vibration velocity increases with increase in speed and depth of cut.

(3) The tool chatter vibration can be reduced by using PVD multilayer TiN coating on the cutting tool.

(4) The study concluded the PVD TiN multilayer coated carbide tool produce better surface roughness at higher speed and high depth of cut, and low feed rate whereas uncoated carbide tool gave poor performance as compared to PVD TiN coated tool.

(5) Surface roughness for soft ductile material like Aluminum from uncoated cutting carbide tool is better as compared from PVD TiN coated carbide tool.

(6) SEM analysis shows that the abrasion and distraction on microstructure of PVD coated is less and wear for uncoated is high.

(7) PVD coated carbide tool gives better performance on hard material machining as compared to uncoated carbide tool.

(8) Uncoated carbide cutting tool gives better performance on soft material as compared to PVD coated carbide cutting tool.

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REFERENCES

1. Yong Huang, Steven Y. Liang, Affect of Cutting Conditions on Tool Performance in CBN Hard Turning, Journal of Manufacturing ProcessesVol. 7/No. 1. 2005.
2. A.K. Chattopadhyay, P. Roy, A. Ghosh, S.K. Sarangi, Wettability and machinability study of pure aluminium towards uncoated and coated carbide cutting tool inserts, Surface & Coatings Technology 203 (2009) 941–951.
3. P. Roy, S.K. Sarangi, A. Ghosh, A.K. Chattopadhyay, Machinability study of pure aluminium and Al–12% Si alloys against uncoated and coated carbide inserts, Int. Journal of Refractory Metals & Hard Materials 27 (2009) 535–544.
4. Renato Franc oso de A vila a, Alexandre Mendes Abra˜o , G. Cristina Dura es de Godoy, The performance of TiN coated carbide tools when turning AISI 8620 steel, Journal of Materials Processing Technology 179 (2006) 161–164
5. R.F. Avila , C. Godoy, A.M. Abra, M.M. Lima, Topographic analysis of the crater wear on TiN, Ti(C,N) and (Ti,Al)N coated carbide tools, Wear 265 (2008) 49–56.
6. D.I.Lalwani,N.K.Mehta,Y.J.Lin,Experimental Investigstion of cutting parameter influence on cutting forces and surface roughness In finish haed turning of MDN250 steel, journal of materials processing technology 206(2008)167-179.
7. Recep Yigit , Erdal Celikb, Fehim Findikc, Sakip Koksalc, Affect of cutting speed on the performance of coated and uncoated cutting tools in turning nodular cast iron, journal of materials processing technology 2 0 4 (2008) 80–88.
8. CH.R. Vikram Kumar, P. Kesavan Nair, B. Ramamoorthy, Performance of TiCN and TiAlN tools in machining hardened steel under dry, wet and minimum fluid application, Int. J. Machining and Machinability of Materials, Vol. 3, Nos. 1/2, 2008.
9. M.A. ElHakim , M.D.Abad , M.M.Abdelhameed , M.A.Shalaby , S.C.Veldhuis, Wear behavior of some cutting tool materials in hard turning of HSS, Tribology International 44 (2011) 1174–1181.
10. Noordin, M.Y., Tang, Y.C. and Kurniawan, D. (2007) 'The use of TiAlN coated carbide tool when finish machining hardened stainless steel', Int. J. Precision Technology, Vol. 1, No. 1, pp.21–29.
11. J. Rech, A multiview approach to the tribological characterisation of cutting tool coatings for steels in high-speed dry turning, Int. J. Machining and Machinability of Materials, Vol. 1, No. 1, 2006.

Nomenclatures used

f	Feed rate
d	Depth of cut
R_a	Average surface roughnes
µ	Micron

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