PERFORMANCE & ANALYSIS OF COATED AND UNCOATED END MILL WITH P-20 STEEL IN MILLING OPERATION

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ABSTRACT

Knowledge of End mill tool performance during milling machining of work material is much required in order to improve the effectiveness of the machining process. The tool-workpiece impact and correlated effects of tool wear and surface roughness are regularly the subjects of importance, although, more work has been done to set up the connection between tool wear and surface roughness during milling, there is no considerable data existing for P20 tool steel. To fill the gap, the machining of P20 tool steel using both uncoated and different coated end mill were performed. An end mill with different coatings outperformed uncoated end mill in terms of tool wear and surface roughness. The results also revealed that the feed rate was the dominant factor affecting surface roughness, whereas the cutting speed significantly contributes to the tool wear. The objective is to analyze the performance of end mill cutting tool coated with different metal in the milling operation of P-20 tool steel. The end mill cutting tool is used for machining rectangular shaped specimen of P-20 tool steel. A number of tests are performed with different coated end mill, cutting speeds, feed rates and depth of cuts.

Keyword : - *End mill cutting tool, Milling operation, P20 tool steel, Endmill tool coatings.*

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1. INTRODUCTION

As the modern expertise demands complex machining profiles, intermittent cut machining is usual nowadays. The increased probability of tool wear and tool breakdown during intermittent cut create the demand to examine the performance of tools on a variety of work materials. The repeated load, impact beating of the tool and uneven tool-chip interface temperature are the factors to be analyzed during the intermittent cut. Poor surface finish & high tool wear rate all over milling consequences in less efficiency and productivity. Tool wear modes and mechanisms of P20 tool steel throughout intermittent milling were not addressed and therefore it is considered to produce machining data for the same. The investigational work is to recognize tool wear modes and pattern of uncoated carbide end mill and AlTiN, TiAlN, TiCN, AlCrN coated carbide end mill during the intermittent cut. Bar plate made of P20 tool steel were selected for the experiment. A Vertical machining center (VMC) – Lead well make selected for the experiment.

Xiaobin [1], Asier. [2], Aslantas [3], Kevin Chou [4], and Ezuguwu [5] stretch details that considerate of tool failure mechanisms in milling process is vital for suitable application and material of dissimilar cutting tools. Many of study articles present on the failure of tool mechanisms in milling machining operation. However huge investigation on failure manners and tool wear mechanisms of tools during milling operation exists, the performance of the tools through milling of P20 tool steel material is still not addressed.

Tool coating is done to increase the performance of end mill cutting tool. Many researchers have done research using PVD i.e. Physical Vapor Deposition and CVD i.e. Chemical Vapor Deposition methods tool coating as Titanium oxide, Titanium carbide, Titanium Nitride.

The machining of hard & chemically reactive materials at greater speed is enhanced by deposition of single and multilayer coatings on conventional tool material to combine the supportive properties of traditional tool materials.
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2. LITERATURE REVIEW

Raising the productivity and the excellence of the machined parts are the main challenge of manufacturing industries. This purpose requires improved managing of the machining structure. This literature contains information on tool-work interface, surface finish and material removal rate in milling operation & coating materials for cutting tools. The machining of hard and chemically sensitive materials at higher speeds is enhanced by putting single and multi-layer coatings on conventional tool materials to join the advantageous properties of traditional tool materials. J.A. Ghani et al. [6] inspect the wear mechanism of coated carbide (TiN) and uncoated tools at a variability of a combination of cutting speed, depth of cut and feed rate for hardened H13 (AISI) tool steel. Research explained that the longer time is taken for the cutting-edge wear of coated carbide tools (TiN) to start cracking than uncoated tools in machining, at the various machining parameter like cutting speed, feed rate and depth of cut. The uncoated tools show higher wear rate on the flank face than coated TiN carbide tools.

Yong Huang [7] have assessed tool performance in relationships of tool life based on the flank wear at standard cutting environments, that is feed, depth of cut & cutting speed. cutting speed plays the main role in defining the tool performance in relationships of tool life, followed by the depth of cut and feed rate in general empathy agree with the forecast from the common tool life Taylor equation as well as an experimental explanation.

Schulz et al. [8] research explain that edges of cutting of carbide tools coated with, CVD i.e. chemical vapor deposition and PVD i.e. physical vapor deposition (TiN, TiC, and Ti, Al) procedures can show an increase of the operational life of tools by a factor of ten associate to uncoated tools. It is found by F Akbar. [9] Explain that the use of coated tools with TiN causes a decrease in heat barrier into the cutting tool compare with the uncoated tool by 17% at conventional cutting speed & high-speed machining zone by 60%.

Astrand et al. [10] offered the coating strategies and cutting tool edge geometry can expressively affect heat distribution into the cutting tool. The research article paper shows the benefits of coatings on the flank face and racks with contact, impact on tool wear. Grzesik. [11] explained that coated tool with multilayer coatings tools performance is improved than an uncoated tool. Corduan [12] found PVD i.e. Physical Vapor coated tool performance is better than the CVD i.e. Chemical Vapor coated tool).
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3. PROBLEM DEFINITION AND OBJECTIVE FUNCTION

From the literature review, it is found that less research work has been done regarding the tool performance while coated with a metal coating with P-20 tool steel as a workpiece. Similarly, different types coating material have not been tired. Considering the literature gap observed our approach uses the end mill tool with different coating metal like TiAlN, AlTiN, and AlCrN on a P20 tool steel. And observe the performance of machining. As the literature gap observed our method is to coat the cutting tool with different metal coating and observe the performance of machining process. Therefore, the objective is “performance & analysis of coated and uncoated end mill with p-20 steel in milling operation”.

4. MATERIAL SELECTION

P-20 tool steel was designated as work material. P-20 tool steel is used in a huge variety of tool products including molds, dies, press tools, machine structure parts, and die casting dies. This is because of P20 is available in a pre-hardened form hardening heat treatment is not required. P20 tool steel which propositions a high amount of hardness with compressive strength and high abrasion resistance.

This Grade is relatively often used for wear-resisting machine constituent and for press instrument which doesn't benefit an additional complex suitable. Typically used of P20 is for relatively low temperature applications such as die casting dies and injection molds

Figure 4.1 Actual P20 work piece for experiment

Table -4.1 Chemical compositions for P20 tool steel

P20 Tool Steel		
Chemical Composition		
Carbon	C	**0.28 - 0.4**
Chromium	Cr.	**1.4 - 2**
Iron	Fe.	**Balance**
Manganese	Mg.	**0.6 - 1**
Molybdenum	Mo.	**0.3 - 0.55**
Phosphorus	P.	**0.03 max**
Silicon	Si.	**0.2 - 0.8**
Sulphur	S.	**0.03 max**

4.1 Properties of P20 Tool Steel:

1) Principal Design Features P20 steel are in the classification regularly sorted as Shape Steels. Nickel and chromium are the alloying components for hardness and toughness. This compound is regularly utilized as a part of the carburized condition.
2) Machinability-Machinability is generally great at around 80% that of the W group water solidifying steels.
3) Forming-P20 may promptly be framed by traditional strategies with the combination in the tempered condition.
4) Welding-This compound is weldable by traditional strategies. Contact the combination provider for points of interest and weld methodology.
5) Heat Treatment-For carburizing warmth to 1600-1650 F in the carburizing medium. For solidifying in the wake of carburizing warmth to 1500 - 1600 F and hold for 15 minutes at that point oil quench.

Table -4.2: Physical properties of P20 tool steel

P20 Tool Steel	
Density	0.284 lb/in3 (7861 kg/m3)
Specific Gravity	7.86
Modulus of Elasticity	30 x 106 psi (207 GPa)
Thermal conductivity	24 Btu/ft/hr/°F 41.5 W/m/°K
Machinability	60-65% of a 1% carbon steel

Table -4.3 Chemical compositions for Tungsten Carbide End Mill.

Tungsten Carbide End Mill	
Cutting Diameter	6 mm.
Shank diameter	6
Flute length	15
No. of Flute	4
Overall length	50
Helix Angle	30
Coating	Uncoated, TiAlN, AlTiN, AlCrN Coated

Figure 4.2: Actual end mill tool for experiment

4.2 Properties of Tungsten Carbide:

1) Strength - Tungsten carbide has high quality for a material so hard and inflexible. Compressive quality is higher than for all intents and purposes all dissolved and cast or alloys forged metals.
2) Rigidity - Tungsten carbide creations go from a few times as inflexible as steel and four to six times as unbending as cast iron and metal. Young's Modulus is up to 94,800,000 psi.
3). High protection from twisting and diversion is extremely important in those numerous applications where a minimum deflection and good ultimate strength merits first thought.
4) Impact Resistant - For such a hard material with high unbending nature, the effect opposition is high. It is in the scope of hardened tool steels of lower hardness and compressive quality.
5) Heat and oxidation resistance - Tungsten-base carbides perform spring up to around 1000°F in oxidizing environments and to 1500°F in non-oxidizing airs
6) Thermal Conductivity - Tungsten carbide is in the scope of twice that of hardware steel and carbon steel.
7) Tolerances - Numerous surfaces of even entire parts can be utilized the way they originate from the furnace, "as sintered, for example, mining or penetrating compacts. In those parts requiring exactness ground precision, for example, stamping kicks the bucket and close-resistance performs is accommodated crushing or EDM.

8). Coefficient of Friction - Tungsten carbide display low dry coefficient of rubbing esteems when compared with steels.
9). Corrosion-Wear Resistance - Particular evaluations are accessible with erosion opposition moving toward that of respectable metals. Customary evaluations have adequate protection from erosion wear conditions for some applications.
10). Wear-Resistance- Tungsten carbide wears up to 100 times longer than steel in conditions including scraped area, disintegration and rankling. Wear opposition of tungsten carbide is superior to anything that of wear-obstruction instrument steels.
11). Surface Finishes - Complete of an as-sintered part will be around 50 miniaturized scale inches. Surface, barrel shaped, or inward crushing with jewel wheel will deliver 18 miniaturized scale inches or better and can create as low as 4 to 8 small scale inches. Precious stone lapping and sharpening can deliver 2 small scale inches and with cleaning as low as ½ miniaturized scale inch.

5. EXPERIMENTAL SETUP

The particular machining process selected for use in this project was a VMC milling operation. This process was chosen for several reasons. Milling is the most common End mill tool machining operation and has long been used as a basis for evaluating tool geometry and materials, work piece materials and tool life. Because a large number of tools were utilized in gathering the data in this experiment, milling was selected for economic reasons as well as because of its simplicity and wide application.

Figure 5.1: VMC (Lead well make) for experiment.

6. EXPERIMENT PROCEDURE

End milling tests were carried out on a homogenous P20 rectangular block of dimensions 250 x 100 x 75 mm. The nominal composition of the alloy is given in Table 1. The hardness of this work piece was measured as 55–60 HRC. The experiments were performed using a tungsten carbide end mill with uncoated, AlTiN, TiAlN, AlCrN coated having Dia6 mm. The geometrical features of the micro-end mill are shown in Table 2. The grain size of the end-mill was measured and found to be between 500–900 nm. Experimental tests were carried out using a vertical machining center (Lead well) characterized by a maximum spindle speed of 12000 RPM.
Using NC programming different parameter like depth of cut, spindle speed, feed rate set and no of cycle experiments perform on P20 material work piece. After each cycle work piece surface roughness and tool wear rate is measure using surface roughness tester and SEM microscope.

Figure 6.1: SEM Analysis setup

7. EXPERIMENTAL VALUES

Table -7.1: End mill wear rate (in mm.) experimental value.

Sr.No.	No. of Cycles	Cutting Speed (rpm)	Feed Rate mmpm	Depthof cut (mm)	Wear (mm.)			
					Uncoated	AlTiN	TiAlN	AlCrN
1	1 Cycle	2250	1130	0.2	0.291	0.041	0.030	0.029
2	2 Cycle	2250	1250	0.3	0.318	0.044	0.033	0.032
3	3 Cycle	2250	1350	0.4	0.376	0.056	0.042	0.038
4	4 Cycle	2500	1130	0.3	0.483	0.060	0.052	0.048
5	5 Cycle	2500	1250	0.4	0.526	0.061	0.054	0.053
6	6 Cycle	2500	1350	0.2	0.570	0.071	0.059	0.057
7	7 Cycle	2750	1130	0.4	0.639	0.090	0.071	0.064
8	8 Cycle	2750	1250	0.2	0.570	0.090	0.072	0.065
9	9 Cycle	2750	1350	0.3	0.538	0.991	0.077	0.060

Table -7.2: Work piece surface roughness experimental value

Tool Type	No. of Cycles	Measurements			Average Measurements		
		Ra(µm.)	Rz(µm.)	Rmax µm.)	Ra(µm.)	Rz(µm.)	Rmax µm.)
Uncoated	3 Cycles	0.26	1.6	2.053	0.087	0.533	0.684
	6 Cycles	0.251	1.547	1.747			
	9Cycles	0.248	1.5	1.63			
AlTiN	3 Cycles	0.223	1.51	1.97	0.074	0.503	0.657
	6 Cycles	0.215	1.42	1.603			
	9Cycles	0.201	1.304	1.531			
TiAlN	3 Cycles	0.241	1.47	2.043	0.080	0.490	0.681
	6 Cycles	0.239	1.347	1.697			
	9Cycles	0.22	1.51	1.43			
AlCrN	3 Cycles	0.18	1.43	1.831	0.060	0.477	0.610
	6 Cycles	0.168	1.31	1.509			
	9Cycles	0.153	1.107	1.317			

8. EXPERIMENTAL RESULTS AND ANALYSIS

8.1 No. of cycles vs. tool wear in mm.:

Chart -8.1: Wear rate vs. No. of experiment (cycles)

Observations:

From the above graph we can conclude that, the x axis represents No. of cycles of milling. and the y axis represents the wear rate value in mm. concluded all experimental trials, the wear rate of tool by each tool was evaluated by measuring the wear area on tool by a microscopically analyzing the cutting edges of each tool. Normal roughness esteems were figured represent to the general level of roughness show on each surface.
These results allow evaluating the specific performance of each tool.

1)Uncoated end mill, having high wear rate of 0.538 mm. which is high compare to coated end mill tool.
AlCrN coated end mill, having low wear rate of 0.070 mm which is low compare to Uncoated, AlTiN, TiAlN coated end mill tool.
So, we can conclude that, the AlCrN Coated end mill well perform in the basis of wear rate term
2) Tool vs. Surface roughness:

8.2 Roughness vs. Types of end mill tool

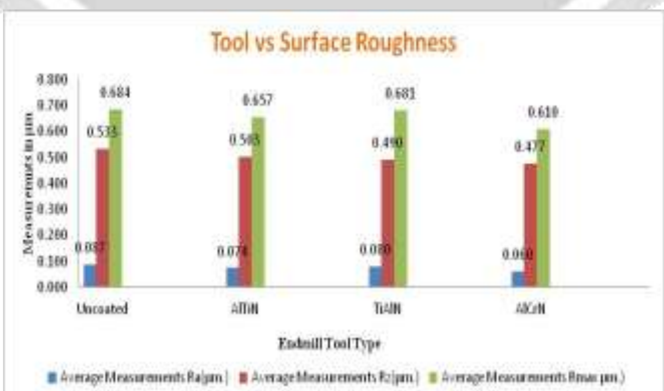

Chart -8.2: Roughness vs. Types of end mill tool

Observations:

From the above graph we can conclude that, the x axis represents Types of End mill tool. And the y axis represents the surface roughness value. Having concluded all experimental trials, the surface finish by each tool was evaluated measuring the surface roughness on work piece machined part and by a microscopically analyzing the cutting edges of each tool. Average roughness values were calculated to represent the overall level of roughness present on each surface. These results allow evaluating the specific performance of
Each tool.

1) Uncoated end mill, having surface roughness characteristics of 0.087 Ra (µm.)0.533 Rz(µm.) 0.684 Rmax(µm.) which is high compare to coated end mill tool.

2) AlCrN coated end mill, having low surface roughness characteristics of 0.060 Ra(µm.)0.477 Rz(µm.) 0.610 Rmax(µm.) which is low compare to Uncoated, AlTiN, TiAlN coated end mill tool.

So, we can conclude that, the AlCrN Coated end mill well perform in the basis of surface roughness term.

9. CONCLUSIONS

Following Conclusions can be drawn from the result obtained from the machining of P20 tool steel.workpiece with uncoated, AlTiN, TiAlN, AlCrN coated tool individually under provided feed, speed and depth of cut.

1) The experimentation showed that further research can be preceded for the coating of tool with metal coating by PVD, CVD method.
2) Measurement of tool with SEM-EDS isa very fine technology. Wear during machining of P20 tool steel by uncoated tool was high compared to coated tool.
3) Surface roughness value increased with uncoated tool.
4) Uncoated tool produced rough surface compared to coated tool but AlCrN coated tool produced fine surface finish.
5) From Wear and surface finish aspect AlCrN can be considered as a good tool for cutting P20 than uncoated, AlTiN, TiAlN coated

10. FUTURE SCOPE

With increasing demand for a high-quality product with the lesser price, the manufacturing industry has been Competitive. Machining is the fundamental process of any manufacturing process and companies are always in seek of better technology the scope of study in the performance of machining process is High. Some of the fields of study for future work can be listed as:
1) Research on the different coating of the cutting tool can be furthered because of its cheapness and ease of technology.
2)further research can be extended to study the performance of end mill cutting tool with a variety of metal coating. Since the surface finish is a crucial factor for any product manufactured the way to increase surface finish may be a great field of study.
3)the study can be continued on the life of the cutting tool and its wear mechanism.
4)since the surface finish is a crucial factor for any product manufactured the way to increase surface finish may be a great field of study.
5)the study can be continued on the life of the cutting tool and its wear mechanism.

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