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Performance and Comparison of Coated and Uncoated Tool Inserts in Machining of C45 Steel

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Abstract

Using coated and uncoated tool inserts, the machining operation is carried out on C45 steel to analyze and compare the tool performance. A study was done on C45 steel, its carbon content ranges from 0.40 to 0.50 per cent. C45 steel has traces of molybdenum, silicon, silicon dioxide, manganese, and phosphorus. In this work, comparison was made between coated and uncoated tool inserts for different samples of C45 steel which is having sulphur and phosphorus of varying percentage. As samples were obtained, they were converted to the desired diameter and examined at various feed rates (0.125, 0.175, and 0.225 mm/min), cutting speeds (11.0, 15.58, and 19.47 m/min), and cut depth (0.5, 1and 1.5mm). Wear and tool tip temperature were looked at and contrasted. Findings indicated that the coated tool inserts used for machining has a good and better properties compared to uncoated tool inserts. Therefore, these traces in a small enough quantity produce superior outcomes. Additionally, the behaviour of the material and how it affected the characteristics of the tool and work sample were examined Using SEM and Energy Dispersive X-Ray analysis.

Keywords: *C45 Steel, Temperature, Wear Surface and SEM T*

1.0 Introduction

The carbon percentage of 0.40-0.50 per cent, C45 is a medium carbon. Because they are simple to utilize and affordable price, simple carbon steels are widely used in most industries. They are classed according to the amount of carbon in them. [1]. Flexibility, strength, and superior wear resistance are all balanced. Axles, gears, and other varieties of drill bits are constructed using C45 bars, and hot-rolled steel is used to make shafts that are turned during machining for a decent surface quality [2].The quality of the steel may be significantly impacted by minute impurities of many other components. The machinability of C45 steel is enhanced by traces of sulphur [3] and to a lesser extent by phosphorus, which also enhances metals have increased yield strength and corrosion resistance. The soft product manganese sulphide that sulphur produces works as a chip-breaking discontinuity, rises [4]. It acts and mechanical characteristics improve as sulphur content as a dry lubricant to avoid clogging near the edge of the tool. Turning is a generalized machining operation with a number of benefits, including a high rate of material removal [5], the ability to produce parts with tight tolerances, and some degree of surface quality [6]. The benefits of employing carbide-tipped tools are its lowcost, capacity to dissipate heat, tool life, ease of replacement, and ability to produce cleaner cuts and finishes [6,7]. PCD, ceramic, and carbide as are sult of cutting tool technology advancements, coated and uncoated tools are now commonly utilized. They can withstand the higher temperatures produced by high-speed operations because of their high hot hardness and toughness [8]. The amount of heat produced during machining is the key factor affecting tool performance. Therefore, it is crucial to study cutting tool temperature before rotating [5]. In the current study, turning was done using coated tungsten carbide tools on two separate C45 steel samples in order to better understand how these components affect the steel's machinability. The prediction and management of wear is one of the most significant difficulties that arise in the design of cutting processes [9]. "When the cost of replacement is less than the cost of maintaining the tool, it is considered wornout" is a relevant definition for the term [10]. While absolute failure (ultimate failure), which is a situation that arises when catastrophic failure happens, is defined as the entire the cutting edge is removed, When an instrument no longer serves the intended purpose, it is said to have failed [11].

2.0 Experimental Data

2.1 C45 Steel

Two samples were chosen for research after samples were analyzed at a metallurgical testing facility accredited by NABL (machining). Table 1 lists the specific chemical compositions of the sample and the standard.

Table 1: C45 Steel's chemical composition, sample and standard

Element	Carbon	S%	P%	Si%	Mn%
Sample 1	0.45	0.006	0.013	0.25	0.76
Sample 2	0.45	0.017	0.025	0.22	0.76

2.2 Tool Inserts

Figure 1: Tool insert fitted in a tool holder

Figure 2: Uncoated carbide inserts

Figure 3: Ti Coated carbide insert

2.3 Machining Parameters

C45 examined at various feed rates (0.125,0.175, and 0.225mm/min), cutting speeds (11.0, 15.58, and 19.47 m/min), and cut depth (0.5, 1 and 1.5mm) using tool inserts coated and uncoated. The impact of temperature and wear on the tool were investigated. The samples were prepared for 28 mm round and length of 150mm and for 1.5 mins of machining time.

The following are the parameters analyzed:

- The tool's flank wear was inspected under a microscope.
- A thermocouple to measure the tool' stip's temperature.

Figure 4: Machined work piece

3.0 Result and Discussion

3.1 Toolwear Microscopic Study

Figure 5 microscopic image of a tool inserts. Figure 5a shows the wear on the surface of the tool coated with titanium which used to machine C45 steel having increased proportion of phosphorus and sulphur (sample-2) and has very minimal wear on it compare to its counterpart sample-1 as show in Fig.5b.

Fig.5c shows the uncoated tool insert surface which is used for machining of C45 with higher % of sulphur and phosphorous (sample-2) has starches and wear on the surface. Whereas, Fig.5d shows the damage tip and fractured surface used for machining of C45 with lower phosphorus and sulphur content.

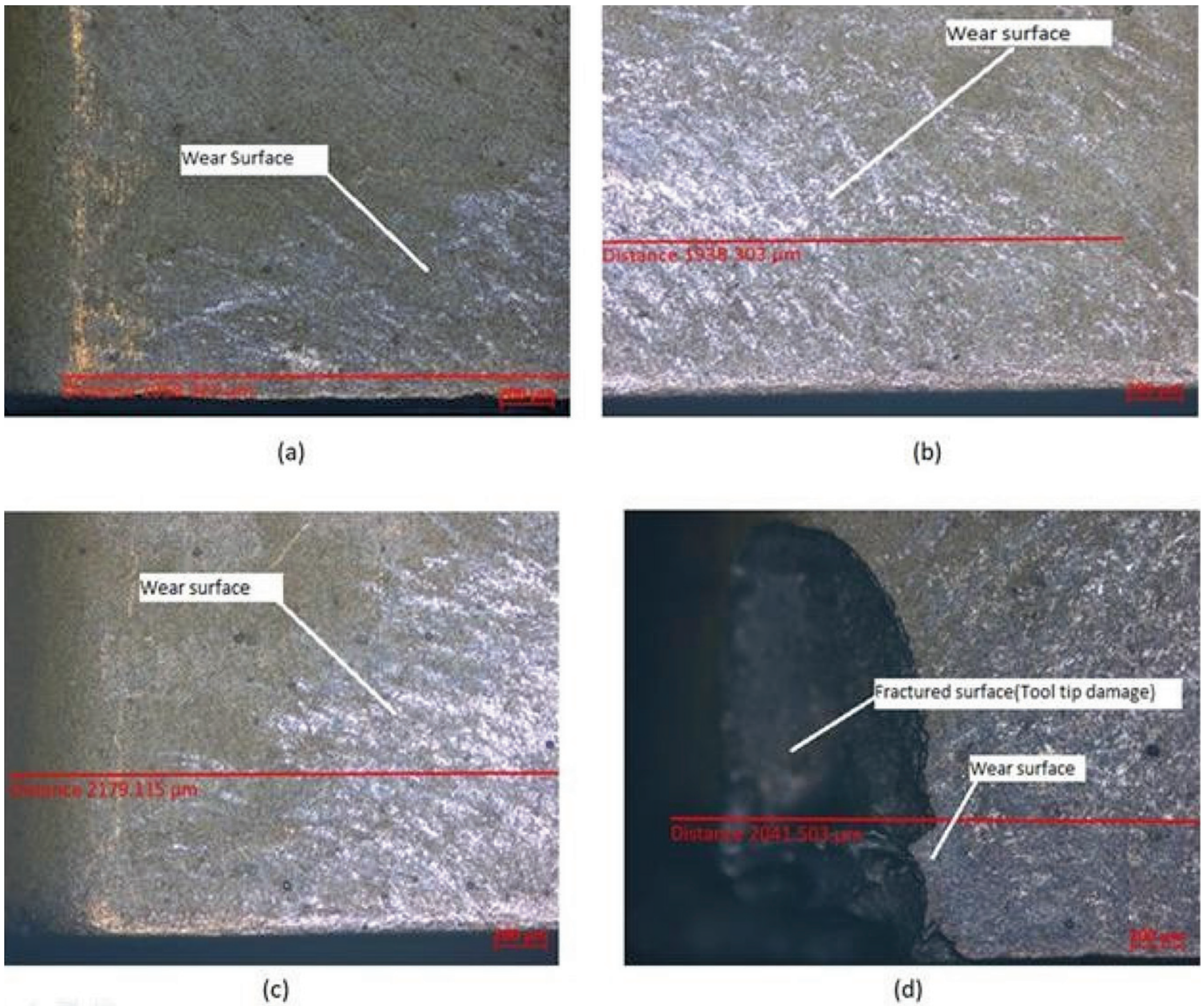


Figure 5: Microscopic image of tool wear surface: (a): worn-out surface of a coated tool insert used to machine C45 steel with a higher concentration of phosphorus and sulphur. (b): worn-out surface of a coated tool inserts when cutting C45 steel with a low phosphorus and sulphur content. (c): worn-out surface of an uncoated tool insert used to machine C45 steel with a higher percentage of phosphorus and sulphur and (d): worn-out surface of an uncoated tool insert used to machine C45 steel with a low sulphur and phosphorus content.

3.2 Toolwear Sem

Fig 6a shows the SEM micrograph of uncoated tool insert used for machining of C45 steel, which has a lower phosphorus and sulphur content. Tool surface has more built-up edge and also craters present in it. Whereas, Fig.6b shows the tool inserts used for machining higher percentage of sulphur and phosphorous with craters and starches present in it.

Fig 6c shows the coated tool surface which is coated with titanium and has a very minimal wear and no tool damages were found. Fig.6d shows the tool surface which is used for machining lower percentage of sulphur and phosphorus.

3.3 Temperature at Tooltip

When turning C45 steel with a coated tool insert at a cutting speed of 11.10 m/min for various feeds, Figs.7a and 7b illustrate the temperature variance with the altering DOC. Fig7a shows that temperature will remain modest at higher feed rates at a shallower cut depth. As the depth of the cut grows, the temperature in C45 steel rises. From Fig.7b, it is clear that adding more sulphur to C45 steel enhances the material's lubricating properties, allowing the tool tip to penetrate the work piece surface more smoothly and lowering the temperature needed to detach the work piece in the form of a chip during turning operations. It can be seen from

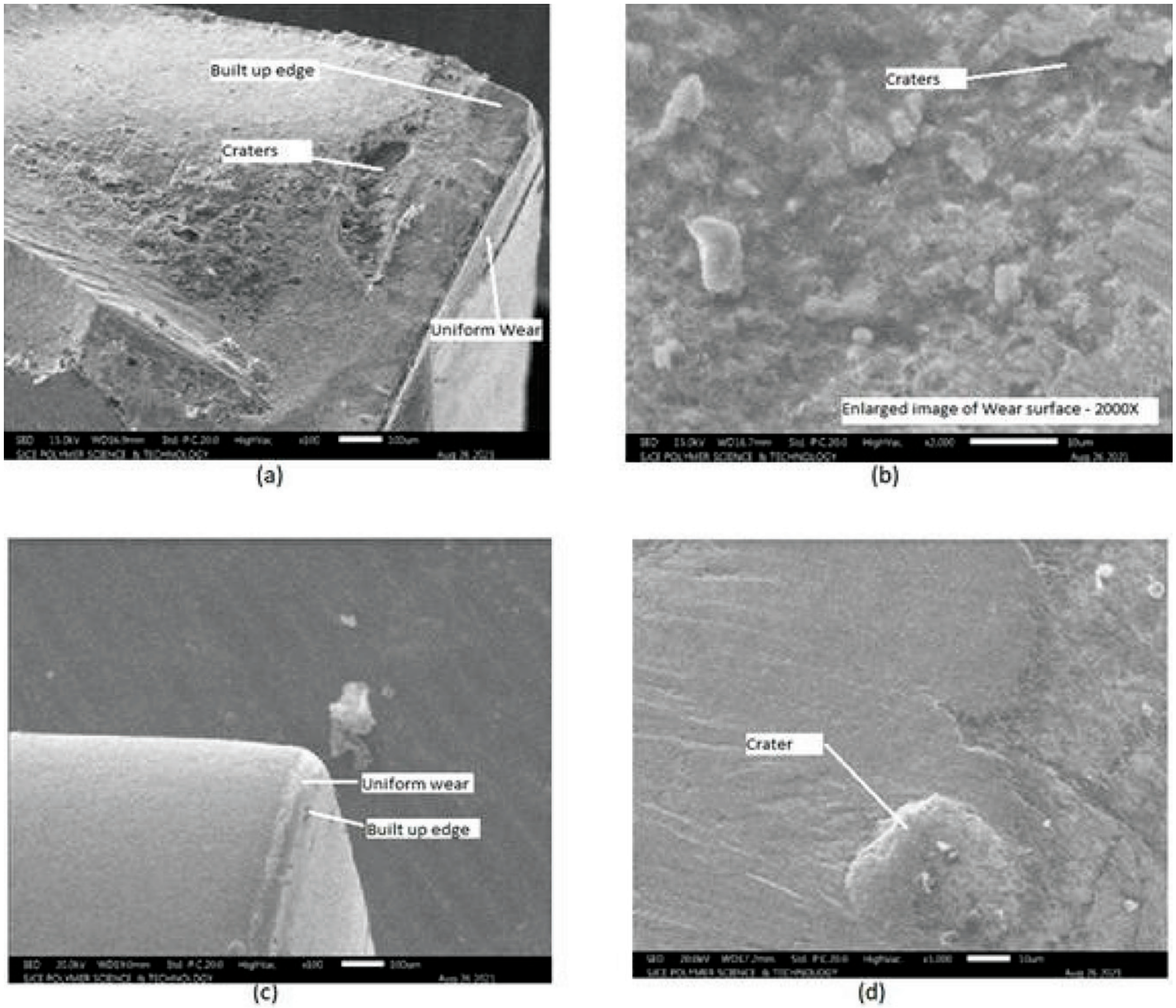


Figure 6: SEM image of tool wear surface (a): Uncoated tool insert at DOC0.5mm and cutting speed of 11.10m/min. (b): Uncoated tool insert at DOC 1mm and cutting speed of 19.47m/min. (c): Coated tool insert at DOC0.5 and cutting speed of 11.10m/min(d): Coated tool insert at DOC1mm and cutting speed of 19.47m/min

Figs.7c and 7d that adding more sulphur to C45 steel enhances the material's ability to lubricate. When turning C45 steel at a cutting speed of 11.10 m/min for different feeds with a coated tool insert. Figs.8a and b illustrate the temperature variance with the altering DOC. Figs.8c and 8d show the increment in temperature when feed rate increments. Compared to coated tool inserts uncoated tool inserts has increment in temperature.

3.4 Edx-Analysis of Tool Inserts

Fig.9 shows some iron material from w/p transferred to tool insert material. Analysis clearly shows the composition of material.

From Fig.10, it is evident that silicon, carbon and other w/p material is transported to uncoated too lsample.

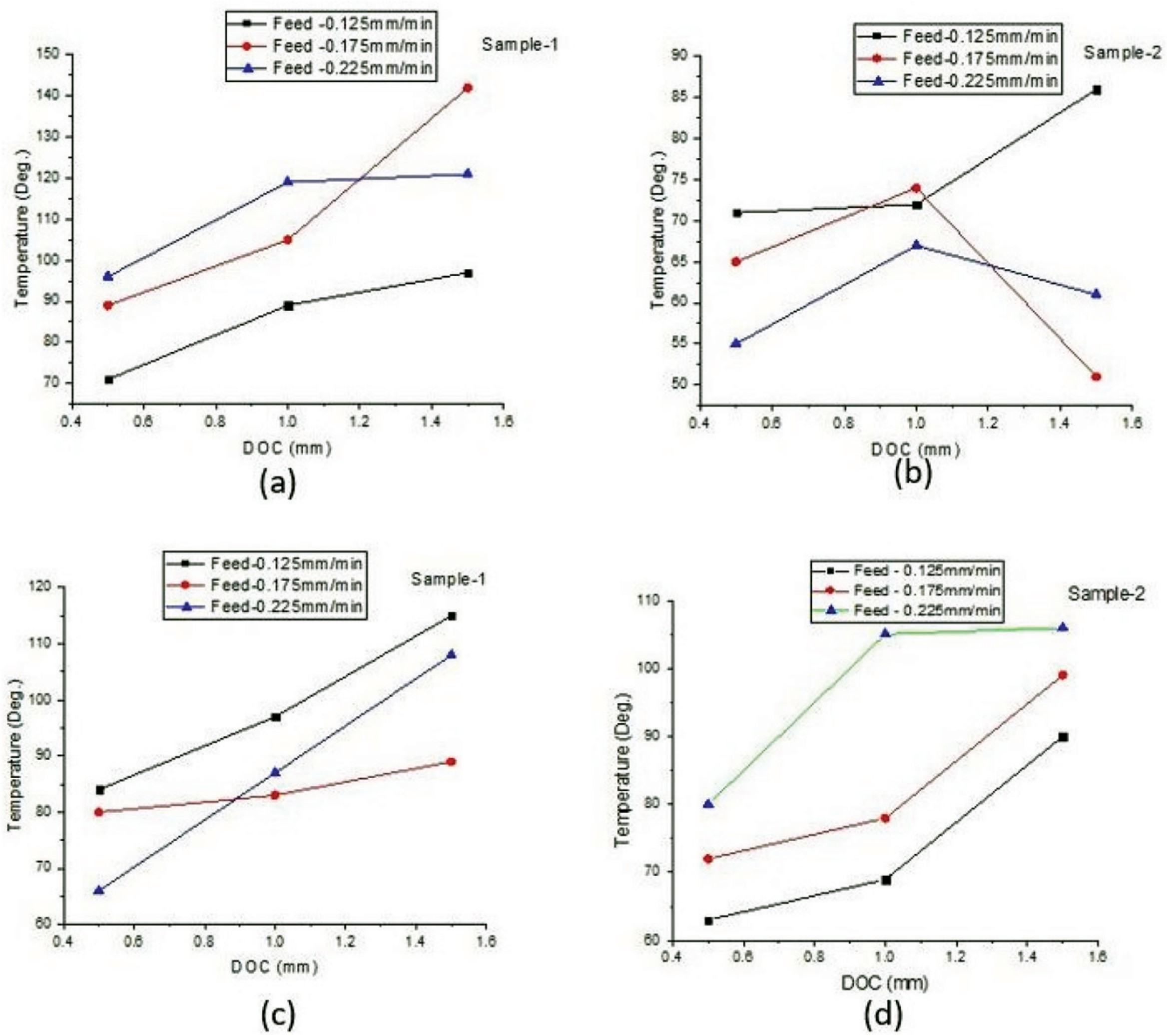
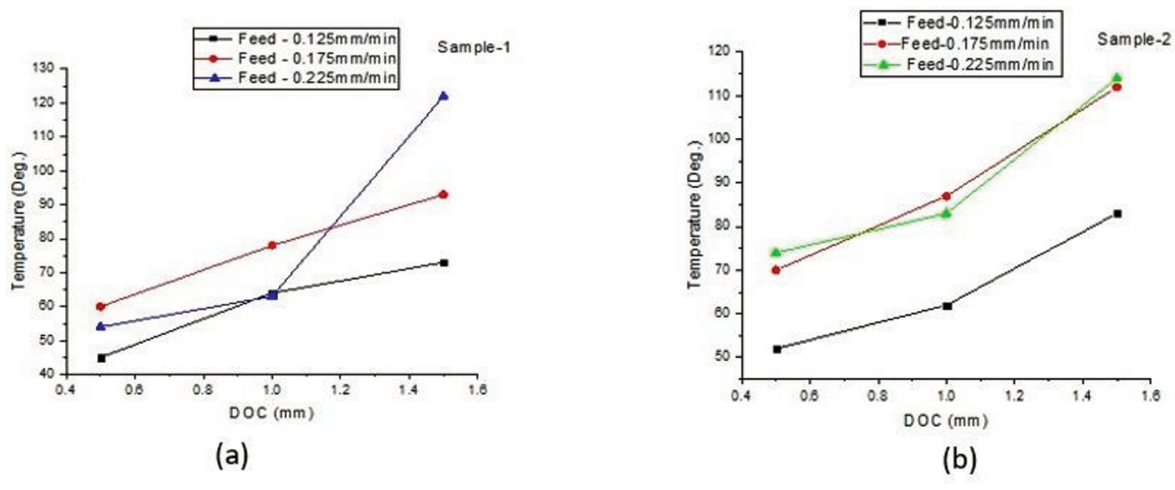


Figure 7: Titanium coated tool tip temperature: (a):Variation of temperature with DOC for speed of 11. 10m/min P 0.013 and S 0.006%, (b): Variation of temperature with DOC for speed of 11.10m/min P 0.025 and S0.017%, (c): Variation of temperature with DOC for speed of 19.47m/min P 0.013 and S 0.006%, (d): Variation of temperature with DOC for speed of 19.47m/min P0.025 and S0.017%.



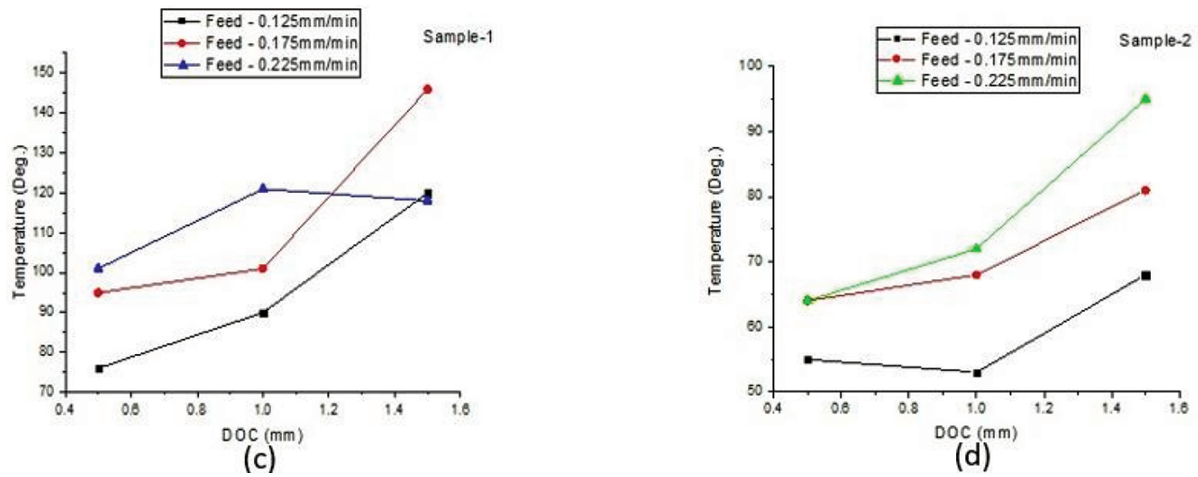
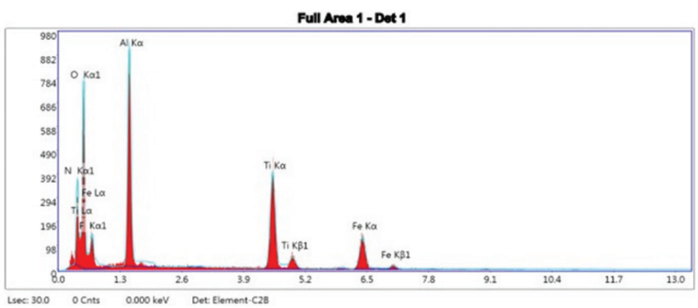


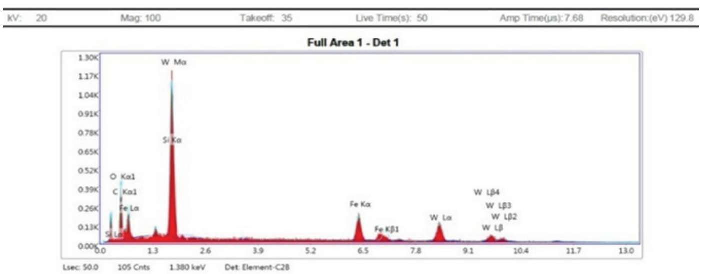
Figure 8: Uncoated Tool tip temperature: (a):Variation of temperature with DOC for speed of 11.10m/min P0.013 and S 0.006%, (b):Variation of temperature with DOC for speed of 11.10m/min P 0.025 and S 0.017%, (c):Variation of temperature with DOC for speed of 19.47m/min P 0.013 and S 0.006%, d): Variation of temperature with DOC for speed of 19.47m/minP0.025 and S0.017%.



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	Kratio
N K	9.21	14.45	57.18	10.65	0.0397
O K	37.73	51.85	182.59	10.72	0.0853
F K	5.06	5.86	20.59	36.87	0.0077
AlK	18.42	15.01	283.62	6.58	0.1062
TiK	18.12	8.32	189.54	3.67	0.1579
FeK	11.46	4.51	71.76	5.75	0.0973

Figure 9: EDXA image of titanium coated carbide tool inserts



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	Kratio
C K	13.65	38.61	22.18	12.84	0.0432
O K	19.40	41.19	55.36	11.22	0.0579
SiK	1.92	2.32	19.16	14.44	0.0152
FeK	13.82	8.41	54.54	5.95	0.1541
W L	51.21	9.46	43.54	9.67	0.3855

Figure 10: EDXA image of uncoated tungsten carbide tool insert

4.0 Conclusions

Based on the test conducted on C45 steel during turning operation with varying % of phosphorus and sulphur using carbide tool insert with titanium coating and uncoated tool insert under dry machining condition, the following conclusion was drawn:

- Microscopic images show clearly that coated tool inserts has very good machining characteristics and has very minimum crater and wear on the surface of titanium coated tool inserts. Due to their superior lubricating qualities over their equivalent, larger percentages of phosphorus and sulphur are used when machining.
- SEM image shows that the damage on the work surface of the uncoated tool inserts when machining reduced sulphur and phosphorous on tentin C45 steel and phosphorous. Whereas, tool coated with titanium has a very less surface wear and worn-out surface on the tool inserts for both sample 1 and 2. Sample 2 has a better and good surface characteristics compared to sample 1
- Temperature at the tip of the tool increase with increase in DOC and increase in speed. The temperature at the tool tip is less and linear in titanium coated tool insert compared to uncoated tool tip temperature.
- From the EDXA image is evident that the material from C45 steel is transported to tool inserts while machining due to heat and lubricating property. Transportation of the work sample is less in coated tool when compared to uncoated tool inserts.

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