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*Research Paper*

# EXPERIMENTAL INVESTIGATION OF HEAT PARTITION, TOOL WEAR AND TOOL LIFE IN HARD TURNING OF AISI-316 STEEL USING cBN CUTTING TOOL INSERT

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Metal cutting is a mature technology involving several disciplines of science. It is continuously change in line with strategies of material development throughout the Manufacturing Industries and leading race to provide better tool material and cutting geometries. Recently cutting tool inserts play an important role in hardened state of machining. The advantage of producing components in hardened state can reduce machining cost, lead time and improve surface integrity. Now a days cBN tool insert are considered to be one of the most suitable material for machining hardened steel because of their high hardness, wear resistance and chemical inertness. In this experimental investigation regarding about heat partition, tool life and develop Merchant circle and tool wear of cBN cutting tool and analyzed while turning of AISI316 steel rods.

Keywords: cBN, Tool life, Tool wear, Heat partition, Merchant circle

## INTRODUCTION

The cutting tools play a critical role when increasing the productivity of metal cutting process. Although the price of cutting tool itself is relatively low, the cost caused by tool failures is considerably high, these costs being important when expensive materials. A major part of the expense caused by tool failures original labor cost for tool replacement operations and consequent production loss during tool replacement. The work piece must be re machined (or) rejected when the tool has failed. Dimensional are usually due to sudden breakage, while errors in the surface texture may be also arise because of tool wear. Dry high-speed machining of hardened material generates the high temperature. But tool substrate has to be protected by a hard coating

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that has a combination of properties such as high hardness, good mach inability, enhanced oxidation resistance, high thermal stability, and strong adhesion and fracture toughness at elevated temperature. A widely used coating such as cBN able to retain its properties up to 900 °C. In multilayer coating, alternate layer of two (or) three different compounds are deposited in a certain sequence. The numerous interfaces creaked individual layers of Multilayer coating causes a drastic increase hardness and strength. Finished hard machining has been a beneficial practice for machining industries due to its high productivity in dry machining. In hard turning high hardness of work piece large cutting forces high temperature at tool-work piece interface impose extreme requirements for tool rigidity and tool wear résistance. The optimization of machining processes are essential for achievement of high responsive of production, which provides a preliminary basis for survival in today's dynamic market conditions, research activities in a real production environment supported by statistical experimental procedures enable continuous improvement of production process. In this present experimental investigation and prediction of tool wear behavior for multi layered/multi coating tool to cutting of Austenitic stainless steel (AISI-316) and identify to optimum surface roughness with a particular combination of cutting parameters. Widely used coating such as cBN able to retain its properties up to 900 °C has been taken these Experiments. In multilayer coating, alternate layer of two (or) three different compounds are deposited in a certain sequence. The numerous interfaces created individual layers of Multilayer coating causes a drastic increase hardness and strength.

## LITERATURE SURVEY

Recently Chou et Thiele *et al.* and Ozel *et al.* (2007) performed experiments on hard turning on various steels and identified the factors that affecting the surface roughness and wear of tool. Piska had given that while machining harden steel the increase of cutting forces, are manilas due to rake angle but an increase of tool edge radius results lesser force increase. He also found that higher rake angle causes higher chip thickness and higher shear angle and with the modification of tool edge. Nalbant *et al.* (2007) has shown that insert radius and feed rake are main parameters like depth of cut, feed rate and cutting speed by taguchi method. Nalbant also recommended that greater insert radius, lsow feed rake and low depth of cut for better surface roughness Tamilmani (2007) has shown that the depth of cut had contributed 15% in providing lower surface finish. Aslantas, Ucan and Goek (2007) also report the possibility of finish turning of steel with CNB inserts under high speeds. Ersan Aslan *et al.* (2007) has shown that the optimized machining parameters while machining A1S1 140 steel with ceramic tool and shown that cutting speed, feed rake and depth of cut inter actions have significant influence on surface roughness. Paulo Davim (2007) express a note on the determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool turning. Matsumu *et al.* (2007) shown that an adoptive prediction of machining Accuracy in turning operation. Sutter (2007) expresses a note on Chip geometries during High speed machining for Orthogonal cutting conditions Devillez *et al.* (2008) has shown that Cutting tool wear creator wear measurement with White light interferometer Wear Abukhshim *et al.* (2008) given a noate on Tool chip phenomena for uncoated carbides in high speed turning of high strength alloy steel. Noodin *et al.* (2007) Performed in Dry turning of Tempered Marten site stainless steel using coated cerments and coated carbide Tools. Matsuma and Obikawa *et al.* (2008) performed turning operation and study the machinability of steel and give key note to determination of optimal cutting conditions for surface finish obtained in turning using design of experiments for carbide coated tool. Sukker (2008) gives analyzing the chip formation and chip geometrics' during high speed machining for orthogonal cutting conditions. Derillez, Lesko *et al.* (2008) study the cutting tool wear crater wear mechanism and measurement with white light interferometer wear. Abukshshim and Matinvenga *et al.* (2008) explains the tool chip contact phenomena for uncoated carbides in high speed turning of high strength alloy. Noordinmy, Venkatesh V C and Sheriff *et al.* (2008) the performance behavior of dry turning of temperature controlled and Martens tic stainless steel using coated cermets and coated carbide tools. He did an experimental investigation on effect of minimum quantity lubrication in machining AISI 1040 steel and Chang, Chih-Wei and Kuo, Chun-Pao have attempted to evaluate surface roughness in laser-assisted machining of aluminum oxide ceramics with Taguchi method. It is to be noted that all the above investigators have reported their results for single tool surface finish operation only. they have dealt with Performance of coated tools during hard turning under minimum fluid application. Further Sharma and Dixit have compared the dry and air-cooled turning of grey cast iron with mixed oxide ceramic tool. Goakkaya, Hasan and Nalbant, Muammer have studied. The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel. All India machine tool design and research conference give a note for factors influencing surface finish during fine turning. Yigit Karat *et al.* (2008) explains the investigation of the effect of cutting tool micro-geometry effects. Mustafa Gunay *et al.* (2008) give a note on experimental investigation of effect of cutting tool rake angle on main cutting force. However all the researchers did not to find tool life, heat partition and Merchand circle for cBN cutting tool insert.

## PROBLEM IDENTIFICATION

The identification of turning problem for AISI 316 Austenitic stainless Steel rods which cannot be tackled using conventional technique because of following problems occurs in turning process.

- Difficult to machine Austenitic stainless steel (AISI-316) in conventional solid tool.
- Difficult to produce good surface finish in conventional solid tool.
- Difficult to reduce tool wear using conventional solid tool.
- Difficult to draw merchant circle for Tool insert
- Difficult to calculate tool life of cBN tool insert
- Difficult to calculate the Heat developed in turning process.

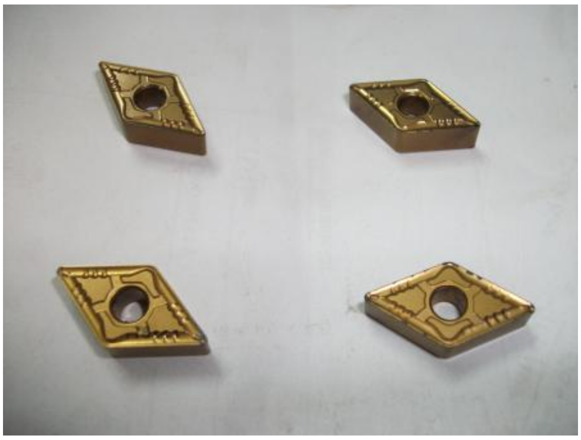
The above problems are have to overcome during turning investigation and achieve minimum tool wear and analyze the thermodynamic process.

## EXPERIMENTAL DETAILS

The Experiments are conducted in Schabulin 120 type CNC Lathe (Figure 1) while turning of Austenitic Stainless rods (100 mm length and 20 mm diameters) using cBN coated carbide tool Insert (Figure 2). Totally 9 Experiments are conducted in different cutting tool parameters and Analyzed by mathematical modeling.

Figure 1: Schabulin 120 CNC Lathe


Figure 2: cBN Coated Tool Inserts



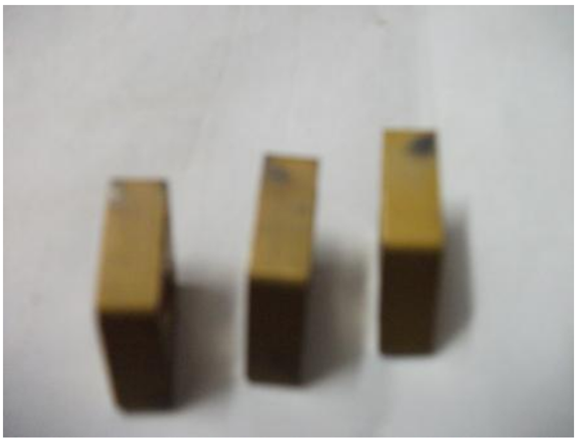
## RESULTS AND DISCUSSION

### Tool Wear of cBN Tool Insert

In this experimental work, Design of experiments are used to determine the minimum tool wear while turning of AISI 316 Austenitic stainless steel by CBN tool under dry environment. it concludes,

- Tool wear rate is minimum at cutting speed 2500 RPM, feed rate 0.025 mm/rev and depth of cut 0.3 mm using CBN Tool.
- The CBN tool insert has been damaged to edge chipping after 300 seconds of machining at a moderate cutting velocity in dry condition and low surface roughness is seen (Figure 3).
- cBN cutting tool tested and seem to have fairly good Machinability to turn AISI 316 Austenitic stainless steels at some machining conditions. Cutting force components are observed to be low compared to that with the CBN cutting tool tested in this work surface finish is obtained is good in all the cases at the highest surface finish obtained The CBN tool inserts and some amount of tool edge chipping and

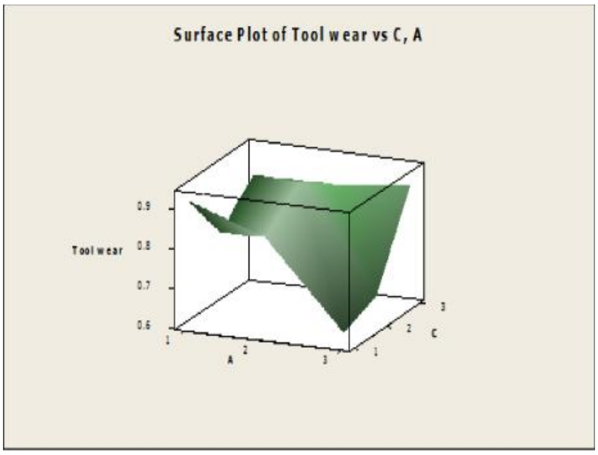
Figure 3: Tool Wear (cBN Tool Insert)



wearing are viewed in both cases (cutting speed and depth of cut) however the tool inserts still show its capability to machine Austenitic stainless steel.

The Figure 4 shows the minimum tool wear occur that 2500 RPM of spindle speed and 0.3 mm of depth of cut in turning of AISI 316 steel rods using cBN tool insert.

Figure 4: Surface Plot for Tool Wear of cBN Tool Insert




## Tool Life for cBN Tool Insert

The time at which cutting edge of cBN tool insert can be usefully employed without regrinding or replacement known as Tool life.It is not economical to continue to use tool insert beyond the useful life. It is expressed as following.

Taylor's tool life equation = $V{\cdot}T^{n}{\cdot}f^{n1}{\cdot}d^{n2} = C$

$V$ = Cutting speed, $T$ = Tool life, $f$ = Feed rate, $d$ = Depth of cut, $n1 = 0.43$, $n2 = 0.1$

Figure 5: Histogram of Tool Wear of cBN Tool Insert

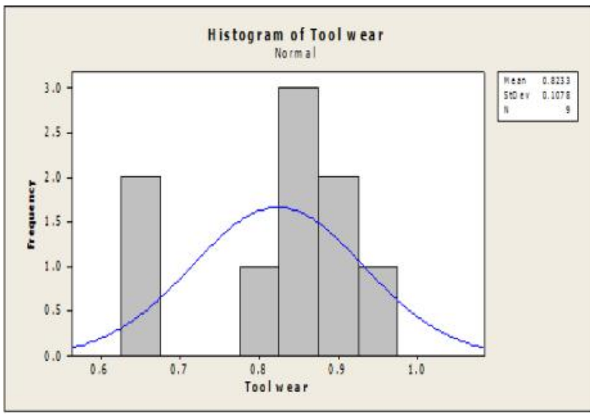
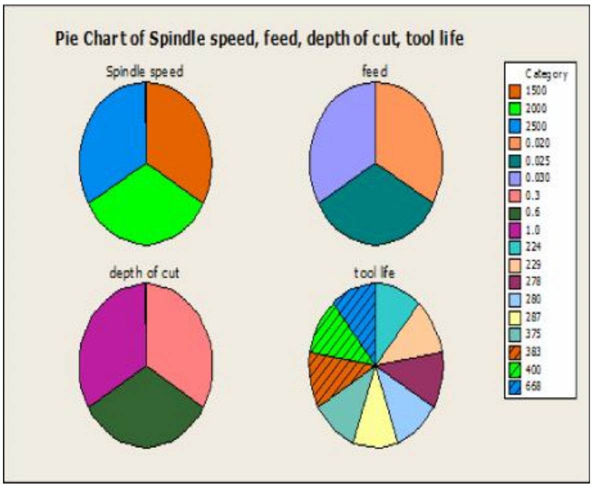



Table 1 shows that tool life is maximum at 2000 Rpm of spindle speed,0.03 mm/rev and 0.6 mm depth of cut in using cBN tool insert in turning of AISI 316 steel rods (Figure 6).

Table 1: Tool Life for cBN Tool Insert

| Test No. | Spindle Speed (RPM) | Feed Rate (mm/rev) | Depth of Cut (mm) | Tool Life (Min) |
|---|---|---|---|---|
| 1. | 1500 | 0.03 | 0.3 | 375 |
| 2. | 1500 | 0.025 | 0.6 | 280 |
| 3. | 1500 | 0.02 | 1 | 224 |
| 4. | 2000 | 0.03 | 0.6 | 668 |
| 5. | 2000 | 0.025 | 1 | 278 |
| 6. | 2000 | 0.02 | 0.3 | 400 |
| 7. | 2500 | 0.03 | 1 | 383 |
| 8. | 2500 | 0.025 | 0.3 | 287 |
| 9. | 2500 | 0.02 | 0.6 | 229 |

Figure 6: Pie Chart for Tool Life of cBN Tool Insert



### Merchant's Circle for cBN Tool Insert

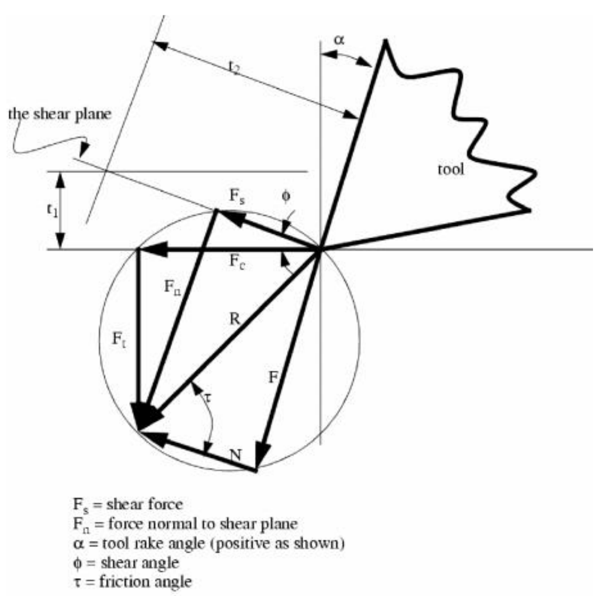
Figure 7 shows the merchant circle of cBN cutting tool insert which is used to determine the relation between the various forces and angles while turning of AISI316 steel rods.

- Shear angle (*A*) = 36
- Friction angle (*B*) = 10
- Rake angle (*c*) = 18
- Resultant forces (*F*) = 1160 N
- Feed force (*Fx*) = 150 N
- Cutting force (*Fz*) = 1150 N
- Normal force (*Fn*) = 900 N
- Chip thickness ratio (*r*) = 0.599
- Cutting ratio (*c*) = 0.3

### Heat Developed in cBN Tool Insert

Cutting temperature is an important factor that machining parameter as it strongly influence the cutting forces,Tool life and workpiece surface integrity. Higher cutting temperature decreases the yield strength of workpiece material. However increased workpiece surface temperature causes problem like white layer formation and tool wear. Most importantly the tool life is affected by increasing cutting temperatures. The heat developed in cBN cutting tool insert is calculated as follows.

Figure 7: Merchant Circle of cBN Tool Insert




$Q = Fc \times V$

$Q$ = Heat developed in joules, $Fc$ = Cutting force in Newton, $V$ = Cutting velocity in m/min

Hence cBN tool insert is suitable for turning AISI 316 steel which provide better tool life and produce optimum cutting forces and angles. Then developed heat in hard turning and stabilize and give better performance and produce minimum tool wear (Table 2).

Table 2: Heat Developed by cBN While Turning of AISI316

| Spindle Speed (Rpm) | Cutting Speed (m/min) | Heat Developed (joules) |
|---|---|---|
| 1500 | 3.92 | 75.13 |
| 2000 | 5.23 | 100 |
| 2500 | 6.54 | 125 |

## CONCLUSION

After conducting experiments on Austenitic stainless steel rods using cBN cutting tool insert in different cutting tool parameters, Indicates cBN cutting tool insert has been damaged in moderate cutting velocities and produce fairly good machinability. Merchant circle has been drawn as per tool geometries and found that shear, friction and rake angle of cBN insert. It also mentioned higher cutting temperature decreases the yield strength of produce white layer formation. However cBN cutting tool insert was suitable for turning of

Austenite stainless steel (AISI316) and produce better performance.

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