JMEMME, 2 (1) June 2018 p-ISSN: 2549-6220e-ISSN: 2549-6239

JOURNAL OF MECHANICAL ENGINEERING, MANUFACTURES, MATERIALS AND ENERGY

Available online http://ojs.uma.ac.id/index.php/jmemme

Study on the CBN Tool Wear Mechanism on Dry High Speed Turning for AISI 4140

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Abstrak

Penelitian ini bertujuan untuk menyelidiki aus pahat dan mekanisme aus pahat ketika pemesinan laju tinggi pembubutan ekstrem minimal bahan AISI 4140 pada kondisi potong keras dan kering. Pahat pemotong terbuat dari CBN CB7015 produksi Sandvik Coromant digunakan untuk pembubutan (turning) baja AISI 4140 dengan tujuan untuk mendapatkan mode kegagalan pahat dan mekanisme keausan dari pahat pemotong tersebut. Proses pemesinan dilakukan pada kondisi pemotongan kering dengan variasi kecepatan laju (cutting speeds / Vc) tinggi , kecepatan suapan (feed rate /.f) dan kedalaman pemotongan (depth of cut / a) pada kondisi laju minimum. Kurva pertumbuhan aus yang diperoleh menunjukkan bahwa pahat CBN mengalami tiga fase yaitu fase awal (initial phase), fase bertahap (gradual phase) dan fase mendadak (abrupt phase). Dari hasil penelitian, diperoleh bahwa mode-mode kegagalan yang terjadi adalah aus sisi (flank wear), aus kawah (crater wear), pengelupasan(flaking), penyerpihan (chipping),dan patahan (fracturing catastrophic failure). Mekanisme aus yang terjadi secara garis besarnya diakibatkan oleh proses pengikisan (abrasive) , proses adhesi (adhesive), dan proses difusi (diffusion). Sedangkan retakan dan patahan yang terjadi diakibatkan oleh kombinasi dari beban kejut impak (impact load) dan beban kejut termal (thermal shock).

Kata Kunci: AISI 4140, Aus Pahat, CBN, Kondisi Pemotongan Keras dan Kering, Laju Kecepatan Tinggi, Mekanisme Keausan

Abstract

This study aims to investigate tools wear and wear mechanisms when machining high-rate extreme minimum lathe AISI 4140 material in hard and dry cutting conditions. Cutting tool made from CBN CB7015 Sandvik Coromant production is used for turning of AISI 4140 steel in order to obtain the failure mode of tool and the wear mechanism of the cutting tool. The machining process is carried out under dry cutting conditions with variations of high velocity Vc, feeding rate f, and a cutting depth a at minimum rate conditions. The wear growth curve obtained shows that the CBN tool undergoes three phases: the initial phase, the gradual phase, and the abrupt phase. From the results of the study found that the failure modes that occur are flank wear, crater wear, flaking, chipping, and fracturing catastrophic failure. The wear mechanism that occurs in outline is caused by abrasive, adhesive, and diffusion processes. While the cracks and fractures that occur due to a combination of impact load and thermal shock

Keywords*: Tool wear, tool wear mechanism, CBN, turning, AISI 4140, high speed rate, hard and dry cutting conditions*

How to Cite: *Umroh, B. (2018), Study on the CBN Tool Wear Mechanism on Dry High-Rate Turning Process for AISI 4140, JMEMME (Journal Of Mechanical Engineering, Manufactures, Materials And Energy), 2 (1): 20-26*

INTRODUCTION

Dry, hard, and high-speed machining are the three current issues on metal cutting technology. These three technological concepts contribute significantly to the manufacturing industry engaged in the metal cutting industry sector. The main focus of the implementation of these three concepts is high productivity and environmental-friendly metal cutting (Ginting, 2003).

Dry machining is a metal cutting process that is done in the absence of cooling media and lubricating medium. The specialty of dry machining is the cheaper production cost of 16-20% because it does not use cutting fluids, and has an effect on saving the environment due to the absence of used cutting fluid discharged into the environment. In dry machining the cutting fluid is used only in a very minimum quantity (50ml / hour) or when it may not be used at all. Therefore the concept of dry machining from an ecological point of view is called a green machining (Bagio, 1995).

Implementation of the three technological concepts in the process of cutting the metal to produce a particular product faces several problems. The main problem is that no cutting fluid is used which results in higher cutting and friction temperatures than when cutting liquids are still used. High temperatures and friction during the cutting process will have a bad effect on the cutting tool. The relatively high cutting potential at moderate cutting machining will increase again when machining proceeds at a high rate of cutting (Che Haron, Ginting, & Goh, 2001).

In the process of forming the fury takes place, allowing the chisel to wear wear and this is a failure of the normal tool function. There are two types of wear that generally occur on the chisel, namely: Flank Wear and Crater Wear (Neil, 2003). Flank wear is a wear and tear that occurs in the main / major areas of the tool. Flank wear is caused by the abrasive process from the cutting edge of the engine surface. Flank wear can be determined by measuring the length of VB (mm), ie the distance between the cutting edge before the wear occurs at the average line of ex-wear on the main plane. Crater wear is wear and tear that occurs in the field of sculpting. Crater wear can increase the working angle of the rake and reduce the cutting force, but will also weaken the cutting edge strength. Crater wear can be measured by surface roughness gauge (A.S & S.A, 1997).

Based on some previous research, there are three types of chisels that are generally used in the application of the above three concepts. The three types of chisels are chisels of ceramics, carbides, and CBN (Bouchelaghem, Yallese, Amirat, & Belhadi, 2007). Based on these three types of materials for chisels suitable for hard machining criteria more recommended to CBN. CBN is the hardest material other than diamond and is suitable for hard machining.

Therefore, in this study will be a study of wear and wear mechanism CBN chisel which will be applied for high-speed, hard, and dry machining for steel alloy material AISI 4140 which is widely used in the industry of making the means of transportation and defense.

METHODOLOGY

The research was conducted in several places, namely: (1) CNC-CAD / CAM Laboratory of USU Polytechnic Engineering

Department in Medan-North Sumatera, (2) Metallurgy Laboratory, Faculty of Engineering, University of Indonesia.

The specimens used are AISI 4140 materials recommended as Landing Gears on aircraft typically made of tool steel with hardness ranging from 54 s / d to 62 HRC. Material cutting tool used in the form of chisel CBNC CB7015 SANDVIK Coromant production (Figure 1). This chisel is recommended for cutting steel with high hardness.

The research tools consist of: Emco MaximatV13 Toolkit, Portable Hardness Tester, Portable Taylor Hobson Surtronic 3+ Portable Portable, USB Digital Microscope, and Scanning Electron Microscopy.

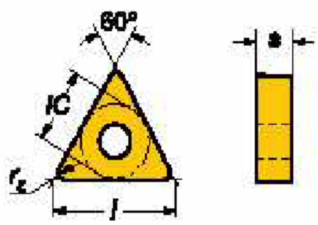


Figure 1. CBN Sculpting Geometric Description: r = 0.8 mm; iC = 12.7 mm; S = 3.18 mm; l = 16 mm

The data collection process was conducted using factorial method with two measurements. Factorial method is one method that is widely used in engineering research. With this method the data obtained is the result of the investigation of the combination of various factors involved. Since there is only one type of chisel (CB7015) analyzed in this study, the same data repetition is eliminated, and data at speeds below 200 m / min, it will be obtained as shown in Table 1.

Tabel 1. Results of cutting conditions

Run	V	f	a	rε	ra	Tipe Pahat	VB	Tc
1	200	0.1	0.3	0.8	91°	CB7015	0.30	9.70
2	200	0.1	0.7	0.8	91°	CB7015	0.14	5.79
3	200	0.15	0.3	0.8	91°	CB7015	0.16	8.16
4	225	0.1	0.7	0.8	91°	CB7015	0.14	8.39
5	225	0.125	0.7	0.8	91°	CB7015	0.30	6.64
6	225	0.125	1.1	0.8	91°	CB7015	0.20	7.35
7	225	0.16	0,7	0.8	91°	CB7015	0.20	6,98
8	250	0.1	0,3	0.8	91°	CB7015	0.30	9,60
9	250	0.1	1	0.8	91°	CB7015	0.21	5.82
10	250	0.15	0,3	0.8	91°	CB7015	0.10	1,87
11	267	0.125	0,7	0.8	91°	CB7015	0.15	1,92

RESULT AND DISCUSSION

From observation and analysis it is shown that wear of chisel at maximum rate conditions occurs at cutting speed V = 225 m / min (f = 0.16 mm / rev, a = 0.7 mm), cutting speed V = 250 m / min (f = 0.1 mm / rev, a = 0.3 mm) and cutting speed V = 250 m / min (f = 0.15 mm / rev, a = 0.3 mm), and at cutting speed V = 267m / min (f = 0.125 mm / rev, a = 0.7 mm). Research is limited to the above data.

The wear rate on the cutting side is the dominant wear form occurring and measured sequentially during the machining experiment. These data were collected from CBN CB7015 chisel observations as seen on the wear growth curve in Figures 2 to 5.

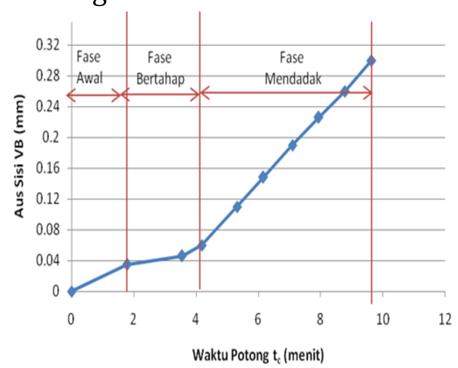


Figure 2. The curve of the relationship between side wear VB vs time cut tc at V = 200 m / min, a = 0.3mm, and f = 0.1 mm / rev.

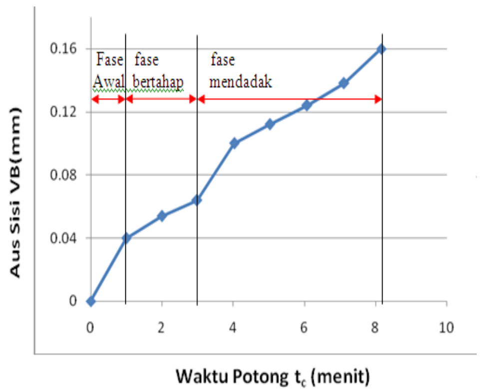


Figure 3. The curve of relationship between side wear VB vs Cut Time tc at V = 200 m / min, a = 0.3 mm, and f = 0.15 mm / rev

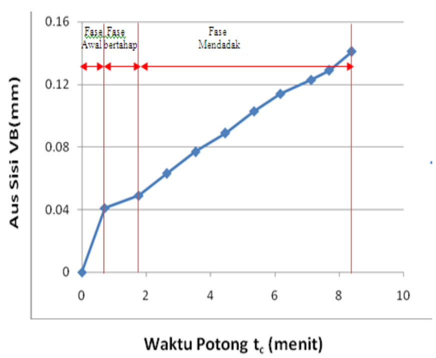


Figure 4. The curve of relationship between side wear VB vs time cut tc at V = 225 m / min, a = 0.7 mm, and f = 0.1 mm / rev

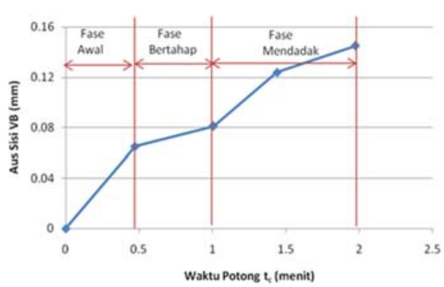


Figure 5. The curve of relationship between side wear VB vs time cut tc at V = 267 m / min, a = 0.7 mm, and f = 0.125 mm / rev

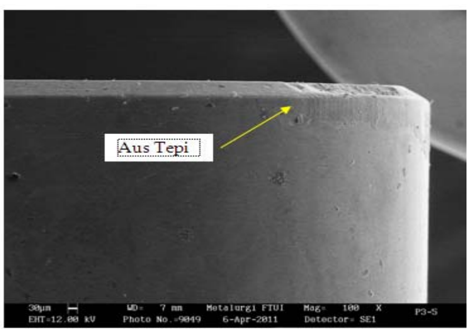
Based on the research result, the failure mode characteristic of CBN CB7015 chopper production of SANDVIK Coromant when used in dry machining process AISI 4140 materials are: wear side, crater wear, flaking, chipping, cracking, and fracturing. Based on the observation result of wear which happened at cutting condition 0,3 mm and rate of feeding 0,1 mm / rev, it is seen that CBN CB1515 tool failure mode at cutting rate V = 200 m / min is in the form of wear side (flank wear) crater wear, and flaking (Figure 6). At a feed rate of 0.15 mm / rev, it appears that CBN CB1515 failure mode at cutting rate V = 200 m / min is in the form of wear side (flank wear), fracture, and flaking (Figure 7).

Based on the observation result, wear which happened at 0.7 mm cutting and 0.16 mm / rev feed rate, it is seen that CBNC CB1515 failure mode at cutting speed V = 225 m / min is in the form of wear side (flank wear) , crater wear, and flaking (Figure 8). The chisel failure mode under V = 200 mm / min (f = 0.1 mm / rev, a = 0.3 mm) is side wear. Side wear occurs due to the presence of hard particles in the workpiece scraping together with the flow of workpiece material in the field of growl and the main area of the chisel. In addition, the abrasive wear process that occurs at this speed is also due to the presence of adhesion forces. The adhesion force results in chipping, which is a buildup of new material layers attached to the vicinity of the main plane and the field of growl.

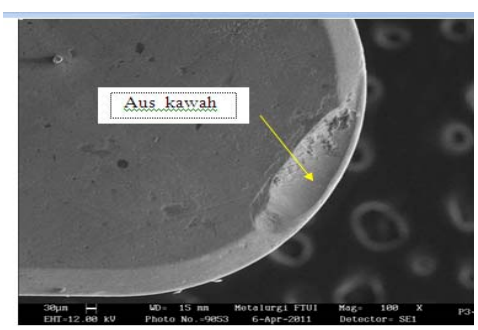
At the rate of cutting rate V = 200 m / min (f = 0.15 mm / rev, a = 0.3, chisel 2 number 4) from SEM photo observation seen friction between the flow of the workpiece material in the field of growling and the main area of the chisel causing large loads received so large that there is fracture with flacking. This condition occurs due to the inconsistent load received by the chisel.

At cutting speed v = 225 m / min (f = 0.1 mm / rev, a = 0.7 mm, chisel 1, number 5) it is seen that the wear occurs at the cutting edge of the nose field although not very visible (Figure 8). The adhesion force in this condition leads to chipping, which is the occurrence of a buildup of newly formed material layers and attached around the main plane and the field of infuriation.

Based on the observation of CBN CB1515 chisel on the cutting speed V = 225 m / min (f = 0.16 mm / rev, a = 0.7 mm, chisel 2 number 1) it was found that at this cutting condition the amount of edge wear formed almost equal to cutting CBN chisel on this condition is characterized by the surface of the main area of the carving more roughly. Side wear on CBN is also caused by friction between material flow of workpiece in field of fist and main area of chisel (Figure 9).



(a)



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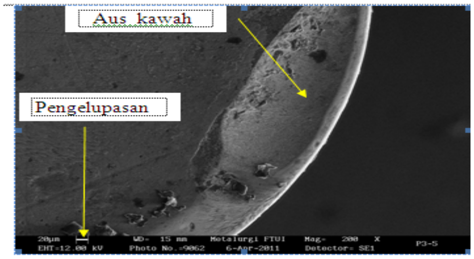
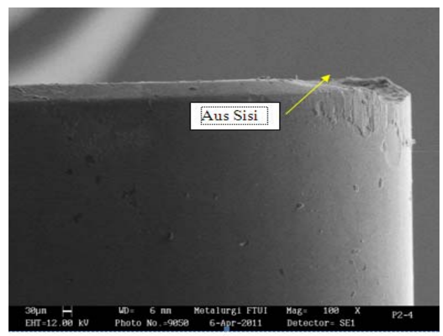


(c)

Figure 6. Display chisel at V = 200 m / min (f = 0.1mm / rev; a = 0.3mm)
(a) Front view
(b) The upper view
(c) the upper view



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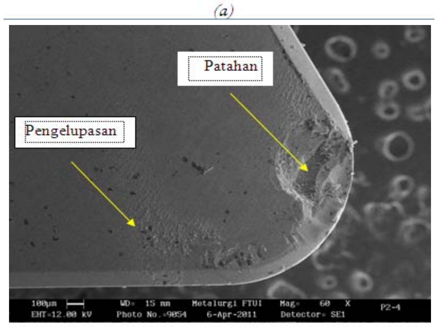

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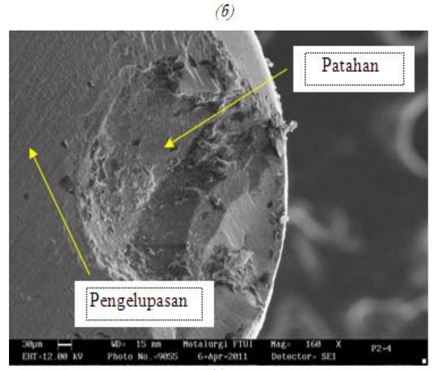

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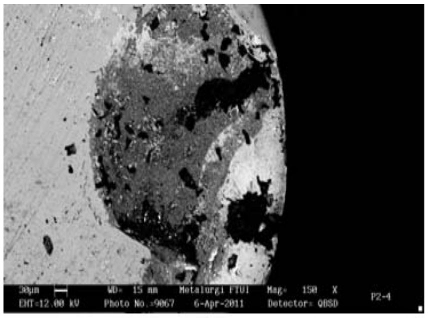
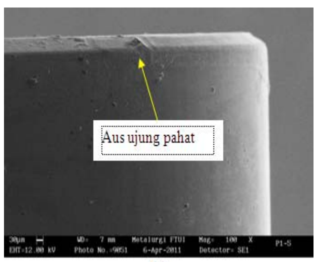


(d)

Figure 7. Chisel Display At V = 200 m / min (f = 0.15mm / rev; a = 0.3mm)
(a) Sculptural View From Front View
(b) Chisel Display From Top View
(c) Chisel Display From Top View
(d) EDS View From Top View



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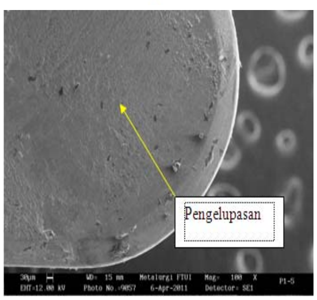

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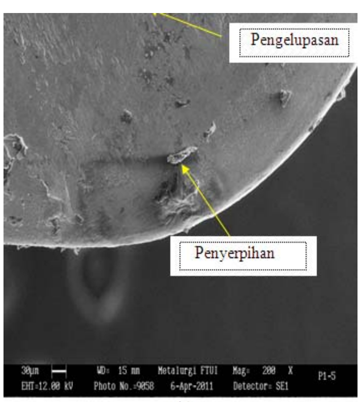
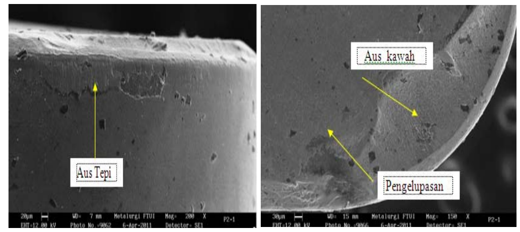


(c)

Figure 8. The chisel display at V = 225 m / min (f = 0.1mm / rev; a = 0.7mm)
(a) Chisel view from the front view
(b) Chisel view of the top view
(c) Chisel view of the upper view



(a) (b)

Figure 9. The chisel view at V = 225 m / min (f = 0.16 mm / rev; a = 0.7mm)
(a) The chisel view from the front view
(b) The view is enlarged from the front

CONCLUSION

During the process of formation of fury takes place, chisel CBN experienced wear and failure of its normal function. Based on the data collected from CBN CB7015 chisel observation result, it was found that the growth of wear on CBN chisel was experienced in initial phase, gradual phase, and abrupt phase. n addition to side wear on CBN chisel during the experiment also found other chisel failure modes as follows: (1) at cutting speed V = 200 m / min (f = 0.1 mm / rev; a = 0.3 mm) occur flank wear, crater wear, and flaking, (2) at cutting speed V = 200 m / min (f = 0.15 mm / rev; a = 0.3 mm) flank wear, fracture, and flaking, (3) at cutting speed V = 225 m / min (f = 0.1 mm / rev; a = 0.7 mm) flank wear, chipping, and flacking, and (4) at cutting speed V = 225 m / min (f = 0.16 mm / rev; a = 0.7 mm) occur flank wear, crater wear, and flacking.

The wear mechanisms occurring in the four conditions of variation in the above cutting rates are due to: (1) the wear mechanism occurring at the cutting speed

V = 200 m / min (f = 0.1 mm / rev = a = 0.3 mm) is the result the abrasive process, (2) the wear mechanism occurring at the cutting speed V = 200 m / min (f = 0.15 mm / rev = a = 0.3 mm) is due to the adhesion and abrasive processes, (3) the wear mechanism at the cutting speed V = 225 m / min (f = 0.1 mm / rev; a = 0.7 mm) is due to the abrasive process, and (4) the wear mechanism occurring at the cutting speed V = 225 m / min (f = 0.16 mm / rev; a = 0.7 mm) is the result of abrasive and diffusion processes.

ACKNOWLEDGMENTS

High appreciation to Prof. Dr. Ir. Armansyah Ginting, M. Eng who has provided support and facilities so that this research can be completed properly.

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