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Research paper

Dry machining technology to the capability of tin coated carbide tool performance on alloy steel TEW 6582 the lathe process

Suhardi Napid [1] *, Abdul Haris Nasution [1], Muksin R. Harahap [1], Abdurrozzaq Hasibuan [2], Istu Sri Poneni [1]

[1] Department of Mechanical Engineering, Universitas Islam Sumatera Utara, Medan, Indonesia
[2] Department of Industrial Engineering, Universitas Islam Sumatera Utara, Medan, Indonesia
**Corresponding author E-mail: suhardi.napid@uisu.ac.id*

Abstract

The objective of research is to study the capability of TEW 6582 steel material with dry machining technology. The re-search determine cutting conditions for the purpose of studying the results of tool ability after the completion of the ma-chining process on the growth of tool wear, tool wear rate, cutting temperature, tool life. The experimental on wet and dry machining each have 27 specimens that is 9 different cutting conditions by three variations of VB tool wear using optical microscope. To study on the growth of tool wear is used by SEM. The data from the experiment were processed and ana-lysed by the standard Taguchi method L9 (34). The growth of TIN carbide tool wear is influenced by cutting speed, cutting depth, feeding, cutting temperature and tool geometry. Optimum cutting conditions with dry machining at 200 m/min cut-ting speed, 0.1 mm cutting depth, 0.15 mm/rev feeding and 6o cutting angle which gives the tool life T = 2456 sec. While cutting conditions on wet machining obtained the tool life T = 2591 seconds. Differentiation of tool life in dry machining and wet machining is not significant. Thus dry machining is a good choice that can be realized in the metal cutting indus-try.

Keywords: *Dry Machining; TIN Carbide Tool; Alloy Steel of TEW 6582; Tool Life; Cutting Condition*

1. Introduction

In the metal cutting industry until now it still tends to use cutting fluid[1]–[3]. The cutting fluid in the machining operation helps remove the heat generated during the cutting; to achieve better tool life and surface smoothness and facilitate flushing of chips[4]. In metal cutting and metal-forming industries it states (16-20)% of production costs and has some negative impacts [5]–[10] on health and environmental issues[3]. As much as 16% of this if converted to the total production cost of the manufacturing industry in the United States is worth 48 billion Dollars and in Germany reached one billion Mark Germany and in Japan reached 71 billion Japanese Yen [11]. Based on this value it is suggested that the cutting fluid be reduced if possible is eliminated so that the cost of production can be reduced and ultimately the selling value of the product is reduced. Although the above suggestions seem to promise a step towards improving the cost of production, but the advice is not a primary goal, but because of environmental issues. A total of 650,000 tons per year of used cutting fluids has been produced by the Automotive Industry in Germany[12]. Usually to dispose of this discharging fluid, the cutting fluid is packaged in containers and dumped in the soil. Of this amount, it can imagine how much amount of used cutting fluid should be thrown into this nature. Ramachandran, 2017[13] state the application of cutting fluids besides to creating environmental problems but also causing health problems in humans that is the form of skin cancer and evaporation of cutting fluid in the cutting zone, which is harmful to the human respiratory system. Responding to the above exposure, machining experts in asking for a way out. Haroen, 2001 [14] suggest that dry machining tends to be better than wet machining if the tool steel tooling is done using a coated carbide tool. The tendency for dry machining has been emphasized by economic and environmental conditions. PVD TiAlN has a wear resistance that can provide advantages in dry machining for cast iron and alloy steel. Thus, it becomes a challenge for producers and researchers to implement dry machinery strategies [15]. So it is time for dry machining to be realized in the metal cutting industry replacing the wet machining method. The benefits of dry machining eliminate the need for the disposal and purchase of coolant fluids and also improve the safety and health of workers. Green machining will also provide a cleaner environment of work pieces such as the absence of oil attached to the work piece. The incidence of Built Up-Edge (BUE) can provide rough surface packaging to obtain the low surface finish machined.

Dry machining without the use of cutting fluids results in high cutting temperatures. This high temperature can produce undesirable conditions in the structure of the work piece, tool wear and build-up-edge[16]. To solve the problem during dry machining. Dry machining is done at high speeds with special coated carbide tool inserts that have high stiffness properties, resistant to high temperatures to help avoid fast tool wear[17]. To solve the problem of machining without cutting fluid, it can be done using a tool type designed to work at high cutting temperatures such as PVD or CVD coated carbide.

Realizing dry machining of metal cutting industry and conducting a study of machine ability TEW 6582 alloy steel in determining the cutting condition.

2. Material and methods

There are few material are being used in this research paper, table 1 until table 3 are the material composition and also figure 1 and 2 are the equipment process.

Table.1: Chemical Composition and Mechanical Properties of Carbide Tool Many Layers

CO (%)	Composite Carbide	Hardness (HV)	Toughness(Mpa)	Layer Specification
11	12	1420	6,9	TiN+Ti(C,N)+Al_2O_3

Table.2: Chemical Composition of Workpiece Materials (%)

C	Si	Mn	P	S	Cr	Mo	Ni
0,30-0,38	0,15-0,40	0,40-0,70	≤ 0,035	≤ 0,035	1,40-1,70	0,15-0,30	1,40-1,70

Table.3: Mechanical Properties of Workpiece

Yield Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%)	Reduction (%)	Impact Strength (Joule)	Hardness HV
785	980-1180	11	50	48	300-360

Fig.1: CNC Lathe.

Fig.2: Optical Microscope and Thermocouple Temperature Control

Table.4: Experimental Plan for Variation VB = 0,1 Mm; 0,3 Mm Dan VB = 0,6 Mm with Wet Machining and Dry Mchining

Sums Experiment	FACTORS			
	V m/min	A mm	F mm/r	Gp (°)
HPB1;HPK1	200	1.0	0.15	6
HPB2;HPK2	200	1.5	0.20	12
HPB3;HPK3	200	2.0	0.25	18
HPB4;HPK4	250	1.0	0.20	18
HPB5;HPK5	250	1.5	0.25	6
HPB6;HPK6	250	2.0	0.15	12
HPB7;HPK7	300	1.0	0.25	12
HPB8;HPK8	300	1.5	0.15	18
HPB9;HPK9	300	2.0	0.20	6

This research was conducted by experimental method using CNC lathe. Variable of cutting conditions are cutting speed, cutting depth, feeding and tool geometry. Factors and levels are determined by the Taguchi method for tool wear of VB 0.1 mm, 0.3 mm and 0.6 mm. The Taguchi method uses the orthogonal standard array L9 (34). The lathe machining process produces nine different cutting forms (table 4) each for dry machining and wet machining. Three forms of cutting that meet the criteria of dry and wet machining, selected an optimum cutting condition. Data collection by measuring the wear of tool, cutting tool rate, tool life and mechanism of tool wear. The data were analyzed based on the figure tool wear for each cutting condition and compared it with the edge wear graph (VB) as the Cutting Time function. The data collected, processed and then analyzed using Taguchi method. The experimental design was carried out with the standard L9 (34) orthogonal array. Standard L9 (34) orthogonal array has nine lines, three levels and four factors[18]. Characteristics of the S/N ratio can be divided into three categories[19]:

1) Nominal best characteristics

$$S/N = 10\log \frac{\bar{y}}{s^2_y}$$

2) The smaller the better

$$S/N = -10\log \frac{1}{n}\left(\sum y^2\right)$$

3) The larger the better

$$S/N = -10\log \frac{1}{n}\left(\sum \frac{1}{y^2}\right)$$

$\bar{y}$ = Average data observed

s^2_y = Variance y, y = observed data

n = Number of observations

3. Results and discussion

Based on material and method in previous section, the result are as in figure 3 until figure 7.

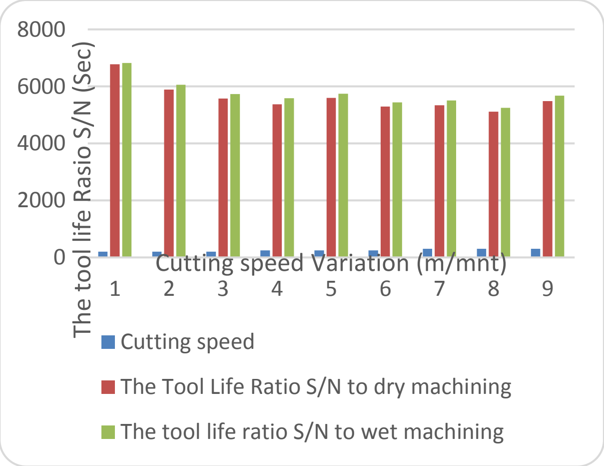

Fig. 3: S/N Ratio Tool Life as Function of Cutting Seed.

Figure. 3 is a conversion of the value of tool life using L_9 (3^4) orthogonal array Taguchi method through the S/N ratio equation which is the result value of dry machining (HPK) and the result value of wet machining (HPB) is not significant on the curve.

The correlation of cutting speed with tool life in figure. 4 shows tool life in wet machining tend to be larger than dry machining results with the same cutting conditions due to wet machining using cutting fluid with the consequence of cutting temperature is relatively lower than dry machining. Although it is not significant that the tool life in wet and dry machining, dry machining results (HPK) meets the criteria to be used or realized to replace wet machining. Increase in cutting speed of HPK-1, HPK-5, HPK-9 and HPB-1, HPB-5, HPB-9 under optimum conditions will reduce tool life gradually. Of the 6 optimum cutting conditions above HPK-1 and HPB-1 are better than HPK-5, HPK-9, HPB-5, HPB-9 due to reduced feeding effect and cutting speed.

Figure. 5 shows that in the HPK-1 in the zone of initial wear the percentage of 29% in area of the flank wear VB = 0 mm to VB = 0.1mm. While the gradual wear zone is in flank wear of VB = 0.1 mm to VB = 0.3 mm with a wear rate of 31% and the dramatic wear zone is in the flank wear area of VB = 0.3 mm up to VB = 0.6 mm obtained by 40%. for HPK-5 and HPK-9.

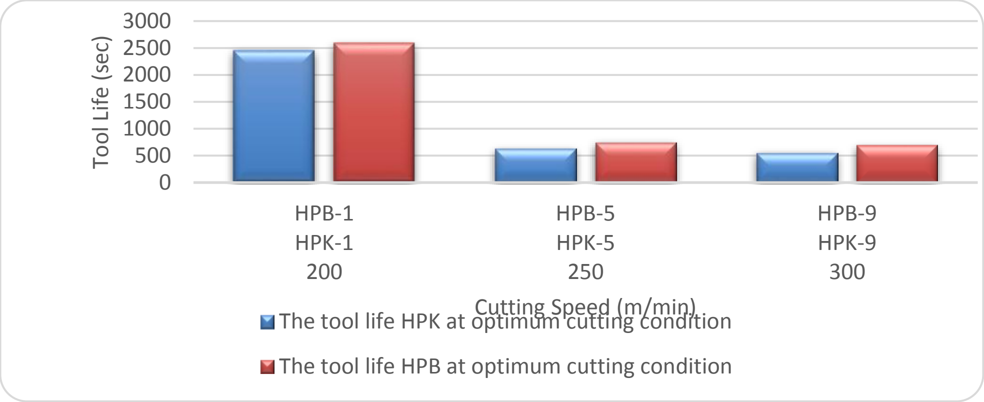

Fig. 4: Tool Life as Function of Cutting Speed.

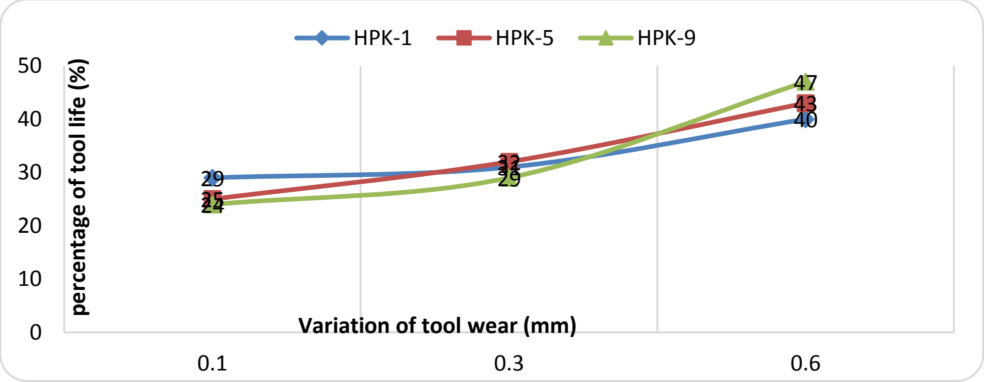

Fig. 5: Correlation of Tool Wearl with Percentage of Toollife at Cutting Condition.

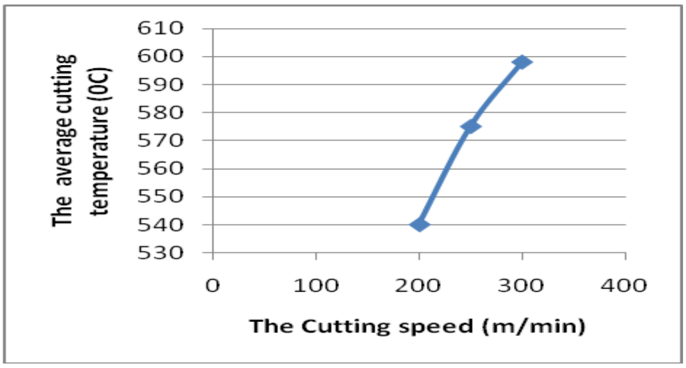

Fig. 6: Correlation of Cutting Speed with Average Cutting Temperature.

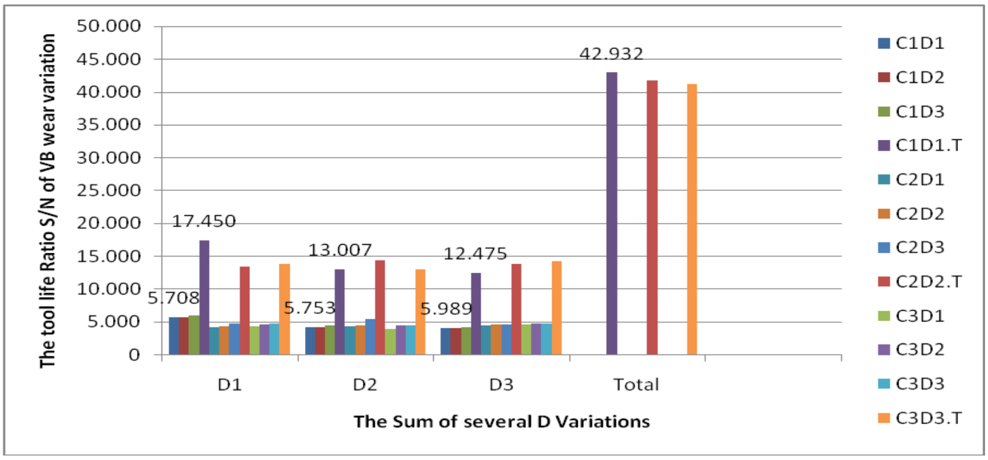

Fig. 7: Two-Way CD for C1D1 Tool Life Optimum Condition.

Figure. 6. At a velocity of 200 m/min the average cut temperature of 540 C^o is then obtained with V = 250 m/min, the mean cutting temperature is 575 C^o and for velocity 300 m/min is obtained at 598 C^o which can be stated that the larger cutting speed is followed by the increase in average cutting temperature.

The S/N ratio of the tool life was obtained through the equation by converting the tool life using VB tool wear variation 0.1, 0.3 and 0.6 mm. Conversion results are summed to be found C1D1, C1D2, C1D3 then summed to get C1D1.T. The sums of C2D1, C2D2 and C2D3 are obtained by C2D2.T and C3D3.T.

4. Conclusion

The optimum cutting conditions of dry and wet machining by Taguchi method at 200 m/min cutting speed, 1.0 mm cutting depth, 0.15 mm/rev and tool geometric 6^0 is obtained tool life were 2456 seconds and 2591 seconds respectively. The amount of cutting time with insignificant tool life between HPK-1 (2456 sec) and HPB-1 (2591 seconds) then dry machining may be considered for realized in TEW 6582 alloy steel machining.

Although the percentage of tool life at HPK-1 40% is less than HPK-5 and HPK-9 (43% and 47%) in the dramatic wear zone 0.6 mm however the optimum cutting condition is on HPK-1 because having a greater tool life can certainly extend the use of the tool due to speed cutting, feeding, cutting depth and tool geometry is smaller than in HPK-5 and HPK-9 (Figure-5).

The increase in cutting speed will be followed by a rise in cutting temperature, where one of the dominant factors in tool failure in other words will accelerate the replacement of the tool (Figure-6).

With the increase in cutting speed of HPK-1 V = 200 m/min, HPK-5 V = 250 m/min and HPK-9 V = 300m/min at optimum cutting conditions for dry machining and wet machining result in reduced tool life followed by increasing cutting temperature. Although the tool life of wet machining tends to be larger than dry machining and is insignificant, dry machining may be possible realized to replace wet machining (Figure. 4).

The sum of S/N C1D1, CID2, C1D3 ratios will be obtained S/N ratio C1D1Total = 42.932 consists of S/N ratio C1D1 =17.450, C1D2 = 13007 and C1D3 = 12.475. As for the total ratio of S/N C2D2 Total = 41.747 and C3D3 Total = 41.210. The largest number of S/N ratios is on C1D1 Total = 42,932 with an option on C1D1, C1D2 and C1D3 turned out to be an option on C1D1 because it has a larger S/N ratio than C1D2 and C1D3. This means selection for optimum conditions is the chirping age or the largest number of life-size S/N ratios (figure 7).

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