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Effect Of Cutting Parameters On Tool LifeTin CoatedCarbide In Turning Dry Machining Of TEW 6582 Steel By Aplication Metode Taguchi

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Abstract

The tool life limit is determined by the tool wear dimension. The tool life will increase as the tool wear increases. Turning experiments were carried out by varying the cutting speed, cutting depth, feed and cutting angle of the tool, while the tool life was evaluated based on the tool flank wear criteria. The purpose of the study was to determine the magnitude of the tool life in dry machining of TEW 6582 steel with various cutting conditions. To study the tool life, 9 cutting conditions were first determined, namely cutting speed 200 m/min, 250 m/min, 300 m/min; feed 0.15 mm/r, 0.2 mm/r, 0.25 mm/r and cutting depth 1 mm, 1.5 mm, 2 mm. Edge wear (VB) 0.1 mm, 0.3 mm and 0.5 mm and measured using an optical microscope. Experimental data were processed and analyzed using the Taguchi L9 method (34). Cutting speed has a significant effect on tool life, where increasing cutting speed substantially reduces tool life. Depth of cut and feed rate also contribute to tool wear, although to a lesser extent than cutting speed. The results show that the optimum cutting conditions are obtained by dry machining at a cutting speed of 200 m/min, a depth of cut of 1.0 mm, a feed of 0.15 mm/r and a tool geometry of 6o. This cutting condition gives a tool life of 2.456 second (40.9 minutes). When this cutting condition is carried out with wet machining, it is found that the tool life is 2.591 second (43.1 minutes). So the difference in tool life between dry and wet machining is not significant so that dry machining is feasible for the manufacturing industry.

Keywords: ***Tool Life, Tin coated carbide, Turning dry machining, TEW 6582Steel***

INTRODUCTION

The manufacturing industry continues to strive to improve efficiency, quality, and sustainability in the production process. One of the commonly used manufacturing processes is turning, which plays an important role in producing cylindrical components with various applications. Traditionally, the turning process often involves the use of coolant to reduce frictional heat, lubricate the cutting area, and help remove chips. The application of wet machining is still carried out to make a machine component. (Liew WYH, 2004). The cost of using cutting fluid is 16 percent to 20 percent . This 16% cost when converted to the total production cost of the manufacturing industry in the United States is worth 48 billion dollars and in Germany it reaches one billion German Marks and in Japan it reaches 71 billion Japanese Yen. Based on the values listed above, it is recommended that cutting fluids can be reduced if possible, so that production costs can be reduced and ultimately the selling value of production can be reduced.

Reported that to dispose of used cutting fluids, generally cutting fluids are packed in containers and buried in the ground. From this amount, we can imagine how much used cutting fluid must be disposed of into nature, if we try to calculate the amount produced by the entire World Manufacturing Industry from the aspect of the influence of cutting fluids on humans. However, the use of coolants causes various problems, including high operational costs, negative environmental impacts due to coolant waste, and health risks for operators. Reported that cutting fluids can cause health problems for operators such as respiratory problems and skin diseases. SME provides a concept of dry machining. meaning that cutting fluids are no longer used. Reported that the tendency of dry machining is better than wet machining when turning steel using carbide tools. The machining process with the dry machining method that the tendency to form Built Up-Edge (BUE) is greater than the wet machining method. Reported that high temperatures on the surface of the machined object will cause changes in the microstructure of the machined workpiece. To overcome this, it is necessary to choose a tool that has high rigidity and is resistant to high temperatures. [9]reported that dry machining was successfully carried out on cast iron, carbon, alloy steel and TIN alloys. Problems that may arise with dry machining in the metal cutting process include:

1. High friction and heat occur when turning TEW 6582 Steel
2. With ductile steel, continuous chips are obtained and chips adhere to the steel surface when cutting speed decreases
3. Chatter can affect surface results and tool life.

As a more environmentally friendly and economical alternative, dry machining is becoming increasingly attractive. In dry machining, the cutting process is carried out without the use of coolant. Although it offers various advantages, dry machining also poses its own challenges, especially related to the increase in temperature in the cutting zone and friction between the tool and the work material. This can significantly accelerate tool wear, which ultimately affects the surface quality of the product and production costs. Carbide coated tools are known for their hardness, wear resistance, and ability to maintain their sharpness at high temperatures. The coating on the carbide tool serves to improve cutting performance and extend tool life, especially under extreme machining conditions such as dry machining. However, the effectiveness of carbide coated tools is highly dependent on the selection of the right cutting parameters.

The main cutting parameters in turning, namely cutting speed, feed rate, and depth of cut, cutting tool angle have a complex effect on cutting force, cutting zone temperature, chip formation, and ultimately, tool life. Suboptimal selection of cutting parameters can lead to premature tool wear, poor surface quality, and production inefficiencies. To overcome the challenges in selecting optimal cutting parameters, various optimization methods have been developed. One of the effective and widely used methods is the Taguchi method. This method is a systematic statistical approach to designing experiments with a minimum number of trials but is able to provide maximum information on the influence of various factors on the desired response. By using an orthogonal array, the Taguchi method allows the identification of the most significant parameters and the determination of optimal parameter levels to achieve desired performance, such as maximizing tool life.

Many studies have been conducted on the influence of cutting parameters on tool life, especially in dry machining using the Taguchi method. These studies have shown that proper selection of cutting parameters is crucial for successful dry machining and the full potential of carbide-coated tools. Further research is needed to further understand the interactions between cutting parameters, work material, tool coating type, and dry machining conditions in order to develop more comprehensive guidelines for the optimization of turning processes.

Tool Life

Cutting time will increase with the growing or enlarged tool wear until at some point the tool is considered unusable because there are certain signs that the tool life has run out.

Provides a definition for tool wear such as changes in the shape of the tool from the original condition to the deformed tool shape during the cutting process. The properties that the tool must have are hardness, toughness, heat resistance and low wear (ISO Standard 3685,1993).

For a fixed price for the wear dimension limit and the combination of the tool and workpiece, the tool life equation is obtained, namely $v.\ T^n = C_T$ (Rochim, 1993).

Dry Machining

Dry machining can also reduce machining operating costs, eliminate the need for waste cutting fluid disposal and coolant purchases, eliminate machine cleaner production shutdowns and improve worker safety and health. Dry machining will also provide a cleaner workpiece environment as there is no oil attached to the workpiece. In addition, the chip will be uncontaminated. Cost advantages of dry machining include no coolant, no coolant pumps, no filter purchases and no chip cleaner sales (Bulloch, 2004).

TIN Carbide Tool

The tool used in the metal cutting process is a TiN-coated carbide tool. This tool is used to machine test specimens from TEW 6582 alloy steel material which can be applied to crankshaft fabrication in order to study the tool wear surface after the machining process using SEM.

TEW Steel 6582

The basic material of this type of carbide chisel is tungsten carbide with TiN coating. The chisel has a stronger cutting edge, lower friction value, BUE is not formed / very low, smoother coating surface and thinner coating thickness.In general, steel is classified into mild steel, ductile steel, semi-hard steel and hard steel. Ductile steel and semi-hard steel are widely chosen for shafts.

Alloy steel for shafts consists of chrome nickel steel, chrome nickel molybdenum steel, chrome steel and chrome molybdenum steel. The type of alloy steel used is chrome nickel molybdenum steel with TEW 6582 standard. Shafts used for high rotation and heavy loads are usually made of alloy steel with skin hardening that is very resistant to wear.

The material used is TEW 6582 steel, which is an alloy steel with the following chemical composition and mechanical properties:

Table-1. Chemical composition of the workpiece material (in %)

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- 2. Mechanical properties

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

In the steel metal cutting process, the workpiece used is a cylindrical shaft with dimensions of 200 m x 50 mm using an Emcotroni 242 CNC machine. Standard Conditions for workpieces with a length/diameter ratio greater than 10 are not recommended (ISO 3685).

Equipment

Fig-1.Emcotronic 242 CNC Machine

Fig-2. Toolholder and insert tool

Fig-3. Surface roughness Tester

Table 3. Chemical Composition and Mechanical Properties of Coated Carbide tools

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

RESEARCH METHODS

For each variation of VB wear from 9 cutting conditions is different when measuring cutting time. It is known that one cutting condition consists of three variations of VB wear. The results of three different VB wear variations are summed after machining is completed. This research is experimental in which data collection and analysis are carried out after machining with 9 cutting

conditions, then the optimum cutting conditions are determined. The experimental design is carried out with the L9 (3^4) orthogonal array standard. The L9 (3^4) orthogonal array standard has nine rows, three levels and four factors [15] .
The characteristics of the S / N ratio and the L9 (3^4) orthogonal array standard are part of the Taguchi method application which can be divided into 3 equations.

This study will use an experimental approach with the Taguchi method application to investigate the effect of cutting parameters on the life of carbide-coated tools under dry machining turning conditions. The steps of the research methodology will be explained as follows:

Identification of Research Variables

Independent Variable (Control Factors)

Cutting Speed (vc) : 200 m/min, 250 m/min , 300 m/min
Feeding (f) : 0,15 mm/r, 0,20 mm/r, 0,25 mm/r
Cutting Depth(a):1 mm, 1,5 mm, 2 mm
Cut corners (Sp) : 6^o , 12^o , 18^o

Dependent Variable (response)

Tool Life,(T) : Diukur kriteria keausan pahat yang telah ditentukan (VB=0.1 mm, 0,3 mm,0,5 mm)

Fixed Variable (Controlled)

Work Material: Specifications of the material to be machined (e.g.,certain carbon steels,aluminum alloys, etc.).
Tool Type: Specifications of the carbide-coated tool used (e.g., tool geometry, coating type).
Lathe: Type and specifications of the lathe used.
Machining Conditions: Dry machining (without use of coolant).
Tool Wear Criteria: The wear standard used as the end limit of tool life (e.g., a certain maximum back side wear width (VB) as per ISO 3685 standard)

Table 4.VB Activity Plan = 0.1,0.3,0.5 m

Trial	Factors				Dimention			
Sum	V	a	f	Sp	d	n	VBn	Tt
PK1	200	1.0	0.15	6				
PK2	200	1.5	0.20	12				
PK3	200	2.0	0.25	18				
PK4	250	1.0	0.20	18				
PK5	250	1.5	0.25	6				
PK6	250	2.0	0.15	12				
PK7	300	1.0	0.25	12				
PK8	300	1.5	0.15	18				
PK9	300	2.0	0.20	6				

RESULTS AND DISCUSSION

Cutting conditions for tool life in dry machining and wet machining are attached as table-5 and table-6.

Table .5. Cutting conditions with tool life Dry Machining

V	a	f	Sp	vb,0.1	vb,0.3	vb,0.5	Tt
200	1.0	0.15	6	715	753	988	2456
200	1.5	0.20	12	157	182	537	876
200	2.0	0.25	18	191	202	216	609
250	1.0	0.20	18	139	158	191	488
250	1.5	0.25	6	160	200	268	628
250	2.0	0.15	12	131	140	174	445
300	1.0	0.25	12	93	174	197	464
300	1.5	0.15	18	111	119	131	361
300	2.0	0.20	6	131	164	256	551

Table .6. Cutting conditions with tool life Wet Machining

V	a	f	Sp	ta,0.1	ta,0.3	ta,0.5	Tt
200	1.0	0.15	6	767	794	1030	25914
200	1.5	0.20	12	229	256	578	1063
200	2.0	0.25	18	222	245	272	739
250	1.0	0.20	18	185	216	223	624
250	1.5	0.25	6	211	243	295	749
250	2.0	0.15	12	148	172	205	525
300	1.0	0.25	12	142	191	231	564
300	1.5	0.15	18	129	143	151	423
300	2.0	0.20	6	190	198	304	692

Table.5 can be explained as follows, Cutting conditions with cutting speed V=200 m/min, depth of cut a =1.0 mm, feed f = 0.15 mm/r and tool geometry Gp = 60 at edge wear VB = 0.5 mm tool life becomes tc = 2456 seconds, then at cutting speed V= 200 m/min depth of cut a=1.5 mm, feed f = 0.2 mm/r and tool geometry Gp = 120 at edge wear VB = 0.5 mm tool life becomes tc = 876 seconds for cutting speed V = 200 m/min, depth of cut a = 2.0 mm, feed f = 0.25 mm/r and tool geometry Gp = 180 at edge wear VB = 0.5 mm tool life becomes tc = 609 seconds. With this data it can be analyzed that tool life is greatly influenced by cutting conditions, at the same cutting speed but the cutting depth, feed and tool geometry increase which results in shorter tool life. Under cutting conditions with cutting speed V=250 m/min, depth of cut a = 1.0 mm, feed f = 0.2 mm/r and tool geometry Gp= 180 at edge wear VB=0.5 mm tool life tc = 488 seconds. Under cutting conditions with cutting speed V=250 m/min, depth of cut a = 1.5 mm, feed f = 0.25 mm/r and tool geometry Gp = 60 at edge wear VB = 0.5 mm tool life tc = 628 seconds.

In cutting conditions with cutting speed V = 250 m/min, depth of cut a= 2.0 mm, feed f = 0.15 mm/r and tool geometry Gp= 120 at edge wear VB = 0.5 mm tool life tc = 445 seconds, from the data it can be explained that what has the most influence on edge wear growth is tool geometry, because the smaller the feed and depth of cut if the tool geometry is large, the tool life is shorter, and this also applies. for cutting conditions with cutting speed V=300 m/min, depth of cut a= 1.0 mm, feed f = 0.25 mm/r and tool geometry Gp = 120 at edge wear VB = 0.5 mm tool life tc = 464 seconds. Under cutting conditions with cutting speed V=300 m/min, depth of cut a = 1.5 mm, feed f = 0.15 mm/r and tool geometry Gp= 180 at edge wear VB = 0.5 mm tool life tc = 361 seconds. Under cutting conditions with cutting speed V = 300 m/min, depth of cut a = 2.0 mm, feed f = 0.2 mm/r and tool geometry Gp = 60 at edge wear VB = 0.5 mm where tool life tc = 551 seconds. From the explanation above, the highest tool life at a cutting speed of 200 m/min is 2456 seconds, equivalent to 40.9 minutes. In table 6, the discussion is identical to table 5, except that the tool life value changes or is different, where there is an increase in the tool life value for wet machining, which is 2591 seconds with a conversion in minutes of 43.1 minutes due to the use of cutting fluid so that the cutting temperature is lower with the consequence of slower tool wear.

Table-7. Optimum Condition of HPK/HPB

V mm/min	Tool life HPK(Second)	Tool life HPB(S)
200	2456	2591
250	628	749

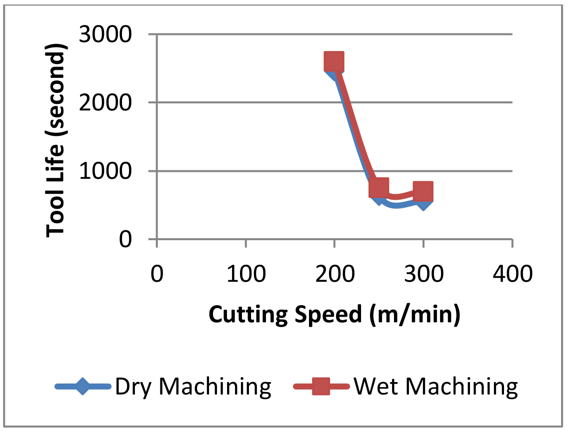

Figure-4. Relationship between cutting speed and tool life

Figure 4 shows the relationship between cutting speed and tool life, where the 2 graphs are almost overlapping because the data obtained are not significant. The optimum cutting condition data for tool life in dry machining and wet machining are at a cutting speed of 200 m/min, a cutting depth of 1mm, a feed f of 0.15 mm/r and a cutting angle of 6o, namely with a tool life Tt = 2456 seconds (40.9 minutes) and a wet machining tool life Tt = 2591 seconds (43.1 minutes). So actually the optimum is the tool life in wet machining with a cutting speed of 200 m/min, a cutting depth of 1mm, a feed f of 0.15 mm/r and a cutting angle of 6o (see table 5 and table 6). Dry machining based on research data is feasible to be applied in the manufacturing industry because both data between dry and wet machining do not have significant tool life values.

By using the Taguchi method in the standard form of the L_9 array (3^4), the following is obtained:

Table-8. Tool life data using the Taguchi method in dry machining

Trial	Factors A B C D	Desain	Measured tool life				S/N ratio with tool life			
1	1 1 1 1	A_1 B_1 C_1 D_1	715	753	988	2456	5,708	5,753	5,989	6,780
2	1 2 2 2	A_1 B_2 C_2 D_2	157	182	537	876	4,391	4,520	5,459	5,885
3	1 3 3 3	A_1 B_3 C_3 D_3	191	202	216	609	4,562	4,610	4,668	5,569
4	2 1 2 3	A_2 B_1 C_2 D_3	139	158	191	488	4,286	4,397	4,562	5,376
5	2 2 3 1	A_2 B_2 C_3 D_1	160	200	268	628	4,408	4,602	4,856	5,595
6	2 3 1 2	A_2 B_3 C_1 D_2	131	140	174	445	4,234	4,292	4,481	5,296
7	3 1 3 2	A_3 B_1 C_3 D_2	93	174	197	464	3,936	4,481	4,588	5,333
8	3 2 1 3	A_3 B_2 C_1 D_3	111	119	131	361	4,090	4,151	4,234	5,115
9	3 3 2 1	A_3 B_3 C_2 D_1	131	164	256	551	4,234	4,429	4,816	5,482

Table-9. Tool life data using the Taguchi method in wet machining

Trial	Factors A B C D	Desain	Measured tool life				S/N ratio with tool life			
1	1 1 1 1	A_1 B_1 C_1 D_1	767	794	1030	2591	5,769	5,799	6,025	6,826
2	1 2 2 2	A_1 B_2 C_2 D_2	229	256	578	1063	4,719	4,816	5,523	6,053
3	1 3 3 3	A_1 B_3 C_3 D_3	222	245	272	739	4,692	4,778	4,869	5,737
4	2 1 2 3	A_2 B_1 C_2 D_3	185	216	223	624	4,534	4,668	4,696	5,590
5	2 2 3 1	A_2 B_2 C_3 D_1	211	243	295	749	4,648	4,771	4,939	5,748
6	2 3 1 2	A_2 B_3 C_1 D_2	148	172	205	525	4,340	4,471	4,623	5,440
7	3 1 3 2	A_3 B_1 C_3 D_2	142	191	231	564	4,304	4,562	4,727	5,502
8	3 2 1 3	A_3 B_2 C_1 D_3	129	143	151	423	4,221	4,310	4,357	5,252
9	3 3 2 1	A_3 B_3 C_2 D_1	190	198	304	692	4,557	4,593	4,965	5,680

CONCLUSIONS

Based on the results of this study, the following conclusions can be drawn:

1. High cutting speed V (m/min) can shorten tool life in dry machining compared to wet machining with the consequence that BUE is absent on the machined surface.
2. The optimum cutting conditions were obtained at cutting speed V=200 m/min, cutting depth a=1.0 mm, feed f=0.15 mm/r and tool geometry 6o because it has a greater tool life (2435 seconds) from 9 cutting conditions (table.5)
3. For optimum cutting conditions, the tool life value obtained was 17.45 with the application of the Taguchi method in table 10, namely 17.45 at C1D1 dry machining.
4. Tool life in dry and wet machining is not significant, therefore dry machining can be / is feasible to be applied in the manufacturing industry.
5. In table 7 and figure 2, it can be seen that from the cutting speed variations of V = 200 m/min, V = 250 m/min and V = 300 m/min, optimum cutting conditions are obtained where the dry machining results are not significant compared to wet machining when observing the tool life value.

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