Analysis of HSS Chisel Hardness on a Lathe Machine Through Heat Quenching Treatment at the Production Workshop of the Department of Mechanical Engineering, Bengkalis State Polytechnic

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Abstract — Based on the results of the Field Study at the Bengkalis State Polytechnic Machine Tool Workshop practice, during the metal cutting machining process, there is an interaction between the tool and the workpiece. The friction experienced by the tool is caused by the flowing grunt surface and the surface of the workpiece that has been cut. As a result of this friction, the tool suffers from wear. The wear of this tool will increase to a certain extent. The length of time it takes to reach this wear limit is defined as tool life. The factors that affect tool wear are temperature and cooling media on the average value of a response. From the data, it can be seen that the decrease in wear from temperature from 800 to 1000 0C there is a significant decrease in the average response. For the refrigerant media factor, the difference in influence between salt, bromus oil, and SAE 20 oil was also seen, where salt provided the highest average HSS tool wear value, followed by bromus oil, and the lowest wear was SAE 20 oil of 0.066 mm. This indicates that the tool wear is lower and the tool is harder than the tool before heat treatment quanching at 1000 ^{0}C.

Keywords: Heat treatment, quanching, wear testing

INTRODUCTION

In the machining process that often changes is the tool (Cutting Tool). Chisels are consumable components and are relatively expensive. The tool will experience wear after being used for cutting, the greater the wear of the tool, the more critical the condition of the tool will be. If the tool is continuously used, the wear of the tool will accelerate and cause the tool tip to be damaged, fatal damage should not occur to the tool because a large cutting force will damage the drill tool, the tool machine, and can harm the operator [1].

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It is so important to pay attention to the life of the tool in the machining process, the criteria regarding the age of the tool or the time limit for using the tool are if the tool can no longer be used or the tool has been damaged. HSS chisels are one type of chisel that has a fairly high hardness [2].

Based on the results of the Field Study at the Bengkalis State Polytechnic Machine Tool Workshop practice, during the metal cutting machining process, there is an interaction between the tool and the workpiece. The friction experienced by the tool is caused by the flowing grunt surface and the surface of the workpiece that has been cut. As a result of this friction, the tool suffers from wear. The wear of this tool will increase to a certain extent. The length of time it takes to reach this wear limit is defined as tool life. It is so important to pay attention to the life of the tool in the machining process, the criteria regarding the age of the tool or the time limit for using the tool are if the tool can no longer be used or the tool has been damaged. HSS chisels are one type of chisel that has a fairly high hardness [2].

In this study, a bar HSS chisel with HSS dimensions of M2 - 1/2 x 6 was used, a Quenching heatreatment process was carried out with the aim of improving mechanical properties so that it is expected to increase the hardness value of the HSS tool, and there is a change in martensitic to the remaining austenitic. The material used for the turning process is ST 37), with a Wet Machining process.

This study aims to determine the hardness of high speed steel (HSS) chisels whether there is an effect of the quenching heatreatment process on the hardness of high speed steel (HSS) chisels by treating before and after *the quenching heatreatment* process using refrigerant variations (Salt water, Bromus /colant, Oil SAE 20), and also to see the extent of the influence on the wear of *high speed steel (HSS) chisels.*

The limitations of this study are focused on the main variables observed are flank wear as a result of the conventional turning process with spindle speed (*V*) = 300 rpm, feeding motion (*f*) = 0.19 mm/put, cutting depth (*a*) = 1.5 mm in ST 37 material

METHODS

LITERATURE REVIEW

1.1 Heat Treatment

Pramono (2016) said that heat treatment is to heat the metal under the melting temperature of the metal and cool the metal or alloy in a solid state for a certain time.

The heating process and the cooling rate greatly affect the final result of the heat treatment process. In the heat treatment process, there are three main stages, namely the heating stage, the holding stage, and the cooling stage. In general, heat treatment can be grouped into several types, one of which is

a. *Annealing*

Annealing is one of the heat treatment processes that is usually carried out to reduce hardness, improve ducility, smooth grain size, and remove residual stress.

b. *Normalizing*

Normalizing aims to obtain a smooth and uniform granular structure, as well as to eliminate internal tensions. For forged materials, construction steels and roller steels do not have the same structure because the number of loads is not proportional and due to uneven deformation at the cooling stages of uneven thickness. Normalizing aims to normalize the mechanical properties lost as a result of the steel in the previous process, smoothing the grain, eliminating residual stress or others

c. *Hardening*

The hardening process is a heating process that is carried out to obtain the hardness of a material. As for the process, the steel is first heated to or above the critical temperature, and then followed by rapid cooling, in every heat treatment operation, the heating rate is an important factor. This process is useful for improving the hardness of steel without changing the overall chemical composition. This process includes heating up to austenization and followed by cooling at a certain speed to obtain the desired properties. The cooling process varies depending on the cooling speed and the desired quenching medium. For fast cooling, hard and brittle metal properties will be obtained, while for slow cooling, soft and ductile properties will be obtained.

1.2 Cooling Media

[3] said that cooling media is a medium used to cool test specimens after undergoing a heat treatment process. To cool the material, various kinds of materials are known to obtain even cooling, the refrigerant is almost entirely circulated. To carry out the hardening process, we must cool quickly using cooling media, in order to obtain a martensite structure. Therefore, the more carbon elements, the better and more martensite structure will be formed. There are several refrigerant media used to cool the test specimen in this study are as follows:

1. Air (water colant)
   Water is a very common medium for quenching because of its low cost, ease of use and fast cooling process.
2. Air
   Air cooling is a heat treatment in which the cooling process is slow. Air as a coolant will provide the process of forming crystals to metals that will bind other elements of the air.

1.3 Chisel

A chisel is a tool that is installed on a tool machine with the function of cutting a workpiece or converting a workpiece into the desired geometric shape. In the process of metal working, the tool is used to cut hard materials (Kalpakjian, 2009) so that in the application a tool needs the following characteristics:

a. Hot hardness (hardness at high temperatures) so that with this property the hardness, strength and wear resistance can be maintained at the temperatures encountered during the machining process.
b. Toughness and impact strength with this property impact loads on the cutting process that are not taken into account or forces due to vibration and chatter in the machining process will not damage the tool.
c. Thermal shock resistance: this is necessary to withstand the cycle of regulated rate change.
d. Wear resistance with good wear resistance tool life criteria are acceptable before replacement is required.
e. Chemical stability is related to the material in the machine, so to minimize the side effects, adhesion and diffusion that have contributed to tool wear.

1.4 Tool Wear

Wear can be defined as the event of the detachment of a material or atom from the surface of a material due to plastic deformation and mechanical force. Wear on the cutting tool will cause a change in the shape of the workpiece so that the geometry and quality of the material surface will decrease. During the process of forming a fur [4] the chisel can experience normal malfunctions due to the following:

1. Increasing wear on the active plane of the tool.
2. Cracks that creep and cause fractures in the cutting edge of the chisel.
3. Plastic deformation that changes the geometry of the chisel.

In the process of cutting metal, tool wear can occur in the main field of the tool or what is then called edge wear (*flank wear*) and wear that occurs in the furious field or what is then called (*creater wear*). The process of measuring the life of the tool will be related to the occurrence of *flank wear* and *creator wear* in accordance with the ISO 3685: 1993 standard. Tool wear characteristics are often presented as a material use plot compared to the shift distance or cutting time for a particular combination of tool and material. Figure 2.5 below is a schematic graph of the edge wear width compared to the cutting length, also describing the process of changing the tool wear.

METHODS

The implementation of the heattreament quanching process on HSS chisels with cooling variations and analysis of data obtained from testing the hardness and wear of the tool and the depth of cut was carried out in Building B, especially in the tool workshop and the Mechanical Engineering material test lab of the Bengkalis State Polytechnic, Jalan Bathin Alam, Sungai Alam, Bengkalis, Riau. The following are the tools and materials used in this research process:

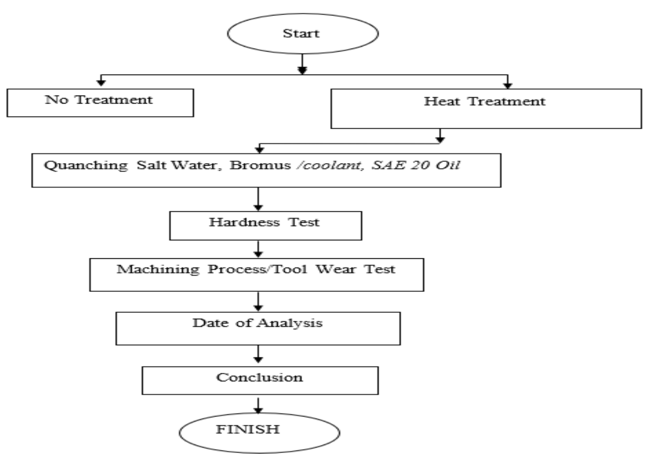


Figure 1. Flow Chart

RESULTS AND DISCUSSION

A. Test Results

The first thing done in this study is to take data on the wear of HSS tools before heattreating quanching with a lathe machining process with a cutting depth of 1.5 mm, spindle speed of 300 rpm and a feeding rate of 0.19 mm/revolution and then the heattreament quanching process with refrigerant variations (Salt water, Bromus /colant, Oil SAE 20). Furthermore, the HSS tool is tested for wear by a lathe machining process with a cutting depth of 1.5 mm, a spindle speed of 300 rpm and a feeding rate of 0.19 mm/revolution. After that, the wear of the chisel is seen with a microscope.

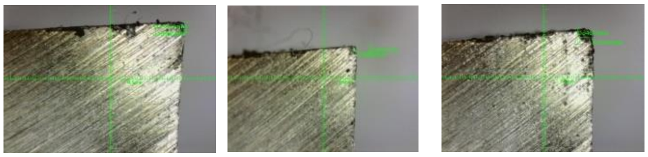
1) High Speed Steel (HSS) lathe tool test results.

Determining the average wear (VB) using a microscope, the data collected includes the average wear of the tool eye with a lathe machining process with a cutting depth of 1.5 mm, a spindle speed of 300 rpm and a feeding rate of 0.19 mm/revolution with constant parameters for all tools. Here the author presents the tool wear test data before heattriatment quanching and a picture of the tool eye with a microscope.

Table 2 above presents the results of tool wear testing before heat treatment quanching with the test carried out in the lathe machining process with a cutting depth of 1.5 mm, spindle speed of 300 rpm and feed rate of 0.19 mm/rev with constant parameters, with varying wear values between 0.08 mm to 0.39 mm. Then the overall average tool wear is 0.25 mm. These results indicate that tool wear tends not to be the same for all tools, even if they are of the same type. The author presents the chisel before the turning process is carried out as shown in the picture below:

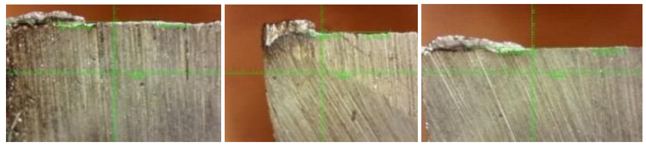
Table 1. Wear test data before *heat treatment quenching*

Specimens HSS Sculpture	Speed Spindle	Depth of cut (mm)	Feed rate (mm/rad)	Result Wear (mm)
Group A				
1	300	1.5	0.19	0,08
2				0,23
3				0,34
Group B				
1	300	1.5	0.19	0,17
2				0,25
3				0,38
Group c				
1	300	1.5	0.19	0,16
2				0,27
3				0,39



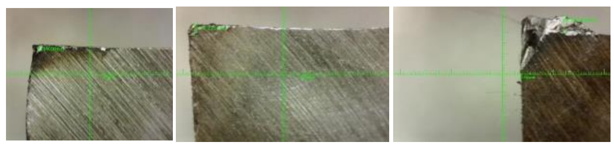
(a) (b) (c)

Figure 2. Specimen wear Group A (a) the first tool has a wear of 0.08 mm (b) the second tool has a wear of 0.23 mm (c) the third tool has a wear of 0.34 mm
Source: application of microscope tools with 1100X zoom



(a) (b) (c)

Figure 3: Specimen wear Group B chisels (a) the first chisel has a wear of 0.17 mm (b) the second chisel has a wear of 0.25 mm (c) the third chisel has a wear of 0.38 mm
Source: application of microscope tools with 1100X zoom



(a) (b) (c)

Figure 4: Specimen wear of group C chisels (a) the first chisel has a wear of 0.16 mm (b) the second chisel has a wear of 0.27 mm (c) the third chisel has a wear of 0.39 mm
Source: application of microscope tools with 1100X zoom

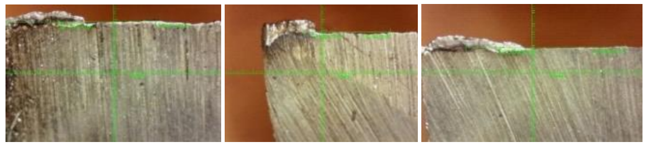
2) Wear test after *heat treatment Quenching*

Determining the Average Wear (VB) of the tool after Quenching Heat treatment Using a Microscope. The data collected includes the average wear of the tool bit and includes observations of the cutting conditions found in the following table:

Table 2. Wear Test Table After *Heat Treatment*

N0	Temperature	Cooling Media	Engine Speed	Cut Depth (mm)	Feeding motion (mm/rad)	Tool Wear (mm)
1	800	Salt	300	1.5	0.19	0.353
2		Bromus Oil				0.266
3		SAE 20 Oil				0.213
4	900	Salt	300	1.5	0.19	0.146
5		Bromus Oil				0.120
6		SAE 20 Oil				0.106
7	1000	Salt	300	1.5	0.19	0.080
8		Bromus Oil				0.073
9		SAE 20 Oil				0.066

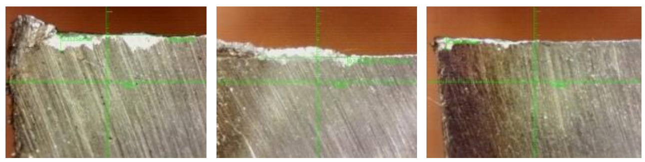
Heat treatment quanching with the test carried out by a lathe machining process with a cutting depth of 1.5 mm, spindle speed of 300 rpm and feed rate of 0.19 mm/rev with constant parameters, with varying wear values. with the lowest wear value at 0.066 mm at a temperature of 1000 ^{0}C on SAE 20 oil cooling media. and the highest tool wear value was 0.353 mm at a temperature of 800 ^{0}C with a cooling medium using salt water. Then the overall average tool wear is 0.15 mm. These results show that tool wear is lower starting at a temperature of 1000 ^{0}C. The tendency is that the higher the temperature, the material strength increases, but it is not significant and is proven by the results of tool wear after the machining process. The author presents the chisel before the turning process is carried out as shown in the picture below:



(a) (b) (c)

Figure 5. (a) Tool Wear Temperature 800 with brine cooling medium has a wear of 0.353 *(b) Tool Wear Temperature 800 with Oil Bromus cooling media has a wear of 0.266 (c) Tool Wear Temperature 800 with SAE Oil cooling medium has a wear of 0.213*

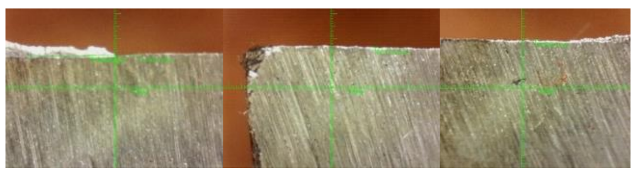
Source:application of microscope tools with 1100X zoom



(a) (b) (c)

Figure 6. (a) Tool Wear Temperature 900 with brine cooling medium has a wear of 0.146 (b) Tool Wear Temperature 900 with Oil Bromus cooling media has a wear of 0.120 (c) Tool Wear Temperature 900^0C. with SAE Oil cooling medium has a wear of 0.106

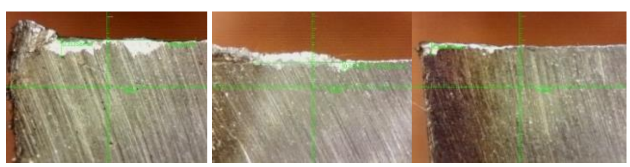
Source: application of microscope tools with 1100X zoom



(a) (b) (c)

Figure 7. (a) Tool Wear Temperature 800 with brine cooling medium has a wear of 0.353 *(b) Tool Wear Temperature 800 with Oil Bromus cooling media has a wear of 0.266 (c) Tool Wear Temperature 800 with SAE Oil cooling medium has a wear of 0.213*

Source:application of microscope tools with 1100X zoom



(a) (b) (c)

Figure 8. (a) Tool Wear Temperature 900 with brine cooling medium has a wear of 0.146 (b) Tool Wear Temperature 900 with Oil Bromus cooling media has a wear of 0.120 (c) Tool Wear Temperature 900^0C. with SAE Oil cooling medium has a wear of 0.106

Source: application of microscope tools with 1100X zoom

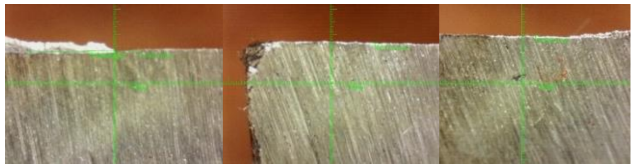

(a) (b) (c)

Figure 9. (a) Tool Wear Temperature 1000 with brine cooling medium has a wear of 0.080 (b) Tool Wear Temperature 1000 ^{0}C.with Oil Bromus cooling medium has a wear of 0.073 (c) Tool Wear Temperature 1000 with SAE Oil cooling medium has a wear of 0.066
Source: application of microscope tools with 1100X zoom

3) Comparison of Tool Wear Testing before and after *Heat treatment Quenching* in Lathe Ordering process

To see a graph comparing the wear values of the tool before and after in Tratment Quanching in the Lathe Ordering process, see the table below:

Table 3. Comparative Results of Wear Test before and after *Heat treatment Quenching* in the Lathe Ordering Process

Specimens HSS Sculpture	Speed Spindle (rpm)	Temperature (°C)	Cooling	Comparison of Wear Test Before And After Treatment (mm)	
				Avarage - Heatreat	Avarage + Heatreat
1	300	800	Brine	0,08	0.353
2			Oil Bromus	0,23	0.266
3			SAE 20 Oil	0,34	0.213
4		900	Brine	0,17	0.146
5			Oil Bromus	0,25	0.120
6			SAE 20 Oil	0,38	0.106
7		1000	Brine	0,16	0.080
8			Oil Bromus	0,27	0.073
9			SAE 20 Oil	0,39	0.066

Table 4 above presents the results of tool wear testing after heat treatment quanching with the test carried out in the lathe machining process with a cutting depth of 1.5 mm, spindle speed of 300 rpm and feed rate of 0.19 mm/rev with constant parameters, that there is a wear value that is the variation with the lowest wear value at 0.066 mm is found at a temperature of 1000 ^{0}C on SAE 20 oil cooling media. and the highest tool wear value is 0.353 mm. This shows that tool wear is lower and the tool is harder compared to the tool before heat treatment quanching was carried out starting at a temperature of 1000 ^{0}C

B. Discussion of *Taguchi Method* Analysis Using *Minitab Software*

After taking data and calculating the average for the age of the tool as shown in the table above, the analysis was carried out using the taguchi method as follows:

1) Wear test data before *heat treatment quenching*

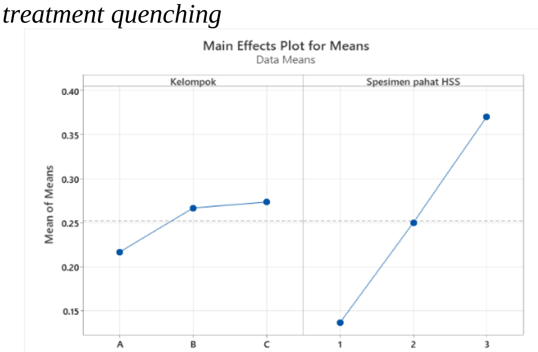


Figure 10. Graph Main Effects Plot For Means Before *Heat Treatment Quenching*

This graph shows the influence of two factors, namely the Group and the HSS Sculpted Specimen, on the measured response. In the Group factor, the average response value increased gradually from A to C, but the increase was relatively small. On the other hand, in the HSS Chisel Specimen factor, a significant increase was seen from specimen 1 to specimen 3, indicating that variation in HSS chisel specimen type had a greater impact on response than variation between groups.

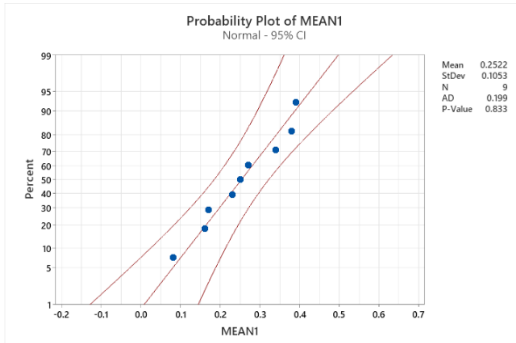


Figure 11. Probability Plot Mean1 Chart

The graph shown is a Probability Plot of the "Mean1" data distribution assuming a normal distribution and a confidence level of 95%. On the horizontal axis is the value of "Mean1" and on the vertical axis is the cumulative percentage. The blue dots depict the actual data, while the red curved lines represent the expected normal distribution. Most of the points are around the normal distribution line, indicating that the data follows the normal distribution well. A p-value of 0.833 indicates that there is no strong evidence to reject the hypothesis that the data is normally distributed.

2) Wear test after *heat treatment Quenching*

Determining the Average Wear (VB) *of the tool after Quenching Heat treatment* Using a Microscope. *The data collected includes the average tool eye wear and includes observations of the cutting conditions contained in the following table*

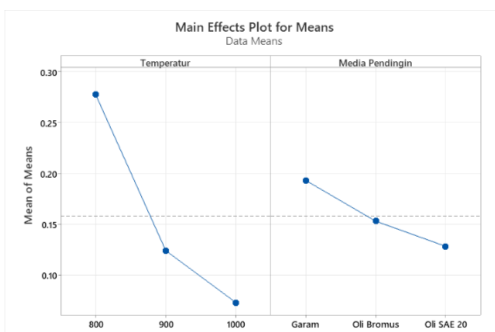


Figure 12. Graph Effects Plot Means

The graph shown is the Main Effects Plot for the average, which shows the main effect of HSS tool wear, namely Temperature and Cooling Media factors on the average value of a response. From this graph it can be seen that the decrease in wear from temperature from 800 to 1000^{0}C. there is a significant decrease in the average response. For the refrigerant media factor, the difference in influence between salt, bromus oil, and SAE 20 oil is also seen, where salt provides the highest average value, followed by bromus oil, and the lowest is SAE 20 oil. These graphs help in understanding how each factor independently affects the results, so that they can be used to optimize the process.

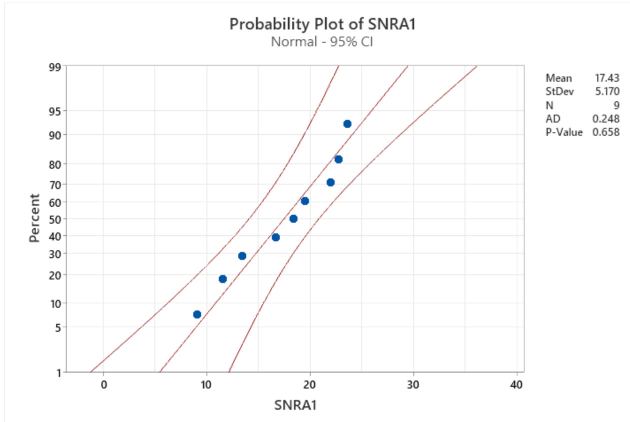


Figure 13. Probability Plot Graph

The graph is a Probability Plot that shows the distribution of data for the SNRA1 variable assuming a normal distribution. The blue dots on the graph show the actual data, and the red lines represent the theoretical normal distribution. Data close to the line indicates that the data follows a normal distribution. The statistical results displayed on the right show that the mean is 17.43 with a standard deviation (StDev) of 5.17, and a P-Value value of 0.658 indicates that there is no strong evidence to reject the hypothesis that the data is normally distributed

CONCLUSIONS

Based on the results of the study and analysis, it can be concluded that it shows the main influence of HSS tool wear, namely Temperature and Cooling Media factors on the average value of a response. From the data, it can be seen that the decrease in wear from temperature from 800 to 1000 ^{0}C.there is a significant decrease in the average response. For the refrigerant media factor, the difference in influence between salt, bromus oil, and SAE 20 oil was also seen, where salt provided the highest average HSS tool wear value, followed by bromus oil, and the lowest wear was SAE 20 oil of 0.066 mm. This indicates that the tool wear is lower and the tool is harder than the tool before the heattriatment quanching starts at 1000 ^{0}C.

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