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The Study Quenching Process on Rubber Tapping Knives Home Industry Production

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Abstract: The rubber tapping knives produced by blacksmiths have cracks and chipped and even broken on their blades, so rubber farmers must often replace them with new knives. Thus the product cannot be used for a long time and has reduced economic value. The cause of this rubber tapping knives made by blacksmiths is easily damaged because the gilding method on the product is not done properly. So the product was produced have a relatively low level of hardness. This study aims to determine the effect of the hardening and quenching process on the hardness of rubber tapping knives made by blacksmiths. Data of test were analyzed using ANOVA with full factorial level design, main effect model design, and 3 replications assisted with Design-Expert software. At a temperature of 800°C, the maximum hardness value of 62,8 HRC obtained from the quenching results using a water cooling media, while the minimum hardness value of 62,2 HRC was obtained from oil cooling media. At a temperature of 850°C the maximum hardness value of 60,4 HRC obtained from the quenching results using water cooling media, and the minimum hardness value obtained from the oil cooling media is 59,1 HRC.

Keywords: rubber, leaf spring, hardening, quenching, tapping knives

1. Introduction

Rubber plantations are still one of the leading plantation commodities in Indonesia and the area of rubber plantations in Indonesia is the second largest in the world. Several regions in Indonesia have land conditions suitable for rubber cultivation, most of which are in Sumatra and Kalimantan.

The area of rubber plantations in Indonesia in 2015 was recorded to reach more than 3.6 million ha spread throughout Indonesia including Sumatra area of 2.5 million ha, Java area of 142 thousand ha, Nusa Tenggara and Bali area of 511 ha, Kalimantan area is 905 thousand ha, Sulawesi is 13 thousand ha and Maluku and Papua is 4.8 thousand ha. To be able to harvest rubber sap, farmers carry out artificial tapping or wounding on the bark of rubber trees using a rubber tapping knife [1].

The tapping knife has a distinctive shape and its use is only for tapping rubber plants [2]. This knife is manufactured by a blacksmith using medium carbon steel from deprecated leaf spring components [3]. Medium carbon steel (Medium Carbon Steel) is steel with a carbon content between 0.25% - 0.60% C. This medium carbon steel is widely used for the purposes of machine tools and can also be used for various purposes such as for industrial vehicles, gears, leaf springs and so on [4].

Often the knives produced by blacksmiths are cracked and chipped and even broken at the blade, so rubber farmers often have to replace them with new knives. Thus the product cannot be used for a long time and its economic value decreases. It is suspected that the reason why this blacksmith's tapping knife is easily damaged is because the heat treatment method on the product has not been carried out properly. One of the heat treatment processes on steel is hardening or better known to the public as the plating process.

The rubber tapping blade is heated to a temperature in the area or above the critical area followed by rapid cooling called quenching. Quenching is an attempt to cool quickly after the steel has undergone a heating treatment. In the quenching treatment there is an acceleration of cooling from the final temperature of the treatment and changes from austenite to ferrite and martensitic to produce high strength and hardness [4-7].

The test results show that the hardness of the experimental knife A in the blade area reaches 730HV with martensitic and chrome carbide microstructures, and in the blunt area the hardness drops to 313 HV with residual martensitic and austenite structures. Meanwhile, the thoroughly hardened experimental knife B reached a hardness of 627HV and the microstructure of martensitic with fine chromium carbide was evenly distributed. The experimental results of knife making obtained are close to the mechanical properties of imported X knives which have a tempered martensitic matrix microstructure with carbide and a hardness level of 640 HV [8-12].

Based on the previous research that has been done above, a research is carried out that aims to increase the hardness of the rubber tapping knife made by blacksmiths through the hardening and quenching heat treatment processes. So that a superior product is obtained as desired.

The purpose of this study is to determine the effect of hardening and quenching heat treatment on the rubber tapping knife product in order to obtain an increase in quality in terms of better surface hardness and a longer product life.

2. Research Methods

There are several tools and materials used to support this research in this study namely:

1. There are 12 test specimens with heat treatment, 3 without heat treatment, 3 raw materials, and 1 specimen for composition testing. (Figure 1).

Figure 1. *Specimens with heat treatment*

2. Nabertherm Chamber Furnace N 321/13.
3. Clamping pliers to lift the specimen from the furnace.
4. Container for quenching media
5. SAE 40 oil quenching medium
6. Rockwell hardness tester Model HR 150 A
7. caliper
8. Hand grinder
9. Sandpaper
10. Miser
11. Iron wire to bind the specimen

The research steps are as follows:

a. Specimen preparation
   The preparation process begins with preparing the rubber tapping knife specimen to be tested. Specimens were measured using a caliper, then cut using a hand grinder. The test specimen is 50 mm long and 5 mm thick. specimens for composition testing measuring 40mm x 40mm and 5 mm thick. After that, it was flattened using a file and continued with sanding so that the specimen became even and smooth.
b. Hardening process
   The first step of all prepare and check the specimen to be tested. The specimens are then tied using steel wire, which serves to facilitate the collection of specimens from the heating furnace. And also to make it easier when doing the cooling process After the specimen is ready, it is then put into the heating kitchen on a regular basis and arranged to make it easier to collect. The heating pan is set to temperatures of 800 °C and 850 °C, with a holding time of 30 minutes. Determination of temperature based on carbon content and Fe3C phase diagram.
c. Quenching process
   After holding for 30 minutes, the specimen is removed from the furnace using clamp pliers, then quickly immersed in water and SAE 40 oil cooling media. Then wait until the specimen is cold after which the specimen is cleaned of dirt or oil that is still [13].
d. Hardness test
   Hardness test was conducted to determine the difference in each variation of temperature and cooling media. Tests are carried out on hardened and unhardened specimens. Hardness testing was carried out at 5 points on the surface of each specimen. The standard used in this test is based on ASTM E18 [14].
e. Composition test
   The composition test was carried out to determine the amount of Fe and C levels as well as other elements contained in the rubber tapping knife specimen. The test was carried out at the Indonesian Institute of Sciences Research Institute for Mineral Technology located in Tanjung Bintang, South Lampung. The composition test was carried out using the Spark-Optical Emission Spectrometer (OES). This tool can analyze the elemental composition of carbon steel, Al-base, Zn-base, and cast iron with relatively fast and accurate tests and precise results.

3. Results and Discussion

3.1. Composition Test

The results of the composition test, it is known that the test specimen belongs to the type of medium carbon steel with a carbon content (C) of 0.544%. This type of carbon steel can be hardened directly so that the hardening heat treatment process can be applied to the test specimen. The data the composition test results can be seen in table 1.

Table 1. *The Composition test result*

No	Elemen	***Medium Carbon Steel*** **Kadar (%)**	Metode
1	C	0,544	*Spark* – OES *Spectromaxx*
2	Si	0,238	*Spark* – OES *Spectromaxx*
3	Mn	0,820	*Spark* – OES *Spectromaxx*
4	P	0,0146	*Spark* – OES *Spectromaxx*
5	S	0,0030	*Spark* – OES *Spectromaxx*
6	Cr	0,754	*Spark* – OES *Spectromaxx*
7	Mo	0,0102	*Spark* – OES *Spectromaxx*
8	Ni	0,00665	*Spark* – OES *Spectromaxx*
9	Al	0,0390	*Spark* – OES *Spectromaxx*
10	Co	0,0095	*Spark* – OES *Spectromaxx*
11	Cu	0,0156	*Spark* – OES *Spectromaxx*
12	Ti	0,0142	*Spark* – OES *Spectromaxx*
13	Sn	0,0011	*Spark* – OES *Spectromaxx*
14	As	0,0022	*Spark* – OES *Spectromaxx*
15	Zr	0,0039	*Spark* – OES *Spectromaxx*
16	Ce	0,0036	*Spark* – OES *Spectromaxx*
17	Se	0,0022	*Spark* – OES *Spectromaxx*
18	Te	0,0047	*Spark* – OES *Spectromaxx*
19	Ta	0,0402	*Spark* – OES *Spectromaxx*
20	B	0,00021	*Spark* – OES *Spectromaxx*
21	Zn	0,0012	*Spark* – OES *Spectromaxx*
22	La	0,00053	*Spark* – OES *Spectromaxx*
23	Fe	97,4	*Spark* – OES *Spectromaxx*

3.2. Hardness Test

The data from the hardness test results are determined the minimum, maximum, average, standard deviation and ratio values of each response and factor in the test are obtained [13], then they are made in the form of tables 2 and 3.

Table 2. *The Average, Deviation, and ratio of Hardness test result water*

Design Model : Main Effect		
Design Type : Full Factorial		
Runs : 6		
	Factor	
	A	R1
Name	Water	*Hardness*
Units	°C	HRC
Minimum	800	59,2
Maximum	850	63,3
Mean		61,65
Std. Dev		1,48155
Observasi		6
Analysis		*factorial*
Ratio		1,06926

Table 3. *The Average, Deviation, and ratio of Hardness test result oil*

Design Model : Main Effect		
Design Type : Full Factorial		
Runs : 6		
	Factor	
	B	R1
Name	Oil	*Hardness*
Units	°C	HRC
Minimum	800	57,8
Maximum	850	62,4
Mean		60,67
Std. Dev		1,84029
Observasi		6
Analysis		*factorial*
Ratio		1,07958

Table 4. *ANOVA Specimen water quenching*

ANOVA ***for selected factorial model***						
Analysis of variance table [Partial sum of squares - Type II]						
Source	*Sum of Squares*	df	*Mean Square*	F *Value*	p-*value* Prob > F	
Model	7,94	1	7,93	9,30	0.0381	*Significant*
A- Air	7,94	1	7,94	9,30	0.0381	
Pure Error	3,41	4	0,85			
Cor Total	11,35	5				

Table 4. *ANOVA Specimen oil quenching*

ANOVA ***for selected factorial model***						
Analysis of variance table [Partial sum of squares - Type II]						
Source	*Sum of Squares*	df	*Mean Square*	F *Value*	p-*value* Prob > F	
Model	14,11	1	14,11	19,96	0.0111	*Significant*
A- Oli	14,11	1	14,11	19,96	0.0111	
Pure Error	2,83	4	0,71			
Cor Total	16,93	5				

Based on the results of ANOVA F_{Calc} (F0) > F_{Table}, the hypothesis (Ho) is rejected, so it can be concluded that the variation of temperature and quenching media with a 95% confidence level (α=0.05) has an influence on the hardness of the rubber tapping knife specimen. The largest F value is found in the oil quenching media parameters; these indicates that the main factor that most influences the hardness of the test specimen is the oil quenching medium. It can be calculated the percentage value of the contribution of each influencing factor, as follows:

$$\sigma_a = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}} \quad (1)$$

$$\text{Factor Water} = \frac{(7{,}94-3{,}41)}{11{,}35} = 39\%$$

$$\text{Factor Oil} = \frac{(14{,}11-2{,}83)}{16{,}93} = 42\%$$

After testing the hardness with the Rockwell method, the average results of the hardness test can be seen in figure 2 and 3.

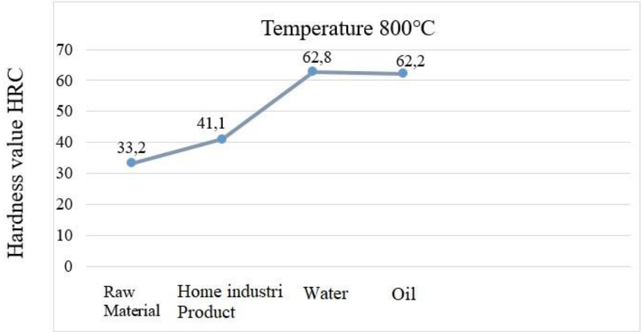

Figure 2. *Hardness test result at Temperature 800°C*

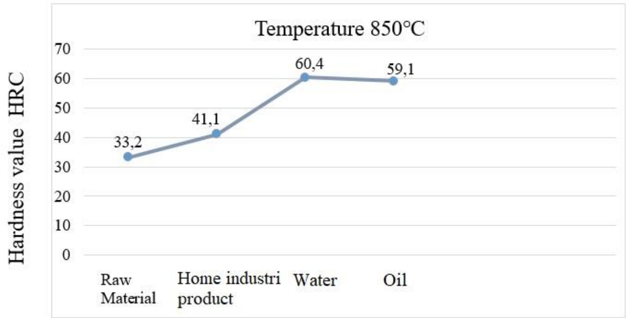

Figure 3. *Hardness test result at Temperature 850°C*

The graphs shown in figures 2 and 3, They are known that the test specimens after the hardening and quenching processes experienced a significant increase in hardness. Differences in temperature and cooling media affect the hardness of each test specimen. At a temperature of 800°C the maximum hardness value is 62.8 HRC obtained from quenching using water cooling media, while the minimum hardness value is 62.2 HRC from oil cooling media. At a temperature of 850°C the maximum hardness value of 60.4 HRC was obtained from quenching using water cooling media, and the minimum hardness value obtained from oil cooling media was 59.1 HRC. From the results of the analysis of variance, it is known that variations in temperature and different cooling media have a significant effect on increasing hardness. The results of the hardness test showed that there were differences in the increase in the hardness of each specimen. However, the calculation of the percentage contribution shows that oil quenching media has more effect than water media on the hardness of the test specimen.

4. Conclusion

Based on the results of testing and data analysis conducted, the following conclusions; the results of the composition test, it is known that the leaf spring steel specimen, the raw material for making rubber tapping blades, is medium carbon steel with a percentage of iron (Fe) 97.4% and carbon (C) 0.544%.

The hardness test, it is known that there is an increase in the hardness of the rubber tapping knife test specimen. At a temperature of 800℃ the maximum hardness value of 62.8 HRC was obtained from quenching using water cooling media, while the minimum hardness value of 62.2 HRC was obtained from oil cooling media. At a temperature of 850℃ the maximum hardness value of 60.4 HRC was obtained from quenching using water cooling media, and the minimum hardness value obtained from oil cooling media was 59.1 HRC. So the right temperature and cooling medium to get a high level of hardness is to use water cooling media at a temperature of 800℃.

The analysis, it is known that the factor that most influences the level of hardness is oil cooling media, with a contribution percentage of 42%, while the contribution percentage of water cooling media is 39%.

The content of carbon elements in the oil compound (C_8H_{18}) allows the addition of carbon to the test specimen so as to increase its hardness. However, this does not apply to specimens with water cooling media (H_2O). The difference in viscosity of the two cooling media also affects the hardness of the specimen. Water cooling media with a fast cooling rate will produce a high level of hardness. Whereas in oil cooling media the cooling rate tends to be slower so that the hardness value of the test specimen is lower than the specimen with water cooling media.

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