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Modification of Grass Chopper Blade from Leaf Spring with Coconut Shell Charcoal Addition by Carburizing Treatment

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Abstract: A grass chopper is a machine used to chop grass and soft stems. In the grass chopping process, a sharp blade is required. The current problem is the blade get wear due to repeated sharpening of the blade, resulting in a non-uniform texture of chopped grass and often found some large grass sizes. Therefore, this research focuses on blade material engineering. This research was conducted by carburizing at 700°C for 60 minutes and adding carbon from coconut shell charcoal followed by quenching using water cooling media. The blade was made from a leaf spring made of JIS-SUP 9 steel. The results showed 106% of enhancement in carbon composition after the blade was treated by carburizing. This carbon composition enhancement affects the performance of the blade, namely higher hardness as shown by a 175% increase in hardness value and a 96.4% lower wear rate than the untreated blade.

Keywords: JIS-SUP 9 Steel; Carburizing; Blade; Leaf Spring; Chopper.

Abstrak: *Pemotong rumput adalah mesin yang digunakan untuk memotong rumput dan batang yang lunak. Dalam proses pemotongan rumput, diperlukan pisau yang tajam. Masalah saat ini adalah pemakaian pisau akibat pengasahan berulang, yang mengakibatkan tekstur rumput yang tidak merata dan sering ditemukan beberapa ukuran rumput yang besar. Oleh karena itu, penelitian ini berfokus pada rekayasa material pisau. Penelitian ini dilakukan dengan melakukan karburasi pada suhu 700°C selama 60 menit dan penambahan karbon dari arang tempurung kelapa diikuti dengan pengerasan menggunakan media pendingin air. Pisau dibuat dari per daun yang terbuat dari baja JIS-SUP 9. Hasil penelitian menunjukkan peningkatan 106% dalam komposisi karbon setelah pisau diolah dengan karburasi. Peningkatan komposisi karbon ini memengaruhi kinerja pisau, yaitu peningkatan kekerasan seperti yang ditunjukkan oleh peningkatan nilai kekerasan sebesar 175% dan tingkat keausan yang 96,4% lebih rendah daripada pisau yang tidak diolah.*

Kata Kunci: *Baja JIS-SUP 9; Karburasi; Pisau; Leaf Spring; Pemotong Rumput.*

INTRODUCTION

Various types of leaves or grass or fruit that are large size and soft texture can be chopped into smaller sizes using a chopping machine [1]. Community groups that have bussiness in animal feed or composter are really need a chopping machine [2]. Because this machine can chop raw materials into small sizes quickly and automatically [3]. In 2012, the community was already using a chopping machine to make animal feed [4]. There is a chopping machine for coconut fiber has been made using an electric motor drive with an engine rotational speed of 450 rpm and a V-Belt linear speed of 3.9 m/s [5]. The elephant grass chopper machine is capable of producing chopped elephant grass around 200-500 kg / hour for animal feed consumption [6], [7].

In general, the main drive of the chopping machine are a diesel motor or electric motor. The frame is used to support all components into one assembly, like some shafts, the chopper knife holder, the container, the transmission system, pulleys and belts, chopper knives. One main component in the grass chopping machine is a blade made of iron material. This knife is designed in the disk form with sharp side, as shown in Figure 1. The mechanism of using a knife on this machine is that the knife moves in rotation continously so that it can chop the grass. The knife install by plug and play system so the knife can be removed easily from the holder, then it can be sharpened if it has begun to blunt by sharpening the sharp blade using a grinding machine and can also use a manual sharpening stone. However, there is a weakness in this machine, namely the blades can wear out easily. Because the use of blades in this chopping machine is repetitive and wear out easily, this research uses car leaf springs made of JIS-SUP 9 steel as a material for making blades. JIS-SUP 9 is a low carbon steel with carbon composition ranging from 0.50-1.00%. Research related to the hardening and tempering process on JIS-SUP 9 spring steel shows an increase in hardness percentage by 40% and toughness percentage by 227% from spring steel without treatment [8].

Figure 1. Blades Grass chopper machine

Another study conducted by Setiani Ibrahim, et al, offered a solution for conducting a heat treatment process on AISI D2 steel blade material. The hardness was obtained after the blade undergoes a hardening process is 710 HV, which is twice of the blade without the heat treatment process [9]. Heat treatment can increase the hardness of metal materials, namely annealing, normalizing, quenching and tempering processes, for example ST 60 steel had gotten heat treatment showing a hardness percentage enhancement value twice of untreated steel [10]. Mohamad Abdul Jaelan, et al, also strengthened the blade of the organic waste chopping machine with a multilevel heat treatment process, namely the carburizing and hardening process which obtained a hardness value of 599.7 VHN from ST 41 steel material [11]. Carburizing treatment of AISI 1020 steel with coconut shell charcoal was carried out by Muslih Nasution, et al, to obtain high hardness properties through the Carburizing process in Quenching variations with water cooling media, salt solution water and oil. Steel that has been treated with carburizing and quenching with water has an average hardness value of 395.3990 VHN, which is twice as high as AISI 1020 steel that has not been treated. [12]. Carburizing treatment can improve the mechanical properties of the material to become hard, elastic, and ductile so metal materials will experience increased performance such as strength, hardness or certain characteristics of the material [13]. Carburizing treatment is carried out to engineer metal materials to be harder by heating the workpiece in a furnace at a specified temperature for a certain period of time and then cooling it quickly with cooling media such as water, salt water, oil and diesel fuel. Each of cooling media has a different cooling density. The hardness of the workpiece resulting from the carburizing process depends on the heating temperature, heating time, cooling rate, chemical composition, surface condition, size and weight of the workpiece [13]. Therefore, this research provides a solution, namely making a blade from a car leaf spring with JIS-SUP 9 steel material and then given a treatment, namely the carburizing process at 700 ° C for 60 minutes with the addition of carbon from coconut shell charcoal followed by a quenching process with water cooling media for 45 minutes.

METHODS

The research was conducted by experimental method, namely making blade specimens and then testing them to determine the characteristics of material. First, a car leaf spring made of JIS-SUP 9 steel was cut into 25 cm length. There are two specimens used in this study, as shown in Figure 2, one specimen for the blade without treatment and the other specimen for the blade with treatment. Each specimens were made into three blades. Second, the treatment given is carburizing process with a temperature of 700 ° C for 60 minutes and added carbon from coconut shell charcoal. Third, after the carburizing process, the blades were quickly quenched in water cooling media with a holding time of 45 minutes. Fourth, the blade was tested for microhardness using the Vickers method, tested for wear using the ASTM G 99 standard, and tested for microstructure using SEM-EDAX.

This study applies variables including dependent variables, namely the percentage of carbon from SEM-EDAX testing, hardness value from microhardness testing with the Vickers method, and wear value from wear testing with ASTM G 99 standards. The independent variables are blades with carburizing treatment and blades without carburizing treatment. The controlled variable is the blade made from car leaf springs JIS-SUP 9 steel. Carburizing treatment is carried out at 700° C for 60 minutes with the addition of carbon from coconut shell charcoal, followed by quenching process.

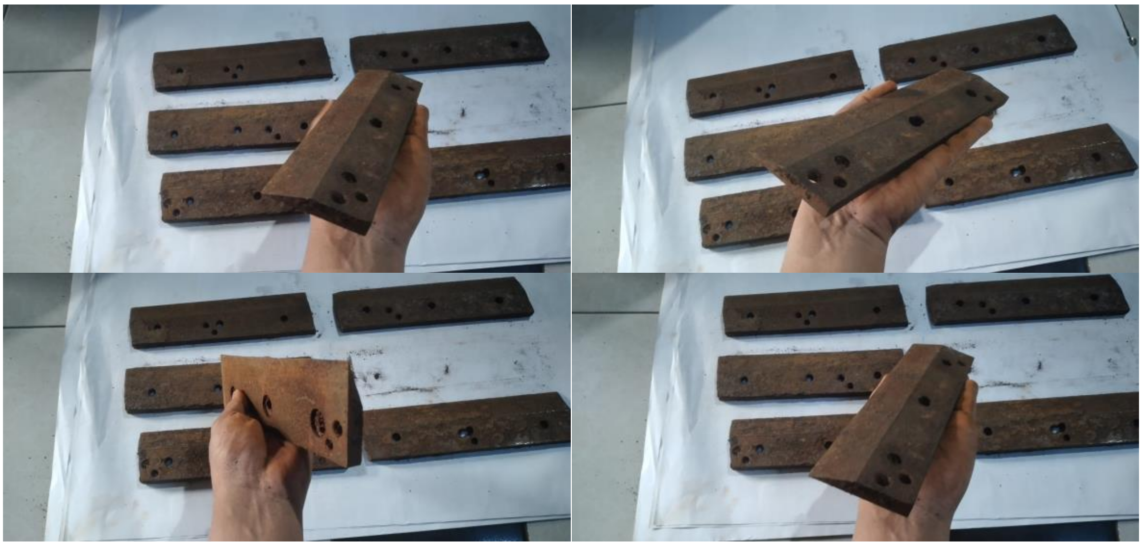

Figure 2. Blade specimens

RESULT AND DISCUSSION

A. SEM-EDAX Testing

SEM-EDAX testing was conducted to observe the elemental composition of carbon in the untreated and treated blade specimens. The microscope magnification reached 500 times to show the EDAX Spot and substrate regions.

A.1 Percentage of carbon in blade specimens without treatment

The results of the EDX picture can be seen in Figure 3 and 4. The SEM-EDAX picture showed carbon the untreated blade specimen in table 1. The results of SEM EDX testing on the blade without treatment have a carbon composition of 0.57% [8].

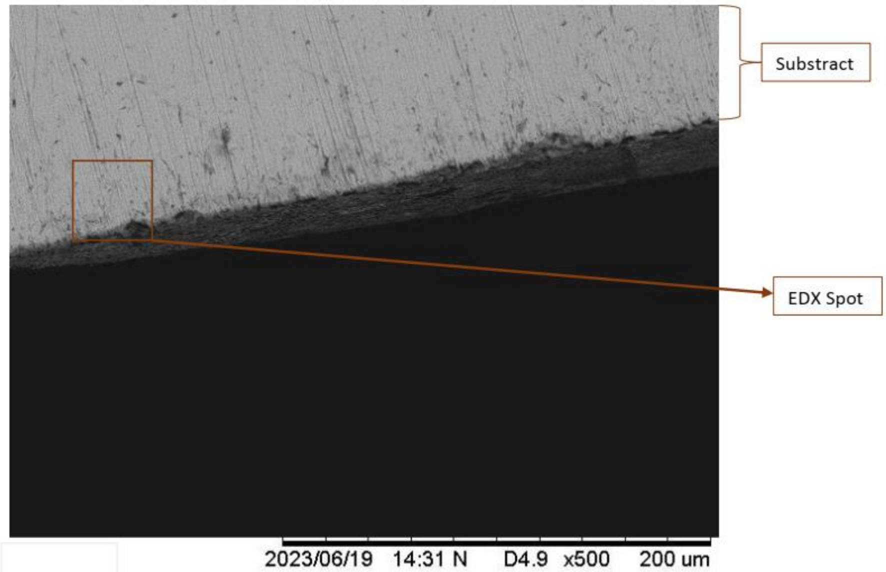

Figure 3. SEM-EDAX picture of blade specimens without treatment

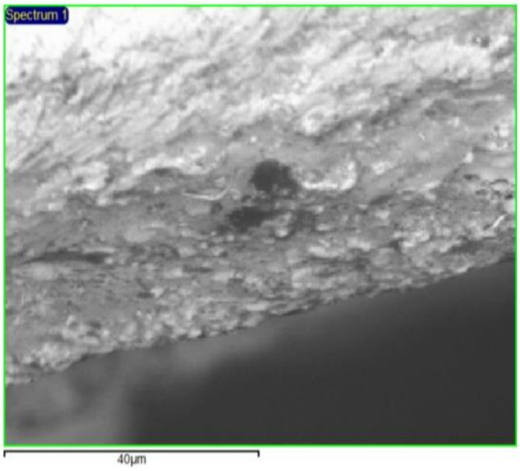

Figure 4. EDX Spot picture of blade specimens without treatment

Table 1. Composition in the blade without treatment

Element	Weight %	Weight % σ	Atomic %
Carbon	0.57	0.536	30.522
Aluminum	0.197	0.079	0.276
Silicon	0.30	0.079	0.727
Iron	98.933	0.560	57.455

A.2 Percentage carbon in the blade with carburizing treatment

The results of the EDX picture can be seen in Figure 5 and 6. The SEM-EDAX picture showed carbon the blade specimen with carburizing treatment in Table 2. The results of SEM EDX testing on the blade without treatment have a carbon composition of 20,014%.

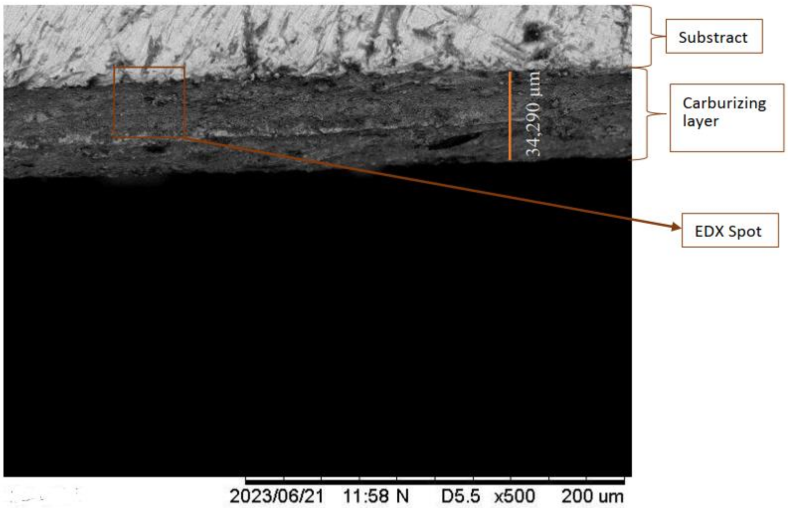

Figure 5. SEM-EDAX picture of the blade with carburizing treatment

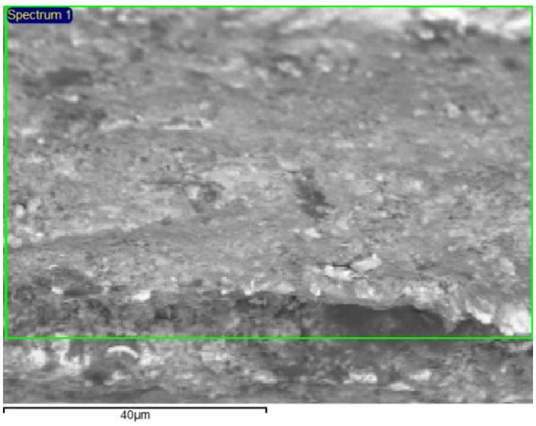

Figure 6. EDX Spot picture of the blade with carburizing treatment

Table 2. Composition in the blade with carburizing treatment

Element	Weight %	Weight % σ	Atomic %
Carbon	20.014	0.352	41.569
Oxygen	23.470	0.280	30.273
Sodium	0.547	0.076	0.491
Aluminum	0.160	0.045	0.122
Silicon	1.394	0.053	1.024
Calcium	0.743	0.049	0.382
Iron	53.673	0.311	26.138

A.3 Discussion of Carbon content in the blade

From the SEM-EDAX test, the carbon content of the blade with treatment is much higher than the blade without treatment, which is an increase of 106%. This is also evident from the hardness and wear tests. If the carbon content is high, the hardness value is high and the wear rate is low. Other research related showed the carbon solubility increases with an increasing Cr-equivalent and that higher Cr- and Ni-equivalents favor the formation of Cr-based M 7C3 over Fe-based Hägg (M5C2) carbide [14].

B. Vickers Method Micro Hardness Testing

Microhardness testing was performed on the blade using the Vickers method. Each specimen was given a compressive force of 10 kg at three test points on both untreated and treated specimens. The test results are presented in graphical form in Figure 7.

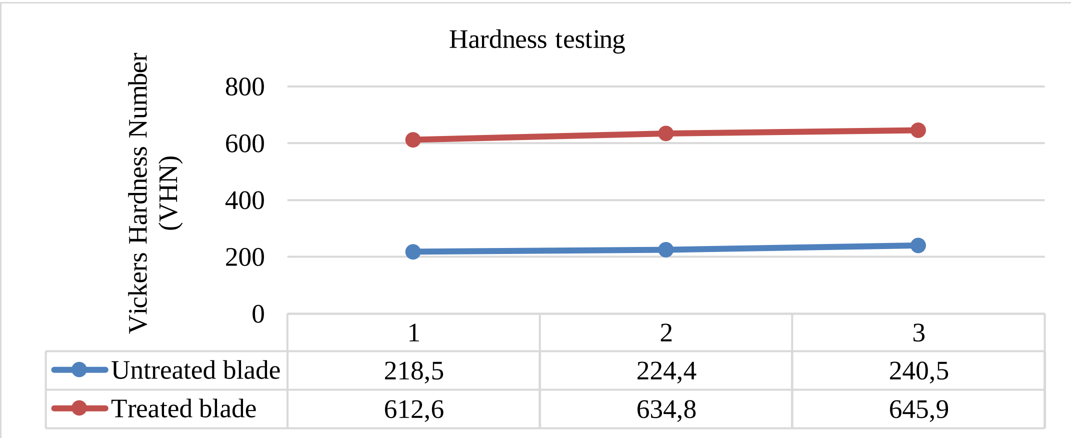

Figure 7. Hardness Testing by Vickers method

Figure 7 shows the microhardness testing data using the Vickers method of the test specimens. The blade without treatment has an average hardness value of 227.8 VHN, while the blade with treatment is 627.76 VHN. After the carburizing process using coconut shell charcoal, the hardness value increased in 175%. It is also evident from SEM-EDAX testing that there is a high carbon content in the blade with carburizing treatment. Other research related showed the carburizing process of AISI 4340 Steel with addition of 60 w/w% BaCO3:40w/w% Na2CO3 composition from pack carburizing can increase the average hardness value of 80.70 HRC and formed martensite microstructure [15].

C. Wear Testing

Wear testing was carried out using a wear machine. Because these blades are used repeatedly, the wear that is likely to occur can be classified as abrasive wear, meaning that wear occurs if hard particles or rough hard surfaces erode and cut the surface resulting in loss of material on the surface [16].

Table 3. Wear testing data

Spesimen	Initial Weight (gram)	Ending Weight (gram)	Lossing Weight (gram)	Lossing volume (mm^3)	Wear Rate (mm^3/menit)
Blade without treatment	201,01	199,34	1,67	212,1982	3,5366
Blade with treatment	197,25	197,19	0,06	7,6238	0,1271

From Table 3, the untreated blade experienced wear of 3.5366 mm^3/min while the wear rate of the treated blade was 0.1271 mm^3/min, which decreased by 96.4%. This shows that the treated blade has a high carbon content so that the wear rate is lower than the untreated blade. Other research related showed the carburizing process conducted in 940°C is best suited for mechanical and wear properties of mild steel because it could increase the resistance of wear [17].

CONCLUSION

The blades of the shredding machine are made from car leaf springs with JIS-SUP 9 steel material. The blades are analyzed for carbon content, hardness, and wear. For comparison, the blades were made in two conditions, namely treated and untreated blades. The treatment given is carburizing process at 700°C for 60 minutes with the addition of carbon from coconut shell charcoal then dipped quickly (quenching) into water cooling media. The treated blades experienced a 106% increase in carbon content from 9.7% to 20.014%. This increase in carbon content influenced the performance of the blade, namely the hardness became higher as shown by an increase in hardness value of 175% and the wear rate became 96.4% lower than the untreated blade.

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