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Utilization of Coconut Shell in Pack Carburizing Process of ST37 to the Rate of Wear at the Different Cryogenic Treatment

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Abstract

Coconut shell waste so far has been widely used as mainly only as traditional fuel. To increase the economic value of the coconut shell, it can be processed into activated carbon. In this study activated carbon was used as a carburizing pack material to increase the wear resistance of ST37 steel. The carburizing pack process is carried out by heating to austenite temperature (γ) with temperature variations of 800^{0}C, 850^{0}C and 900^{0}C with carburizing time for 1, 2 and 3 hours, then cooling by quenching in water. The development of methods to improve wear resistance of materials is carried out with an advanced process namely cryogenic treatment. Cryogenic processes were carried out by immersing the specimen in liquid nitrogen (temperature ± -195^{0}C) for 2 hours, 24 hours and 48 hours. Furthermore, wear testing is done using a rotary disc with a load of 10kg for 3 minutes. In general, based on test results, it appears that there is a decrease in the wear rate of ST37 steel which has undergone a carburizing pack process without a cryogenic process, from the raw material wear rate of 0,0003499685 g/m down to 0,0001166562 g/m to 0,0000272198 g/m or decreased wear rates ranging from 66% to 92%. While the specimens that received additional cryogenic treatment the wear rate decreased from 0.0000777708 g/m to 0.0000194427 g/m or decreased in the wear rate ranged from 78% to 94%. The lowest wear rate occurred in specimens with carburizing treatment at 900^{0}C for 2 and 3 hours, with cryogenic treatment for 48 hours. This shows that the carburizing pack process followed by the cryogenic process can reduce the wear rate of ST37 low carbon steel or it can be said to significantly increase its wear resistance.

Keywords: Actived carbon, pack carburizing, cryogenic treatment

IINTRODUCTIONS

Utilization of coconut shell waste has now evolved to be used as an activated carbon material which is used as a Pack Carburizing process media to increase surface hardness and metal wear resistance. The carburizing pack process utilizes activated coconut shell carbon at 900^{0}C with 90 minutes holding on low carbon steel in fact can increase the hardness of low carbon steel up to 13.5% from HV231.65 to HV 262.85 (Yahya et al, 2013). The results of the study of A. Suprapto, et al (2014) stated that cryogenic and tempering processes can increase the life of the carbide tool by up to 100% on Austempered Ductile Iron (ADI) metals. This is also supported by the results of the Suriansyah et al (2015) study which showed the influence of cryogenic cooling, temperament and temper treatment on FCD-45 increased violence by 9%. While the effect of cryogenic on Austempered Ductile Iron (ADI) chisels shows a 77% reduction in wear (A. Suprapto et al, 2016).

Low carbon steel cannot be hardened because its carbon content is insufficient to form a martensitic structure. Its surface can be hardened by the carburizing process. The results of the study using low carbon steel as a hoe, the surface hardened through a pack carburizing process can reach 686 HV (Surojo, E., et al., 2018), so based on previous research, researchers conducted a study by combining the carburizing pack process followed by the cryogenic treatment process on low carbon steel ST37. The method used in this study uses a pack carburizing process in activated carbon media from a coconut shell by heating to austenite (γ) temperatures of 800^{0}C, 850^{0}C and 900^{0}C. Warming is done with a variation of time for 1 hour, 2 hours and 3 hours, then cooling is done by dipping quickly in water. The results of the carburizing pack are then carried out the cryogenic treatment process immersed in liquid nitrogen at –195 ^{0}C variations in the immersion time of 2 hours, 24 hours, 48 hours, then heated to room temperature. The carburizing pack process aims to increase carbon content especially on the surface of low carbon steel. Cryogenic treatment is a process of cooling a steel material, stainless steel and others from room temperature to -320^{0}F (-196^{0}C) then at that temperature is held for a certain time and continued with heating to room temperature (Singh, S. et al., 2012). The purpose of this study is to improve the wear resistance of low carbon steel metals so that it can be applied to components that receive friction loads on surfaces such as gears (gear) but remain tenacious in the middle that accepts twisting loads. This study is about how to increase the wear resistance of low carbon steel ST37 with pack carburizing process at different temperature and holding time, then continued with cryogenic treatment at different immersion time.

Wear is the failure/damage to a solid surface due to gradual friction of two material surfaces so that the loss of material on a softer surface or removal of a number of materials from a surface as a result of relative movement between one surface with another surface. A Suprapto, et al (2017) research results showed an increase in wear resistance of 83% resulting from the Cryogenic Treatment process compared with the results of the Martemper process.

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MATERIALS AND METHODE

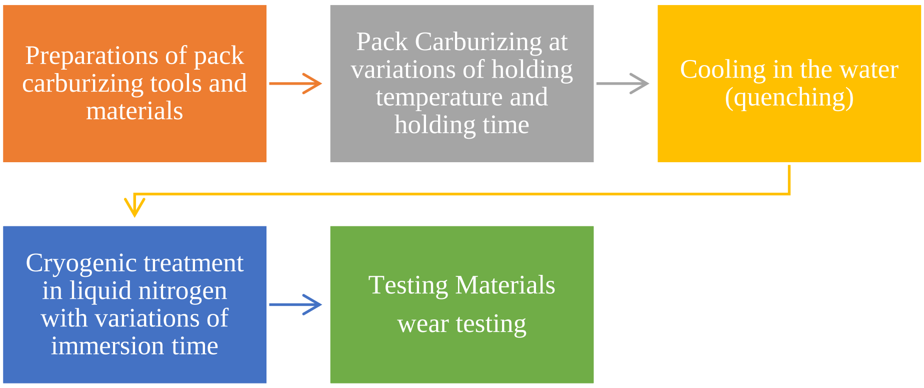
Raw material:

- Material: Low Carbon Steel ST37
- Dimension of specimen: 50x30x5 (mm)
- Chemical composition:

Table 1. Chemical composition of low carbon steel ST37

Element	Fe	C	Mn	P	S	Cr	Cu
percentage	98.42%	0.062%	0.75%	0.008%	0.006%	0.22%	0.1%

Arrangement of carburizing and cryogenic treatment



Research parameters for pack carburizing process:

- Pack carburizing temperature: 800^0C, 850^0C and 900^0C
- Cooling: quenching in water
- Holding time at each temperature variation: 1 hour, 2 hours and 3 hours
- Soaking time for liquid nitrogen (cryogenic treatment): 2 hours, 24 hours and 48 hours

Pack Carburizing steps:

a. The specimen (ST 37) is placed in a cementation box piled with activated carbon powder from coconut shell waste
b. Put the cementation box into the electric kitchen, and close it, turn on the electric kitchen until the temperature rises various to 800^0C, 850^0C and 900^0C, then hold the heating arrest with a variation of 1 hour, 2 hours and 3 hours.
c. Turn off the electric kitchen then open and remove the cementation box from inside the electric furnace by using holder. Next remove the test specimen and put it in the water cooling media.

Procedure for cryogenic treatment process:

a. Specimens after receiving the carburizing pack process are cooled in a liquid nitrogen tube at -195^0C.
b. Soaking time in a liquid nitrogen tube (temperature of -195^0C) held on variation of 2 hours, 24 hours and 48 hours.
c. Next removed from the cryogenic tube.

Wear Testing Procedure:

a. Measure the initial weight of specimen resulting from cryogenic treatment
b. The specimen is mounted on the wear resistance test clamp
c. Wear testing is carried out by loading 10 kg, 1000 rpm disc rotation, disc diameter 27.3 mm, test time for 3 minutes.
d. Measure the final weight of specimens after wear testing.
e. Count the rate of wear for specimens at all conditions

RESULTS AND DISCUSSIONS

Wear testing is carried out by loading 10 kg, 1000 rpm disc rotation, disc diameter 27.3 mm, test time for 3 minutes and its result :

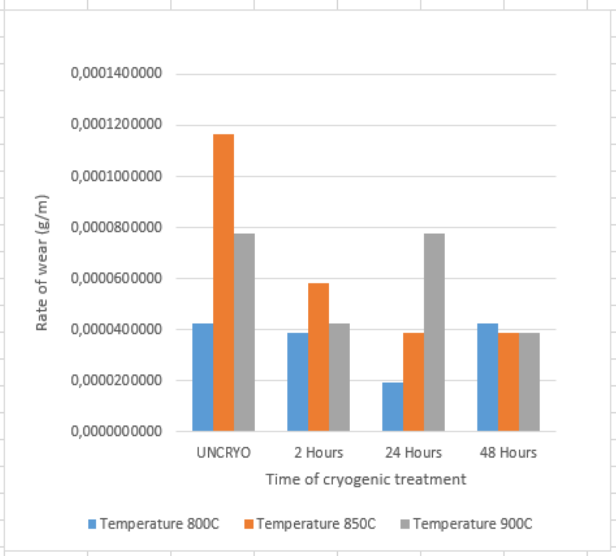
Table 2. Rate of wear ST37 after Carburizing and Cryogenic Treatment Pack Process

PROCESS	TEMPERATURE	CRYOGENIC TREATMENT			
		UNCRYO	2 Hours	24 Hours	48 Hours
RAW MATERIAL		0,0003499685			
CARBURIZING 1 Hours	800	0,0003629562	0,0000388854	0,0000194427	0,0000427739
	850	0,0001166562	0,0000583281	0,0000388854	0,0000388854
	900	0,0000777708	0,0000427739	0,0000777708	0,0000388854
Mean		0,0001857944	0,0000466625	0,0000453663	0,0000401816
CARBURIZING 2 Hours	800	0,0000272198	0,0000583281	0,0000388854	0,0000194427
	850	0,0000388854	0,0000388854	0,0000583281	0,0000388854
	900	0,0000972135	0,0000427739	0,0000388854	0,0000194427
Mean		0,0000544395	0,0000466625	0,0000453663	0,0000259236
CARBURIZING 3 Hours	800	0,0000388854	0,0000388854	0,0000583281	0,0000388854
	850	0,0000388854	0,0000388854	0,0000777708	0,0000388854
	900	0,0001166562	0,0000388854	0,0000699937	0,0000194427
Mean		0,0000648090	0,0000388854	0,0000686975	0,0000324045

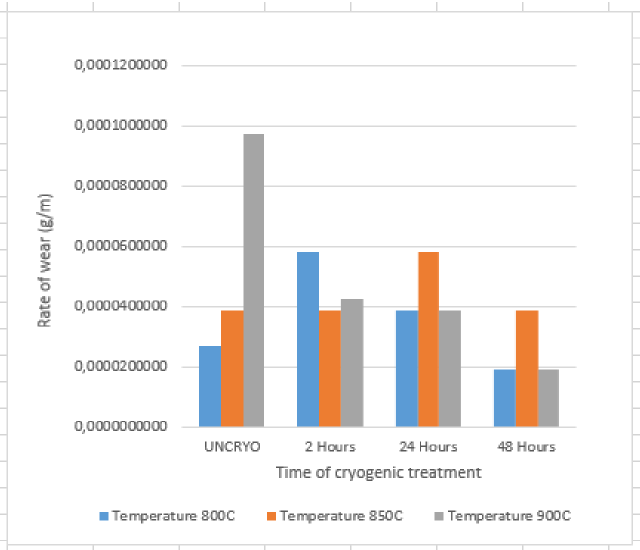
Table 2 shows the results low carbon steel ST 37 rate of wear before and after pack carburizing process with variations in the length of the heating time, in conditions without and with cryogenic treatment. Pack carburizing process are carried out at different temperatures and varying heating times. At cryogenic treatment, the carburizing pack specimens were immersed in liquid nitrogen with variations in the duration of immersion time of 2 hours, 24 hours and 48 hours. This table present the rate of wear ST37 at different holding time pack carburizing process and immersion time at cryogenic treatment these graphic present that relationship with rate of wear (g/m) at different carburizing temperature and different cryogenic treatment.

Graph 1 shows the wear rate of specimens resulting from carburizing packs with different cryogenic times and carburizing temperatures at a constant carburizing time of 1 hour. In general, there appears to be a decrease in the wear rate of the raw material compared to specimens that have undergone pack carburizing without cryogenic treatment or cryogenic treatment. The results of the rate of wear on specimens without cryogenic average of 0.0000790670 g / m to reach 0.0000401816 g / m on cryogenic treatment for 48 hours. This shows that with the increase in cryogenic time, the wear rate that occurs on average has decreased or increased wear resistance. Increased wear resistance of ST37 steel on average in specimens by carburizing for 1 hour without cryogenic processes reached 77% and increased to 88% in cryogenic treatments for 48 hours. So the longer the cryogenic process, the wear resistance of ST 37 steel will increase.

Meanwhile, when viewed based on differences in carburizing temperature in each cryogenic process the average wear rate increases with an increase in temperature so that wear resistance will decrease. The average wear resistance in specimens with 8000C carburizing process reaches 89% and decreases to 83% at 9000C temperatures. Decreased wear resistance with increasing temperature of the carburizing process is possible to cause the specimen to be softer due to high temperature so that it is easily scratched or high wear rate, but still much lower than raw material.

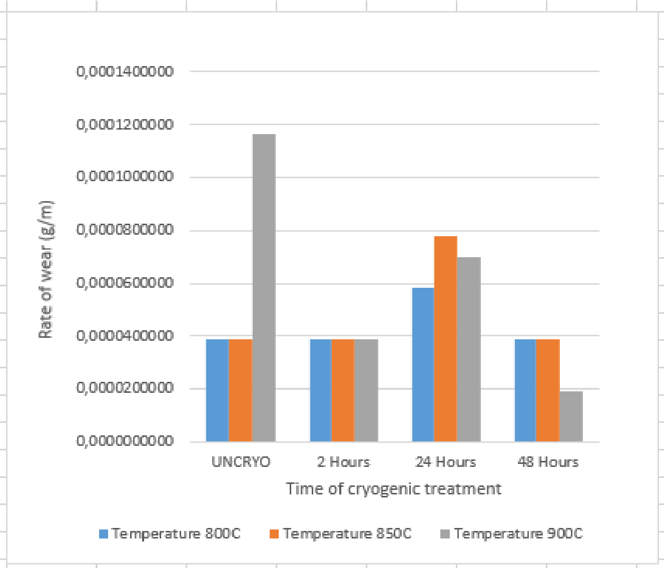


Graph 1. Effect of Cryogenic Treatment to Rate of Wear at 1 hour Carburizing Treatment



Graph 2. Effect of Cryogenic Treatment to Rate of Wear at 2 hours Carburizing Treatment

Graph 2 shows the wear rate of specimens resulting from carburizing packs with different cryogenic times and different carburizing temperatures at a constant carburizing time of 2 hours. In general, there appears to be a decrease in the wear rate of the raw material compared to specimens that have undergone pack carburizing without cryogenic treatment or cryogenic treatment. The results of the rate of wear on cryogenic specimens on average by 0.0000544395 g / m to reach 0.0000259236 g / m on cryogenic treatment for 48 hours, so it can be said that with increasing cryogenic time the average wear rate decreases. Increased wear resistance of ST37 steel up to 2 hours carburizing up to a maximum of 92% in cryogenic treatment for 48 hours. Meanwhile, when viewed based on differences in carburizing temperatures in each cryogenic process the average rate of wear increases with an increase in temperature. The reduction in wear rate compared to ST 37 raw material at 8000C was 89% and decreased to 85% at 9000C. The results from the graph show that the results of pack carburizing with increasing temperature will reduce the rate of wear which means that wear resistance is increasing.



Graph 3. Effect of Cryogenic Treatment to Rate of Wear at 3 hours Carburizing Treatment

Graph 3 shows the wear rate of specimens resulting from carburizing packs with different cryogenic lengths and carburizing temperatures at a constant carburizing time of 3 hours. In general, there appears to be a decrease in the wear rate of the raw material compared to specimens that have undergone pack carburizing without cryogenic treatment or cryogenic treatment. The results of the rate of wear on cryogenic specimens by an average of 0.0000648090 g / m to reach 0.0000324045 g / m in cryogenic treatment for 48 hours, so it can be said that with increasing cryogenic time the average wear rate decreases. Increasing the cryogenic time to 48 hours will increase the wear resistance of ST37 steel by up to 90%. Meanwhile, when viewed based on differences in carburizing temperatures in each cryogenic process the average wear rate increases with an increase in temperature. Specimen wear resistance in the 8000C carburizing process was 87% and decreased 82% at 9000C. Based on the data above, a decrease in rate of wear occurs when the temperature of the carburizing process increases, while an increase in cryogenic time increases wear resistance.

Based on the data in table 2 it can be calculated that the average increase in wear resistance in specimens with different carburizing times is an increase in wear resistance with increasing carburizing time. When compared with raw steel ST37 material, there will be an increase the wear resistance significantly 84% to 87%.

CONCLUSION

The conclusion of carburizing and cryogenic treatmen of steel ST 37 are:

a) Wear resistance will increase at longer time of carburizing process.

b) Wear resistance will increase at longer time of cryogenic time.

c) Wear resistance of low carbon steel will decrease at higher carburizing temperature.

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