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Behavior Effects of Carburizing and Cryogenic Treatment to the Wear Rate of Spur Gear with Load and Rotation Variations

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Abstract

This study purposed to understand the effect of carburizing and cryogenic treatment on the wear rate of spur gear. This study was related to wear of spur gear that tested of hardness and wear rate on some of spur gear treatment that made from SCM 440 steel with variations of load and rotations. The treatment of spur gear were conducted by carburizing process at 950°C for 2 hours and then cryogenic treatment (soaking in liquid nitrogen) at -195°C for 48 hours. Analysis of this test was conducted by analytical methods and hardnes testing. The findings of this research were (1) specimen with carburizing and cryogenic treatment has the highest value of surface hardness compared to carburizing specimen with uncryogenic treatment, (2) the smallest rate of wear area was obtained for carburizing and cryogenic treatment specimen and the highest rate of wear occurred to specimen without treatment.

Keywords: Cryogenic, carburizing, wear of rate, load, rotation.

1. INTRODUCTION

Two objects that are in contact with each other and move relative to each other will cause friction. The friction will cause a damage are loss of material from the surface of the object called wear.Wear occurs on two objects which have a lower hardness. Factors that influence wear are rotational speed, magnitude of load, surface roughness and hardness of the material. The results of another study, stated that ADI cutting tool with cryogenic treatment and soaking for 48 hours, cutting speed Vc = 70 m/min, feed motion f = 0. 1 mm/rotation and cutting depth a = 1 mm show that wearing of cutting tool edge decrease 77% than untreated [1].

In addition, friction between spur gear also produces heat which greatly affects wear. It is stated in the material study that the hardness of the material will decrease with increasing surface temperature. The impact of friction between two materials can be reduced by increasing the surface hardness of objects. An increment the hardness of low carbon steel up to 13.5% from HV231.65 to HV 262.85 as the result of the carburizing pack process utilizes activated coconut shell carbon at 900^0C with 90 minutes holding on low carbon steel [2].

Research about cryogenic treatment on ADI (Austemper Ductile Iron) which indicatesthe increase in hardness for 18% as the result of Subzero treatment [3]. The influence of cryogenic cooling, martemper and temper treatment on FCD-45 increased hardness by 9% [4]. This is also supported by another study result show that hardness of martemper is HRc 51.33, and Cryogenic treatment resulted with HRc 55.33, indicating an increase in hardness, results of cryogenic treatment show an increase of 83% in wear resistance compare to martemper process result [5].

Nowadays, there have been many studies that discuss the wear of gears, especially spur gears. However, in this case, what is often examined is wear and tear after the gears wear due to the mechanism of action in a certain time and condition. Based on this, this study is associated with a review of the wear rate of spur gears with variations in load and rotation.

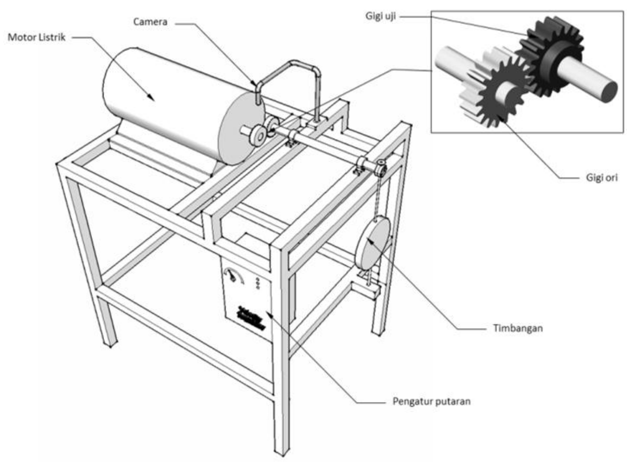

Fig 1. Setup of gear wear testing

Retrieval of wear data in this study focused on calculating the area of spots as a sign of the rate of wear on a spur gear due to variations in load and rotation with various constraints. The limitations of the problem are (1) testing the wear of gears in dry conditions (without lubrication) (2) the basic material of a spur gear is SCM440 (3) variations in load 0 kg, 5 kg and 10 kg (4) rotation variation of 200 rpm, 500 rpm and 1000 rpm.

2. METHODOLOGY OF RESEARCH

The study begins with the preparation of test equipment in the form of wear test equipment with the main parts being

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3-phase electric motors, electric motor speed regulators, weighing scales and tachometers as gauges for rotating spur gear. The working process of the gear wear testing machine is shown in Figure 1. which is a variation of the test carried out by adjusting the speed regulator of the electric motor and giving loading to the shaft rotated by the electric motor.

The spur gears tested were based on JIS standard SCM440 with their chemical composition being C = 0.38%; Si = 0.15%; Mn = 0.6%; P = max 0.03%; S = max 0.03%; Cr = 0.9%; Mo = 0.15%; Ni = max 0.25%; Cu = max 0.3%. The gears are made using a manual hobbing machine that uses a gear module (m) of 3 with the number of teeth (z) equal to 18.

Fig 2. Fixturing the gears in the carburizing process

The carburizing process on the spur gears is conducted by providing protection on both sides of the gears see Figure 2. So that in this carburizing process, only the gear profile that gets the carburizing process carried out at a temperature of 950 ºC for 2 hours with carburizing material is coconut shell carbon.

The cryogenic process is carried out with the aim of increasing the hardness of a spur gear surface. In the cryogenic process using Nitrogen liquid media with a temperature of -159 ºC. The gears result from the carburizing process at a temperature of 950 ºC for 2 hours and then dipped in a flask filled with liquid Nitrogen and soaked for 2 hours.

The results of the spur gears tested are photographed for each tooth surface. An example of a photo of spur gear wear can be seen in Figure 3.

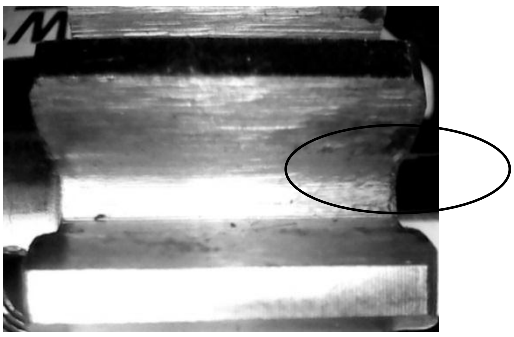

Fig 3. Sample photo result of a spur gear with a variation of 0 kg load, 200 rpm rotation and testing time 30 minutes.

Photo of the test results (Figure 3), then processed using the AutoCAD software. By using the AutoCAD sketch command, then we can calculate the area of spur gear wear with the area command.

3. RESULT AND DISCUSSION

This section will discuss and analyze the results of research on the Behavioral Effects of Carburizing and Cryogenic Processes on the Wide Wear Rate of Spur Gears With Load and Rotation Variations. Discussion.

3.1. Hardness Profile Test Results of Gears

The hardness profile testing of the gears is carried out using a Rockwell hard testing machine with type A indenter which produces a hardness value in HRA units. Based on Figure 4 it can be seen that carburizing treatment using activated carbon from shell waste will be able to increase the surface hardness of the spur gear profile by 4.40 HRA (5.22%) while the additional cryogenic treatment process will further increase the hardness value of the spur gear profile by 7.75 HRA (10.17%) of hardness spur gear profile without treatment.

The condition of increasing the spur gear surface hardness profile matches the purpose of the treatment being carried out. This illustrates that the process of adding carbon elements to the surface of the gear profile has been successfully carried out. In addition, the cryogenic process has also been successfully carried out by showing the value of the hardness of the process increased by about 10%..

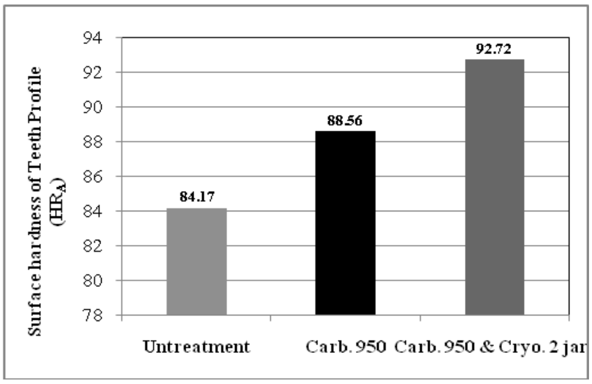

Fig 4. Graph of surface hardness measurement o gear profile

3.2. Wear Rate of Spur Gear in Load Variation

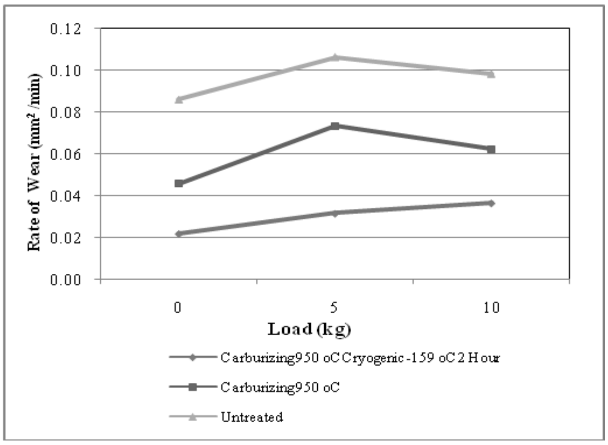

Fig 5. Graph of wear rate of spur gears in load variations

Based on Figure 5 it can be seen that the greater the load the overall wear rate of the spur gear profile will increase. The highest increase in wear rate occurred in the spur gear profile which was not subject to treatment (untreated) of 0.02 mm^2 / min (0.25%).This is influenced by the spur gear profile that does not experience the treatment that has the lowest hardness value.

3.3. Spur Gear Wear Rate in Rotation Variation

Figure 6 shows that the higher the rotation applied to the spur gear profile, the wear rate will increase. However, a fairly large increase (large slope) occurs at rotations below 500 rpm, but an increase in wear rates above 500 rpm tends to be more gentle (low slope).

Increased wear rate with rotational variation also shows that the gear profile that did not undergo treatment was the largest at 0.04 mm2 / min (5%).This is influenced by the spur gear profile that does not experience the treatment that has the lowest hardness value.

According to the results of general testing that the carburizing treatment process 950 ºC and cryogenic process 2 hours has increased the surface hardness profile of the teeth. So that the increase in the value of the hardness has implications for the slowing of the wear rate of the spur tooth profile given a variation of loading and rotation variation.

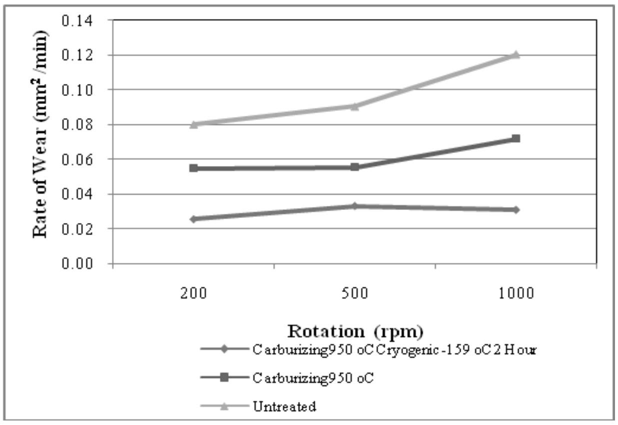

Fig 6. Graph of wear rate of spur gears in rotation variation

4. CONCLUSION

1. The hardness of carburizing treatment using activated carbon from shell waste will increase the surface hardness of the spur gear profile by 4.40 HRA (5.22%) while the additional cryogenic treatment process will further increase the hardness value of the spur gear profile by 7.75 HRA (10.17 %) of hardness of spur gear profile without treatment.
2. The higher the surface hardness of a spur tooth profile, the smaller the rate of growth of the wear
3. Carburizing and cryogenic treatments have been shown to increase surface hardness of the tooth profile so that the rate of wear growth can be slowed.

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