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Effect of Quenching Media on the Strength of AISI 1045 Steel Applied to Chain Sprockets: Impact Test Method

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ABSTRACT

A chain sprocket is a geared wheel attached to a chain, track, or other long geared object made of AISI 1045 steel, which is subjected to friction and pressure in its application. Each steel has different characteristics, such as physical, mechanical, and chemical properties; therefore, it needs a special handling which is expected to have a longer life from the design, then the wear resistance of the material can be done through heat treatment by hardening followed by a quenching process using oil, salt solution and water aimed at increasing resistance to friction and pressure. The results of the impact test on AISI 1045 steel (original) have shown an average of 10.24 joules while the steel by hardening and quenching with various media has proved to show a higher average value, for instance, the AISI 1045 steel by oil, its value is 53.35 joules, by salt solution 69.02 joules, and by water 91.60 joules. Meanwhile, the average impact strength of AISI 1045 steel (original) is 0.128 J/mm^2, 0.665 J/mm^2 by oil, 0.862 J/mm^2 by salt solution, and 1.144 J/mm^2 by water.

Keywords: Sprocket chains, AISI 1045 steel, hardening, quenching

INTRODUCTION

Concerning materials, two methods of heat treatment to increase the hardness value of steel are noted as heat treatment and plastic deformation. Carbon steel which is heated to the austenitic temperature and then cooled rapidly will form a martensitic structure which has a higher hardness than the pearlite or ferrite structure; this process is called quenching. Steel specification of AISI 1045 is a medium carbon steel has a carbon composition ranging from 0.43 to 0.50%. This steel is generally used as an automotive component, for example, for gear components in motorized vehicles by which, in its applications, often undergoes friction and pressure, so it is resistant to wear and hardness is very much needed[1].

To get the hardness and wear resistance of the material can be done through heat treatment by means of hardening followed by a quenching process. The goal is to get a hard martensitic structure and has good wear resistance. From the quenching process, specimens often experience cracking, distortion and non-uniformity of hardness caused by the non-uniform temperature of the cooling solution[2].

In the quenching process, heat transfer occurs from the coolant dissolving steel specimen which is characterized by the formation of air bubbles which then continues with the formation of an air envelope on the surface of the specimen. The presence of this air shroud can make the cooling rate smaller than the critical cooling rate[2]. The decrease in the cooling rate can cause the martensite phase to fail to form. Therefore, to increase the time for air envelope formation or to increase the cooling rate, an aqueous medium is needed in the agitation quenching device.

The formulation of the problem in this paper is to compare toughness by carrying out the impact testing process on AISI 1045 steel with a hardening process then quenching it with the media oil, salt solution, and water used in motorcycle chain sprockets. The limitation of the problem in this paper covers the impact of testing using AISI 1045 steel material used in motorcycle chain sprockets with a hardening process which is then quenched with the media.

This paper is aimed at obtaining the absorbed energy value of the original AISI 1045 steel material and with the hardening process which is then quenched with oil, salt solution and water used in motorcycle chain sprockets, at getting the value of the impact strength of the original AISI 1045 steel material and with the hardening process which is then quenched with the media used in motorcycle chain sprockets, and at comparing the original AISI 1045 steel material and with the hardening process which is then quenched with the media used in motorcycle chain sprockets[3].

METHODS

Location and time

Research/testing was carried out at the Mechanical Engineering Laboratory of the University of North Sumatra (USU) as shown in Table 1.

Table 1. Activities and locations

Activities	Location
Manufacturing of impact test specimens	Mechanical Engineering Laboratory, Universitas Sumatera Utara
Impact test examination	Mechanical Engineering Laboratory, Universitas Sumatera Utara

Tools and materials

In the impact testing process, it is very important that tools and materials are used for testing and help make impact test material specimens. The tools used for the manufacture and impact testing process include scrap machine, grinding machine sits, grinding machine, hand grinding machine, sigmate (caliper), meter, steel calipers, steel bar, blander, and impact test equipment[4]. The material is AISI 1045 steel (see Fig. 1).

Figure 1. AISI 1045 steel

Process for impact test specimens making

Manufacture of impact test specimens must be carried out with a predetermined size. The steps for making impact test specimens are carried out in two steps[5].

1. The cutting of AISI 1045 steel specimen with saw machine

The AISI 1045 steel is initially cut using an iron saw and the process can be seen in Fig. 2.

Figure 2. Cutting process of AISI 1045 steel

2. AISI 1045 steel scraping

Steel previously cut with a saw machine is then scraped with scraping machine to get a predetermined size (see Fig. 3).

Figure 3. Scrapping process

Impacts of testing process

Impact of specimen measurement test

First of all, the impact of material test for DIN 2344 steel is measured in advance for the thickness, width and length of the material as shown in Fig. 4[6].

Figure 4. Material measurement of impact test

Installation of impact test specimens

The impact test material is installed in the impact test stub of the impact tester. The impact test material fits perfectly before the pendulum is swung to hit the impact test material and can be seen in Fig. 5[7].

Figure 5. Installment of impact test material

Setting needle in position 0

The impact of material test is installed snugly and the needle must be set first to a value of 0, as shown in Fig. 6[8].

Figure 6. Needle setting at impact rating

Untie the pendulum arm

The pendulum is released or dropped to strike the impact test material snugly in the notches made to be struck in the impact test material (see Fig. 7)[9].

Figure 7. Hitting process of impact test material

Observing the value on the needle guide of the impact tester

After the pendulum is dropped and has hit the impact test material, attention should be focused on the direction of the needle which should lies with the existing values so that calculations can be carried out on the impact test formulas (Fig. 8)[10].

Figure 8. needle observation after test

Analyzing materials after testing

After the testing process finishes, the impact test material is analyzed to see whether the test material is broken or not (see Fig 9)[11].

Figure 9. Impact test material after testing process

RESULTS AND DISCUSSION

Table 2 shows the comparison results of AISI 1045 steel material (original) with hardened AISI 1045 steel and with several variations of quenching. From the results of the data obtained from the test results attached in Table 2 above, the additional information can be explained in Fig. 10.

Table 2. Impact test results on AISI 1045 steel

	Types of AISI 1045 steel specimen							
	Original		Oil		Saline solution		Water	
	E_{serap}	Is	E_{serap}	Is	E_{serap}	Is	E_{serap}	Is
I	8,72	0,109	51,81	0,647	67,66	0,847	86,53	1,082
II	10,24	0,128	53,74	0,669	69,70	0,870	93,04	1,160
III	11,78	0,147	54,51	0,681	69,70	0,871	95,24	1,190
Everage	10,24	0,128	53,35	0,665	69,02	0,862	91,60	1,144

1. Absorption comparison ($E_{Absorved}$) of impact test results of original AISI 1045 steel

Figure 10 shows the comparison of the absorption energy of the original AISI 1045 steel after heating (hardening) with variations in quenching media; the average results of impact test with $E_{absorved}$ value on the original steel is 10.24J, while the steel hardened by quenching oil absorbs 53.35J, absorbs salt solution of 69.02J, and absorbs water of 91.60J. So, the highest absorption is found in hardened and quenched steel using the water method with $E_{absorved}$ value of 91.60J. Meanwhile, the lowest $E_{absorved}$ value is found in original steel with an absorption value of 10.24J.

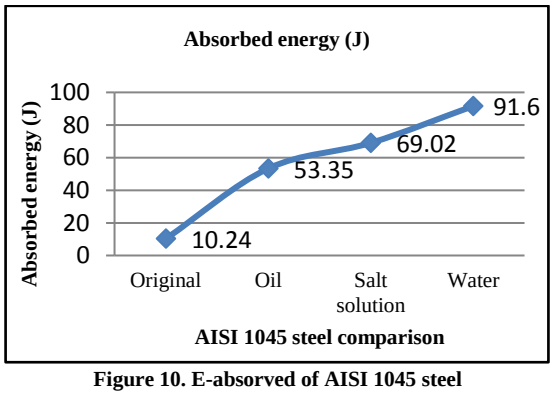

Figure 10. E-absorved of AISI 1045 steel

2. Strength comparison of impact test results of original AISI 1045 steel

Figure 11 shows the comparison of the impact strength of the original AISI 1045 steel after heating (hardening) with variations in quenching oil, salt solution, and water; it can be seen that the average of the impact test results with each impact strength value on the original steel has an average of 1.128J/mm^2, while the steel that is hardened by quenching oil has a value of 0.665 J/mm^2, by salt solution of 0.862 J/mm^2, and by water of 1.144J/mm^2. Then, the steel that gets the highest strength value is hardened and quenched using the water method consisting strength value of 1.144J/mm^2. The lowest strength value is found in original steel with a value of 0.128 J/mm^2.

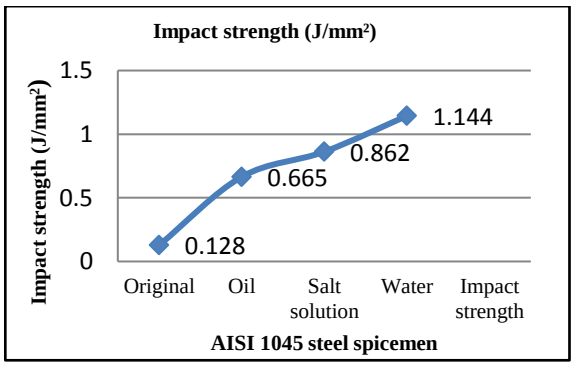

Figure 11. Comparison chart of average impact strength of AISI 1045 Steel

CONCLUSION

Based on the results of the impact test on the original AISI 1045 steel material and AISI 1045 steel by hardening process at 800^0 and quenching with several media variations, conclusions can be drawn. The impact test results of original AISI 1045 steel material and of 800^0 heating as well as quenching with the determined media produces energy absorption ($E_{absorved}$) of 10.24J for original steel, 53.35J for oil, 69.02J for salt solution, and 91.60J for water. The impact test results of the original AISI 1045 steel material by 800^0 plus quenching with the determined media produces an impact strength value

with an average of 0.128 J/mm^2 for original steel, 0.665 J/mm^2 for oil, 0.862 J/mm^2 for salt solution, and 1.144 J/mm^2 water. From the average value of ($E_{absorved}$ and impact strength resulted from impact testing on original AISI 1045 steel at 800^0 plus quenching proves that the steel has absorption energy and greater impact strength compared to the original AISI 1045 steel.

Declaration by Authors

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