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Effectiveness of Palm Oil Waste Cooling Media to Increase Surface Hardness of AISISAE 1020 Steel Under Pack Carburizing Quenching

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ABSTRACT: *The effects of various cooling media on the hardness of AISI SAE 1020 steel that was pack carburized were investigated. The carburizing media were charcoal powder and barium carbonate ($BaCO_3$) with a ratio of 70:30 by weight percentage. Pack carburizing was carried out at various temperatures of 825°C, 850°C, and 900°C with a soaking time of 90 minutes, quenched with cooling media, water, waste palm oil and palm oil to room temperature. Furthermore, hardness testing was carried out using the Vickers method and microstructure testing. The results surface hardness number, microstructure of AISI SAE 1020 steel specimen given pack carburizing heat treatment is influenced by the use of cooling media. The use of waste palm oil cooling media is better because in addition to the high surface hardness number of the specimen, it is also more ductile compared to water cooling media. The percentage of ferrite microstructure is greater, compared to water cooling media, less than palm oil cooling media. So that palm oil waste is suitable for use as a cooling media in the AISI SAE 1020 steel pack carburizing process.*

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I. INTRODUCTION

SAE AISI 1020 steel material is a low carbon steel known for its excellent machinability and weldability. This mild steel is characterized by its balanced composition, which gives it favorable mechanical properties and versatility in a variety of applications. The carbon content, which affects hardness and strength, is found in SAE AISI 1020 in the range of 0.17% to 0.23%. This relatively low carbon content ensures that the steel remains ductile and easy to machine, making it suitable for applications requiring moderate strength and high workability.

Low carbon steel AISI SAE 1020 has a number of disadvantagesdespite its popularity. The main drawbacks are its low strength due to its carbon content of only about 0.20%, this steel has lower tensile strength and hardness than medium or high carbon steelwere discussed bySantoso et al., [1]. Its low hardness results in low wear resistance, making it unsuitable for applications that experience heavy friction or constant wear without additional heat treatment was provided by Karim et al.,[2]. It is not suitable for long-term high temperature applications because its strength will quickly decrease had investigated by Marulandaet al., [3]. Like most carbon steels, AISI SAE 1020 does not have good corrosion resistance and needs to be coated or protected for use in humid or corrosive environmentshad studied byEbraheem et al., [4]. It is difficult to harden by rapid cooling, due to its low carbon content, this steel cannot be significantly hardened by heat treatment such as quenching without the addition of alloying elements.

The final product made of low carbon steel material, the surface hardness often does not meet the requirements. In order to meet the surface hardness requirements such as high carbon steel, low carbon steel is given case hardening treatment. The purpose is to increase the hardness of parts that need to be hard externally to withstand wear, but soft internally to withstand vibrationwere discussed by Nasution et al., [5]. Review of pack carburizing methods were discussed byBoumediri et al., [6] low carbon steel is heated to red at a certain temperature, then coated with charcoal powder, so that carbon atoms diffuse to the surface, producing a surface structure with higher hardness. The heat treatment process to increase the surface hardness is usually called carburizing. Based on the media used, carburizing is divided into pack carburizing (using solid media), liquid carburizing (using liquid media) and gas carburizing (using gas media). The pack carburizing process is generally carried out at temperatures between 850 °C and 950 °C and then held at that temperature for a certain period of time (soaking time)was provided by Ramadhanet al.,[7]. According to researchOyetunji et al., [8] at the austenitization temperature for low carbon steel AISI SAE 1020 ranging from 870 °C to 920 °C, the crystal structure changes from the BCC phase (ferrite) to austenite (FCC phase). In this austenitic region; there is high solubility for carbon and the depth of the carburized steel casing is a function of the carburization time and the carbon potential available on the surface were discussed by Lichioiu et al., [9].

From the previous study, it is very necessary to conduct research aimed at experimentally investigating the effect of palm oil waste as a cooling medium on the surface hardness and microstructure changes of AISI SAE 1020 steel in pack carburizing cooling. The effect of pack carburizing parameters such as carburizing temperature, soaking time, and cooling media, on changes in surface hardness and microstructure changes of AISI SAE 1020 steel has been investigated..

II. EXPERIMENTAL SETUP

In general, the experimental setup of the pack carburizing process is shown in Figure 1. The main equipment used is an electric furnace, with the condition that it can reach a heating temperature of 900–950°C. A carburizing box made of heat-resistant steel plate, as a place for the specimen, which is evenly wrapped with carburizing media. Carburizing media consists of charcoal powder as a carbon source and an energizer or activator such as barium carbonate ($BaCO_3$) which functions to accelerate chemical reactions, accelerate carbon release. Quenching setup and cooling media, in the form of water, palm oil waste and palm oil.

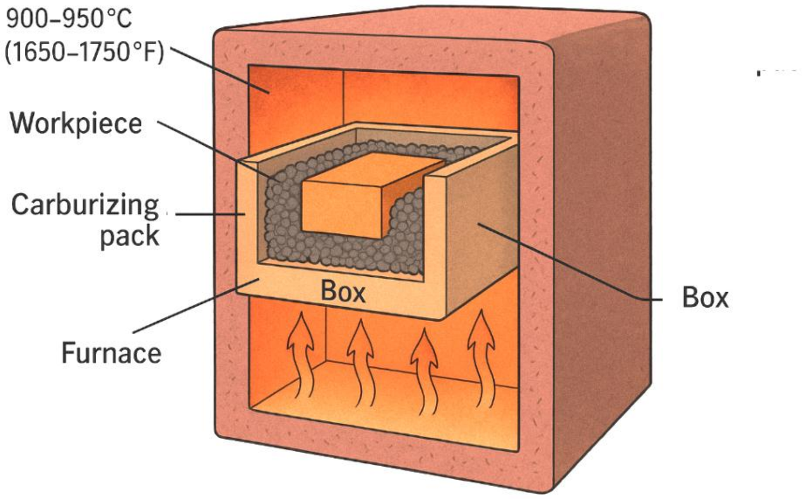

Fig. 1 Experimental setup for pack carburizing process

Pack Carburizing Process, shown in Figure 2. In the preparation stage, the specimen is cleaned from dirt/oil, inserted into the carburizing box with carburizing media (a mixture of charcoal powder and energizer ($BaCO_3$). with a ratio of 70:30 weight percentage

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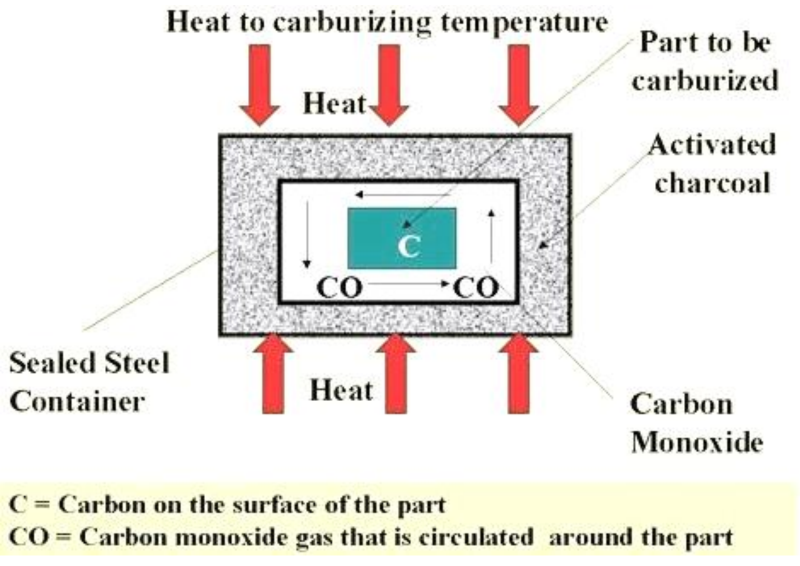

Fig. 2 Pack carburizing process

The carburizing box is tightly closed and then inserted into the electric furnace, heated to a temperature of 900°C, soaking time 90 minutes. The carburizing media decomposes to form CO gas. CO gas approaches the steel surface and decomposes into C (carbon) + CO_2 . Carbon diffuses to the surface of the specimen. After the pack carburizing process is complete, the specimen is immediately removed and dipped into the cooling media.

III. RESULTS AND DISCUSSION

Hardness testing using the Vickers method, refers to the ASTM E92 standard. The aim is to determine the surface hardness of the specimen after pack carburizing treatment with variations in cooling media. Surface hardness testing using the Vickers Microhardness Tester Mitutoyo HM-122. The hardness value is obtained by forcing a 10 mm diameter diamond indenter into the surface of the steel sample under static load. The test was repeated three times.The average results of the surface hardness test using the Vickers method after pack carburizing treatment for each variation of cooling media used are shown in Figure 3.

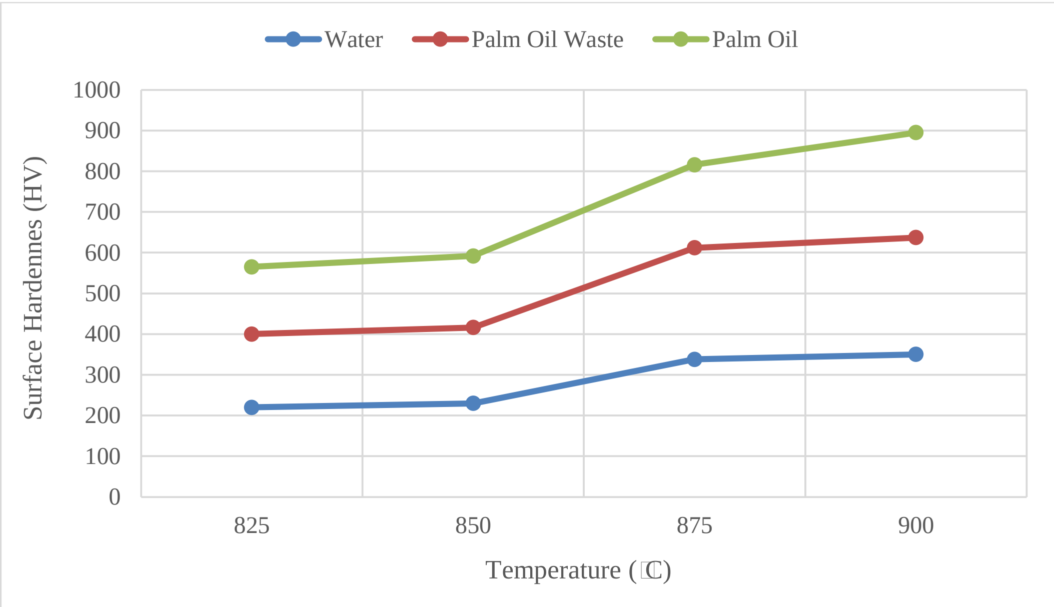

Fig. 3 Effect of cooling media on surface hardness of AISI SAE 1020 steel

The surface hardness number of AISI SAE 1020 steel specimens given pack carburizing heat treatment by heating at a temperature of 825˚C with variations of cooling media of water, waste palm oil, palm oil respectively around 222, 180, 165 HV. At carburizing temperature heating of 850 ˚C, with variations of cooling media respectively the hardness number is around 230, 186, 176 HV. At carburizing temperature heating of 875 ˚C, with variations of cooling media respectively the hardness number is around 338, 274, 204 HV. At carburizing temperature heating of 900 ˚C, with variations of cooling media respectively the hardness number is around 350, 287, 258 HV. Overall, the highest hardness number obtained in the pack carburizing process is by using water media. In line with research results by Rochmad et al., [10]. The use of waste palm oil cooling media also provides a higher surface hardness number compared to the use of palm oil cooling media, in accordance with the conclusion of the research results Sujita et al.,[11].. The use of waste palm oil cooling media is better because in addition to the high surface hardness number of the specimen, it is also more ductile compared to water cooling media. The percentage of ferrite microstructure is greater.

In this study, metallographic testing of the specimens was carried out using an optical microscope with a magnification of 500x. Furthermore, microstructure photos were analyzed using Image J software to determine the content of ferrite, pearlite, martensite of AISI SAE 1020 steel, due to differences in cooling media after pack carburizing**.**The results of metallographic testing are shown in Figure 4.

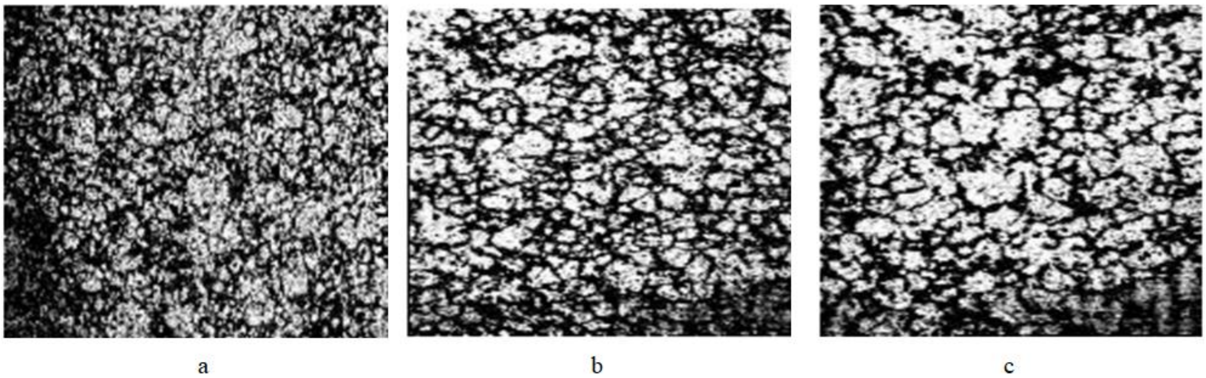

Fig. 4 Effect of cooling media on microstructure of AISI SAE 1020 steel

Based on metallographic testing, shown in Figure 4., the difference in cooling media affects the percentage of microstructure formed on the surface of AISI SAE 1020 steel specimens. Figure 4a. shows the microstructure formed on the specimen using water cooling media, after pack carburizing treatment produces 68% Pearlite and 32% Ferrite microstructure. Figure 4b. shows the microstructure formed on the specimen using waste palm oil cooling media produces 58% Pearlite and 42% Ferrite, Figure 4c, shows the microstructure formed on the specimen using waste palm oil cooling media produces47% Pearlite and 53% Ferritemicrostructure. The results of this study are in accordance with the results of the study Ambiger[12]

IV. CONCLUSION

Surface hardness number, microstructure of AISI SAE 1020 steel specimen given pack carburizing heat treatment is influenced by the use of cooling media. The use of waste palm oil cooling media is better because in addition to the high surface hardness number of the specimen, it is also more ductile compared to water cooling media. The percentage of ferrite microstructure is greater, compared to water cooling media, less than palm oil cooling media.So that palm oil waste is suitable for use as a cooling agent in the AISI SAE 1020 steel pack carburizing process.

REFRENCES

[1]. Santoso, E., Fatkhurrohman, F., Firmansyah, A. R., & Putra, S. C. (2024). Hardness and Microstructural Characterization of Pack Carburizing AISI 1020 Low-Carbon Steel by Temperature and Holding Time Variations. *Advance Sustainable Science, Engineering and Technology*, *6*(1), 2–9. https://doi.org/10.26877/asset.v6i1.17583

[2]. Karim, A., Azmy, I., Khoiriah, S. Q., & Bintoro, C. (2022). Microstructure and Mechanical Properties of Pack Carburized AISI 1020 Steel Using Na2CO3 and CaCO3 Catalysts. *Journal of Renewable Energy and Mechanics*, *5*(02), 52–59. https://doi.org/10.25299/rem.2022.vol5.no02.9965

[3]. Marulanda Cardona, V. F., et al. (2017). Effects on hardness and microstructure of AISI 1020 low-carbon steel processed by high-pressure torsion. Journal of Materials Research and Technology 6(4): 355-360

[4]. Ebraheem, A. A. and Fairouz, L.K. (2019). Effect of Mechanical Surface Treatments on Impact Strength for Low Carbon Steel AISI 1020. IOP Conference Series: Materials Science and Engineering 518(3)

[5]. Nasution, M. and Nasution, R. H. (2020). Analisa Kekerasan Dan Struktur Mikro Baja AISI 1020 Terhadap Perlakuan Carburizing Dengan Arang Batok Kelapa. Buletin Utama Teknik 15(2): 165-173

[6]. Boumediri, H., Touati, S., Debbah, Y., Selami, S., Chitour, M., Khelifa, M., Kahaleras, M. said, Boumediri, K., Zemmouri, A., Athmani, M., & Fernandes, F. (2024). Effect of carburizing time treatment on microstructure and mechanical propertiesof low alloy gear steels. *Materials Research Express*, *11*(7). https://doi.org/10.1088/2053-1591/ad5cd6

[7]. Ramadhan, M. R., & Sunyoto, S. (2022). Pengaruh Temperatur Pada Pack Carburizing Menggunakan Campuran Arang Tempurung Kelapa Dan Arang Bambu Terhadap Kekerasan Dan Struktur Mikro Baja EMS 45. *Jurnal Rekayasa Mesin*, *17*(3), 527. https://doi.org/10.32497/jrm.v17i3.3468

[8]. Oyetunji, Akinlabi & Adeosun, Samson. (2012). Effects of Carburizing Process Variables on Mechanical and Chemical Properties of Carburized Mild Steel. Journal of Basic & Applied Sciences. 8. 10.6000/1927-5129.2012.08.02.11.

[9]. Lichioiu, Iuliana. (2022). Pack Carburizing Effect on Microstructure and Hardness of 1.7131 Steel. RECENT - REzultatele CErcetărilor Noastre Tehnice. 23. 112-117. 10.31926/RECENT.2022.68.112.

[10] Rochmad Winarso, Slamet Khoeron, R. W., & Darmanto. (2023). Effect of cooling media on hardness and microstructural changes in S45C carbon steel during heat treatment process. *Polimesin*, *20*(2), 121–127. https://e-jurnal.pnl.ac.id/polimesin/article/view/3626/3230

11] Sujita, S., Okariawan, I. D. K., & Hakim, L. (2023). Characteristics of ASTM A36 steel mechanical properties in pack carburizing with carburizing agent coconut shell charcoal and goat bone powder mixed. *Dinamika Teknik Mesin*, *13*(1), 57. https://doi.org/10.29303/dtm.v13i1.619

[12] Ambiger, K. D., Murthy, B. R. N., Hiremath, P., & Shivamurthy, R. C. (2025). In fl uence of gas carburization on the microstructure , mechanical properties , and alloying elements behaviour in plain and alloyed low carbon steels. *Materials Research Express*, *12*(4), 46507. https://doi.org/10.1088/2053-1591/adc9fe