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The Effectiveness of the Effect of Holding Time on the Toughness and Macro Structure of Low Carbon Steel Due to Carburizing Pack of Pine Charcoal

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ABSTRACT

This study aims to determine the effectiveness of holding time variation of fir charcoal with oil cooling media SAE 20 on the toughness of low carbon steel ST 37 due to the pack carburizing process. This research method, namely impact test, and macrostructure. In the pack carburizing process using fir charcoal and SAE 20 oil cooling media on the toughness and macrostructure of low carbon steel ST 37. The holding time used is 1,2,3,4 and 5 hours. After the carburizing process, a toughness test and macrostructure observation were conducted. From the results of the toughness test obtained the value of each: 17.513 kJ/mm2 at a holding time of 1 hour, 11.920 kJ/mm2 at a holding time of 2 hours, 13.196 kJ/mm2 at a holding time of 3 hours, 7. 917 kJ/mm2 at a holding time of 4 hour, and 3.081 kJ/mm2. Then for macro photo observations greatly, it can be seen that holding time variations greatly affect the holding time, the more tenuous the steel structure.

Keywords: *Low carbon steel, holding time, toughness, pack carburizing, structure macro*

Introduction

Steel is an important element in the world of construction. various types and forms that can be used so that now it is no longer fixated only on wood or concrete elements as one of the main factors steel elements are the main choice in construction, of course in certain shapes and types and at the strength level of a particular construction structure. The advantage of steel is that it is easy to form and has properties such as tensile strength, toughness, ductility, hardness, elasticity and plasticity. In addition, steel is easily available in the market in the form of plates, sheets, pipes, rods and profiles and the price is relatively cheap. Steel has characteristics from the softest to the hardest, from steel materials various forms of metal structures can be made, thus it is necessary in addition to the very hard surface of the component to be resistant to friction. This is what causes steel to be called a material that is rich in properties, where the main alloying element is carbon [1]. Low carbon steel is a material that is widely used for general construction. Because low carbon steel has high ductility, but low hardness and not wear resistance. Low carbon steel is a metal that is easily attacked by corrosion, as is mild steel [2].

Low carbon steel (mild steel) has many uses, one of which is as a material for making plate sheets or what is called steel plates. Apart from its relatively low hardness, softness and high ductility, this steel is also easy to test. ASTM A36 steel plate is a low carbon steel that has good strength and also coupled with the properties of steel that can be machined. ASTM A36 steel plate can be used for various applications, depending on the thickness of the plate and also the level of corrosion resistance. Several products that use this type of steel plate such as building construction, tanks, and pipes. ASTM A36 steel plate was also selected to be the specimen for testing the mechanical properties and macro structure [3] [4], [5].

The carburizing process (case hardening) itself is defined as a process of adding carbon (C) to the steel surface [6]. Where the surface layer of steel, low carbon content can be enriched by slow cooling in a heating furnace at a temperature between 800ºC-950ºC in a carburizing medium. This will result in a hard, wear-resistant surface layer with a tough core. The carburizing medium can be a solid phase, a liquid phase or a gaseous phase. Carburized steel is used in hard or wear-resistant surfaces or hard surfaces with a tough core that is not easily fatigued [7]. In the carburizing process, carbon is added to the steel surface. The purpose of this process is to increase the hardness of the material, but the material has good toughness.

In heat treatment processes, holding time refers to the period of time during which an object or material is heated to a certain temperature and then maintained at that temperature to achieve the desired structural transformation. Holding time is very important in the heat treatment process because it affects the microstructure and mechanical properties of the material being treated [8]. The right holding time allows chemical reactions and atomic diffusion to occur properly, thus achieving the desired transformation. Too short

a holding time can result in a structure that is not very homogeneous, while a holding time that is too long can cause over-aging or unwanted structural changes [9][10], [11].

Holding time also depends on the type of material being processed and the purpose of the heat treatment process. Some materials, such as steel, require a longer holding time to achieve the desired transformation, while other materials, such as aluminum, have a shorter holding time. In addition, temperature also plays an important role in determining holding time. At higher temperatures, the reaction and diffusion will be faster, so the holding time can be shorter. However, it should be noted that too high a temperature can also cause deformation or damage to the material [12].

Research Methods

This research was conducted in May 2022. This research was carried out at the Ujung Pandang State Polytechnic (PNUP) laboratory. The material used is low carbon steel with toughness and macro structure tests, pine charcoal which before being used is refined at a fineness level of 30 mesh, Sodium Carbonate (NaCO3) [13]–[21]. The tools used are a furnace, a carburizing steel box made of 5 mm steel plate with a temperature resistance of 1500ºC, a toughness test kit, sandpaper with a roughness of 120 girt, a digital scale with an accuracy level of 1/100 gr, a file for leveling. material surface, a hacksaw for cutting material and a microscope for macro testing tools. Impact strength (impact strength) or also called the charpy number can be found by the formula:

$$a_k = \frac{E}{A} \quad (1)$$

Where a_k = Impact Strength (kgm.cm^{-2}).
A = Specimen Fracture Surface Area (cm^2)

$$K = \frac{W}{A} \quad (2)$$

Where:
W = Work (Joules)
A = Cross-Sectional Area (mm2)
K = Impact Value (J/mm2)

Results and Discussion

Table 1. Data on the effect of holding time on the toughness of low carbon steel at 30 mesh and a heating temperature of 850°C

Num.	Holding Time (hour)	Toughness (kJ/mm^2)
1.	Normal	9.057
2.	1	17.513
3.	2	11.920
4.	3	13.196
5.	4	7.917
6.	5	3.801

Based on Table 1 above, it can be described in graphical form in Figure 1 below:

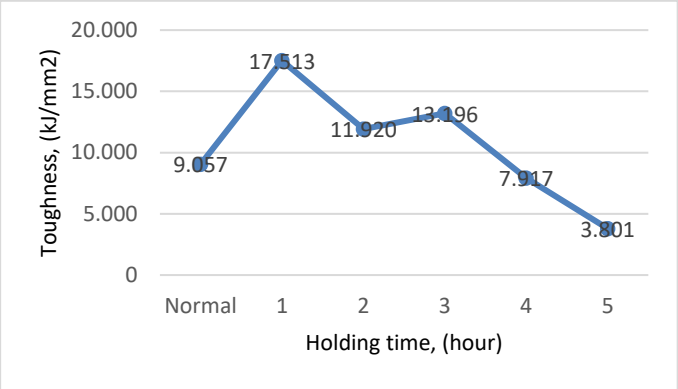

Figure 1. Graph of the effect of holding time on the toughness of low carbon steel at 30 mesh and heating temperature of 850°C

From Figure 1, it can be seen that there is a decrease in toughness where the holding time is in the carburizing process of cypress charcoal, where the longer the holding time, the toughness value decreases, where the highest toughness value is at 1 hour holding time, namely the toughness is 17,513 kJ/mm2 and the lowest toughness value is at holding time 5 hours at a mesh size of 30, heating temperature 850°C, with a volume percentage of cypress charcoal 80%ACR+20%NaCO3.

Conclusion

From the results of the research conducted, regarding the effectiveness of the effect of holding time on toughness and macrostructure of low carbon steel due to pack carburizing of cypress charcoal, the following conclusions can be drawn: Variation of holding time affects the toughness of carburizing low carbon steel where the highest toughness value is at 1 hour holding time which is 17,513 kJ/mm^2 and the lowest toughness value is at 5 hour holding time which is 3,801 kJ/mm^2. Variations in holding time in the carburizing process greatly affect the physical and mechanical properties of the low carbon steel material, where the longer the holding time, the more tenuous the steel structure.

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