Properties of Brass under Different Pouring Temperatures in Sand Casting Process

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ABSTRACT
This study aimed to determine the toughness of casts produced by the sand casting process at various temperatures against brass, and to investigate the structure contained in the cast made using brass metal mould. This study was experimental research that observed the results of a treatment applied to a specimen group. This pre-experimental study used the one-shot case study model in which a group of samples was given treatment. The results showed that the specimen poured at 900°C exhibited a microstructure consisting of good Cu-Zn content, while that at 700°C had the least Cu content. It indicates that the higher the temperature used for metal casting (brass), the more brittle the cast. The toughness of the material was influenced by the alloy composition and the pouring temperature of each specimen; the higher the pouring temperature, the better the treatment of alloy. The photomicrographs indicate that the higher the pouring temperature used in the metal casting (brass), the lesser the carbon element contained in the material.

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I. Introduction
Metals are elements found in mining ores and have the ability to conduct heat and electricity. At room temperature, all metals but mercury are in a solid state. Metals can melt when heated to a certain point (melting point) [1][2][3]. Metals can be obtained by mining into the ground at a certain depth. Generally, metals are in the form of rocks or sand called metal ores.

Brass is a metal that is widely used in households as well as in industry, but its use is mostly for household appliances and accessories [4]. This research was conducted to investigate the characteristic of the alloy from wreck and brass residue from crucible furnace, whether or not it can be directly utilised for standard machining component based on its physical and mechanical properties [5]. The result of chemical testing shows that brass alloy contains the main elements of copper (Cu) of 65.493% and zinc (Zn) of 34.506% and other elements. Its tensile strength is 19.3055 kg/mm2. The hardness is HB 110.44 kg/mm2. This material is classified as soft 4D brass (CuZn) and thus brass castings are not yet feasible for use as the core materials of machining components [6].

The variations in pouring temperature affect the solidification of the brass casting; high pouring temperatures increase porosity. The toughness and hardness decrease due to a large amount of hydrogen gas trapped in the brass cast. In the pouring process, it is necessary to adjust the pouring temperature. In fact, the pouring process has a significant influence on the casting quality; too low pouring temperatures cause short solidification, and poor fluidity causes casting failures. The higher the pouring temperature, the higher the gas solubility (especially hydrogen).

The impact test is a test performed at rapid loading to measure the resistance of a material to shock loading [7][8]. In this test, a large amount of energy is absorbed when the load strikes the specimen. Microstructure is one of the elements determining the mechanical properties of a material. To identify the microstructure of a material, the phase diagram of the material has to be known [9]. The phase diagram is used for reference in the process of smelting, casting, crystallisation and others.

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II. Research method.

This research was pre-experimental with one-shot case study model, where a sample group was given a treatment and then observed [10]. The variables used in this research were 1) pouring temperature as the independent variable, 2) toughness and phase change as the dependent variables, and 3) brass (CuZn) and impact test as the control variables. The method used to analyse the data in this study was descriptive data analysis [11]. The descriptive analysis described the data on the impact test and phase change of brass (CuZn).

III. Results and discussion.

A. Impact Testing

The result of descriptive analysis of impact tests is shown in figure 1.

1. The material poured at a temperature of 700°C had an average toughness of 0.0267 Joule/mm².
2. The material poured at a temperature of 800°C had an average toughness of 0.1294 Joule/mm².
3. The material poured at a temperature of 900°C had an average toughness of 0.2046 Joule/mm².

The photomicrograph shows the contents of cast results visible on the object surface after enlarged at a magnification of 600x. The opaque red areas are Cu, the shiny white elements are Zn, and the black spots are precipitate.

1. The specimen produced with a pouring temperature of 700°C consisted of Cu which was less visible compared to Zn which was larger. Also, the precipitate present in the specimen was apparent.
2. The amount of Cu present in the specimen produced with a pouring temperature of 800°C was higher than that of 700°C; this is due to an increase in temperature variation. The photomicrograph shows that the size of copper increased and the Cu atoms could enter the Zn crystal lattice well. Moreover, the amount of precipitate present on the specimen appeared to be less than the amount of carbon in the specimen produced with a pouring temperature of 700°C.
3. In the specimen produced with a temperature of 900°C, the atoms of Cu-Zn present could enter the crystal lattice (Zn) well. The higher the pouring temperature, the better the result. With the Cu atoms able to enter the Zn crystal lattice well, the precipitates were much more apparent. Also, twinning appeared at this temperature. Twinning occurs when a part of a crystallite changes its orientation so that the arrangement of atoms in that part becomes symmetrical with other parts that do not experience twinning. The arrangement of atoms in this twinning part is a mirror image of a part that does not have twinning.
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Fig. 2. Photomicrograph of Cu-Zn (Brass)

Table 1. XRF (X-Ray Fluorescence) on Cu-Zn composition at temperatures of 700°C, 800°C, 900°C

<table>
<thead>
<tr>
<th>No</th>
<th>Temperature</th>
<th>Cu (αPhase)</th>
<th>Zn (βPhase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7000</td>
<td>43.2 +/- 0.4</td>
<td>27.1 +/- 0.7</td>
</tr>
<tr>
<td>2</td>
<td>8000</td>
<td>45.57 +/- 0.27</td>
<td>29.4 +/- 0.3</td>
</tr>
<tr>
<td>3</td>
<td>9000</td>
<td>46.66 +/- 0.48</td>
<td>30.2 +/- 0.4</td>
</tr>
</tbody>
</table>
B. Phase Change of Cu-Zn (Brass)

The results of XRF (X-Ray Fluorescence) on Cu-Zn composition at temperatures of 700°C, 800°C, 900°C are as follows.

1. The alloy (Cu-Zn) poured at 700°C was at β̄ phase where a phase mixture was formed i.e. phase(α) with (Cu) of 43.2+/−0.4 and phase(ζ) with (Zn) of 27.1+/−0.7.

2. The alloy (Cu-Zn) poured at 800°C was at phase γ in which a mixture of phase (α) with (Cu) of 45.57+/−0.27 and phase(ζ) with (Zn) of 29.4+/−0.3 was formed.

3. The alloy (Cu-Zn) poured at 900°C was at phase γ+β̄ where a mixture of phase (α) with (Cu) of 46.66+/−0.48 and phase(ζ) with (Zn) of 30.2+/−0.4 was formed.

In each variation of temperature, there was precipitate. This precipitate was phase (ζ̄). Phase (ζ̄) was formed by the presence of other elements contained in brass (Cu-Zn). The temperatures of 700°C, 800°C, 900°C were in phase (β̄ + ζ̄). Phase (β̄) is the mixture of phase (α) i.e. (Cu) and phase (ζ̄) i.e. (Zn); phase (ζ̄) is precipitate.

IV. Conclusion.

1. Based on the research findings and discussion that have been elaborated, it can be concluded as follows:

2. The material poured at a temperature of 700°C had an average toughness of 0.0267 Joule/mm².

3. The material poured at a temperature of 800°C had an average toughness of 0.1294 Joule/mm².

4. The material poured at a temperature of 900°C had an average toughness of 0.2046 Joule/mm².

5. The alloy (Cu-Zn) poured at 700°C was at β̄ phase where a mixture of phase (α) with (Cu) of 43.2+/−0.4 and phase(ζ̄) with (Zn) of 27.1+/−0.7 was formed.

6. The alloy (Cu-Zn) poured at 800°C was at phase γ in which a mixture of phase (α) with (Cu) of 45.57+/−0.27 and phase(ζ) with (Zn) of 29.4+/−0.3 was formed.

7. The alloy (Cu-Zn) poured at 900°C was at phase γ+β̄ where a mixture of phase (α) with (Cu) of 46.66+/−0.48 and phase(ζ) with (Zn) of 30.2+/−0.4 was formed.
References