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Effect of Compaction Pressure of Evaporation Boats, Kaolin and Rice Husk Charcoal Composition on Thermal Conductivity and Microstructure

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Abstract

Evaporation boats waste is a waste that is difficult to decompose which has characteristics as a material for makingowi, but its utilisation is still not optimal. The purpose of this study was to determine the effect of compaction pressure on the thermal conductivity and microstructure of aowi made from evaporation boats, kaolin and rice husk charcoal. The research method used was experimental. The independent variable used in this study is the kowi compaction pressure with variations of 20 MPa, 25 MPa, 30 MPa, 35 MPa. The composition of the materials used is 50% evaporation boats, 35% kaolin powder, and 15% rice husk charcoal and 15% water from the total weight of the materials in the mixing. The dependent variables in this study are thermal conductivity testing and microstructure observation. Control variables in this study are powder particle size 100 mesh, mixing time 90 minutes, thickness 2 and 4 mm, specimen diameter 40 mm, firing temperature used 8000C, and holding time 2 hours. The results showed that the average value of the highest thermal conductivity of 4.1045 W / MK at a compression pressure of 35 MPa and the lowest thermal conductivity value of 3.3499 W / MK at a compression pressure of 20 MPa. The higher the compression pressure, the greater the value of thermal conductivity. This is because the greater the compression pressure, the stronger the bond between particles and pores are reduced so that the density increases. The microstructure shows a difference in phase at each compression pressure given. The greater the compression pressure applied, the tighter the density of the material.

Keywords: Compression Pressure, kowi, evaporation boats, kaolin, rice husk charcoal

INTRODUCTION

The development of the metal casting world has progressed rapidly to date, especially in the field of induction furnaces such as kowi. According to [1], the development of induction furnaces is still limited and further development is needed in the future. Evaporation boats as a material that is still not maximally utilised containing refractory materials in the form of boron nitride and titanium diborite are considered suitable as materials for making kowi. The purpose of this study is to determine the effect of the compaction pressure of the composition of bowls made from evaporation boats, kaolin and rice husk charcoal on thermal conductivity and microstructure. Thermal conductivity is the ability to conduct heat from a material that can be a necessary parameter in material characteristics [2].

Casting is a manufacturing process that has the function of forming something by melting metal in a furnace then poured into a mould and cooled until a finished product is formed [3]. Metal smelting equipment in the form of a saucer as a container for melted metal is called aowi [4]. The use of kowi on the market uses graphite material, while in this study using alternative materials, namely evaporation boats. Evaporation boats is a material that contains boron nitride and the industrial world has widely used it as a heat-resistant material. This research uses variations in compaction pressure with the aim of knowing the compaction pressure that can be used to produce the best qualityowi. Thermal conductivity testing is needed to determine the strength of a material against heat. This research is supported by the results of microstructure observation images on various types of variations in the compaction pressure of theowi composition.

RESEARCH METHOD

The research method used was experimental which was carried out at the Mechanical Engineering Laboratory of Semarang State University and the Mechanical Engineering Heat Transfer Laboratory of Gajah Mada University. This research is described in the research flowchart **Fig. 1.**

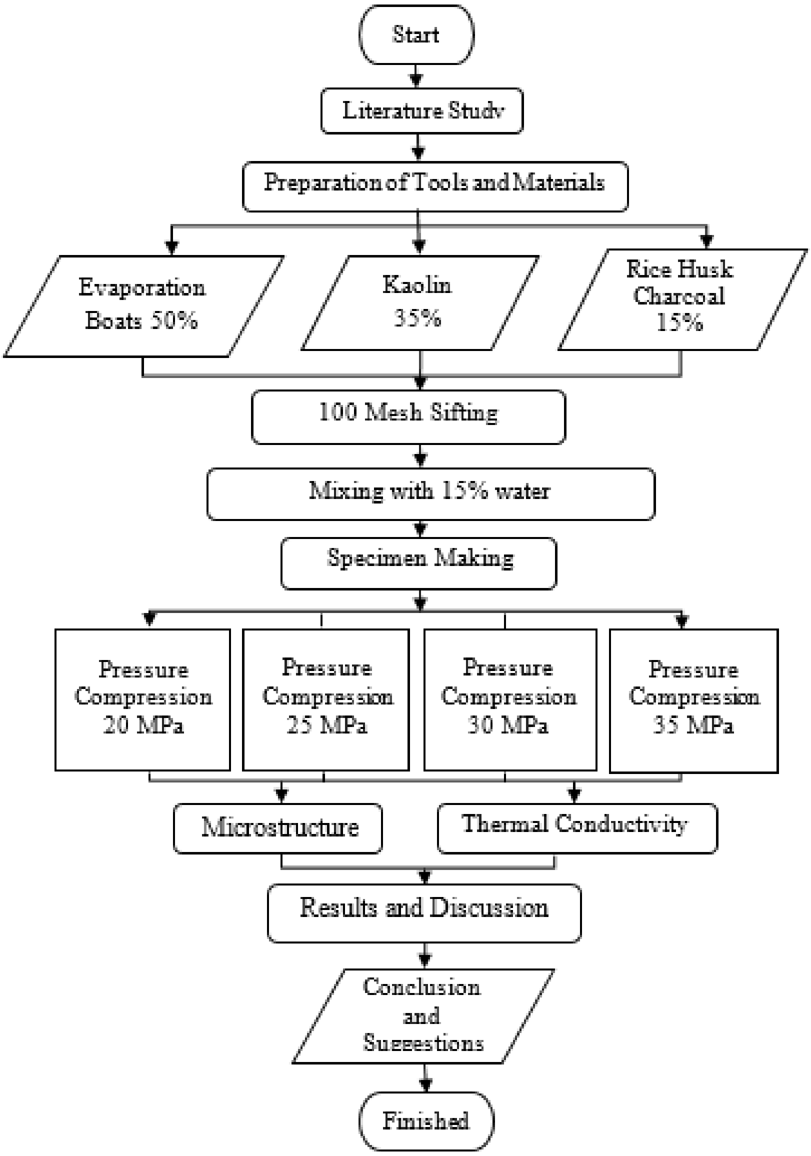


Fig. 1 Research Flowchart

The research flowchart **Fig. 1** is explained as follows:

1. Preparation of Tools and Materials
   Prepare tools to support the research, namely crusher machine, sieve, vernier frame, specimen mould, compacting machine, sandpaper, plastic clips, mixer, digital scales, furnace, microscope and thermal conductivity test equipment. The materials used are evaporation boats, kaolin, rice husk charcoal and water.

2. Manufacturing Process of Test Specimens
   The prepared material is processed with a mixer and then a coin-shaped specimen is made according to the mould provided using a compacting machine. The specimens are sintered with a furnace tool for further sandpaper.
3. Thermal Conductivity Testing
   The research specimens were tested for thermal conductivity in the heat and mass transfer laboratory of Gajah Mada University Mechanical Engineering Yogyakarta.
4. Microstructure Observation
   This research was conducted using a meiji techno UM7200 microscope in the Mechanical Engineering laboratory of Semarang State University to see the characteristic cross section of the specimen.
5. Analysis of Results and Discussion
   This process is done after testing the thermal conductivity and microstructure observation. The goal is to be a benchmark in making kowi material.
6. Conclusion and Suggestion
   This study explains the results of the research and future researchers and users will know theowi's capabilities and shortcomings.

The process of making specimens by mixing evaporation boats (50%), kaolin (35%), rice husk charcoal (15%) and water (15%) from the total weight. Then the process of making tube-shaped specimens with a diameter of 40 mm and a thickness of 2 mm and 4 mm with variations in compaction pressure of 20 MPa, 25 MPa, 30 MPa, and 35 MPa and sintering at a temperature of 800 ℃ with a holding time of 2 hours. Thermal conductivity testing was carried out by taking temperature values from T1 to T12 and then calculating using the fourier series equation. Microstructure observation using a microscope with a magnification of 100 times to then analyse the characteristics of the image displayed.

RESULTS AND DISCUSSION

Thermal Conductivity Testing

The research used is experimental, where this method is used to determine the relationship between the independent variable and the dependent variable. The independent variable used is the variation of compaction pressure 20 MPa, 25 MPa, 30 MPa and 35 MPa. The dependent variable of this research is thermal conductivity testing and microstructure observation. Thermal conductivity test results are calculated using the equation 1.

$$\lambda = \frac{Lb - La}{\{\frac{Lb}{\lambda b'} - \frac{La}{\lambda a'}\}} \tag{1}$$

Based on the calculation using equation (1), **Table 1.** below is obtained

Table 1. Thermal Conductivity Calculation

Compression Pressure (MPa)	Test Temperature (^{0}C)	λ (W/Mk)	Average
20	50	1,499	3,3499
	100	4,979	
	150	3,571	
25	50	3,1188	3,5106
	100	3,4714	
	150	3,926	
30	50	5,8005	3,8054
	100	1,8799	
	150	3,726	
35	50	4,5438	4,1045
	100	4,0042	
	150	3,7657	

Table 1. shows the difference in thermal conductivity value of the compression pressure variation. Based on this, the compression pressure has an influence on thermal conductivity**. Table 1** shows the lowest average conductivity value of 3.3499 W/mK at a compression pressure of 20 MPa. While the highest average

thermal conductivity value of 4.1045 W / MK at 35 MPa compaction pressure. The value of thermal conductivity presented in **Table 1** shows the difference and the greater the compression pressure given to produce higher thermal conductivity values, this can be seen in the **Fig. 2.**

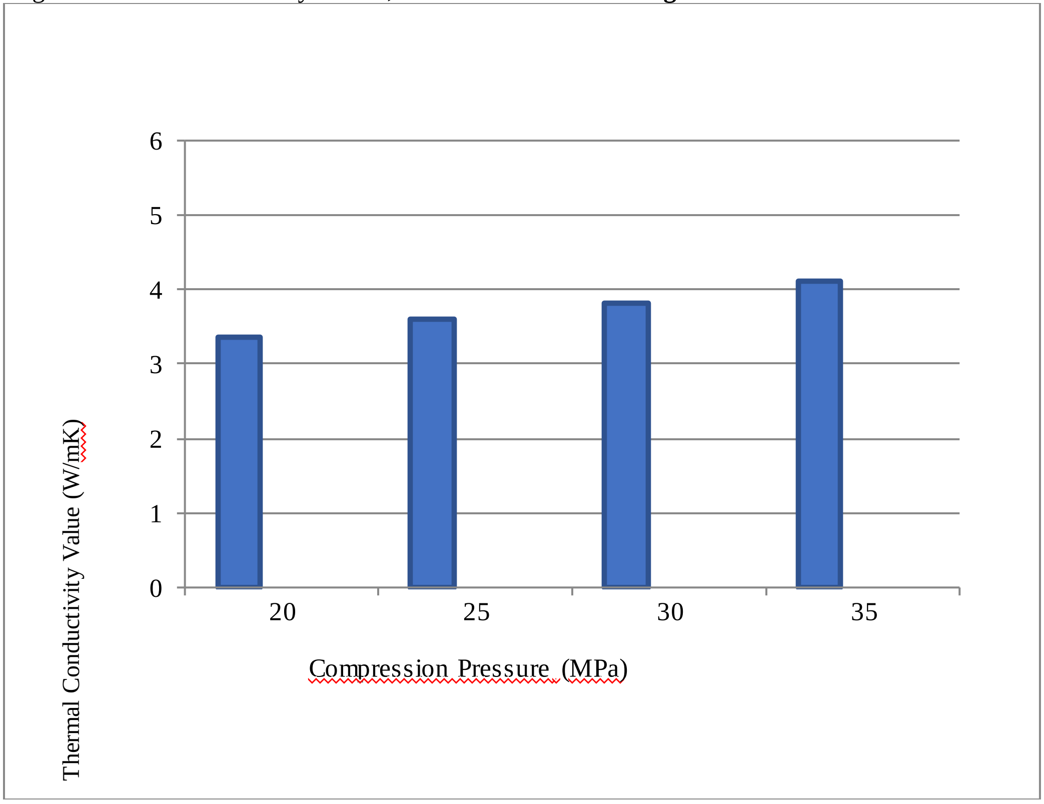


Fig. 2 Average Value of Thermal Conductivity

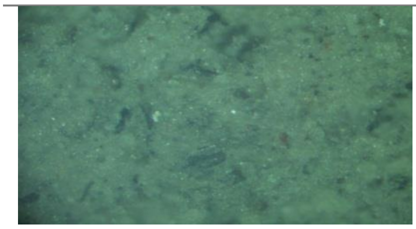
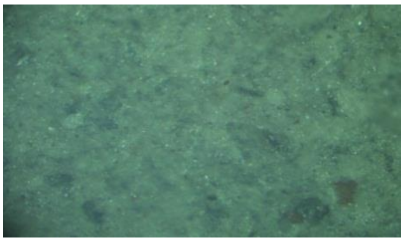
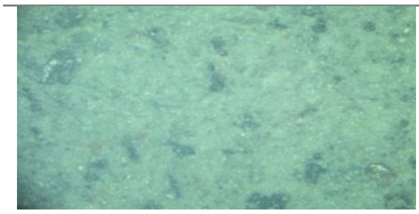
An increase in the value of thermal conductivity in accordance with research [5], which states that the higher the value of the compressive force given, the higher the value of thermal conductivity produced. This occurs because of the increased density in specimens with various variations of compression pressure so that the heat flow becomes more leverage. According to [6], high compression pressure will result in low porosity. This affects the value of thermal conductivity.

The results of each variation of different compaction pressure caused by several factors, one of which is the composition of the material, namely the value of density and porosity. Material that has a large density then the material has the ability to conduct high heat and vice versa material with high porosity has the ability to conduct low heat [7]. It is also mentioned in research [8] that thermal conductivity is influenced by the composition of the material, materials containing silica can be an obstacle to heat transmission because silica is an insulator.

Micro Structure

The purpose of observing the microstructure is to see a photo cross-section of the surface of the material being tested [9]. This is useful for analysing the distance between grains from various variations in the compaction pressure given. Each compaction pressure that is carried out produces a different image. Below is a table of images of microstructure observations with 100 times magnification this can be seen in the **Table 2.**

Table 2. Microstructure Observation Results

Micro Structure Picture	
 **(20 MPa)**	 (25 MPa)
 **(30 MPa)**	 (35 MPa)

Based on **Table 2,** each compaction pressure shows the spread and distribution of different phases. The microstructure at a compression pressure of 20 MPa and 25 MPa shows an uneven distribution of phases. The microstructure at a compression pressure of 30 MPa shows a balanced distribution of phases between the white phase and the black phase so that the distribution and distribution of phases is maximised. The microstructure at 35 MPa compaction pressure shows uneven or unbalanced phase distribution and distribution. This is because the better the thermal conductivity value of a material, the better the resulting image [10].

CONCLUSION

This study shows the effect of variations in compaction pressure on the value of thermal conductivity. The highest value of an average of 4.1045 W/mK at a pressure of 35 MPa and the lowest thermal conductivity value of an average of 3.3499 W/mK obtained at a pressure of 20 MPa. The higher the compaction pressure, the higher the thermal conductivity value. There are differences in the cross-section of the surface of the microstructure observation results. The greater the compaction pressure given it produces a cross section of the white phase decreases and the black phase increases. Kowi products on the market with a compression pressure of 35 MPa has a thermal conductivity value of 4.0 W / MK, so this research can be applied to a kowi product on the market.

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