Thermal Conductivity and Permeability Studies of Recycle Copper Wire Mesh

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Abstract. Copper is well known as a valuable material, particularly for electrical industries due to its excellent properties. Besides, the price for copper scrap is also higher in comparison with other metal scrap materials found in many electrical appliances such as computer equipment, electric motor, transformer, and other components. This paper describes the potential of recycled copper wire shaped into a form suitable for heat sink application. The samples of wire mesh for this research were fabricated by compacting copper wire with different weight. Compaction was done to form a cylindrical shape with a diameter and height of approximately 25 mm and 30 mm, respectively. These samples were evaluated for porosity, thermal conductivity, and permeability. The experimental results showed that the sample with the lowest porosity exhibited great promising conductivity. In addition, lowering the amount of copper wire in compaction resulted in low density, thus improved its lightweight properties. The greater amount of porosity resulted in greater permeability. The optimum properties with a combination of the excellent thermal conductivity and permeability are necessary for heat sink application to ensure that the parts work effectively.

1. Introduction
Recently, electrical device has a huge usage in the world of industry. The production of electrical devices has been found mainly in electric and electronic devices, and one of the applications is in computer production. In this new era, computer or laptop is mainly used in daily life activity, as without computer most activities such as businesses and documentation cannot be done efficiently. Besides, a rapidly developing country like Malaysia needs computers which can sustain in processing more data with high speed [1].

Most of the computers can operate 24 hours on working day and they operate continuously which is mainly for industrial purpose. This situation may lead to greater thermal density and it increases heat dissipation, due to the increase of CPU temperature. As a result, the life cycle of electrical parts become shortened [2] and this will give adverse effects if the heat is not dissipated efficiently, and it will make the processor inefficient and fail to operate with optimum performance in processing data [1]. Due to that, it is important to maintain the operation of the processor without working above a certain level, otherwise, the reliability of the processor may be compromised [3].

Due to this problem, a component called heat sink basically is installed on a computer board which is used to dissipate heat from the processor itself. The main function of a heat sink is to decrease the temperature by dissipating heat [4]. Besides, the heat sink will work more efficiently with forced air...
convection, where a fan is used at the heat sink component to ensure that the process the dissipating of heat is more efficient for a processor to work at an ideal temperature condition. Hence, the existing heat sink could extend the life of circuit structures in Computer [5]. Therefore, this paper focused on the study of the recycle heat sink through experimental work on thermal conductivity and permeability of recycle copper wire mesh.

2. Literature Review

Nowadays, most electrical appliances were invented to facilitate human daily life. Generally, an electrical product will generate heat and affect the durability of the product. For many years, there are numerous improvements which have been made to increase the efficiency of a product and work at an ideal temperature condition. Excessive heat will form when there is no component used to dissipate heat or the designation of a heat sink is not working efficiently [6]. Due to that, when it does not have any hardware to dissipate the heat it will increase the temperature surface of a product and this will also affect their functionality.

One of the examples is a desktop computer set which contains a CPU heat sink. Basically, a desktop computer is used for personal or for business purposes. It has various functions and to operate all the system input, it needs a device called as central processing unit (CPU). Usually, these devices are the heart and brain for every computer as without them a computer cannot be switched on and will not function normally. The processors of a computer are used to interpret signals and codes from other devices such as Random Access Memory (RAM) and a keyboard.

2.1. Heat sink

The heat sink is the component attached to the processor that is placed on the motherboard [7]. This component will come together with a cooling fan. Most gaming computers use a gaming heat sink. Therefore, the heat sink was developed to control the temperature of the processor and to ensure that the components work normally to become an ideal temperature when the excessive workload is on it.

Heat sink is known as a passive heat exchanger. The function of this component is to transfer the heat that is generated by an electrical, electronic or any mechanical appliances using coolant air in motion towards the ideal temperature. Therefore, it allows the regulation of the device temperature to remain at the physical feasible level. Figure 1 shows the illustration of a heat sink application, and this illustration explains how the heat sink removes the heat using forced convection or fan that is used to increase the rate of heat removal. The air from outside is being sucked into by using a fan, which is to carry out the hot air inside the processor. Due to this situation, a processor temperature will become the ideal temperature.

Most of the heat sink design is affected by the air velocity flow, the material used, design and surface treatment. The standard heat sinks are usually used in the CPU. This component comes together with a cooling fan which is used to increase the cooling rate with the air flow towards a heat sink. Usually, the standard cooling fan can achieve a speed between in range 8 000 RPM to 12 000 RPM. This speed can control the temperature of a processor that produces heat.

In addition, to improve the purpose of heat sink application, it needs some additional attachments, namely thermal interface materials. This interface material will make the temperature of integrated
circuit decreases and remains in ideal temperature. The function of thermal adhesive or thermal grease is to ensure that there is no air gap between the heat sink and integrated circuits. Therefore, this can increase the performance of the heat sink’s itself and the heat will be dissipating efficiently.

Thermal paste is usually placed on the top of the processor. This is important before a heat sink is attached on top of the processor. Processor reliability will decrease if a thermal paste is not placed before attaching a heat sink because heat cannot be transferred effectively towards a heat sink. This clearly shows the importance of thermal paste.

2.2. The significance of heat sink towards a Central Processing Unit (CPU)
Generally, a processor is installed together with a heat sink to dissipate heat away from the processor. This is crucial to increase and improve the reliability and prevent the component from forming premature breakdown [8]. Due to that, it can become the best heat sink that is able to control the temperature. A processor generally operates within a temperature between 70°C to 95°C [9], which is basically the range of temperature which is the normal result after applying a heat sink attached with a cooling fan.

Besides, a standard processor usually uses power around 80 W to 130 W. This range is used to ensure that a processor is able to operate without facing any problem [10], but in gaming specification, a manufacturer has developed the best specification of the processor to ensure that the processor operates in optimum condition.

The previous studies found that some parameters will affect the performance of a heat sink such as the shape of the fin, the base materials and the materials for the fin used [8]. The material used should have high thermal conductivity value and able to transfer the heat from one point to another point efficiently. As a result, it can reduce the failure of a mechanism and increase the reliability of a product.

3. Material Selection
Copper has been used in electrical component before the innovation of the electromagnet and telegraph in the 1820s [11]. Copper is commonly applied in electrical wiring and only react with atmospheric oxygen to form a layer of brown-black copper oxide, but it does not react with water and as a result, reaction with oxide had formed unlike rust occurs when the iron is exposed towards the air and protects the underlying copper from becoming extensive corrosion. Copper is the preferred and the predominant choice in the electrical industry because their advantage is higher in thermal conductivity. The new creation of the telephone in 1876 developed more copper wire used in an electrical conductor. Generally, copper mine is used to fabricate an electrical wire and a cable as conductors. Therefore, electrical wiring whether in the building or at home is the most vital use to increase the market in the copper industry.

3.1. Physical Properties of copper
Copper, silver, and gold consist of group 11 in the periodic table and they contribute certain attributes: on top of a filled d-electron shell they have one s-orbital electron and it is characterized by high ductility and electrical conductivity. It can simply be explained that the purity of copper has a good thermal conductivity which is 388 W/m.K [12]. Due to that, the resistivity of electrons to carry in metal at room temperature commonly begun from irregular of electrons on thermal vibrations of the lattice. This value should be made for the reference value for further experiment.

3.2. Electrical conductivity of copper
Kelvin meters per watt (K·m·W⁻¹) is the unit for thermal resistivity and the result of the reciprocal of the thermal conductivity. Electrical charge is formed in electrical conductivity flow process and this is important to determine the quality of the material used. Copper is categorized as non-precious metal and has the highest electrical conductivity rating. The electrical resistivity of copper is 1.72 Ω·m at room temperature [13]. There is a difference between the definition of the construction's thermal resistance and the reciprocal property and thermal conductance.

The electrical application mainly used electrolytic-tough pitch (ETP) copper (CW004A or ASTM designation C11040). This type of copper known as 99.90% pure and has an electrical conductivity of at least 101% IACS and contains a little percentage of oxygen (0.02 to 0.04%) [13].
These elements have a little resistance of conduction electrons flow under an electric field and exhibit high conductivity. In addition, copper has a large outermost electron and become an excellent conductor; about 100 atomic spacing between collisions.

3.3. Selection of Recycled Copper Wire

Nowadays, the largest growing waste stream is currently electrical and electronic waste which is normally known as e-waste. This situation occurs partly due to lack of legislation or enforcement. At present, there are proper ways for the e-waste to be discarded such as the general waste stream. Most of the developing countries like Bangladesh and Indonesia have an informal economy and lead them to recycle and reuse the materials by applying the rudimentary technique. These are the consequences to the production of wire rod and wire cable product. According to the world consumption of metals, copper metals is situated in the third rank after iron and aluminum.

In Malaysia, in August of 2015, scrap imported from Malaysia alone totalled to 14,733 tonnes. According to the record, the largest supplier of the scrap material to Malaysia was the US in August of 2015 which was totalled at 5,609 tons. The second largest import of the scrap metal which is Singapore with hit total 4,326 tons. Lastly, Australia is in the third place with 1919 tons [14], [15]. Due to the increasing of scraps of copper wire, the heat sinks were developed by Computer Trading Sdn. Bhd.

4. Methodology

The flow chart in Figure 2 presents the preparation flow of the specimen until it is tested. It also illustrates from the scratch where the material is collected and fabricated.

![Flow chart of the specimen preparation](image-url)

**Figure 2.** Flow chart of the specimen preparation
4.1. Collecting Recycled Copper Wire
The scrap of copper wire was collected from Scrap Computer Trading Sdn. Bhd. The company’s main business is buying and selling of any kinds of recycled material such as copper, brass, aluminum, and steel.

The recycled copper wires were collected and selected based on their grade and quality. There are various types of recycled copper wire such as enamelled copper wire and standard copper wire.

4.2. Fabrication of mold
The mold is fabricated with the diameter of 25 mm and 30 mm height. There are several designs specification that need to be considered for making a mold.

Furthermore, the mold will be used to form a specimen through a compacting process. The complete shape of the mold is fabricated based on the proposed design shown in Figure 3. This mold were designed through several processes using lathe machine and milling machine.

![Figure 3: Designated mold to produce sample](image)

4.3. Fabrication of specimen
The specimen was fabricated by using the designated cylindrical mold shape with the assistance of hydraulic press machine. This machine will compact the recycled copper wire to a specified height required for testing. The compaction process is required to form the samples for the thermal conductivity test and permeability test. These specimens should be fit into the thermal conductivity apparatus. This can avoid error during testing. The recycled copper wire was loaded into a mold and a compression rod is placed on the top part of the middle rod. Furthermore, the load is applied to the mold to form the specimens.

4.4. Density and Porosity
Both density and porosity for each specimen in this study were considered. These factors are important to compare the specimens based on its weight. Equation (1) will be used to calculate the density for each specimen.

\[ \text{Density}, \rho = \frac{\text{Mass}, m}{\text{Volume}, v} \]  

Equation (2) is used to determine the percentage of porosity for the specimens. Each specimen has a different value of porosity due to the different value of mass.

\[ \text{Percentage of Porosity}, \%_{\text{porosity}} = \frac{\rho_{\text{solid copper}} - \rho_{\text{specimen}}}{\rho_{\text{solid copper}}} \]  

4.5. Thermal conductivity Test
At the early stage, an experiment was done for each specimen by measuring their efficiency as it transferred heat from one place to another. It is followed by the concept of Fourier’s law of heat conduction. This concept is defined as the process of heat transfer from a hot region to a cold region. It
can be assumed that the cylindrical bar is the plane of wall thickness (Δx), temperature difference (ΔT) while uniform hot temperature (T1) is imposed on one end and a different temperature (T2) is imposed on the other. Thermal conductivity test needs to follow the amount of heat transfer during the test transfer which are 30 W, 40 W, 50 W, and 60 W.

Figure 4. Heat Conduction Apparatus

Figure 4 shows the heat conduction apparatus connected to the power source. The wire connectors were connected into 3 sections which are the heater (A), specimen (B) and cooler (C). Heat flows from the heater section to the cooler section. Each section is connected with 3 thermocouple wires. Each wire is separated at 10 mm in between and the thermocouple provides the readings of temperature based on these distances. The apparatus consists of a power source, temperature display, heat transfer control, and heat transfer display. This section enables the researcher to control the amount of temperature when heat is applied to a specimen. The specimens were tested for 10 minutes for each test.

As a result, for the whole test a specimen needs to be tested 4 times but with different angles which are 0°, 90°, 180°, and 270°. The total time to complete a test for one specimen is 40 minutes. Due to that, all the data need to be recorded, and the average value is taken. The thermal conductivity was also tested.

The equation (3) used in this experiment is known as Fourier’s Law of heat conduction, and the directional flow of heat in the axial direction.

\[
\dot{Q} = -KA \frac{\partial T}{\partial n}
\]  

(3)

Where (\(\dot{Q}\)) is the rate of heat conduction in the axial direction, K is the thermal conductivity to measure the ability of a material to conduct heat, \(\partial T/\partial n\) is the temperature gradient and A is known as the cross-sectional area of the specimen. While a negative sign indicates the heat was transferred towards x direction and the temperature flow in decrease situation [16]. Generally, Fourier’s Law comes out with a vector relationship which affects towards all directions of heat conduction and it is expressed in terms of its components as Equation (4):

\[
\vec{\dot{Q}}_n = \dot{Q}_x \hat{i} + \dot{Q}_y \hat{j} + \dot{Q}_z \hat{k}
\]  

(4)

Where \(\hat{i}, \hat{j}\) and \(\hat{k}\) known as a unit vector while \(\dot{Q}_x, \dot{Q}_y\) and \(\dot{Q}_z\) are the magnitude of heat conduction rates in the x-, y-, and z- direction which again to determine Fourier’s Law as:

\[
\dot{Q}_x = -KA_x \frac{\partial T}{\partial x}
\]  

(5)

\[
\dot{Q}_y = -KA_y \frac{\partial T}{\partial y}
\]  

(6)

\[
\dot{Q}_z = -KA_z \frac{\partial T}{\partial z}
\]  

(7)
For the experimental test, Equation (5), (6) and (7) are referred. To determine the value of thermal conductivity, $K$, these equations will be rearranged to form Equation (8). The thermal conductivity, $K$ of the solid cylindrical copper value will be compared with the actual values from the other references.

$$K = -\frac{\dot{Q}}{A \frac{\partial T}{\partial x}}$$

(8)

The experimental errors value for the test can be calculated by using Equation (9).

$$Percentage\ error, \%_{error} = \left| \frac{k_{Theoretical\ value} - k_{Experimental\ value}}{k_{Theoretical\ value}} \right|$$

(9)

4.5.1. Figure captions.
Permeability was conducted to determine the efficiency of the specimen. To obtain the permeability of the specimens, water is used as medium and tested with different temperature which is $34^\circ C$, $40^\circ C$, $60^\circ C$, and $80^\circ C$. The schematic diagram of the permeability test setup is shown in Figure 5.

![Figure 5. Permeability Test Setup](image)

The effect of different temperature was used for identifying the correlation between the porosity and permeability of different temperature.

![Figure 6. Permeability Test Apparatus](image)

Figure 6 shows the apparatus used in the permeability test. A hot plate was used to undergo the heating process towards water from $34^\circ C$, $40^\circ C$, $60^\circ C$, and $80^\circ C$. This is crucial to get a varied reading for each specimen when in different temperature condition. This condition is needed to observe any effect occurs during the test. The value of the permeability test can be calculated using Equation (10). During the
experiment, the amount of water and the time taken during the experiment must be considered and this is important as both criteria could give a good result of permeability.

\[
Permeability = \left| \frac{Volume, V(\text{liter})}{time, t_{\text{final}}(s) - time, t_{\text{initial}}(s)} \right|
\]  

(10)

5. Results and Discussions
In this section, the fabrication process, thermal conductivity test, and permeability test are discussed in detail.

5.1. Recycle copper wire mesh compaction
The specimens of the recycled copper wire mesh (as shown in Figure 7) after being compacted using a hydraulic press machine and different levels of porosity using different amount of copper wire can be observed. The specimens were evaluated to determine the value of thermal conductivity and permeability. This is crucial because the porosity adversely affects the result on thermal conductivity test and permeability test [17].

![Figure 7. Compacted Recycle Copper Wire Mesh](image)

The top view and side view of a specimen after the compaction process are shown in Figure 8. The cylindrical shape is selected because the equipment used in this experiment is cylindrical shape condition.

![Figure 8. (a) Top view of specimen](image)  ![Figure 8. (b) Side view of specimen](image)
5.2. Density and Porosity
Density is important in the heat sink application because it adversely affects the efficiency of the material in thermal conductivity activity [17]. Table 1 shows the density and percentage of porosity of compacted recycle copper wire based on the different weight. The density and percentage of porosity errors for the specimens could be obtained by using Equation (1) and Equation (2), respectively.

Table 1: The value of density (g/cm³) and porosity errors (%) with different weight.

| Weight (g) | Density (g/cm³) | Porosity (%) |
|------------|-----------------|--------------|
| 30         | 2.04            | 76.37        |
| 40         | 2.72            | 68.49        |
| 50         | 3.40            | 60.61        |
| 60         | 4.07            | 52.74        |
| 127 (Solid Cylindrical Shape) | 8.62 | 0.00 |

Basically, the highest weight of a solid cylindrical shape of copper wire obtained the highest density of 8.62 g/cm³ with zero porosity and achieved the best value of thermal conductivity among the specimen.

The density and porosity were measured at various weights as shown in Figure 9. The porosity of specimens decreased as the weight increased, which resulted in the increase in density. This has been reported in the previous study, where the density of copper is affected with porosity [18]. Due to that, the value of thermal conductivity becomes more efficient when the value of density increases and this situation can be clearly seen where the value of thermal conductivity error decreases when the weight of specimen increases. Both criteria; density and porosity are important in heat sink application, where the lifespan of the processor maybe shortened and could not dissipate heat effectively.

5.3. Thermal Conductivity Test
The four sections of 0°, 90°, 180° and 270° angle as shown in Figure 10 were taken for the thermal conductivity test. The data is taken repeatedly with four-times for an average concept [19]. This is important due to the different shape of specimens, and different angle which resulted in different porosity. Figure 11 shows that the porosity of the same specimen has different porosity.
Each specimen requires 40-minutes to be completed in one section. Then, the apparatus needs to let the specimen reduce their temperature until it reaches room temperature.

**Figure 10.** Four sections of angle

**Figure 11.** Similar specimen with different views

The collected data were presented in graphs as shown in Figure 12, Figure 13, Figure 14, Figure 15 and Figure 16. These graphs are used to indicate the trends of the temperature for each specimen.

**Figure 12.** Distance (mm) against Temperature (°C) [Weight 30 g]

**Figure 13.** Distance (mm) against Temperature (°C) [Weight 40 g]

**Figure 14.** Distance (mm) against Temperature (°C) [Weight 50 g]

**Figure 15.** Distance (mm) against Temperature (°C) [Weight 60 g]
Based on these graphs, the evaluation of thermal conductivity is not counted in the heater section (from 0 to 20 mm) and cooler section (from 60 to 80 mm). Both sections do not require a calculation of thermal conductivity. It can be seen that the graphs patterns were quite the same for the whole specimen but different in temperature value. This situation occurred because of the different amount of porosity. When the amount of porosity is greater, the efficiency of heat transferred from one section to another section decreases [20].

![Figure 16. Distance (mm) against Temperature (°C) [Solid Copper Cylinder]](image)

Table 2 below shows the thermal conductivity, \( k \) of the specimen.

| Heat (W) | Weight (g) | 30 g | 40 g | 50 g | 60 g | Solid Copper Cylinder |
|---------|-----------|------|------|------|------|-----------------------|
| 10 W    | 698.43    | 244.45| 479.31| 407.41| 381.95|
| 20 W    | 240.84    | 275.13| 315.42| 362.15| 381.95|
| 30 W    | 218.91    | 233.55| 291.01| 349.21| 392.16|
| 40 W    | 255.30    | 235.05| 324.85| 350.46| 384.96|

The heat transfer efficiency of specimens was compared with a solid copper cylindrical shape and used as the benchmark for the other specimens.
Figure 17. Rate of Heat Conduction (W) against Thermal Conductivity (W/m.K)

Figure 17 shows the linear graph of thermal conductivity and the linear graph of weight 60 g are around the value similar with the value of theoretical (388 W/m.K) which is between 350.46 W/m.K to 407.41 W/m.K. This situation occurred because the efficiency of the specimen to transfer the heat is high while the amount of porosity is smaller. Due to that, other specimens are not recommended for the thermal conductivity purposes especially for a specimen which weights 30 g. This is due to the highest error calculated. The error usually happened because of the different amount of porosity.

Table 3: Thermal Conductivity Test Error, (%)

| Heat | Weight | 30 g | 40 g | 50 g | 60 g | Solid Copper Cylinder |
|------|--------|------|------|------|------|-----------------------|
| 10 W |        | 80.01| 37.00| 23.53| 5.00 | 1.56                  |
| 20 W |        | 37.93| 29.61| 18.71| 6.60 | 1.56                  |
| 30 W |        | 43.58| 39.81| 25.00| 10.00| 1.07                  |
| 40 W |        | 41.93| 39.42| 16.28| 9.67 | 0.78                  |

Table 3 shows the thermal conductivity test error. The theoretical value for thermal conductivity is 388 W/m.K, while the calculated experimental value for copper solid cylindrical shape is between 381.95 W/m.K to 384.96 W/m.K. This shows that the value of error of these specimens is about 0.78 % to 1.56 %, respectively. This error happened because of the lack of contact between the specimen with hotter section and cooler section. This situation can be clearly seen as according to the graph, it shows at the temperature distance between 20 mm to 30 mm, it fluctuated and dropping especially when a heat transfer achieves at 40 W. Due to the poor contact of specimen, thermal paste is required to attach them and to have a good value for heat transfer.
Figure 18 shows the linear graphs of error. A specimen of 60 g was the best among the others specimen, as the error values in between 5.00% to 10.00%. This indicated that 60 g is the lowest value of the error. This situation occurred due to the lowest amount of porosity itself. In addition, a porosity that in the specimen gives an effect to the thermal conductivity value [21] and when the percentage error of a specimen increases, the value of thermal conductivity increases.

Meanwhile, the highest value of error was found in 30 g of weight. This situation happened due to the formation of porosity in a specimen. A porosity gives bad effect toward heat transfer activity [17]. As a result, this type of weight is not suitable to be applied in thermal conductivity activity because the specimen is not able to transfer heat from one section to another section effectively due to the formation of pores.

5.4. Permeability Test
Permeability is the capability of substances to past through the obstacles which is in pore condition as an example such as soil, sponge, and fabric. This research had been made to determine the permeability of the specimen and the effect that occurred towards heat transfer [22]. As a result, it can determine the effectiveness of pore on the specimen and to prove the specimens which have a large amount of porosity and good in permeability. Due to the deformation porosity on the specimen, the value of permeability and the flow of the fluid is affected during the water past through the specimen. Table 4 shows the complete data of the permeability test for the whole specimen with different temperature condition.

| Weight | Temperature | 34 °C | 40 °C | 60 °C | 80 °C |
|--------|-------------|-------|-------|-------|-------|
| 30 g   | 2.37        | 2.70  | 2.95  | 3.34  |
| 30 g   | 2.16        | 2.33  | 2.71  | 3.04  |
| 40 g   | 2.00        | 2.24  | 2.45  | 2.70  |
| 60 g   | 1.86        | 2.07  | 2.26  | 2.47  |

The medium used for the permeability test is water, and it was tested with different temperatures, which are 34°C, 40°C, 60°C, and 80°C. Figure 19 shows the permeability test results. When temperature
increases the value of the permeability is increased. This situation happened because of the increase of water temperature, and the molecular kinetic energy of the water also will be increased. Due to that, it will affect the velocity of the molecule and the molecule easily moved between the pores that have deformed in the specimen.

![Figure 19. Weight (g) against Permeability (l/min)](image)

Based on the results, the specimen with 30 g shows that the permeability is higher. This is caused by the amount of porosity that is higher when compared to the others. In addition, high porosity also leads to poor thermal conductivity.

5.5. Correlation Between Porosity, Thermal Conductivity, and Permeability
The efficiency in heat conduction, influence of porosity on the fluid flow rate and thermal conductivity of the specimen are illustrated in Figure 20. The graph shows that the increase of porosity could affect the fluid flow rate and thermal conductivity.

![Figure 20. Porosity (%) against Thermal Conductivity (W/m.K) and Permeability (l/min)](image)
The linear line drawn on this graph obtained several intersection points with the thermal conductivity and permeability. It is anticipated that the intersection at point C will exhibit porosity properties for heat sink application, thermal conductivity and its greater than the currently used aluminium heat sink. Higher permeability is necessary to ensure that the heat can be dissipated faster from the hot component.

6. Conclusion
A parametric study is experimentally conducted to evaluate the porosity and thermal conductivity characteristic of recycled copper wire. The effects of density with different weight of specimen are investigated based on the experimental results. The conclusion of this study can be summarized as follow:
- The best specimens have been identified and meet the standards and criteria.
- Copper wire mesh with different weight of porosities has been successfully fabricated by employing the compaction technique. The main goal is to study the thermal conductivity and permeability of recycled copper wire mesh. Besides, it indirectly gives some advantage to increase recycling activity.
- The porosity adversely affects the permeability and thermal conductivity.

Finally, the objective of this study has been achieved by determining the value of thermal conductivity and permeability of the copper wire mesh. The findings would be useful to assist researchers in recognizing which specimen has the least error in thermal conductivity.

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