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Research Article

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Development of a Low-Cost Thermal Heater-Cooler Blocks Using Locally Recycled Waste

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Abstract

In the determination of the thermo-physical properties (viz thermal conductivity and thermal diffusivity) of composite solids using steady state methods, one of the key components of the test column assembly is the heater-cooler block which is used either as a heater or cooler according to the experimental procedure. In this research work, a heater-cooler block was developed using aluminum coated materials gotten from recycled waste. The waste materials were subjected to a high temperature and the aluminum oxide extracted. The resulting solid aluminum block was machined to specifications to form a heater-cooler block. The heating element was also salvaged from a car cigarette lighter and embedded in the heater-cooler block. The heater block was powered from a 12 V designed power supply and was found to perform well as expected.

Keywords: Heater block; Aluminum; Thermal conductivity; Thermal diffusivity; Composites; Thermo-physical properties

Introduction

Materials are usually classified in four categories namely metals (polycrystalline solids), ceramics (amorphous inorganic solids), polymers (amorphous organic solids) and composites (a heterogeneous combination of the former three). The most popular method for determining the thermo-physical properties viz thermal conductivity and thermal diffusivity of composite materials is the steady state method based on the ASTM standard E-1225 [1].

Metals is one of the most useful substances known to man and can be recycled repeatedly without altering their properties [2]. Metal recycling reduces pollution, reduces waste going to landfills, prevents destruction of habitats, and conserves natural resources by reducing greenhouse gas emissions which is contributing to the solution of global warning by using less energy compared to producing new metal from virgin ore.

Aluminum has been adjudged as the world most abundant metal with a versatility that makes it the most widely used metal and recycled material on the planet after steel [3] estimates the worldwide demand for aluminum to around 29 million tons per year with 22 million tons as new aluminum while 7 million tons are recycled aluminum scrap without any significant difference in quality between new and recycled aluminum alloys.

Recycled aluminum scraps are used in this research work to develop the heater-cooler block because it was readily available, sensitive to heat, has low melting point [4,5] and a thermal conductivity that is three times greater than that of steel. This property makes aluminum an important material for both cooling and heating applications as desired in this research work.

Materials and Methods

In conducting this research work, the metal recycling process was used, and the main stages are subsequently discussed below:

Collection and sorting of recycled scraps

Aluminum coated scraps were salvaged from different areas of Ede in Osun State and Oko in Oyo State, both in Nigeria. The recycled wastes were scavenged from places such as refuse dump, electronic repair workshop and car mechanic workshop and sorted. The heater device incorporated in this research work was scavenged from a car cigarette light gotten from the remains of a dismembered vehicle. Figure 1 shows the recycled waste materials collected for the research work.

Processing, melting and purification of the scraps

The processing of the aluminum scrap was done using local techniques. Figure 2 shows a local furnace setup powered by a manually rotated bicycle wheel designed to supply air to the furnace needed for melting the aluminum. The aluminum to be melted was poured inside a bad compressor can that was also salvaged from a refrigerator repair workshop. The bad compressor can was used owing to its ability to withstand very high temperature even far above the melting point of aluminum.

Palm kernel shafts were used as fueling agent because they burn

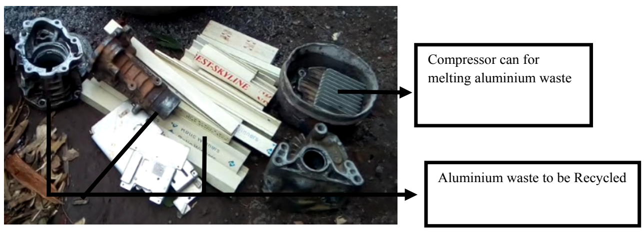

Figure 1: Aluminium coated scraps to be recycled.

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steadily unlike coal or firewood. With continued manual rotation of the bicycle wheel shown in Figure 2(a) (used as an air-blower to the burner of Figure 2(b)), continuous heat was applied to the compressor can until all the aluminum had completely melted. Purification was done using a scoop; to remove contaminants and unwanted residues of other alloys found in the melted aluminum ore as shown in Figure 3(a). More aluminum materials were added and further melted until all the scraps had completely melted as shown in Figure 3(b). The temperature of the locally designed oven rose up to 700°C which was burner point of aluminum.

Molding of the heater block

Figure 4 shows a special type of sand (specifically Kaolin) used in casting the molds of the heater block. The mold for the heater block was placed on the sand as shown in Figure 5(a) the mold was pressed against the sand to leave an impression of its image on the sand after which it was removed as shown in Figure 5(b). Figure 6 shows the completed mold of the heater block to which the melted aluminum ore was to be poured. Two molds were developed using the same technique described.

Solidifying

Having completed the mold, Figure 7 shows the melted aluminum being poured inside the heater-cooler block mold by the help of a metallic tong. After the aluminum had solidified, the mold built from sand particles was dismantled and Figure 8(a) reveals the developed heater-cooler block. Figure 8(b) shows the pairs of the developed heater-cooler blocks.

Machining and refinements

The aluminum bar produced was subjected to further engineering refinements by machining into the desired shape and engineering dimensions as shown in Figure 9. Holes of specific diameter were bored into the aluminum bar to obtain the heater-cooler block shown in Figure 10. Figure 11 shows the complete setup of the developed heater-cooler block with a heating element embedded in the block and a pipe

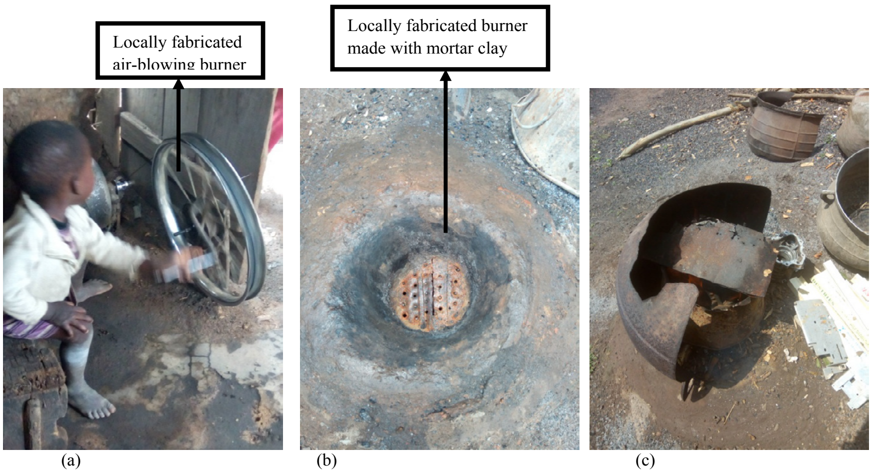

Figure 2: A local furnace constructed for melting aluminium scraps.

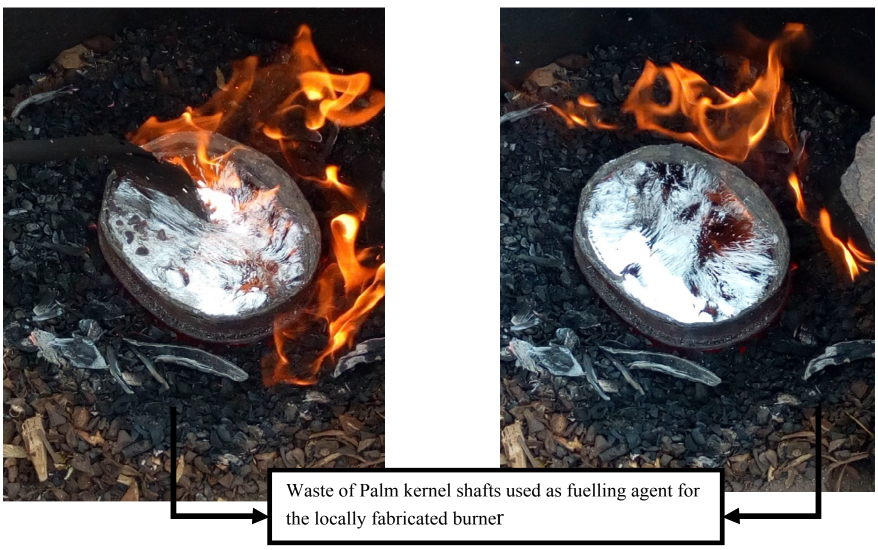

Figure 3: (a) Contaminated and (b) Purified Aluminium Ore.

Figure 4: Kaolin sand used for making the Mould.

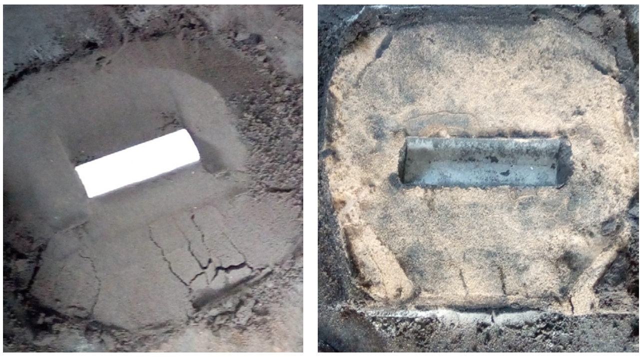

Figure 5: Fabrication stages of the mould.

Figure 6: The completed mould of the heater block.

Figure 7: Pouring the melted aluminium inside the moulds.

fitted into the holes for easy flow of water through the block to create a cooling effect even as heat is applied to the block. The heater was powered by a 12 V battery.

Figure 8: The heater blocks aluminium bar.

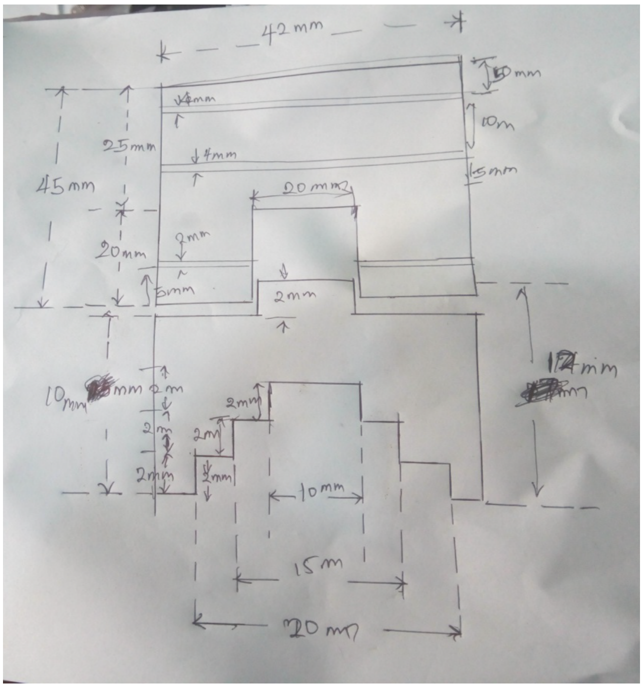

Figure 9: Hand sketch engineering dimensioning of the heater-cooler blocks.

Figure 10: The heater-cooler blocks after refinements.

Results and Discussion

After the completion of the setup of the developed heater-cooler block assembly as shown in Figure 11, the continuity test revealed good result. Also, it was ensured that there was no continuity between the developed blocks and the heating element adapted for use in this research work.

A 12 V DC power supply was supplied to the heater assembly and within two minutes the aluminum block was hot to touch attaining a

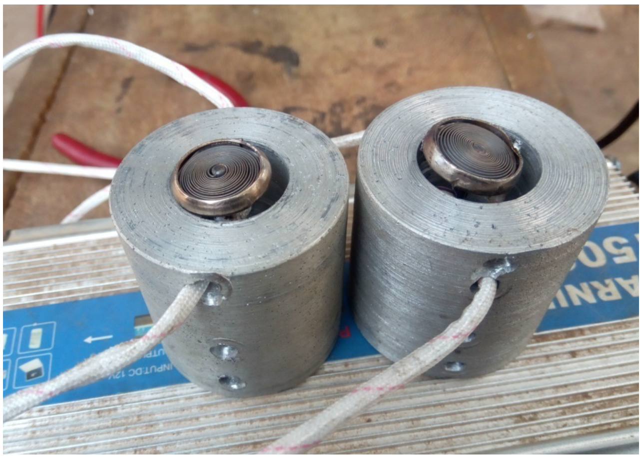

Figure 11: Setup of the heater-cooler block assembly with heating elements.

temperature of around 120°C before the battery source was switched off. It was observed that the temperature had potential to rise higher than the observed value particularly if the setup is enclosed in an airtight vacuum and heat lost to the surrounding is greatly minimized.

Conclusion

In this research work, an aluminum-based heater-cooler block unit was fabricated from locally recycled aluminum waste melted in a local furnace with a temperature of around 700°C. The fabricated block was further machined to specified dimensions and when heating element was embedded in the aluminum block setup, the block behaved as a good thermal conductor and showed good performance suitable for use in the thermo-physical properties determination for which it was intended for.

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