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COCONUT COIR AS THERMAL INSULATION IN METAL MELTING FURNACES: PERFORMANCE AND LIMITATIONS

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Abstract:

Extremely high temperature can cause severe harm and become a safety hazard. However, by insulating mini metal furnace can protect workers of heat hazard over time. This study was conducted to determine the effect of coconut coir in the outside temperature and humidity of a locally made metal melting foundry furnace. This established a process of constructing mini melting furnace with insulator using cement and cementitious waterproofing materials with coconut coir content. This investigates the effect on outside temperature and humidity using used lubricant oil as fuel. The mini metal furnace was an initial study of melting furnace, which was constructed by implementing various enhancements incorporating an additional element into the apparatus and was used to investigate the effectiveness of coconut coir in regulating the dispersion of high temperatures beyond the equipment. This involved applying a partial covering of coconut coir with cement and cementitious waterproofing in order to examine the impact on temperature and humidities in areas covered and uncovered by the insulator. Coating the mini metal melting furnace with a mixture of coconut husk powder and pozzolan cement introduces new features. Some areas of the furnace walls adjusted to 16.67% increase in thickness and an additional weight of 8.33%. Despite this, the total weight attributed to the coconut coir remains negligible. Other technical features of the furnace remain unchanged from the original design. During a brief period of burning using lubricant oil as fuel, the precision hygrometer and thermometer were used to measure the temperature and humidity in the air. it was noted that the outside temperature increased more rapidly in areas without insulator. Additionally, humidity displayed a swifter decrease in the uncovered areas than in the sections coated with insulator. However, the insulator ignited at extreme temperature and perfect humidity.

Keywords:

Coconut Coir, Outside Temperature, Metal Furnace, Humidity, Insulation

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Introduction

Metal melting furnaces range up to extremely high temperatures as they're required to melt down various metals, such as steel, into liquids for casting. Due to these high temperatures, there is a risk of metal penetration through the working lining, which can cause severe harm and become a safety hazard. It is thus highly necessary to have high temperature furnace insulation. Insulation helps to further improve the overall performance for it protects workers of heat hazard over time. Foundries where non-ferrous metals are casted are often very hot and is not uncommon in the height of summer for a foundry to be closed shortly on midday because condition is too hot for sustained work (Turner, 1957). There are studies conducted of applying thermal insulators on metal melting foundries for thermal insulators are essential in terms of making structures conducive for people to live in and a nice place to work on (Ganiron, 2013). Among them are redesigning of mini compact crucible furnace using stainless steel plate cylinder combined with ceramic blanket in which a heat insulator was attached on inner wall to maintain temperature in the heating chamber and to avoid heat loss (Soemowidagdo et al 2020). A method to increase the service life of the heat-insulating insert in the air passage of the blast furnace tuyere suggested gluing heat-resistant siliceous fabric onto its outer surface, to reduce heat loss and increase the tuyere resistance to burnout, fixing a ceramic disk to the end of the tuyere's nose (Tarasov et al, 2020). Glass wool was used as insulating material in this furnace that can insulate temperature up to 250 0 C which is favorable to the aluminum melting (Bhamare et al, 2017) while Mineral wool is used for insulation which can withstand temperature up to 1200C making the fiber materials mostly used as thermal insulation in industrial furnace.

Coir which is a lignocellulosic natural fiber derived from the coconut's husk has some unique characteristics, such as its resistance to seawater, microbial attack, high impact, etc., but its low thermal conductivity or high thermal insulating property makes it suitable for being used as insulators, (Mahmud et al, 2023). Although it was found that the coconut fiber's main weakness was that it's easy to decay but the problem was solved by applying treatment process that was carried out on the fibers (Omar et al, 2020). The development of coconut coir into composite materials is an interesting alternative because they have a low thermal conductivity which would lead to the solving problem in simultaneous energy, environment, and thermal comfort (Isa & Majid, 2022). In economical point of view, coconut coir is cheaper compared to other expensive thermal insulating materials such as glass-wools or rock-wools (Chuen et al, 2015). As insulating material, this study was conducted to determine the effect of coconut coir on outside temperature and humidity of a locally made metal melting foundry furnace. Specifically, this study was aimed to:

1) To establish a process of insulating a mini melting furnace using cement, Cementous material and coconut coir
2) describe the technical aspect of the mini melting furnace
3) investigate the effect on outside temperature and humidity when ignited with used lubricant oil as fuel

Methodology

The method used are as follows:

Materials and Equipment Used

Among the materials used are old cylindrical tank, 10 mm Φ reinforced structural bar, 1/4 "Φ metal pipe, metal tube, welding rods, and steel epoxy, plastic bottles, plastic controllers, metal

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stand and plastic hose, coconut coir, hygrometers, thermometers, used lubrication oil, cement and Powermix Cementous water proofing materials. The equipment used are welding machine, electric grinder and electric cutter.

Fabrication Procedure and Assembly

The cylindrical tank was cut to dimension and shaped to form the cylindrical structure of the furnace. The reinforced structural bar was cut and welded to form as stand and frame of the cylindrical furnace. The burner was provided with small holes and was attached through the metal tube serving as the exit of the airflow. The airflow was provided by a small fan which is attached to the metal tube. The small fan has a control selector than can be used to direct the fan rotation to produce air from either from minimum to maximum velocity. Metal pipe was attached to serve as the passage of used lubricant oil from container to the furnace. The metal pipes are attached to the oil plastic container through the plastic hose. The plastic container was mounted vertically serving as the injector of the oil to the furnace. The injection process is using gravitational force so that the oil container is attached to the metal stand at higher location. Metal epoxy which is heat resistant was used to attain stability in the attachment of the metal tube and pipes. Inovation was done by attaching coconut coir with cement and Cementous water proofing materials as additional feature on the constructed equipment. The purpose is to give way in order to determine if the coconut coir is effective to control the spread of hot temperature outside the equipment. Partial coating of coconut coir with cement and Cementous water proofing facilitated the investigation on the effect on temperature between portions that are coated and non-coated with the coconut coir. Used lubrication oil was utilized to fuel the furnace. Omari (2008) concluded that used lubrication oil is a very significant energy source and represents an energy management opportunity with great potential. There is an acute shortage of petroleum oils so that regeneration of fuels from used lubricating oils can be potential substitute of fossil fuels (Sharma et al, 2015). Two hygrometers were placed 15.00 cm besides the wall of the furnace. One of which is placed within the wall covered with coconut coir while the other is placed on the uncovered area as shown in Figure 1. Thermometers were also used to measure the temperature.

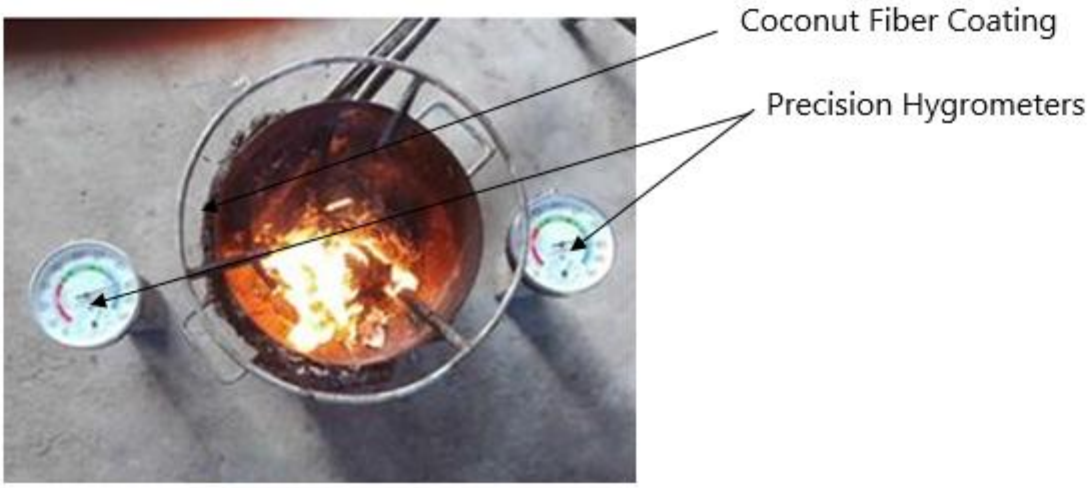

Figure 1: Hygrometer Positioning

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The outside temperature and humidity near the different parts of the melting furnace was investigated specifically that this study looked into the difference between parts coated and non-coated with the coconut coir insulation. Observation was done simultaneously between the area covered and noncovered with coconut coir insulation. A hygrometer is an instrument used to measure the temperature and humidity or moisture content in the air. It provides a quantitative measurement of the amount of water vapor present in the atmosphere. Humidity is an important parameter in meteorology, as it can impact weather conditions, human comfort, and various industrial processes. The parameters used to interpret the humidity of the air are the following:

Table 1: Parameters Used to Interpret the Humidity

Moisture Content (%) in the Air	Interpretation
0-35	Dry
35-65	Perfect
65-100	Humid

Maintaining perfect humidity levels is challenging, but there are several things that can be done to manage and improve humidity conditions, whether they are too high or too low. Suitable indoor air humidity can improve human comfort, optimize indoor air quality and protect indoor furniture items (Yu et al, 2016). The ideal humidity level can vary depending on personal comfort and health considerations. It was recommended to maintain indoor humidity levels between 35% and 65% for it is a perfect humidity based from the device used. Providing a high-quality indoor environment with appropriate indoor humidity levels for residential buildings is essential for good physical and mental health, occupant comfort, and long-term building performance (Liu et al. 2023).

Result and Discussion

The process of insulating the mini melting furnace, its technical aspect, the effect on outside temperature and humidity when ignited with used lubricant oil as fuel were discussed. Time versus temperature and time versus humidity were briefly deliberated.

The Process of Insulating the Mini Melting Furnace

The designed structure of the equipment was shown in figure 2. From the original structure, the partial portions of the metal melting furnace were covered with coconut husk using water,

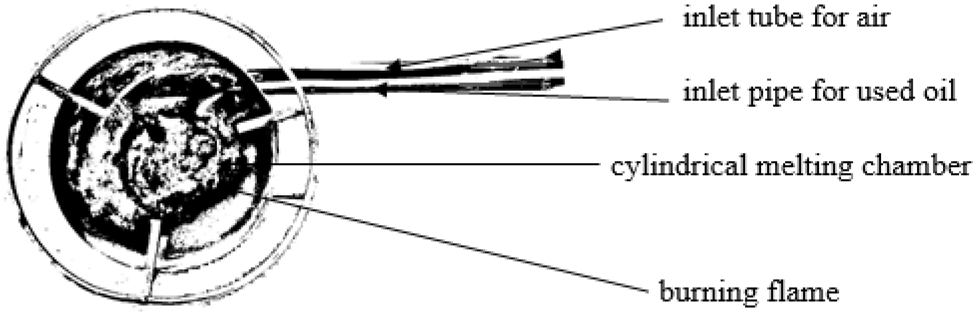

Figure 2: The Designed Structure for Melting Operation

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Powermix Cementous material and pozzolan cement as the binder. The ratio is 1:1:1 components of coconut husk, power mix and pozzolan cement by weight. The highlight of this study was when half portion of the cylindrical tank was covered with coconut coir using cement and Power mix, a flexible Cementous water proofing as the binding materials. With the designed structure shown in the figure 2 it was modified as shown in figure 3.

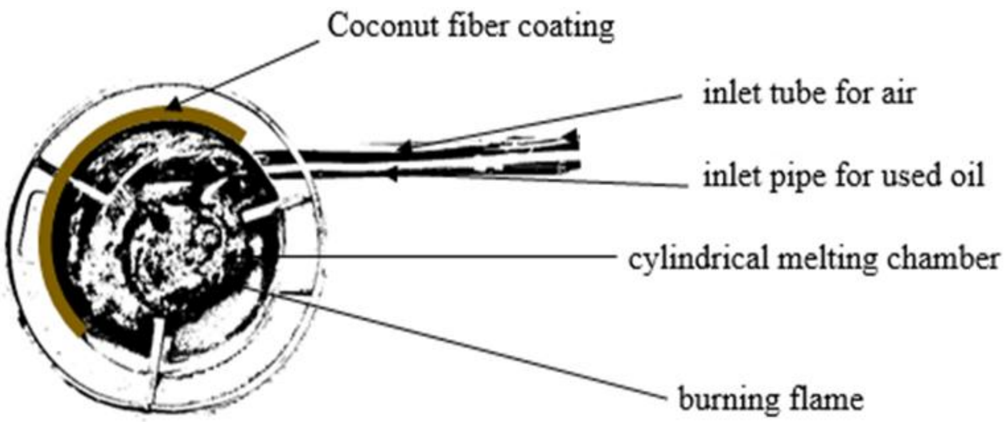

Figure 3: The Designed Structure of Portions Coated with Coconut Coir Fibers

Several steps were followed in order to attach the portion of the coconut coir to the metal melting furnace.

a) With coconut husks as the material, separate the coconut coir from the main bark.
b) Separate more coconut coir to gather substantial coir suited to cover the targeted area of the metal melting foundry furnace then clean it by removing dust particles.
c) Using scissor, cut the separated coir into smaller length to facilitate the pasting of the coir to the metal furnace.
d) Mix the coir with Power mix Cementous material, cement and water as the binding materials.
e) Install the mixture by pasting it to the identified portions of the metal melting furnace.
f) Do the pasting carefully to place the coir in a more stable position.
g) Let the mixture dry for several days.

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Figure 4 shows the structure while the procedures were done in attaching the coir to the furnace.

Fig. 4a: The Separated Fibers from the Bark

Fig. 3b: The Cleaned Fibers

Fig. 3c: The cut fibers

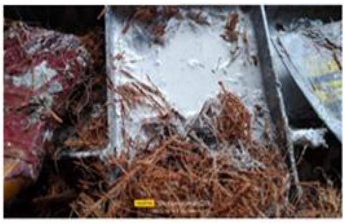

Fig. 3d: The fibers mixed with binders

Fig. 3c: The fibers attached in stable condition

Figure 4: Procedures of Attaching the Coconut Fibers to the Furnace.

Technical Aspect of the Melting Furnace.

Insulating the equipment with coconut husk, power mix and pozzolan cement as binder provides new features from the originally built mini metal melting foundry furnace. There is an additional thickness of 16.67% to some area of the wall of the melting foundry furnace and an additional weight of 8.33%. This implies that the weight contributed by the coconut coir is very minimal. Other technical aspect of the equipment from the original structure does not change.

Effect on Outside Temperature Utilizing Used Lubricant Oil as Fuel

Shown in Table 2 is the result of the experimental study demonstrating a set of data related to temperature (t) and humidity (H) at different time points. Observations were also provided. With used lubricant oil burning in the furnace, recording was started at 2:05 PM. The observations indicate a consistent pattern of increasing temperature with decreasing humidity. The final entry at 2:16 PM was noted that the coconut coir cover started to burn, suggesting a significant rise in temperature. It's essential to monitor such changes, especially when there is a noticeable increase in temperature, as it could have safety implications. The conditions became extreme, possibly exceeding the safe operating limits, leading to the ignition of the coconut coir cover. It is apparent in the data that the coconut fiber ignited even when the air

Table 2: Effect on Outside Temperature Using Used Lubricant Oil as Fuel

Time (PM)	No Cover		With Cover		Observation
	t	H	T	H	
2:05	30	75	30	79	Start of recording the data
2:10	34	66	32	74	There is an increase in temperature but decrease in humidity. The air is humid in both area.
2:11	42	59	38	68	There is an increase in temperature with air in non-covered area is perfect while in covered area is humid.

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2:12	59	50	43	62	There is an increase in temperature. Humidity becomes perfect in both areas.
2:13	70	44	48	56	There is an increase in temperature. Humidity is perfect in both areas.
2:15	103	39	49	48	There is an increase in temperature. Humidity is perfect in both areas
2:16	108	37	52	46	The temperature is so hot. Humidity is perfect in both areas. The coconut coir cover started to burn

temperature is at perfect condition. Monitoring and controlling temperature and humidity are crucial, especially in situations where materials may be sensitive to heat. Temperature is an important factor that affects thermal conductivity while the influence of humidity on the thermal conductivity was more obvious than that of temperature, hence the variations of thermal conductivity with humidity were studied at a constant temperature as Wang et al, (2023) cited that when building materials are exposed to different temperature and relative humidity conditions, their thermal insulation performance will change. Coconut coir is frequently used as a coating material in certain applications, but being organic can burn easily under high temperatures.

Used lubricant oil generate significant amounts of heat and create an environment where nearby materials, such as coconut coir, can easily catch fire. This contains residues, chemicals, and carbon particles that makes the material even more flammable leading to intense localized heat within the furnace. Although perfect humidity implies an environment where the coir's moisture content is low enough to be flammable, but is not so high that the material would be damp and difficult to ignite. Excessive carbon buildup or accumulation of oily residues possibly contributed to the ignition of nearby materials like the coconut coir. Although cement and Powermix are typically designed to be heat-resistant, but under extreme temperatures can undergo chemical changes or degradation, especially if they are exposed to high heat for extended periods. Powermix, as a cementitious material, could contain additives or polymers that might degrade under intense heat, potentially releasing flammable gases or chemicals contributing to the ignition of the underlying coconut coir.

Time Versus Temperature

The graph of time vs. temperature is shown in figure 5 where y axis represents the temperature and the x axis represents the time.

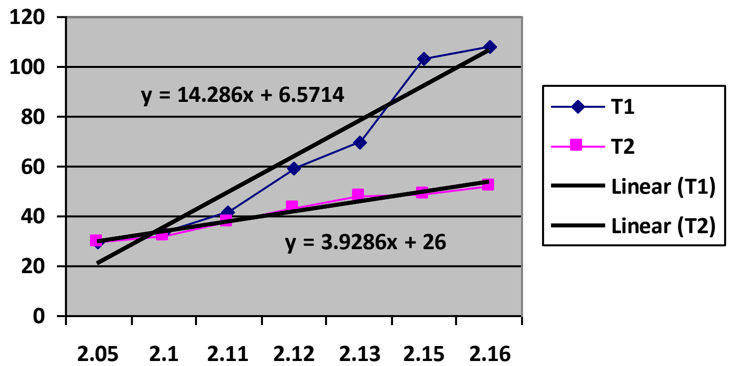

Figure 5: The Graph of Time Versus Temperature

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The equations were determined representing linear relationships between two variables, where y is the dependent variable, and x is the independent variable. For the portion of the furnace not covered with the coconut fiver, the linear (T_1) equation is:

$$y=14.286x+6.5714$$

if differentiated the equation will become:

$$\frac{d_y}{d_x} = 14.286$$

The coefficient of 14.286 represents the slope which is the rate of change of temperature with respect to time while the constant 6.5714 is the y-intercept, representing the initial temperature when time is zero. On portions of the furnace covered by the coconut fibers, the linear (T_2) equation is:

$$y=3.9286x+26$$

if differentiated the equation will become:

$$\frac{d_y}{d_x} = 3.9286$$

the coefficient of 3.9286 represents the slope of the line which is the rate of change of temperature with respect to time while the constant 26 is the y-intercept, representing the initial temperature when time is zero for the covered parts of the furnace. The rate of change of temperature with respect to time is significantly higher for the portion of the furnace not covered with coconut fiber at 14.286 degrees per unit of time compared to the portion covered with the fiber at 3.9286 degrees per unit of time. This shows that the presence of coconut fiber has an effective cooling effect on the furnace environment by slowing down the temperature increase. The coconut fiber serves as an insulating material, acting as a barrier that delays the rapid transfer of heat. This is helpful in scenarios where temperature control is vital, as it helps sustain a more stable and moderate temperature in the covered portions of the furnace. However, a certain limitation is seen in the fact that the coconut fiber ignited in a shorter period of time while the used lubricant oil is burning inside the furnace. This shows a potential vulnerability in relying solely on coconut coir for insulation, as its flammability might compromise its usefulness in certain conditions. Balancing the benefits of temperature regulation with the fire risk associated with the chosen insulation materials becomes a critical consideration in the overall design and safety of the furnace system. Sharahi & Sawlan (2023) were used to estimate temperature and dependent thermal conductivity that has many engineering and industrial applications, such as those for the building sector and chemical reactors. Another approach to estimate thermal conductivity is using a simple integral approach considering the estimation of temperature as dependent parameters in a one-dimensional heat equation heated from one end and insulated from the other end (Kim et al, 2002).

Time Versus Humidity

The graph of time vs. humidity is shown in figure 6 where y axis represents the temperature and the x axis represents the time. The data was taken at the moment that the temperature was recorded for the same period of time. The equations were determined representing linear

$$y = -6.5357x + 79$$

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relationships between two variables, where y is the dependent variable, and x is the independent variable. For the portion of the furnace not covered with the coconut fiver, the linear (H_1) equation is:

If differentiated, the equation will become:

$$\frac{d_y}{d_x} = -6.5357$$

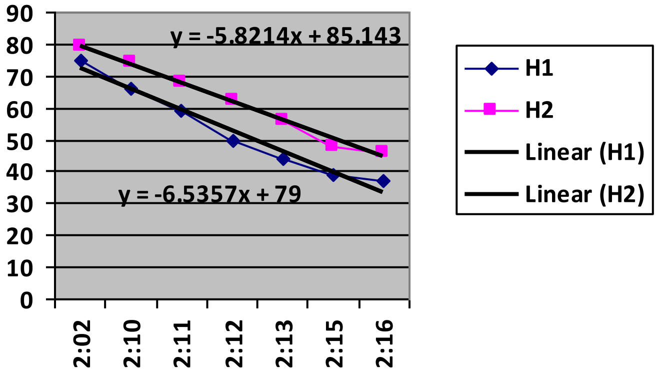

Figure 6: Graph of Time Versus Humidity

The coefficient of -6.5357 represents the slope of the line is the rate of change of humidity which is decreasing with respect to time while the constant term 79 is the y-intercept, representing the initial temperature when time is zero. On portions of the furnace covered by the coconut fibers, the liner (H_2) equation is:

$$y = -5.8214x + 85.143$$

If differentiated, the equation is:

$$\frac{d_y}{d_x} = -5.8214$$

The coefficient of 5.8214 is the rate of change of humidity which is decreasing with respect to time while the constant 85.143 is the y-intercept, representing the initial temperature when time is zero. It appears that the coconut fibers slow down the decrease in humidity during the burning of the furnace which is demonstrated by the different coefficients in the two equations. The initial humidity levels also vary between the two situations. Coconut fiber was found to be the preferred insulator because it has the required attributes to maintain thermal comfort and improve the energy efficiency specifically on residential dwellings (Iwaro & Mwasha, 2019).

Conclusion

The mini metal furnace was constructed by incorporating an additional element into the apparatus which was used to investigate the effectiveness of coconut coir in regulating the dispersion of high temperatures beyond the equipment. This involved applying a partial covering of coconut coir with cement and cementitious waterproofing to examine the impact on temperature and humidities in areas covered and uncovered by the coir. Coating the mini metal melting furnace with a mixture of coconut husk powder and pozzolan cement introduces new features. Some areas of the furnace walls adjusted to 16.67% increase in thickness and an

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additional weight of 8.33%. However, the total weight attributed to the coconut coir remains negligible. Other technical features of the furnace, aside from these changes, remain unchanged from the original design. During a brief period of burning using used lubricant oil as fuel in the metal furnace, it was noted that the outside temperature increased more rapidly in areas without coconut coir coverage compared to those covered with the coir. Additionally, humidity displayed a rapider decrease in the uncovered areas than in the sections protected by coconut coir. However, the coconut coir coating ignited at extreme temperature and perfect humidity in air. The coconut coir as the materials used to control the increase of the outside temperature in the furnace can be adopted at higher temperature only but is not capable to resist the combustion at extremely high condition.

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References

Al-Omari, S. B., (2008). Used engine lubrication oil as a renewable supplementary fuel for furnaces. Energy Conversion and Management, *Energy Conservation and Management.* 49(2008), 3648–3653.

Bhamare, R. Wagh, S. More, P. Zole, A. and Sonaye, S.Y. (2017), Design and manufacturing of portable metal melting furnace, *International Conference on Ideas, Impact and Innovation in Mechanical Engineering*, 5(6), 748-752.

Chuen, K.W. Qian, C.W. Hwa, C.C. and Fouladi, M.H. (2015), Effect of using coconut fibre and polypropylene for thermal insulation in a flat plate collector, *Journal of Engineering Science and Technology*, January(2015), 41-49.

Ganiron, T.U. (2013), Investigation on the use of coco coir polypropylene as thermal insulator. *International Journal of Advanced Science and Technology*, 59(2013), 13-26.

Hayatul, N. Isa, S.M. and Majid, M.A. (2022), A review on coconut coir as thermal insulation material in building application, *Recent Trends in Civil Engineering and Built Environment* 3(1), 389-397.

Joseph, I. and Mwasha, A. (2019). Effects of Using Coconut Fiber-Insulated Masonry Walls to Achieve Energy Efficiency and Thermal Comfort in Residential Dwellings. *Journal of Architectural Engineering*, 25(1): 04019001.

Kim, S. Kim, M.C. and Kim, K.Y. An integral approach to the inverse estimation of temperature-dependent thermal conductivity without internal measurements. Int. Commun. *Heat Mass Transf.* ***2002***, 29, 107–113.

Liu, P. Alonso, M.J. Mathisen, H.M. Halfvardsson, A. and Simonson, C. (2023), Understanding the role of moisture recovery in indoor humidity: An analytical study for a Norwegian single-family house during heating season, *Building and Environment,* 229(2023).

Mahmud, M.A. Abir, N. Anannya, F.R. Khan, A.N. Masudur Rahman, A.N.M. and Jamine, N. (2023), Coir fiber as thermal insulator and its performance as reinforcing material in biocomposite production, *Heliyon*, 9(5)

Omar, M. Abdullah, M.H. Rashid, N. Rani, L. and Illias N. (2020), The application of coconut fiber as insulation ceiling board in building construction, *IOP Conference Series: Materials Science Engineering.*

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 22 (September 2025) PP. 486-496
DOI 10.35631/IJIREV.722027
Sharma, A. Gupta, G. and Agrawal, A. (2020), Utilization of waste lubricating oil as a diesel engine fuel, *IOP Conference Series: Materials Science and Engineering*, 840(2020)012015.

Sharahy, A., and Sawlan, Z. (2023). Estimation of Temperature-Dependent Thermal Conductivity and Heat Capacity Given Boundary Data. *Computation*, *11*(9), 184.

Soemowidagdo, A. Surahmanto, F. Rezani, R. Pramana, S.B. and Lutflan, F. (2020), Redesigning mini compact crucible furnace to improve its performance, *Journal of Physics Conference Series.*

Sonawane, A.A. Chopde, T.R. Shinde, S.K. and Pawar, G.V. (2019), Design and manufacturing of portable metal melting furnace*, Journal of Emerging Technologies and Innovative Research,* 6(4), 50-52.

Tarasov, Y. Kobelev, O. and Sayfullayev, S. (2020), Improving the heat insulation efficiency of the blat furnace tureye, *IOP Conference Series: Materials Science and Engineering.*

Wang, Y. Zhang, S. Wang, D. and Liu, Y. (2023), Experimental study on the influence of temperature and humidity on the thermal conductivity of building insulation materials, *Energy and Built Environment*, 4(4), 386-398,

Yu, S. Cui, Y. and Feng, G. (2016) Research on performance of humidity-controlling materials based on E+, *Procedia Engineering*, 146(2016), 318-326.