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EFFECTS OF DYNAMIC COMPRESSION ON THE THERMAL CONDUCTIVITIES OF SELECTED WOOD PRODUCTS OF DIFFERENT PARTICLE SIZES

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ABSTRACT: *The study examines the effects of dynamic compression on the thermal conductivity of five different wood species of the families of Sterculiaceae, Moraceae and Ulmaceae. These species are; Nesogordonia papaverifera, Milicia excelsa, Antiaris africana, Celtis zenkeri and Celtis phillipensis. The results showed that, increase in compacting pressure resulted to increase in the thermal conductivities of the wood samples. It was also noted that, the thermal conductivity decreases with increase in the particle sizes of the wood material. The thermal conductivity values obtained for the samples fall within the range 0.0890 - 0.1534* $Wm^{-1}K^{-1}$ *for wood materials. This range lies within the thermal conductivity values of common material used in Asbestos, Rubber, Diatomite and Chlorinated poly- ether. In addition, 850* μ*m of Nesogordonia papaverifera (Danta) pose the best insulation among the particle sizes considered Hence, the selected wood materials could find useful applications in industrial insulating devices and could also serve as good potential devices as heat resistant*.

KEYWORDS: Thermal conductivity, Dynamic compression, Particle sizes.

INTRODUCTION

Wood is a material that can be found all around us, comes in different sizes, colours and shapes. Wood has been used and adapted by man since the earliest recognition that the material could be utilised for solving basic needs. Wood products are used to meet different human needs in peace, farming and in industry. People have come to understand that wood has so many uses and is essential to human life, overtime; a lot of research has gone into the properties of wood (Atalla *et al*. 2005). Throughout the world, there has been a high cry in the environmental degradation caused by high industrial activities; the need therefore arises to develop useful devices from waste materials that constitute negative impact on the environment. There are lots of waste materials ranging from nuclear waste to biomass.

Sawdust has hitherto been classified as a waste and a nuisance to man and his environment, but in recent years, a lot of researches have been carried out on the properties, uses, and applications of sawdust (Ogunleye and Awogbemi, 2012; Oluyamo and Bello, 2014). This research revealed that, particle sizes consideration had been shown to considerably improve the insulation properties of wood materials (Adekimi, 2004). The use of sawdust in energy generation and utilization are also essential in human daily need / activity.

Thermal conductivity is a critical attribute when offering energy conserving building products (Korkut *et al*. 2013). This is due to the fact that wood has excellent heat insulation properties. Lower thermal conductivity values equates to greater heat insulating properties (Daniel, 2010). Thermal conductivity (a property of material) depends essentially upon the following factors; material structure, moisture content, density of the material, pressure and temperature (operating condition), e.t.c (Rajput, 2006). Wood exhibits low thermal conductivity (high heat-insulating capacity) compared with materials such as metals, marble, glass and concrete. Due to the significance of wood and wood products in buildings, the energy design of wood frame buildings and the evaluation of their energy performance depend in part on thermal properties of wood products (TenWolde *et al.* 1988). Information on the thermal conductivity of wood and its relationship to other wood properties is of interest from the standpoint of thermal insulation, drying, plasticizing, preservation, gluing of wood, and where heat resistance of wood is a major consideration in its application (Şahin *et al.* 2010).

This present research, however, is aimed at investigating the effects of dynamic compression on the thermal conductivities of selected wood products of different particle sizes.

MATERIALS AND EXPERIMENTAL PROCEDURE

The materials that were used in the study include five different wood species of the families of S*terculiaceae, Moraceae and Ulmaceae* found in the rainforest region, South Western Nigeria. The wood samples were collected from different sawmill in Akure South Local Government Area of Ondo State, South Western Nigeria. These wood samples were shaved into particle dust/ sizes at the wood laboratory of The Federal University of Technology, Akure (FUTA). A mechanical test sieve shaker was used in the study to sieve the particles using different mesh, such as 300 µ m, 600 µ m and 850 µ m respectively. The samples were compressed into different compacting pressure, turned into circular disc's shape using a modified California Bearing Ratio (CBR). The final configurations of the samples are shown in Figure 1. The thermal conductivities of the sample were determined using the modified lee's disc apparatus. Details of the procedure can be found in the literatures (Griffin and George, 2002; Duncan and Mark, 2000). The Thermal Conductivity (λ) of each sample of thickness (d) and radius (r) was estimated using equations (1) and (2)

$$\lambda = \frac{ed}{2\pi r^2}\left[a_S\left(\frac{T_A+T_B}{2}\right)+2a_AT_A\right] \tag{1}$$

where e is given by:

$$e = \frac{IV}{\left[a_AT_A+a_S\left(\frac{T_A+T_B}{2}\right)+a_BT_B+a_CT_C\right]} \tag{2}$$

where a_A , a_B , a_C and a_S are the exposed surface areas of discs A, B, C and the wood sample respectively. T_A, T_B and T_C are the temperatures of the discs A, B and C above ambient. V is the potential difference across the heater and I is the current which flows through it.

RESULTS AND DISCUSSION

The variations of the compacting pressure with thermal conductivity of the different wood species are illustrated in Figures 2-6. The thermal conductivity increases as the compacting pressure increases in agreement with previous research in the study of local thermal insulating materials for thermal energy storage (Ayugi *et al.* 2011). In addition, 850 µm of *Nesogordonia papaverifera* at a compacting pressure of 2.6 MPa pose the best insulation among the wood particles considered. The thermal conductivity values obtained ranged from 0.1201 - 0.1534 $Wm^{-1}K^{-1}$ for *Celtis phillipensis* (Ita funfun), 0.1012 - 0.1480 $Wm^{-1}K^{-1}$ for *Celtis zenkeri* (Ita pupa), 0.1025 - 0.1452 $Wm^{-1}K^{-1}$ for *Antiaris africana* (Oriro), 0.1077 - 0.1479 $Wm^{-1}K^{-1}$ for *Milicia excelsa* (Iroko) and 0.0890 - 0.1360 $Wm^{-1}K^{-1}$ for *Nesogordonia papaverifera* (Danta). All the samples have high thermal conductivity values at 300 µm particle size. *Celtis phillipensis* recorded the highest thermal conductivity value of 0.1534 $Wm^{-1}K^{-1}$ while *Celtis zenkeri* and *Milicia excelsa* had close conductivity values of 0.1480 and 0.1479 $Wm^{-1}K^{-1}$ at a compacting pressure of 3.0 MPa. For particle size of 850 µm, *Celtis phillipensis* still recorded the highest thermal conductivity value of 0.1351 $Wm^{-1}K^{-1}$for all the samples. The increase in thermal conductivity with compacting pressure could be due to decrease in porosity as the compacting pressure increases. As sample particle sizes decreases, thermal conductivities, λ increases. This could also be due to reduction in intermolecular distance between the grains in the wood materials as the particle sizes decreases. This is being expected since, as the particle sizes increases, the porosity of the materials also increases, leading to decrease in conductivity. The values of the conductivities of the wood species as the compacting pressure increases are shown in Table 1. The range of values of the thermal conductivity falls within 0.0890 - 0.1534 $Wm^{-1}K^{-1}$. Hence, the wood materials could be harnessed for use in thermal insulators and solar device materials.

CONCLUSION

The effects of dynamic compression on thermal conductivity of wood species had been investigated. The thermal conductivity of wood samples increase with increase in compacting pressure. The wood samples considered at specific particle sizes exhibit low thermal conductivity that is comparable with materials used as industrial insulators. The result in the study revealed that dynamic compression affects the thermal properties of the wood samples. Hence, the effects of pressure on wood utilization need to be considered in their various modes of applications in lagging materials, industries and home appliances.

Figure 1: Final disc shape of the samples for different particle sizes

Table 1: Compacting Pressures and Thermal Conductivity ($Wm^{-1}K^{-1}$) Values of the Wood Samples for Different Particle Sizes

Compacting Pressure (MPa)	**Thermal Conductivity**														
	Celtis phillipensis			***Celtis zenkeri***			***Antiaris africana***			***Milicia excelsa***			***Nesogordonia papaferivera***		
	300 µm	600 µm	850 µm	300 µm	600 µm	850 µm	300 µm	600 µm	850 µm	300 µm	600 µm	850 µm	300 µm	600 µm	850 µm
2.6	0.1335	0.1234	0.1201	0.1235	0.1129	0.1012	0.1197	0.1148	0.1025	0.1233	0.1103	0.1077	0.1117	0.1046	0.0890
2.7	0.1431	0.1334	0.1232	0.1314	0.1182	0.1123	0.1234	0.1208	0.1140	0.1322	0.1237	0.1103	0.1244	0.1101	0.1093
2.8	0.1509	0.1398	0.1262	0.1348	0.1234	0.1151	0.1352	0.1307	0.1211	0.1391	0.1323	0.1141	0.1283	0.1151	0.1106
2.9	0.1512	0.1406	0.1306	0.1410	0.1315	0.1188	0.1408	0.1331	0.1256	0.1401	0.1375	0.1217	0.1319	0.1198	0.1124
3.0	0.1534	0.1435	0.1351	0.1480	0.1367	0.1249	0.1452	0.1379	0.1285	0.1479	0.1401	0.1349	0.1360	0.1212	0.1210

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Fig. 2: Thermal Conductivity ($Wm^{-1}K^{-1}$) as a function of Compacting Pressure (MPa) for *Celtis phillipensis*(Ita funfun)

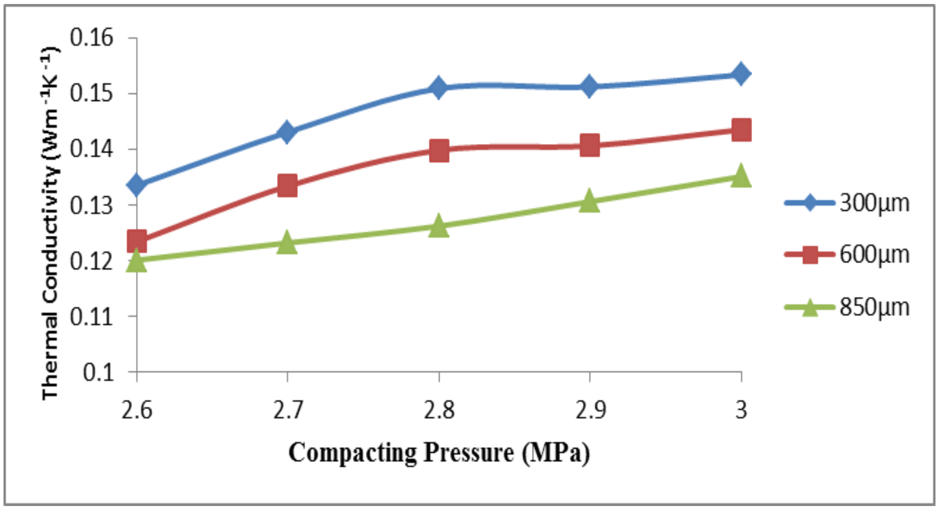


Fig. 3: Thermal Conductivity ($Wm^{-1}K^{-1}$) as a function of Compacting Pressure (MPa) for *Celtis zenkeri* (Ita pupa)

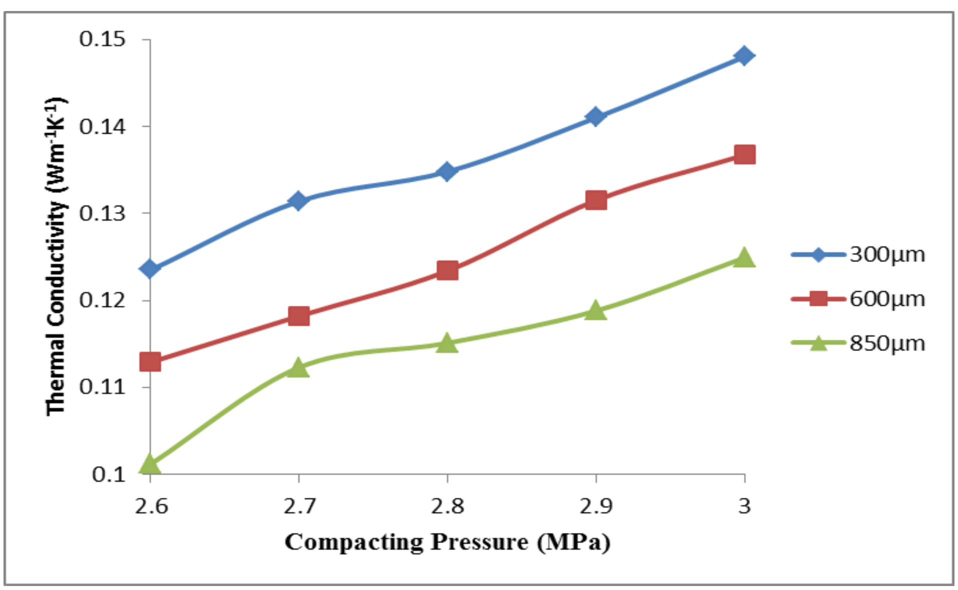


Fig. 4: Thermal Conductivity ($Wm^{-1}K^{-1}$) as a function of Compacting Pressure (MPa) for *Antiaris africana* (Oriro)

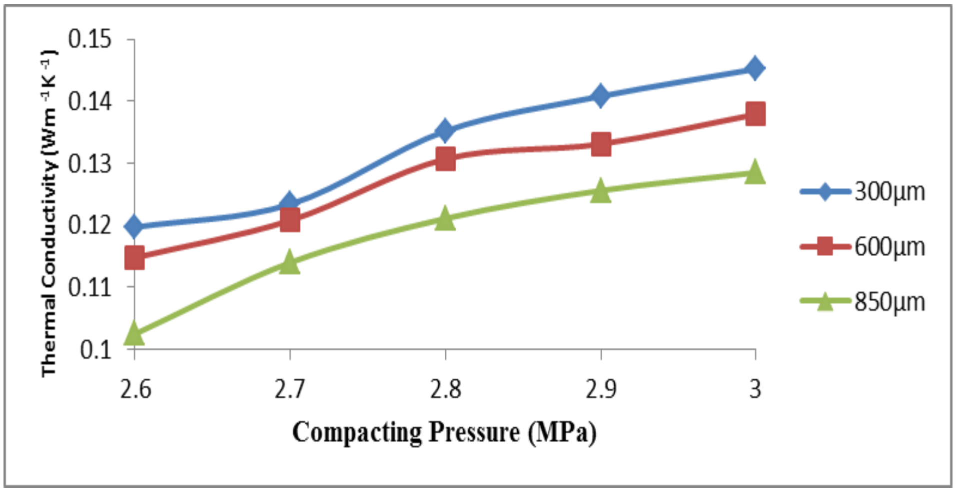


Fig. 5: Thermal Conductivity ($Wm^{-1}K^{-1}$) as a function of Compacting Pressure (MPa) for *Milicia excelsa* (Iroko)

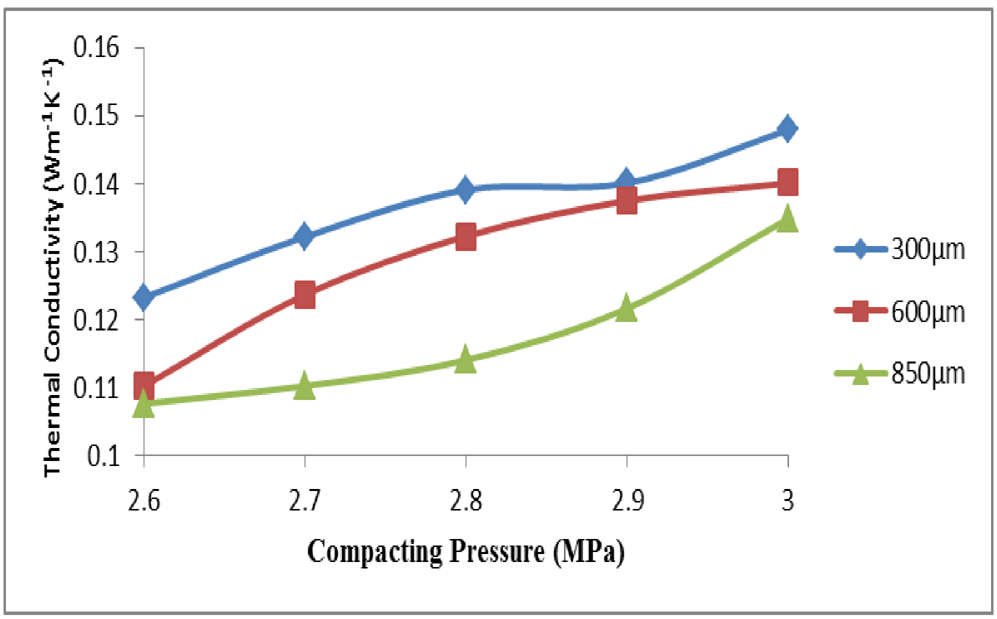
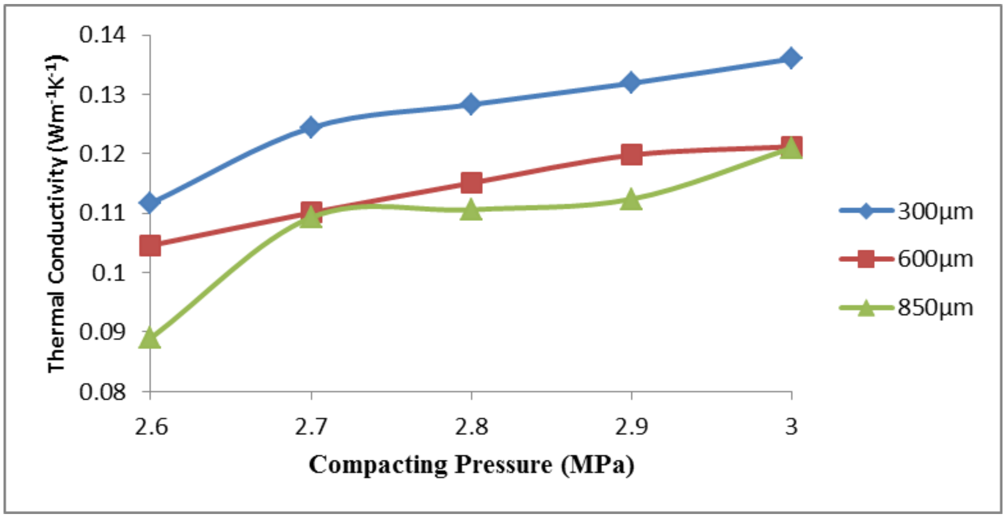


Fig. 6: Thermal Conductivity (Wm $^{-1}$K $^{-1}$) as a function of Compacting Pressure (MPa) for *Nesogordonia papaverifera* (Danta)



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