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Thermal properties of *Myrtaceace* and *Mimosoideae* family Indian wood species

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ABSTRACT

Thermal properties such as thermal conductivity, specific heat and thermal diffusivity of *Mimosoideae* and *Myrtaceace* family Indian wood species were measured at normal dried condition. A significant variation in thermal properties is observed with respect to each species of same botanical family as well as in same species also. The variation in thermal properties is critically discussed with density and porosity. Structural variations in wood have been analyzed on the basis of variation in thermal parameters.
Keywords: *Mimosoideae* and *Myrtaceace* wood species, thermal conductivity, specific heat, thermal diffusivity, density, porosity, structural variation

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INTRODUCTION

Wood is a natural complex composite material, lignocelluloses, which is comprised of components having different chemical nature. Because of temperature variation, the crystalline structure of cellulose may be altered, resulting change in strength and considerable variations in physical behaviour, including its ability to conduct heat (Yacipi. F2011).

Thermal properties of wood are of high interest in the wood industry such as drying, thermal treatment, steaming and hot gluing to optimize their process technology, more essential in building physics for modeling energy efficient timber constructions. Thereby, thermal conductivity, heat capacity and thermal diffusivity are the most important parameters necessary to most accurately calculate and simulate the thermal behaviour of wood, Science wood is an anisotropic material; thermal conductivity and diffusivity depend strongly on the anatomical direction. The heat capacity is a material-immanent parameter independent from the anisotropic structure and has similar values for all wood species. All three parameters are strongly influenced by temperature and moisture (Pozgaj et al. 1997, Niemz et al. 2010), density (Harada et al. 1998), moisture content (Hrcka 2010), temperature (Olek et al. 2003), mechanical load (Bucar and Straze 2008), etc.

The goal of the present investigation is study of the thermal properties such as specific heat, thermal conductivity and thermal diffusivity of *Mimosoideae* and *Myrtaceace* Indian wood species in the tangential direction at normal dried condition.

MATERIAL AND METHODS

For the study of Thermal properties, wood species are taken in pellet form. Thermal conductivity is determined by Lee's apparatus; Specific heat of materials is determined by the method of mixtures and thermal diffusivity is calculated by using the experimental values of thermal conductivity, specific heat and density.

The sample pieces, spherical in shape, were heated to a study temperature (θ_2) in a Regnault's apparatus .The weight of copper calorimeter with stirrer (W_1) was determined by using single pan balance. The calorimeter was filled with water just sufficient to immerse the solid samples in it. The weight of the calorimeter, stirrer and water (W_2) was determined. The initial temperature (θ_1) of calorimeter and water kept at room temperature was noted. The calorimeter was enclosed in a wooden box with wool to minimize lose of heat due to conduction and convection. Loss of heat due to radiation the solid sample pieces, at temperature θ_2, was then dropped into calorimeter containing water. The mixture was stirred well and the resultant temperature (θ_3) was measured. The weight (W_3) of calorimeter with stirrer, water and the samples was determined.

If'S' is the specific heat of the calorimeter, the specific heat 'S' of the samples is given by

$$S = \frac{[(W2 - W1) + W1s](\theta 3 - \theta 1)}{(W3 - W)(\theta 2 - \theta 3)}$$

If'S' is the specific heat of the disc, the thermal conductivity (K) of the samples is given by

$$K = \frac{ms\,(r+2d)\,\alpha t}{2(r+d)\,\pi r2\,(\theta 1 - \theta 2)}$$

Here mass (m) of the lower bras disc without the attachment of strings was determined by a single pan balance. The thickness (d) and the diameter (2r) of the lower brass disc were determined with vernier calipers. The thickness of the sample (t) was determined by a screw gauge.

Thermal diffusivity of the samples is calculated from experimentally obtained values of specific heat, thermal conductivity and density

$$\text{Thermal diffusivity} = \frac{\text{Thermal conductivity}}{\text{Specific heat X density}}$$

RESULTS AND DISCUSSION

Heat exchange in living organisms, under natural conditions, is one of the most important processes where this process is under constant interaction with external environment. Thermo regulation in living organism, through the process of heat transfer, can be understood by the study of thermal capacity and thermal conductance of macro molecular, fluids and extracts present in different systems which carry out life process.

The table present below is data on thermal properties such as specific heat, thermal conductivity and thermal diffusivity along with density and porosity of 8 types of wood species taking 10 samples each at normal dried condition. It is evident from the data that 8 species of woods of *Mimosoideae* and *Myrtaceace* botanical families' exhibit considerable variation in observed parameters as represented in graphs. Results on thermal parameters of 8 types of wood species reveal that considerable variations in different wood samples and also in different specimens of the same wood, obtained from the variation in different wood samples. This may be attributed to the inhomogeneous deposition of mineral content in different wood samples and also in different specimens of the same wood, obtained from various parts of the tree. Wood density and porosity investigated on thermal parameters were significantly interrelated. The present investigations on thermal properties of woods reveals that values of specific heat and thermal conductivity of hard woods and soft woods are different in woods belonging to different botanical families. Specific heat of hard woods and soft woods of different species are independent of density or species(Simpson and TenWolde, 1999). The heat capacity of fresh wood that contains water is greater than that of dry wood; specific heat of wood depends on the temperature and moisture content of the wood. The dependence of specific heat with temperature reveals that bound water undergoes only a limited phase change which occurs over a large temperature range.

Table: Data on thermal properties of wood species

Name of the wood species	Type	Botanical Family	Density gm/cm^3	porosity	specific heat cal gm^{-1o}C^{-1}	Thermal conductivity K(X10^{-4}cal s^{-1}cm^{-1o}C^{-1})	Thermal diffusivity cm^2 S^{-1}
Psidium guajava (PG)	Hard wood	*Myrtaceace*	0.79±0.06	0.48±0.08	0.49±0.04	2.6±0.46	8.64±1.21
Eucalyptus melliodora(EU)	Hard wood	*Myrtaceace*	0.83±0.04	0.46±0.15	0.71±0.01	3.1±0.21	5.84±0.4
Syzium Cumini(SC)	Hard wood	*Myrtaceace*	0.71±0.07	0.54±0.25	0.52±0.05	2.85±0.11	8.02±0.76
Prosopis juliflora(PJ)	Hard wood	*Mimosoideae*	0.84±0.12	0.45±0.06	0.41±0.03	3.46±0.23	9.18±2.1
Acacia Nilotica (AN)	Soft wood	*Mimosoideae*	0.75±0.17	0.51±0.18	0.63±0.05	3.52±0.14	6.3±0.1
Leucaena leucocephala(LL)	Soft wood	*Mimosoideae*	0.43±0.04	0.65±0.14	0.78±0.07	2.19±0.21	11.9±0.44
Pithecellobium dulce(PD)	Hard wood	*Mimosoideae*	1.1±0.11	0.28±0.08	0.34±0.02	4.2±0.33	6.52±0.79
Albizia saman (AS)	Soft wood	*Mimosoideae*	0.48±0.06	0.69±0.15	0.8±0.02	1.76±0.2	4.38±0.17

Thermal conductivity of hard woods (*Pithecellobium dulce(PD)*:45.2, ±0.33) is found to be more compared to soft woods (*Annona squamosa*(AS): 1.76, ±0.2).The variation in thermal conductivity in different woods of same and in different botanical families is due to the density variations (shahin kol and Altun;2009). Wood is a good thermal insulator; its thermal conductivity values are low. The thermal conductivity of wood is affected by a number of basic factors: density, moisture content, extractive content, grain direction, structural irregularities such as checks and knots, fibril angle, and temperature. Thermal conductivity increases as density, moisture content, temperature, or extractive content of the wood increases.

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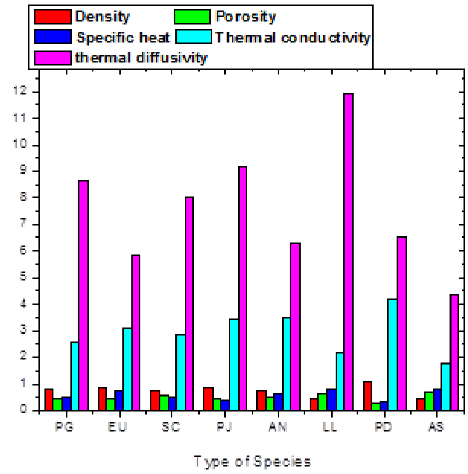

Figure 1 A Comparison on thermal parameters of Indian wood species

The significant variation in specific heat and thermal conductivity of wood species of different botanically families are due to the structural and composition of organic and inorganic matter present in wood. Thermal diffusivity is a measure of how quickly a material can absorb heat from its surroundings. Thermal diffusivity of different wood species of different families varies with density and porosity is present in wood.

CONCLUSIONS

Thermal characteristics of wood are affected by composition, water absorption and extractives present in wood. If significant porosity exists in structure, the area available for conduction is reduced and rate of heat flow is reduced.

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