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THERMAL CONDUCTIVITY OF CHICKEN FEATHER AND PUMICE STONE REINFORCED THERMOPLASTIC COMPOSITE MATERIALS

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Abstract: *Natural fibres are green materials and have some advantages i.e. are renewable, reasonably cheap, biodegradable and ecologically freindly. Conversely, composites made of natural fibers can be used as a reinforcement material either long or short forms or recycled fibres. In the production of this NFC materials are made from a combination of natural fibers and polymeric matrice. In this study, thermoplastic-based polypropylene chips composites were produced by making use of pumice stone with different grain structures and chicken feather as reinforcement. In the composite production process hot-pressing machine was used to develop novel composites. Prior to the production process, the pumice stones were determined in the sizes of 0-1mm, 1-2mm and 2-3mm by passing them through a regular sieve. Later, chicken feathers with 0-1 mm granule structure were chopped in a blender and mixed with pumice stones separately. These mixtures were sewn in between polypropylene nonwoven fabrics. The composite plates were obtained by placing polypropylene chips on top and bottom of the sewn fabric. The samples for thermal conductivity tests were cut with a diameter of 28 mm from these plates. And heat conductivities of these samples were tested on the P.A. HILTON LTD. H940. By reinforcement materials such as chicken feather and pumice stone, it is aimed to improve the heat conductivity properties of the produced composites. Overall results showed that an increas in particle size of pumice stone has negative effect on the thermal conductivity of natural fiber composites.*

Keywords: *Pumice, chicken feather, polipropilen, composite, heat conductivity*

1. INTRODUCTION

Technological innovations have helped the humanbeings to improve their living standards, with the pace of development and research throughout the history. However, some technological improvements have also a negative environmental impact. Therefore, nowadays more efforts are being made to use natural-based biological and sustainable materials that exist in nature instead of creating new materials. The engineering and technical applications of textile structures have gained importance in fiber reinforced composite production, especially due to their lightness, strength, durability, thermal resistance, low density and stability [1-3]. CFF (Chichen Feather Fiber) is often defined as a waste by-product and contributes to environmental pollution due to disposal problems. There are two main chicken feather removal methods available in industry, which are burning and embedding. Unfortunately, both have negative effects on the environment. Recent studies on chicken feather wastes have shown that they can be a potential composite reinforcement material. The CFF composite reinforcement application offers a more efficient way to solve environmental problems compared to conventional disposal methods. There are some advantages of CFF, they are cheap, renewable and readily available. CFF as a composite reinforcement material has desired features such as being light, having high thermal isolation and excellent acoustic properties, non-corrosive behaviour and excellent hydrophobic properties. CFF has the lowest density value compared to other all natural and synthetic fibers [4-7]. Castano et al reported that CFF keratin biofuels provide a uniform distribution and adhesion between polymers due to their hydrophobic nature and CFF-reinforced composites have good thermal stability and low energy distribution [8-9]. In composite structures, properties such as lightness, strength and modulus, fatigue strength, electricity and heat conductivity and also their economy play a role in the selection of reinforcing material. Properties like providing tension transfer between fiber and matrix, fiber corrosion, oxidation, environmental impact and protection of matrix material are the important selection criterias of the composites. The advantage of composite materials is that it combines the best features of its components [10]. Pumice-based products are resistant to fire, mould and pests. Fine-grained, pure white, hard, light and neutral pumice stones are used as natural puzzlers in Portland cement production as mineral additives. In this study, heat permeability values of produced composite materials were tested. Chicken feathers and pumice stones were added into polypropylene to produce composite materials [11]. Some researchers [12] also indicate that, in natural fibre composites (NFCs) novel manufacturing processes and surface modification methods can be developed in future studies; therefore in this study we first aimed to produce reinforced composite materials both made of pumice stone with different grain structured and chicken feathers. Later, we will highlight its thermal conductivity properties.

2. MATERIAL AND METHOD

In this study, pumice stone and chicken feathers were used as a reinforcing material. Polypropylene nonwoven fabrics have been used in the upper parts of the chips to prevent slippage in the composite. In addition, polypropylene sewing threads were used to sew the fabrics. Thermoplastic-based composites are manufactured by reinforcing the chicken feathers and pumice stone into polypropylene chips as polymer matrix material.

In the hot press machine, the upper and lower tables pressed the reinforcement materials with 200^{o}C temperature under 1.00 bar pressure to obtain composite structures as shown in Figure 1. Pumice stones with 0-1 mm, 1-2 mm and 2-3 mm sizes were determined by passing through sieves. Later, they were mixed separately with chicken feathers having a grain structure of 0-1 mm by passing through the blender. These blended materials were planted by placing them between polypropylene and nonwoven fabrics. Composite plates were obtained by placing polypropylene chips on the upper and lower parts of the fabric. Heat samples were cut in 25 mm diameters from these plates for the heat permeability tests.

Fig 1: *Production stages of composites in hot press machine*

3. HEAT CONDUCTIVITY ANALYSIS

Heat conductivity tests of the samples were performed with P.A. HILTON LTD. H940 heat transmission device. Composite material samples for the heat conductivity test were cut in a circle form with a 25 mm diameter and placed in the device. Linear conduction module is applied on the heat conduction device.

The heat flow rate (Q) can be obtained from the digital display unit of the device. The K (heat transfer coefficient) value is determined by placing the values in the formula at Equation 1.

$$K = (Q \cdot Dx) / (A \cdot Dt) \quad \textbf{(1)}$$

$$Dt = T3 - T7$$

A: area of the field (m^2), Dx: thickness of material (m), Q: heat flow rate (w), T3: given heat (^oC), T7: received heat (^oC), Dt: temperature difference (^oC), K: heat transfer coefficient (W/m^oC)

Fig.2: *Heat transmission device and a tested sample*

As a result of the testing operation, the heat transfer coefficient (K) was calculated in W/m^oC unit. The test samples used in the heat testing is as shown in Figure 2. Before starting the heat conductivity measurement test, the machine has been calibrated. The temperature was fixed at 22°C and test procedures were performed.

4. RESULTS AND DISCUSSION

The results of heat conductivity test for 4 different pumice and chicken feather reinforced composite materials with 25 mm diameter and 2 mm thickness are given in Table 1. The results of the heat conductivity tests are as given in Table 1.

Table 1. *Heat transfer coefficients of composite materials*

Pumice stone and chicken feather reinforced composite materials	**Heat transfer coefficient (k)(W/m^0C)**
1-2 mm grain structured Chicken feather reinforced composite	1,48259114
Chicken feather and 0-1 mm pumice stone reinforced composite	1,452339317
Chicken feather and 1-2 mm pumice stone reinforced composite	1,425868972
Chicken feather and 2-3 mm pumice stone reinforced composite	1,474218864

The best heat conductivity value of the produced material was the reinforced composite material with chicken feather and 1-2 mm of pumice stone sample.

5. CONCLUSIONS

In the produced reinforced composite materials, the particle size of the reinforcement material is one of the important factors in heat isolation. Thermal transition increases or decreases according to the grain size. Effects on heat conductivity values were determined by adding pumice and chicken feathers to polymer materials. The increase in particle size of pumice stone negatively affected the heat permeability values.

The tensile and flexural properties of the control (0%) composites for the resins, vinylester and polyester, have significantly superior properties to the CFF reinforced composites. The tensile and flexural values decrease when the fibre loading percentage increases. The control (0%) composite tensile strength was found to be 5000N whilst the CFF reinforced vinylester composite tensile strength was at maximum 1891N. It is evident that the reinforcement material decreases the tensile property of the composites almost three times. For the flexural property, the reinforced composites indicate around two times lower value than the control composite. Only the Charpy impact values of the CFF reinforced composites are considerable better when compared with the control (0%) composites [12].

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