STUDY THE THERMAL PROPERTIES AND WATER ABSORPTION OF COMPOSITE MATERIALS RRINFORCED WITH DATA AND OLIVE SEEDS

Alaa Abd Mohammed
Asst. Lec. Mat. Eng. Depart.
Uni. of Technology
Alaa _eng.2010 @ yahoo.com

ABSTRACT

This work focuses on the study the effect of data seeds (DS) and olive seeds (OS) on thermal and water absorption properties of epoxy resin. Olive and dates seeds were added to epoxy matrix at weight fraction (0, 8, 13&18%wt) with grain size (300, 450 & 600µm). The composite specimens were prepared by Hand-Layup technique according to standard test. The results show that the thermal and water absorption properties of composites increasing with increase weight fraction of particles. Also its found the higher value of thermal conductivity, thermal diffusivity, specific heat and water absorption happened at (=18 wt%) and grain size (300µm) for specimens reinforced with olive seeds. The mathematical model results show that the weight fraction of particles have higher effect than grain size on properties.

KEY WORDS:- **Composite materials, data seeds, olive seeds, thermal properties, water absorption, mathematical model.**

دراسة الخواص الحرارية وامتصاصية الماء للمواد المتراكبة المقواة بنوى تمر وزيتون

الخلاصة :-

يتركز هذا العمل على دراسة تأثيرمسحوق نوى الزيتون والتمر على الخواص الحرارية وامتصاصية الماء لمادة الايبوكسي. تم أضافة نوى الزيتون والتمر الى مادة الاساس الايبوكسي بالكسور الوزنية التالية (0, 8, 13 &18%wt) مع حجم حبيبي (mµ300, 450 &600). حضرت العينات المتراكبة بطريقة الخلط اليدوي حسب المواصفة القياسية لكل فحص. بينت النتائج بإن الخواص الحرارية وامتصاصية الماء للمتراكبات تزداد بزيادة الكسر الوزني للمساحيق. ايضاً وجد بان اعلى قيم لمعامل التوصيل الحراري، الانتشار الحراري ,الحرارة النوعية وامتصاصية الماء كانت عند كسر وزني (18% wt) وحجم حبيبي (300 mµ)عند التقوية بمسحوق نوى الزيتون. بينت نتائج الموديل رياضي بإن الكسور الوزنية لمادة التقوية كانت ذو تأثير أكثر من الحجم الحبيبي على الخواص.

الكلمات المرشدة:- مواد متراكبة، نوى زيتون، نوى تمر، خواص حرارية، امتصاصية الماء، موديل رياضي.

INTRODUCTION :-

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Given the vast range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple, and useful definition. However, as a common practical definition, composite materials may be restricted to emphasize those materials that contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent. The resulting composite material has a balance of structural properties that is superior to either constituent material alone (Carl, 1998).

There has been an expanding search for new materials with high performance at affordable costs in recent years. With growing environmental awareness, this search has particularly focused on eco-friendly materials. In the last decade, a growing interest in the use of vegetable reinforcements in the development of composite materials has gained momentum. Lignocellulosic reinforcements present interesting features such as low cost، low density, and besides they are biodegradable and non-abrasive (Jimenez, 2008).

The widespread use of plastic materials has created severe environmental, economic, social, and political problems. The availability of landfill space has decreased rapidly and the cost of landfilling plastic wastes has increased enormously. To alleviate these problems, plastic recycling is becoming a priority in most waste management programs (Yam, 1990). The other method to take this problem is to use natural materials as the reinforcements in polymers (Rozman, 2001).

Olive seeds, a lignocellulosic material, is currently used mainly as energy source. Recently, we can found in the literature references to its use as a raw material to produce activated carbon and furfural and as heavy metal bio-sorbent. Steam-explosion was also applied to this material in order to separate the main components: cellulose, hemicellulose and lignin (Sibaja, 2005).

These materials thus form inexpensive “new or secondary resources”, which could make them more valuable for wider utilization. When such materials are used in composites, developing countries, which produce these, become part of global composite industry as developer and manufacturer leading to increasing revenues and the creation of jobs (Rijswijk, 2002 & Sao, 2002).

Jimenez, L. et al in (2008) have illustrated a composite material using unsaturated commercial polyester resin (UPE) and olive brush seed (OBS) was prepared. OBS was treated with sodium hydroxide and maleicanhydride (MAN) and subsequently utilized in a proportion of 35 wt.% to prepare a composite material. These materials were evaluated in terms of moisture absorption, surface density، and mechanical properties such as flexure and tensile tests (Jimenez, 2008).

Qutaiba, A. in (2011) has studied of a new range of sustainable reinforced polymer composite materials using powdered olive pits as a novel filler material to be used with synthetic resin. Also the influence of the untreated and treated powder loading (weight fraction) on the void content and the mechanical properties of the composites was examined (Qutaiba, 2011).

Perinovic, & Andricic, (2012) have investigated the influence of different processing techniques on the thermal properties of poly (L-Lactide) reinforced with olive stone. It was found that the results of thermal properties of composites depend on the processing technique (Perinovic, 2012).

Koutsomitopoulou, et al. in (2013) have illustrated the effect of olive pits powder reinforced PLA-matrix. This study is focused on recycling potential of some waste materials, such as olive pits, i.e. the solid phase derived from an olive oil mill, blended with thermoplastic polymers and used for the production of new materials applied in manufacturing containers and formworks. The olive pit powders are described and characterized. Then the powder is introduced in a bio-based and biodegradable matrix (polylactic acid, PLA) at various percentages (Koutsomitopoulou, 2013).

Hamma, et al. in (2013) have studied the effects of date stone flour (DSF) on morphology, thermal, and mechanical properties of polypropylene (PP) composites in the absence and presence of ethylene-butyl acrylate-glycidyl methacrylate (EBAGMA) used as the compatibilizer (Hamma, 2013).

The aim of this research was to study and modeling the influence of weight fraction of powder and grain size on thermal and water absorption properties of epoxy reinforced by olive seeds and data seeds.

Theoretical Analysis

Thermal conduction is the phenomenon by which heat is transported from high to low temperature regions of a substance. The property that characterizes the ability of a material to transfer heat is the thermal conductivity (Holman, 2010). This property (k) is calculated according to Eq. (1)

$$K = \alpha\, C_p\, \rho \qquad (1)$$

Where

α :The thermal diffusivity (m^2/s).

C_p: Specific heat (J/kg.°c).

ρ : Density (kg/m^3).

In the present work, hot disk thermal constant analyzer is used to measure the thermal conductivity. In addition, both, the specific heat and thermal diffusivity can be evaluated.

The mechanism of water absorption is explained to be the direct uptake and flow of water by capillary and transport along the reinforcement-matrix interface (Dhakal, 2006).

Water absorption percentage is calculated using (Archimedes base) according the following formula (Ghani, 2011):

$$\text{Water absorption} = \frac{w_2 - w_1}{w_2} * 100 \qquad (2)$$

Where:

w_1: mass of specimen before immersion (gm).

w_2: mass of specimen after immersion (gm).

Experimental Work

Basically two main tasks were carried out to achieve the objectives of study represent by the preparation of composite material by combining the epoxy with olive seeds and dates seeds with different weight fraction of powder (0, 8, 13 & 18 wt%) and grain size (300, 450&

600 µm).Then it was continued by performing the thermal and water absorption tests carried out to determine the characteristics of the studied composite. The usage of epoxy resin as a matrix was chosen because it is the standard economic resin commonly used, preferred material in industry and besides, it yields highly rigid products. The type of epoxy resin is provided from the Saudi Arabia Company in the form of transparent viscous liquid at room temperature. Epoxy and hardener used in this study in ratio of 3:1.

Preparation of Composites

The composite specimens were fabricated by using hand lay-up technique. Composites having different powders content were prepared by varying the type and weight for olive and dates seeds powders. In the first process of preparing the composite specimens' preparation process is to set the weight and grain size of powders content in the composite. The amount of resin needed for each category of composite was calculated after that. Then the resin was mixed uniformly with hardener, the mixture was poured carefully into the moulds and left in the mould for 24 hours. After the composites were fully dried, they were separated off from the moulds, and then put the specimens in oven at (55 $^{\circ}$C) for (1 hrs) (Flex, 2012).

The thermal conductivity of each specimen is measured by using hot disk. Samples have been cut into a diameter of (40mm) and a thickness of (5mm).Figure (1) shows standard specimens for this test.

The water absorption test is performed according to (ASTM D 570- 98) as shown in figure (2). The specimens were immersed in distilled water at room temperature. Specimens were taken out of the water after one day and wiped with a cotton tissue to remove surface water.

Mathematical Model

Response surface method (RSM) is a collection of a mathematical and statistical technique that are useful for modeling, analysis and optimizing the process in which response of interest is influenced by several variables and the objective. In some systems, the nature of relationship between y and x values might be known. Then, a model can be written in the form (Harring, 2011):-

$$z = f(x, y, \ldots, N) + \mathcal{E} \qquad (3)$$

The variables (*x*, *y* and N) are independent variables where the response (*z*) depends on them. The experimental error term, denoted as Ɛ.

In this study, multiple polynomial (least square fitting) regression analysis is used to establish a mathematical model among the experimentally obtained parameters. Multiple regression analysis techniques are applied to relate the weight and grain size of powder for two type of powder (data seed and olive seed), the best form of the relationship between the property, weight and grain size of powder parameters is chosen in the form of (Harring, 2011):-

$$z = a_{\circ} + b * x + c * y + d * x^2 + e * y^2 + g * x * y \qquad (4)$$

The analysis of variance (ANOVA) is also called coefficient of multiple determination referred to (R) measure the proportionate reduction of total variation in associated with use of the set of predictors in the model (is used to cheek the validity of the model) it is defined in terms of SST, SSR, and SSE as (Gilberto, 2011) :-

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST} \qquad (5)$$

Where:-

SSE:- the sum of squared error.
SSR:- the regression sum of squares.
SST:-the total correct sum of squares.

RESULTS & DISSCUTION

Thermal Test Results

This result of thermal conductivity, specific heat, and thermal diffusivity are measured experimentally using hot disk technique. Figures (3&4) gives the relationship between thermal conductivity (k) and weight fraction for composite reinforced with olive and dates seeds. It can be seen, the increase in weight fraction of particles causes an increase in thermal conductivity for all composite specimens. This is because of the increasing weight fraction means an increase of reinforcement which have a higher thermal conductivity than that in epoxy resin.

Figures (5&6) show the value of specific heat for composite specimens. It can be seen that, the increase in weight fraction of particles causes an increase in specific heat (C_p) for all composite specimens. This is because of the increasing weight fraction means an increase of reinforcement which have a higher specific heat (C_p) than that in epoxy resin.

Figures (7&8) gives the relationship between thermal diffusivity (α) and weight fraction for composite reinforced with olive and dates seeds. It can be seen, the increase in weight fraction of particles causes an increase in thermal diffusivity for all composite specimens. This is because of the increasing weight fraction means an increase of reinforcement which have a higher thermal diffusivity than that in epoxy resin.

Water Absorption Results

Figures (9-14) show the variation of ratio of water absorption versus exposure time for composite specimens with different particles content and grain size (300, 450 & 600µm). It can be seen from these figures that, the composite with higher content of particles show more water absorption. This is due to the higher content of particles in the composites that can absorb more water. As the particles content increases, the formation of agglomerations increases due to the difficulties of achieving a homogeneous dispersion of particles at higher particles content. The agglomeration of the particles in composites increases the water absorption of the composites. Also it can be seen from these figures the composites filled with small size of particles (300µm) showed higher ratio of water absorption than for size of particles (450 &600µm) because of the surface area (Hussein, 2011).

Mathematical Model Results

The experimental results are modeled using RSM. Figures (15-22) show the summary of models and coefficient multiple determinations (R^2) of the properties as function of (x= weight fraction of powder) and (y=particle size). It can be seen from these models that the weight fraction of powder have greater effect than the particle size on the properties.

CONCLUSIONS

The main conclusions of results are:-

1. The composite specimens reinforced with olive seeds give high thermal and water absorption properties than composites specimens reinforced with data seeds.
2. Higher value of thermal conductivity, thermal diffusivity, specific heat and water absorption obtained at (=18 wt%) and grain size(=300µm) for two types of particles.

3. Mathematical model results show that the weight fraction of particles have higher effect than grain size on properties.

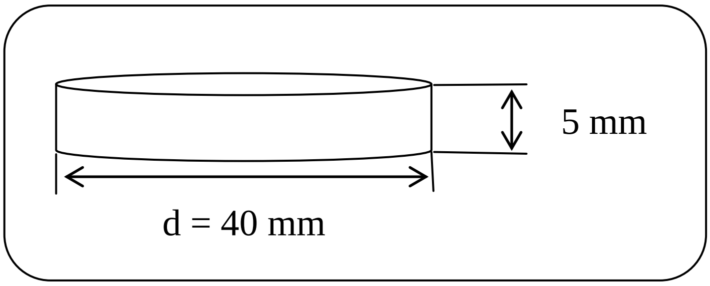


Fig. (1): thermal conductivity standard specimens.

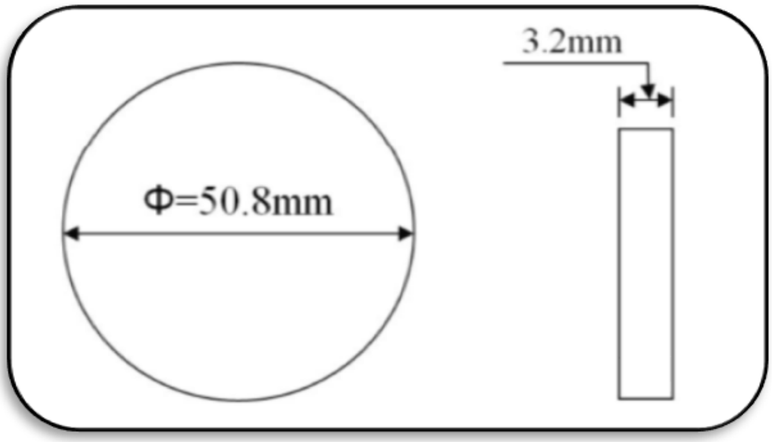


Fig. (2): water absorption standard specimens [19].

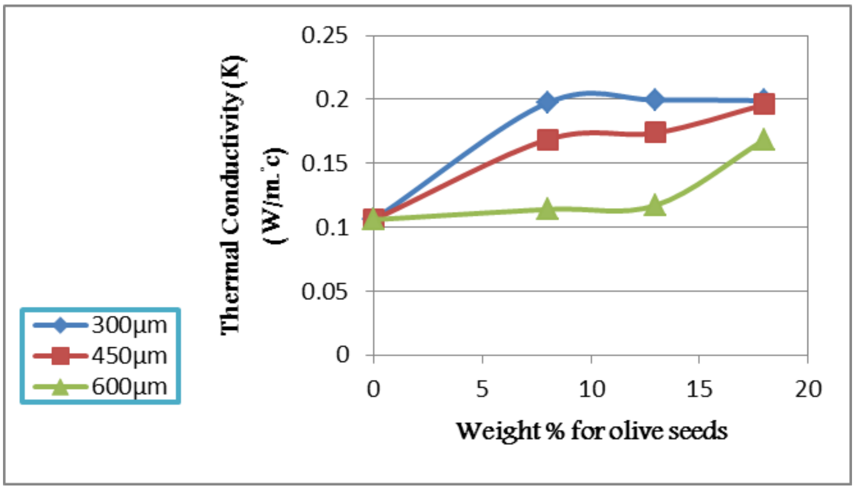


Fig. (3): the relationship between thermal conductivity& wt% for composite reinforced with olive seeds.

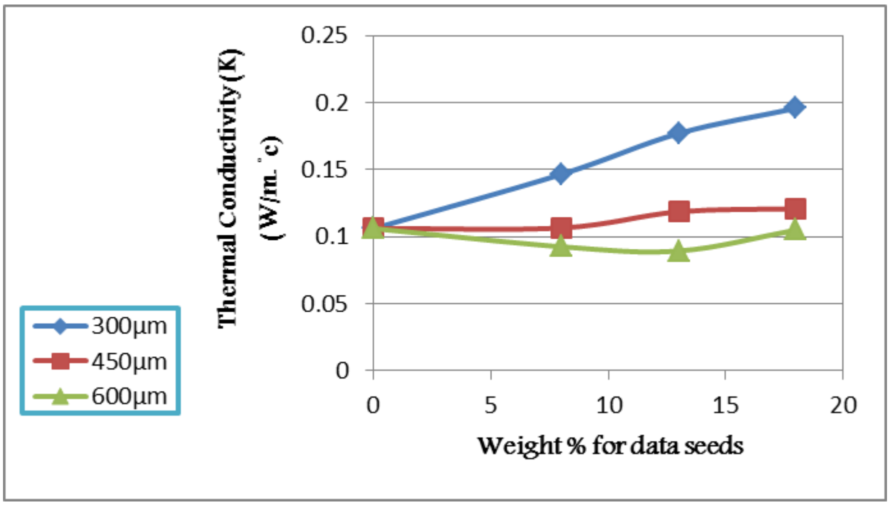


Fig. (4): the relationship between thermal conductivity& wt% for composite reinforced with data seeds.

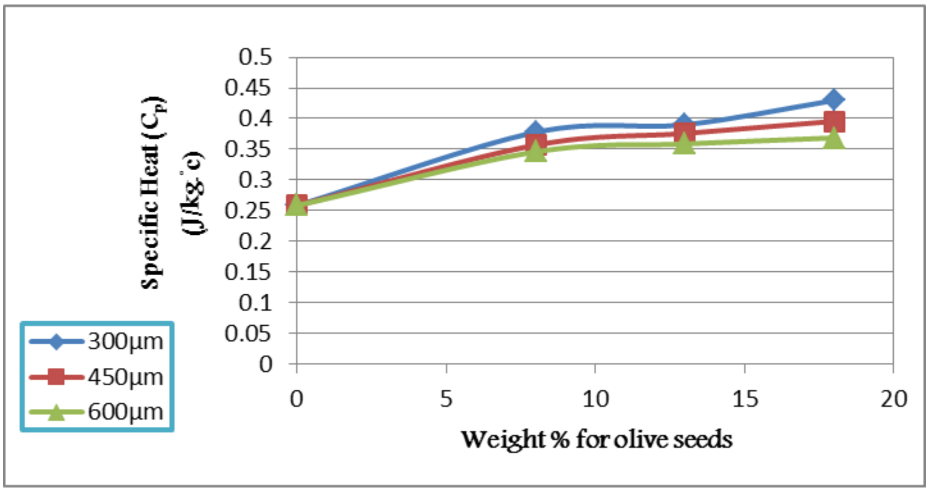


Fig. (5): the relationship between specific heat & wt% for composite reinforced with olive seeds.

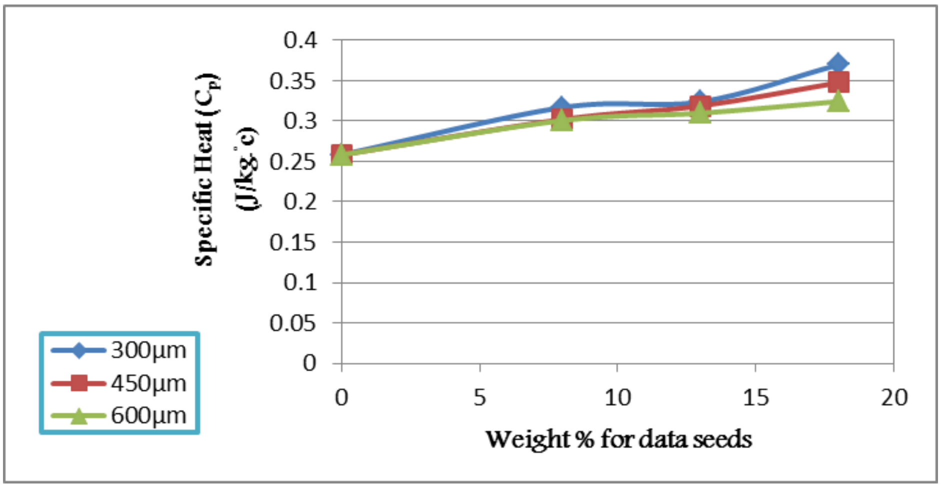


Fig. (6): The relationship between specific heat & wt% for composite reinforced with data seeds.

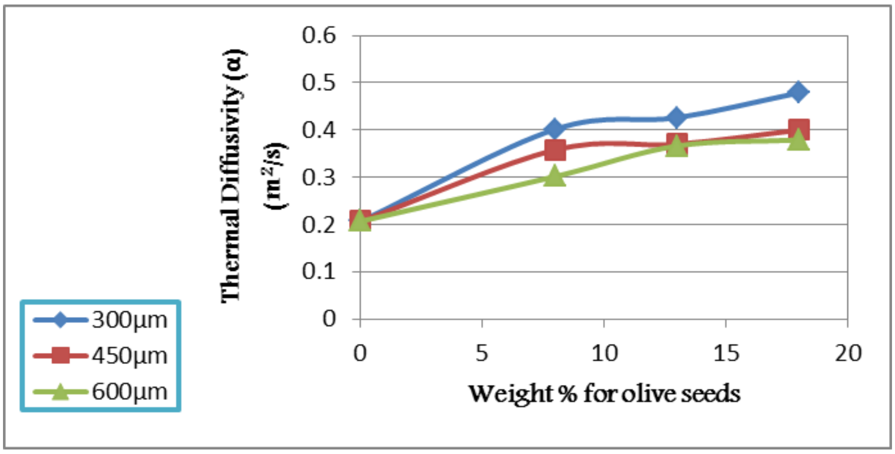


Fig. (7): the relationship between thermal diffusivity & wt% for composite reinforced with olive seeds.

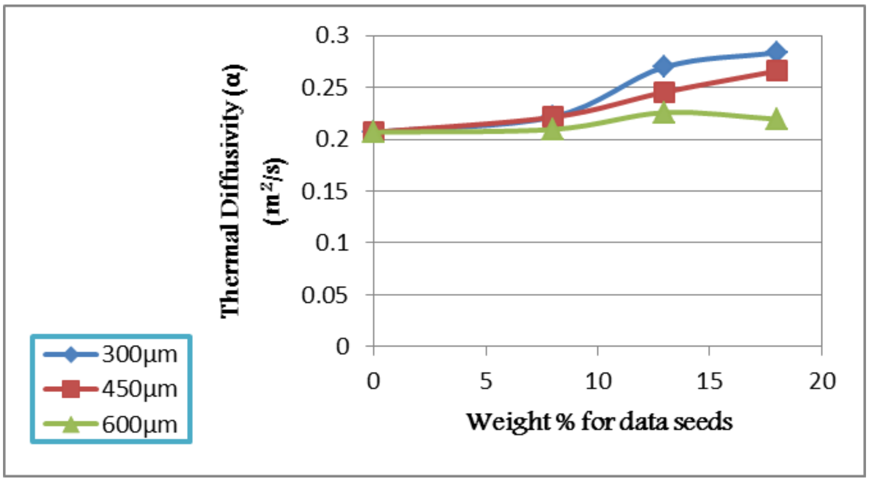


Fig. (8): the relationship between thermal diffusivity & wt% for composite reinforced with data seeds.

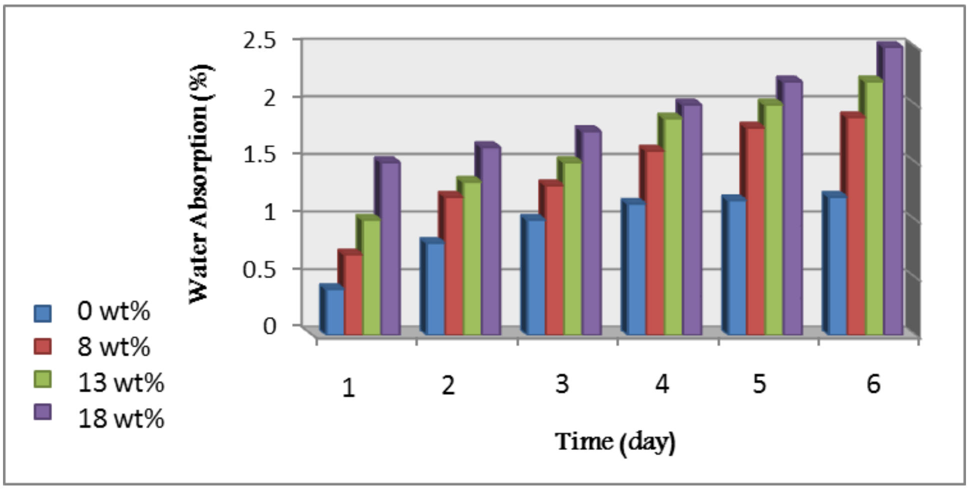


Fig. (9): effect of exposure time on the water absorption for composites reinforced with olive seeds powder at grain size (300µm).

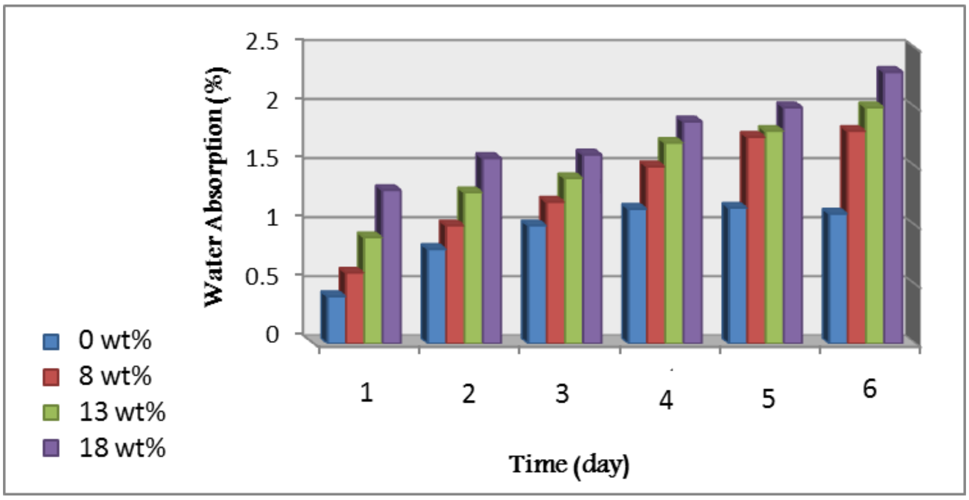


Fig. (10): effect of exposure time on the water absorption for composites reinforced with olive seeds powder at grain size (450µm).

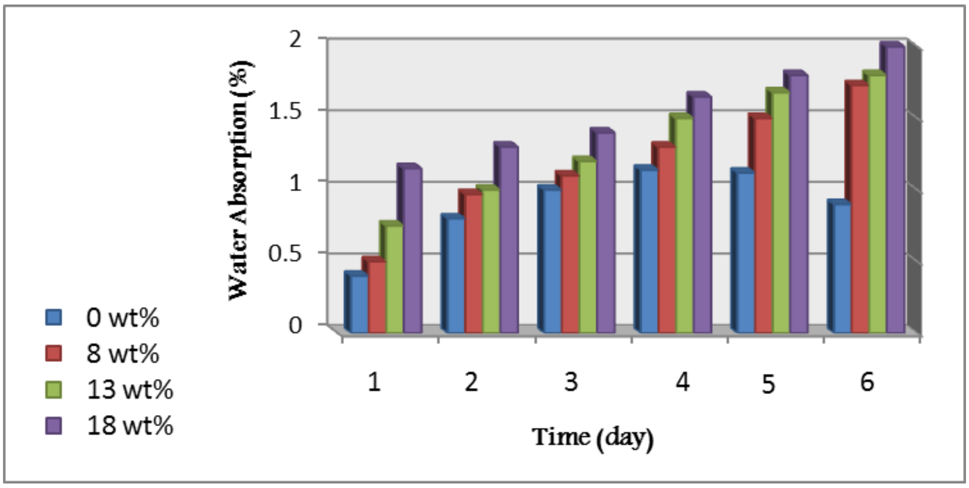


Fig. (11): effect of exposure time on the water absorption for composites reinforced with olive seeds powder at grain size (600µm).

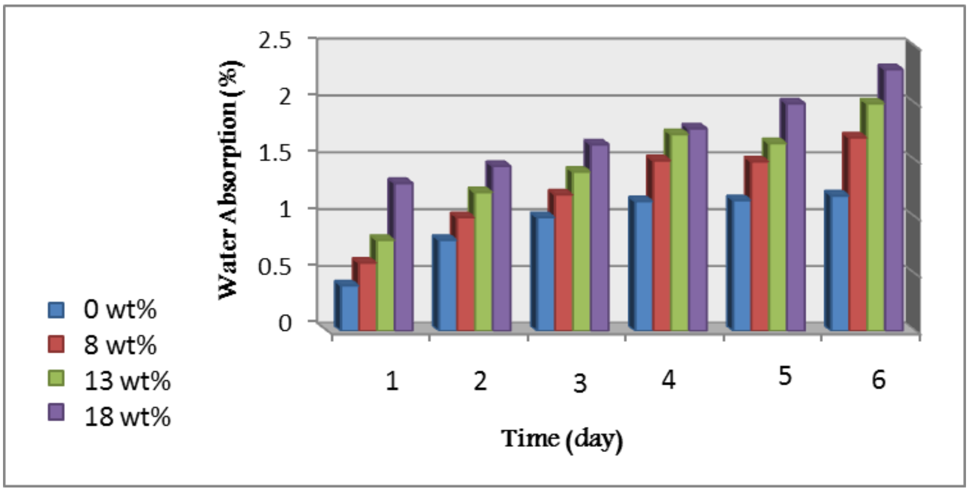


Fig. (12): effect of exposure time on the water absorption for composites reinforced with dates seeds powder at grain size (300µm).

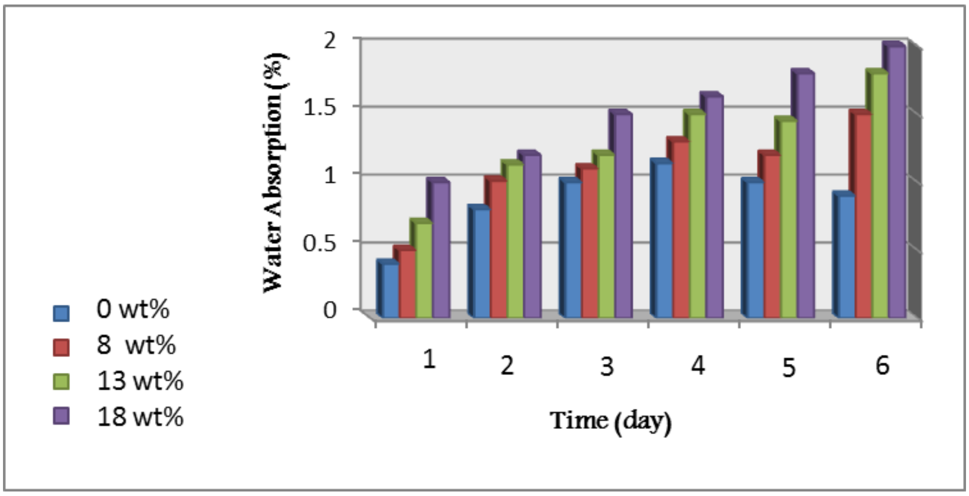


Fig. (13): effect of exposure time on the water absorption for composites reinforced with dates seeds powder at grain size (450µm).

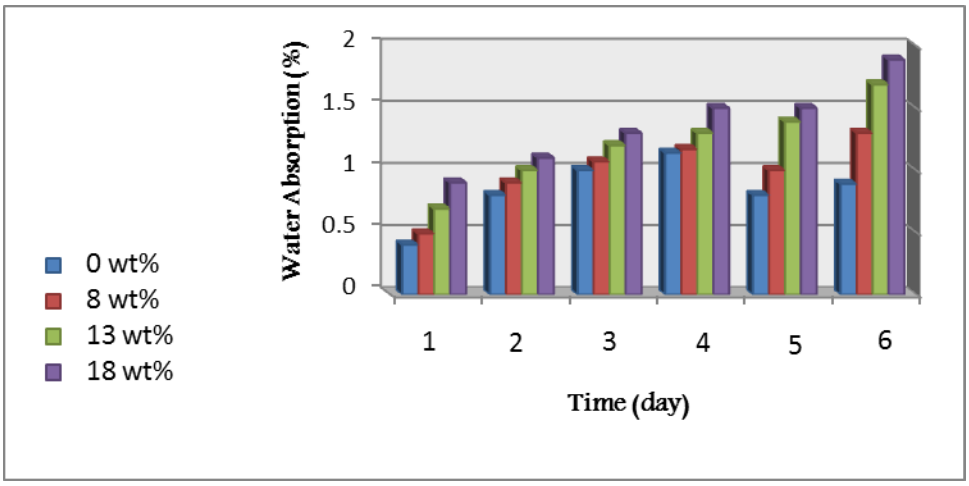
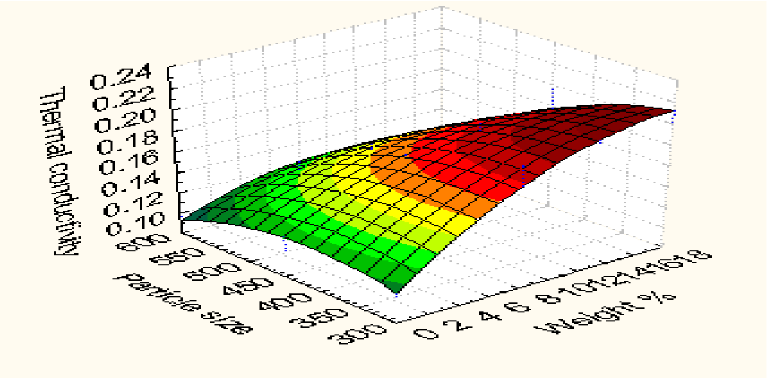


Fig. (14): effect of exposure time on the water absorption for composites reinforced with dates seeds powder at grain size (600µm).



Z=-0.01812+(0.016)*x+(0.00066)*y+(-0.0003)*x^2+(-7.927e^{-7})*y^2 + (-0.000017)*x*y

R^2=0.96164

Fig. (15): the mathematical model results with equation for thermal conductivity of composite specimens reinforced with olive seeds powder.

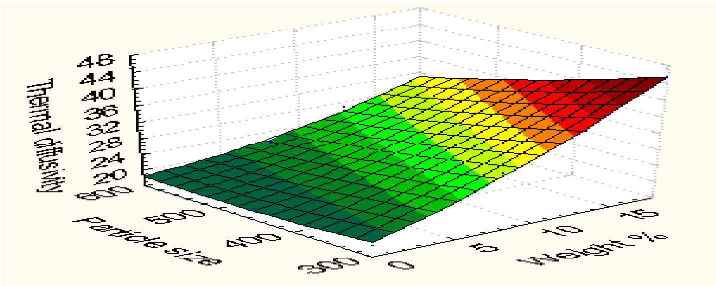


Fig. (16): the mathematical model results with equation for thermal diffusivity of composite specimens reinforced with olive seeds powder.

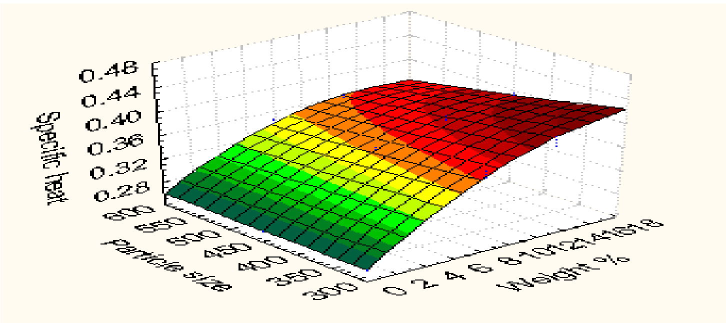


Fig. (17): the mathematical model results with equation for specific heat of composite specimens reinforced with olive seeds powder.

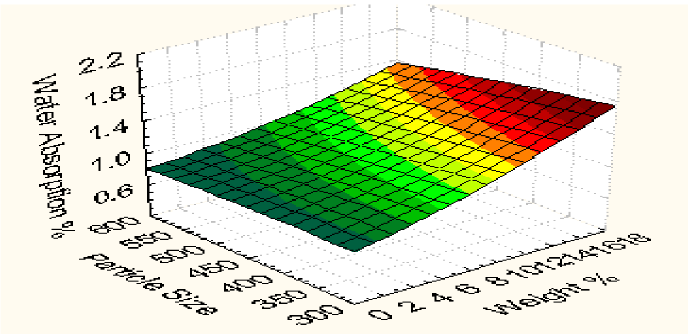


Fig. (18): the mathematical model results with equation for water absorption of composite specimens reinforced with olive seeds powder.

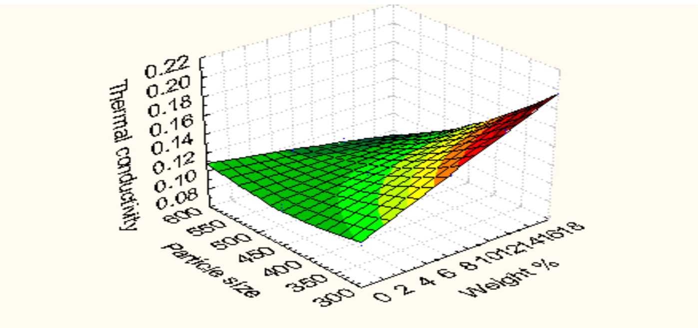


Fig. (19): the mathematical model results with equation for thermal conductivity of composite specimens reinforced with dates seeds powder.

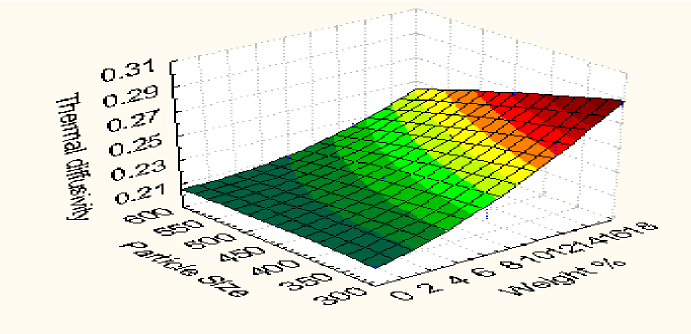


Fig (20): The mathematical model results with equation for thermal diffusivity of composite specimens reinforced with dates seeds powder.

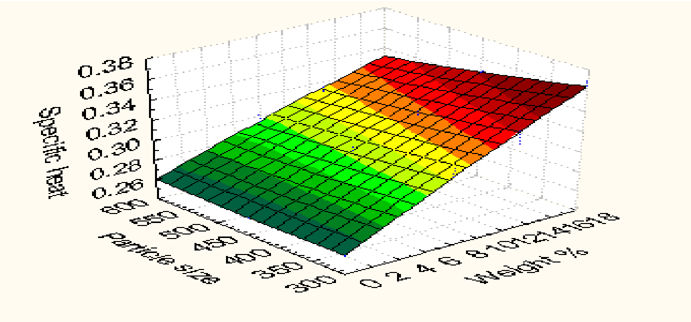


Fig. (21): the mathematical model results with equation for specific heat of composite specimens reinforced with dates seeds powder.

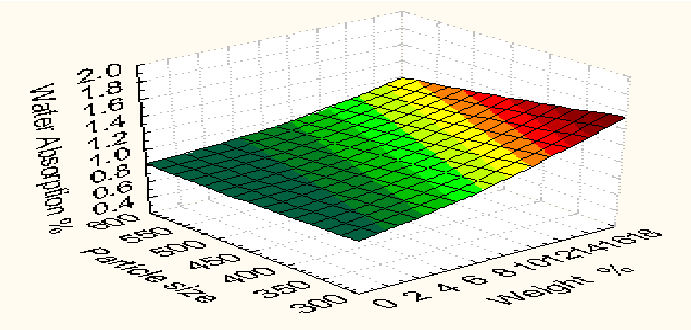


Fig. (22): the mathematical model results with equation for water absorption of composite specimens reinforced with dates seeds powder.

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