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# Study of Water Effect on some Specimens of Epoxy Composites Reinforced with Different Types of Fibers

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**Abstract:-** The aim of this paper is to study the effect of water on some properties of a composite materials consists of (epoxy resin reinforced with E-glass and carbon fibers with volume fraction of 25% foamed silica was applied to the composites with values of (0.01% $V_f$) ; then physical tests for different times were applied to both specimens including (Thermal conductivity; Hardness; and Roughness); results showed that value of thermal conductivity increased after immersion in water for both specimens ; Shore hardness decreased and Roughness increased also.

**Index Terms: -** Epoxy Composite, Mechanical Properties, Thermal Conductivity, Water effect

## I. INTRODUCTION

For better overall performance we require unusual combination of properties that cannot be provided by conventional materials like metal, ceramic and polymers, these a new class of materials known as composites which shows extra ordinary properties is well depend called composites which is different and better than any of the individual components for their strength, heat resistance or stiffness[1].

Technologically the most important composites are these in which the disperse phase is in the form of fiber, which produce high specific strength with low density fiber and matrix materials[2].

Thermal conductivity of the composite depends mainly on its value for each fillers and matrix , orientation of fibers and bonding between fibers and matrix[3].

When a liquid comes into contact with a polymeric material , the molecules of the chemical first enter the material, next they move through the solid by molecular diffusion, diffusing molecules in a polymer increases the free volume and has a direct effect on the diffusion coefficient, also the penetration of these foreign substances can lead to swelling and/or chemical reactions with polymer molecules, and often to a depreciation of the material's mechanical and physical properties[4].

Diffusion coefficient "D" can be calculated with each liquid using Fix's 2nd law by equation 1:

$$D=\pi\left(\frac{kb}{4M_{\infty}}\right)^2 \qquad (1)$$

Where:

D: Diffusion coefficient ($m^2$/sec),

K: slop of the curve(weight gain Vs root square of time) b : thickness of the sample (mm),

$M_{\infty}$: maximum weight gain

Thermal conductivity of polymers and composites is a very important property for applications and processing, typically polymers have intrinsic thermal conductivity lower than these for metals and ceramic materials , and therefore are good thermal insulators.

Temperature , degree of crystallinity of matrix, orientation of fibers, volume fraction of reinforcement may affect the value of thermal conductivity, and these property can be evaluated using Lee's disc apparatus; and due to equation 2:

$$\frac{k[T_B-T_A]}{d_s}=e\left[T_A+\frac{2}{r}\left(d_A+\frac{1}{4}d_s\right)T_A+\frac{1}{2r}d_sT_B\right] \quad (2)$$

k: thermal conductivity (w/m.$^o$k)

$d_s$: thickness of sample

$T_A$, $T_B$, $T_C$: Temperature of disc A,B,C respectively

r: radius of the disc

e: heat amount through the disc and can be calculated from equation 3:

$$IV=\pi r^2 e\left\{(T_A-T_B)+2\pi re\left[d_AT_A+d_s\tfrac{1}{2}(T_A+T_B)+d_BT_B+d_CT_C\right]\right\} \qquad (3)$$

where:

I: Current pass through the circuit,

V: applied voltage [5].

## II. MATERIALS AND METHODES

The materials used in this work consist of:
1- Epoxy risen (Ep10) type with density 1.17 g/cm$^3$ and viscosity of 200 MPa.s.
2- E- glass unidirectional fiber (50 µm diameter) with density (2.5 gm/cm$^3$). Tensile strength (2000 MPa) and Young modulus (75 GPa).
3- carbon unidirectional fibers (65 µm diameter) with density (2 gm/cm$^3$), tensile strength (1800 MPa).

## III. MOLD PREPARATION

A hand lay up technique was applied in preparation the mold using each fiber ( E-glass and carbon) fibers with volume fraction 25% ($V_f$ 0.25); with weight methods.

## IV. MEASUREMENTS

Thermal conductivity: (Lee's disc) technique was applied to calculate the value of each case.
Each specimen was immersed in water for a week each time then calculating (k) value after 75 days; using (Griffenand Goerge Lee's disc instrument).

Also shore D hardness was calculated using (Shore D Hardness tester TH 210 –China), instrumental. Roughness of the surface was calculated before and after immersion in water using (TR 220 Portable Roughness Tester-China) instrument.

## V. RESULTS AND DISCUSSION

(Lee's disc) technique was used to evaluate thermal conductivity for specimens (Ep +glass fibers) and (Ep+carbon fibers) results showed that carbon fibers owned higher value than the glass fibers due to its characterization and also to improve the bonding; after 75 days in water , the value of thermal conductivity was increased as shown in Figures (1) and (2). This may be explained that cavities; micro cracks and porosities may be occurred in the interface region between fiber and matrix [6,7].

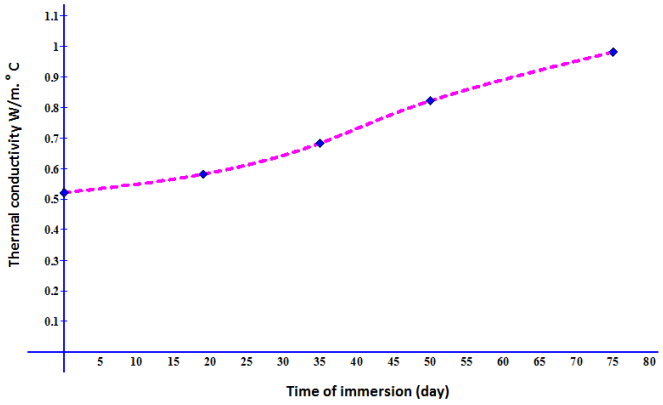


**Fig. 1**.Thermal conductivity and immersion time of Ep/carbon specimens

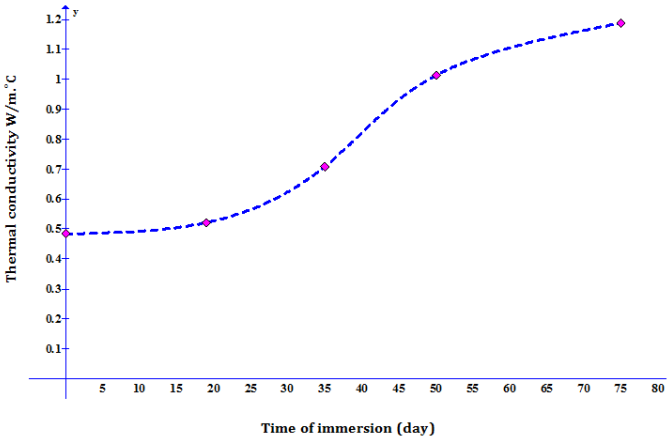


**Fig. 2.** Thermal conductivity and immersion time of Ep/glass specimens

Composite materials used showed a good hardness values and it was higher for epoxy reinforced by carbon fibers than the glass fibers and this was due to its properties; and these values decreased when the specimens immersed in water results in plasticization ,(polymer – fibers) interface and formation of cavities filled with this water causes embrittlness of the exposed specimens, [8,9]. Figures (3) and (4) showed the change in shore D hardness for the tow specimens.

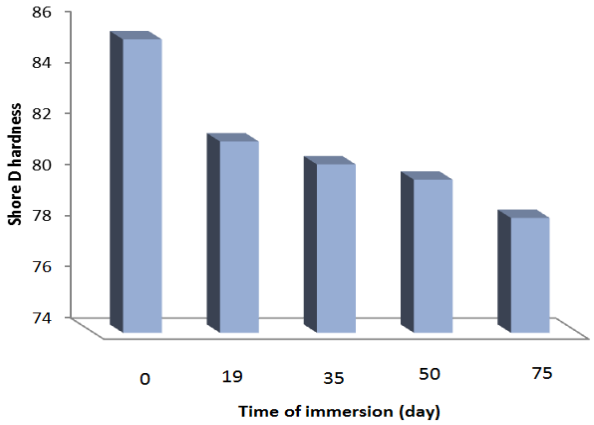


**Fig. 3**.Shore D hardness and immersion time of Ep/carbon specimens

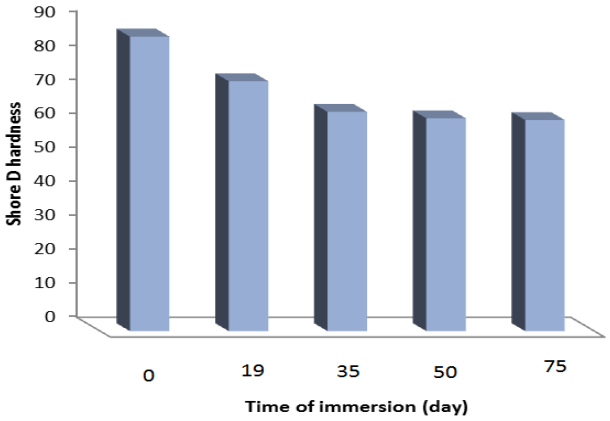


**Fig. 4**.Shore D hardness and immersion time of Ep/glass specimens

Roughness test showed that the water causing increase in its values for both specimens after 75 days and this also caused by the effect of water molecules on the surface of the sample when swelling occurs. Figures (5) and (6) showed the change in roughness values for the both specimens, this swelling caused increase in the thickness of the samples as shown in Figures (7) and (8).Corrosion of the surface due to immersion caused the roughness to increase. According to this figure diffusion of water occurs and swelling of the sample appeared when the water penetrate the interface region causing plasticization and hydrolyzing and causes also weight loss [10,11].

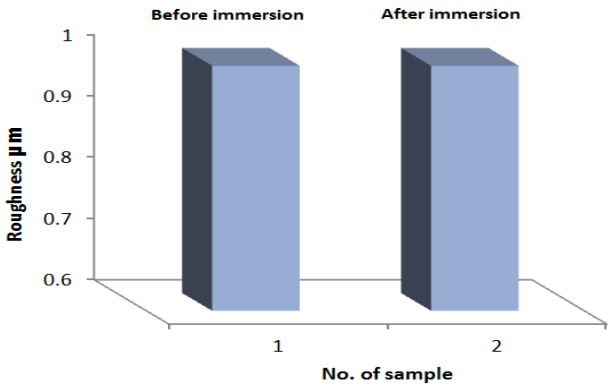


**Fig. 5**.Roughness of surfaces and immersion in water for 75 days for Ep/glass specimens

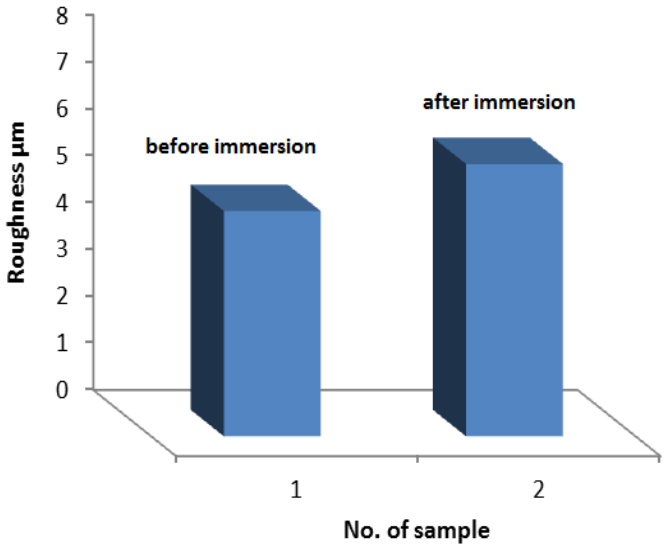


**Fig. 6**.Roughness of surfaces and immersion in water for 75 days for Ep/ carbon specimens

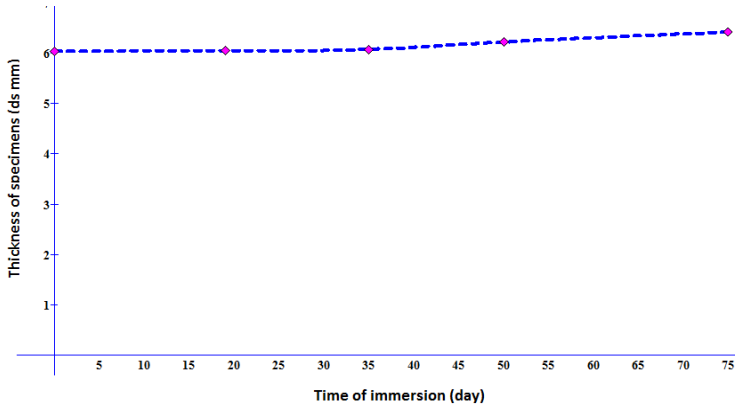


**Fig. 7.** Thickness of specimens and immersion time ofEp/carbon specimens

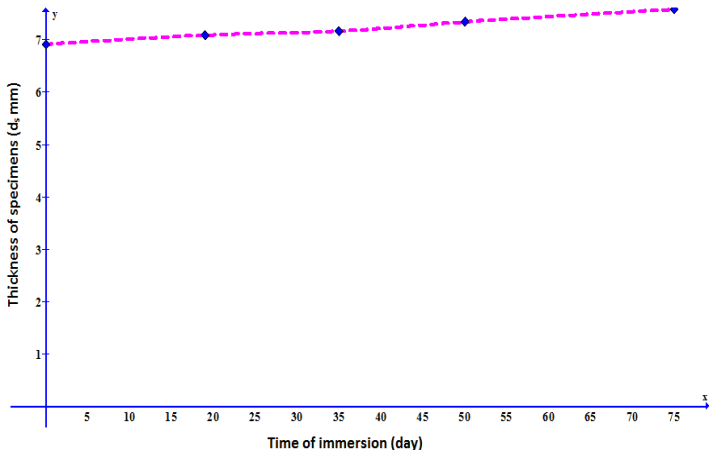


**Fig. 8.** Thickness of specimens and immersion time of Ep/glass specimens

## VI. CONCLUSIONS

1- (Ep – carbon) composite owned higher value for thermal conductivity; Roughness and Shore D hardness than (Ep-glass) composite.
2- Water affected the above mentioned properties and reduced hardness values.
3- Water caused the thermal conductivity, Roughness to increase.

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