The Natural Influence on Some Engineering Properties Of Advance Composite

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Abstract:

This research studies the effect of thermal shock of (80^oc) on some engineering properties of advanced composite with matrix of unsaturated polyester reinforced by the artificial fibers kind of (E glass) and (Kevlar) as a woven roven and continuous fibers, with weight percent of (7%). The results show the heat has a passive effect on the structure of materials. In general the Kevlar reinforced specimens appear better quality than the others which reinforced by glass fiber. The results were discussed.

الخلاصة :

يدرس هذا البحث تأثير الصدمة الحرارية (80^oc) على بعض الخواص الهندسية لماده عاليه التراكب ذات أساس بولي استير غير المشبعة مقساة بواسطة الألياف الصناعية وهي ألياف زجاجيه نوع (E- glass) والكفلر(Kevlar) بهيئة حصيره محاكة وألياف مستمرة وبنسبه وزنيه مقدارها (٧%). تشير النتائج بان للحرارة تأثير سلبي على تركيب المواد. بصوره عامه أظهرت العينات المقواه بالكفلر خواصا أفضل مما هي عليه تلك العينات الأخرى المقواه بواسطة ألياف الزجاج، وقد نوقشت النتائج.

1. Introduction

Fiber reinforced plastics are gaining wide popularity as modern replacement conventional materials such as steal and aluminum.

Polymeric materials used in composite are known for their susceptibility towards temperature due to their viscoelastic nature [1].

Glass fibers are one fifth cost of Kevlar fibers [2] and lower thermal conduction [3], as well as its density is double that of Kevlar [4] but the specific strength, specific stiffness and elasticity modules of Kevlar fiber is the highest [5].

This research depends on study and comparison different glass and Kevlar of mat and continuous fibers reinforced specimens of unsaturated polyester matrix (control specimen of unsaturated polyester, PE, reinforced specimen with Kevlar mat, KV (mat), continuous Kevlar fibers, KV (cf), glass fiber mat, G (mat), and continuous glass fibers, G (cf). Each of compressive strength, Brinell hardness, water sorption, thermal conductivity, and density tests are carried out to evaluate the materials before and after their exposure to the thermal shock of (80^oc).

2. Experimental

2.1 Specimens Preparation

Unsaturated polyester resin used in the preparation of the composites (from Dow Company, USA). E glass and Kevlar fibers supplied by (Crazer Company, Germany). Open molding a technique was used to prepare laminates. The addition weight percent of E glass and Kevlar as mat and continuous fibers is 7wt %.

2.2 Physical and Mechanical Tests

The compression strength and Brinell hardness have been measured by using the apparatus of Universal Test Machine (PHYWE).

Each Brinell hardness value (HBV) represents a mean value of five tests for each specimen [6]:

$$HBV = \frac{P}{4\pi D(D - \sqrt{D^2 - d^2})}$$

Where D is the hard sphere diameter (10 mm), d is the trace diameter, and P is the subjected load of 3 KN for 15 sec.

The density of specimens measured by using Archimedes principle and the coefficients of thermal conductivity measured by using Lee's disc.

The test of specimens' sorption for the distilled water carried out by putting them in a desiccators containing silica gel which was stored in an incubator at a temperature of 37 ^{o}c for 24 hrs. and then weighed with an analytic balance of (0.0001 gm). The samples were then immersed in distilled water at (≈37 ^{o}c). At period of 1 week for 7 weeks, the samples were removed from the water with tweezers, wiped with clean, dry hand towel until free from visible moistures, waved in the air for 15 second, and weighed one minute after removed from water. The sorption calculated by using the following relationship [7]:

$$Sorption(mg/cm^2) = \frac{mass\ after\ \ immersion(mg) - \ conditioned\ \ mass\ \ (mg)}{surface\ \ area(cm^2)}$$

The above tests have been carried out for two groups of specimens, the first one which prepared at (25^{o}c) and the second one which has been exposed to thermal shock of (80^{o}c) by using an oven (SOLA BASIC S-B LINBBERG) where leaved to cool outside it.

3. Results and Discussion

Table (3.1) lists the values of compression strength. It is obvious the positive influence of the advance reinforcing of fibers on the compression strength of unsaturated polyester specially that of Kevlar mat which surpasses on the other kinds of reinforcing styles. This result belongs to the highest stiffness strength of the Kevlar mat and its bond with the matrix [8, 9, and 10]. It can be seen that the compression strength affected after specimens exposure to the thermal shock of (80^{o}c) where the values rates are decreasing due to degradation of matrix as well as the weak adhesion of fibers and matrix [5]. When the composite specimens are suffering a thermal shock and because of the different abilities of thermal expanding for each of fibers (as mat or continuous fibers) and matrix there should be a shear stress applied on the contact region [11].

Table (3.1): Values of compressive strength (MPa)

Specimen	Before thermal shock	After thermal shock
PE	80	70
KV(mat)	110	150
KV(cf)	105	90
G(mat)	٦٥	63
G(cf)	60	58

From table (3.2), perhaps the change of measurement results of materials densities indicates to what happen of defects in these materials and increasing distant among their molecules and especially in the composite material which have anisotropy properties.

Table (3.2): Values of specimens densities (gm/cm^3)

Specimens	**Before thermal shock**	**After thermal shock**	**The decreasing**
PE	1.311	1.297	0.014
KV(mat)	1.330	1.294	0.036
KV(cf)	1.327	١.٢٨٩	0.038
G(mat)	1.357	1.317	0.040
G(cf)	1.398	.368١	0.030

Table (3.3): lists hardness Brinell values of all the specimens, in general before the thermal shock of (80°c) fibers reinforcing specimens would have better hardness than that of control specimen. After the thermal shock, matrix polymer would lose its plasticizers to be harder [6]. Generally, the reinforcement at this case of weight percent 7 % seem to has contrary results because of the arising of cracks and other defects in materials especially the composites, hence hardness Brinell values of composites being lower than that of unreinforced material. Where this test indicates just to the penetration resistance of material surfaces [6].

Table (3.3): lists hardness Brinell values of the specimens

Specimens	Before the thermal shock	After the thermal shock
PE	83.95	157.40
KV(mat)	145.15	107.00
KV(cf)	157.40	170.30
G(mat)	102.15	107.00
G(cf)	102.15	١٣٣.٥٠

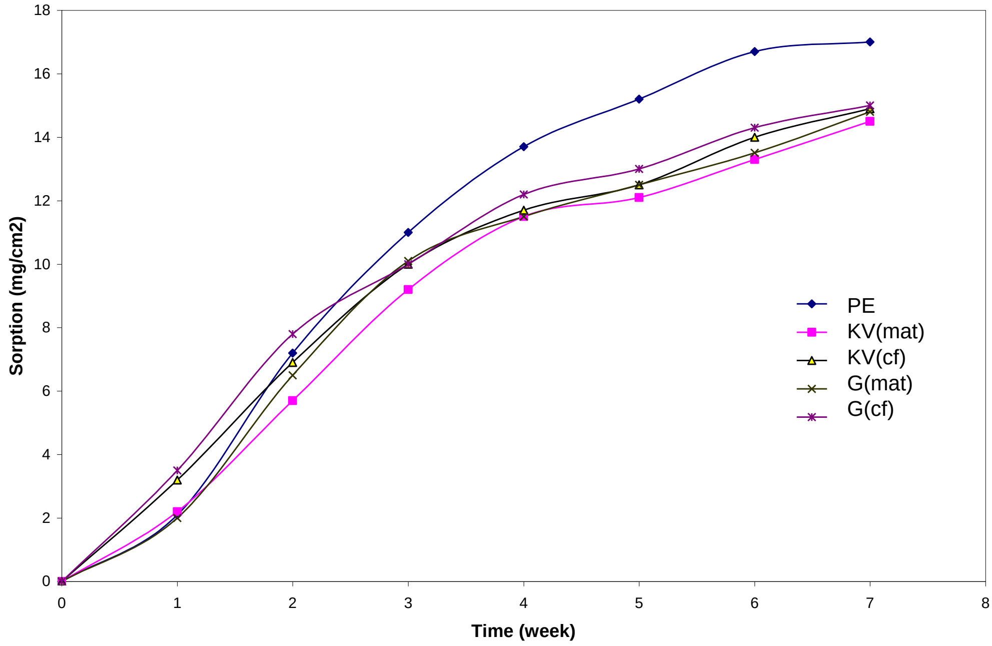
Table (3.4) shows the values of the coefficients of thermal conductivity of all specimens. It is notable the fibers reinforcing effect in increasing coefficients of thermal conductivity of materials. The reinforcing defects involve present of spaces, cracks, and un- homogeneous material structure especially after the exposure to the thermal shock and this is why the increasing of thermal conductivity. The defects contribute to lower the effect of fibers as thermal isolation. This explanation may be supported by table (3.2) which shows the change of material densities. This explication agrees with the result of Kevlar fibers as a greatest thermal isolator although glass fibers have greater thermal isolation than Kevlar fibers [3]. But we must put in our mind that the adhesion force and homogeneity which is found in Kevlar reinforced specimen greater than that of others, this fact supported by the results of table (3.1). Where the variation of the thermal expanding of fibers and in other side the matrix to create shear stress subjected to the contact region [11] and this leads to defects. However, the increment of the thermal conductivity always can be observed to be coupled with increment of the surrounding temperature and this agrees with the results of A.A.Berlin [12] who found the raising of thermal conductivity of reinforced epoxy resin by carbon fibers of both sorts (HTS AND HMS). In addition there is agreement with the results of researcher Frank P. Gertle [5] that show the reduction of glass fiber thermal conductivity with low temperature.

Table (3.4): lists values of coefficients of thermal conductivity of materials (W/m °c).

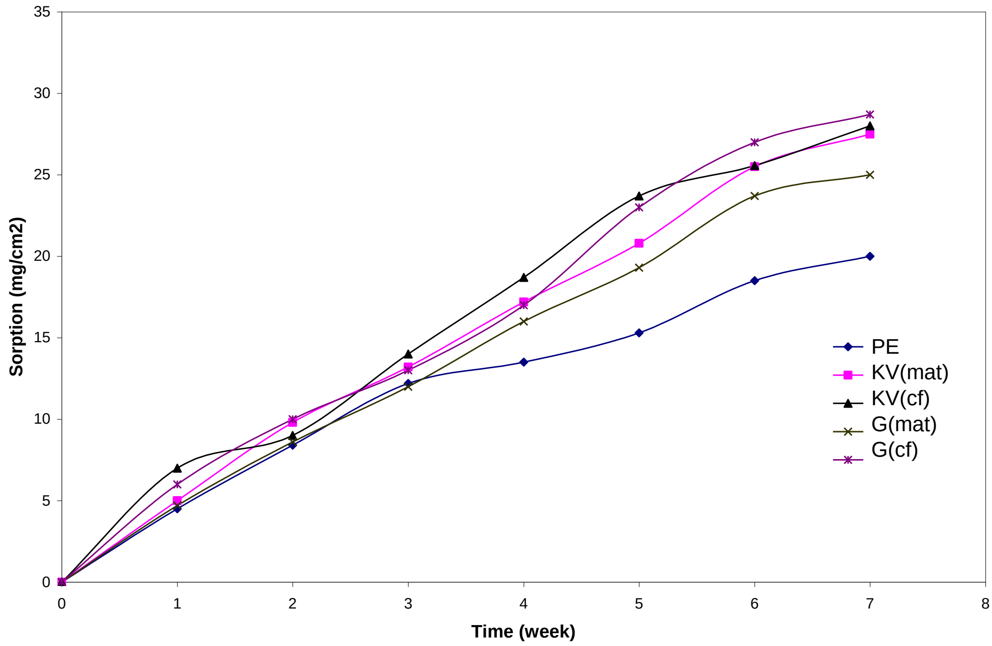
Specimen	Before the thermal shock	After the thermal shock
PE	1.507	1.880
KV(mat)	0.880	1.507
KV(cf)	1.500	1.570
G(mat)	١.٢٥٠	١.٩٦٨
G(cf)	1.370	1.713

Fig. (3.1) demonstrated the role of artificial fibers in the reduction of material sorption for water and to restrict the occupation of water molecules to position between polymer chains [13] and any crack or space inside the specimen. It is obvious the reinforced materials being less sorption to water than that of unreinforced material. What happened may be attributed for the low Kevlar density comparison with glass fiber density (equals half density value of the latter) [4], and so Kevlar fibers would occupy more space of the whole volume of a specimen than what happened when glass fibers are used [4]. Hence the increment of fibers in a reinforced specimen leads to lower sorption [14].

It is noticeable the high sorption of thermal shocked specimens which attained because of the defects and so water molecules should get a good chance to penetrate the materials and get in wherever channel may be permitted to them. This state may be more popular in composites than other materials of higher homogeneity because of the stresses which aroused by the thermal shock spread in homogeneous direction therefore cause fewer defects, where table (3.2) may give indication about this idea.



(a)



(b)

Fig. (3.1): Specimens sorption for distilled water (a) before the thermal shock (b) after the thermal shock.

4. Conclusion

1. In general, the reinforcing of unsaturated polyester by using glass and Kevlar fibers make the composite material have better mechanical properties, specially the woven roven of Kevlar.
2. The most thermal shocked materials get lower compression strength and density and higher hardness values.
3. The supported material by fibers has low coefficient of thermal conductivity and vise versa after its exposure to the thermal shock.
4. The advance composites have low water sorption, but high when to be exposed to a thermal shock.

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