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Effect of water absorption on impact strength for epoxy-glass fibers composite.

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ABSTRACT

Hand lay-up method was used to prepare sheets of epoxy (EP) reinforced with 12 layers of (0°-90°) glass fiber mat with volume fraction equal to 30%. The sheets of Ep- glass fiber composite were cut to samples with standard dimensions for charpy impact test. The main objective of this research was to study the effect of water absorption on impact strength for epoxy-12 glass fiber composite. Diffusivity behavior and diffusion coefficient were investigated. The samples were dividing to three groups immersed in distilled water for different time, the first group 15 days ,the second group 27 days and the last 39 days at constant temperature(±20)C^{o} the mass gain recorded every 3 days till saturation (M_{∞}) after that the mass gain decreased .the results showed that the maximum diffusion coefficient (minimum absorption resistance) was for sample (A),while the minimum diffusion coefficient (maximum absorption resistance) was for sample (C). The impact strength has been investigated for samples before and after the immersion in distilled water for different time. The results show that the impact strength decreased with increasing the time of immersion for samples.

Introduction

Glass fibers reinforced composites have been well accepted as engineering materials for various applications, as a common feature of composites, prominent, anisotropy in mechanical properties was observed, which has high fracture strength and stiffness along the fiber strengthening component. [1] Epoxy resins are one of the most popular materials used in industrial applications such as adhesives, coating and especially composites depending on the chemical structures of the resins and the curing agent, and the availability of numerous modifying reactants epoxy resins can have a broad range of physical properties, mechanical capabilities and processing conditions that make them invaluable compared to other thermosetting resins. [2_ 4]

The instrumental impact test is generally used to measure the toughness of materials. It is general practice to measure and record the force which is acting on the specimen during the impact [5], there are a number of different types of impact tests .these tests depend on the sample geometry and the method of measurement .these include the widely used Izod and charpy tests in which a hammer like weight strikes a specimen and the energy-to-break is determined from the loss in the kinetic energy of the hammer In charpy test the specimen is clamped at both ends. Other variations include the falling ball test, where by the energy –to-bresk is determined from the weight of the ball and the height from which it is dropped [6, 7]

Impact strength is calculated from the relation [5]

$Gc=U/A$ (J/m^2) (1)

Where

Gc= impact strength

U= Energy of fracture in (Joule)

A=cross section area in (m^2)

The impact energy seen by a given test specimen is affected by a number of factors, such as: [8]

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Yield Strength and Ductility.
Notches.
Temperature and Strain Rate.
Fracture Mechanism.

The generally accepted mechanism for solution absorption in polymers is an activated absorption diffusion process. The molecules first dissolve into the polymer surface and then diffuse through the bulk of the polymer by a series of activated steps; the amount of absorbed water depends on the temperature, the structure and the morphology of the polymer [9]

The relative mass gain can be obtained by: [9]

M%=mass of wet sample- mass of dry sample ×100 (2)

Mass of dry sample

And diffusion coefficient can be obtained by: [9]

$$D = \pi\left(\frac{kb}{4M_{\infty}}\right)^2 \quad (\text{mm}^2/\text{day}^2) \quad (3)$$

Where:

D: diffusion coefficient.

b: thickness of the sample=3.77mm.

M∞: saturation water mass.

k: the slope of the curve between mass gain and square root of immersion time.

This diffusivity D, defined as the amount of liquid passing per second through a unit area under the influence of a unit gradient of concentration is still a function of the temperature T given by an Arrhenius expression: [9]

$$D = D_o \exp(-H_D / RT) \quad (4)$$

Where:

H^D : activation energy for diffusion.

R: gas constant.

Experimental part:-

Hand lay-up method was used to prepare sheets of epoxy (EP)(DGEBA) reinforced with 12 layers of (0^o-90^o) mat of glass fibers. The samples were cut with standard dimensions (ISO-179) for charpy impact strength test as shown in the figure (1)

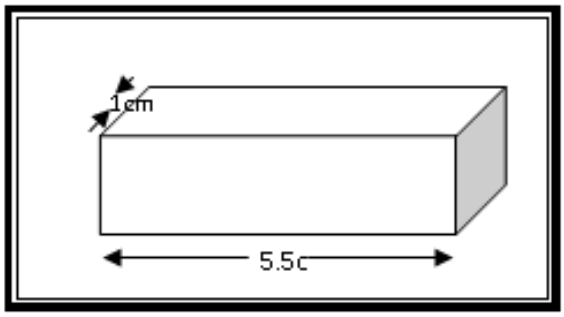

Figure (1) the dimensions of samples

The samples were dividing to three groups and immersed in distilled water for different time: - the first group (A) for (15) days, second group (B) for (27) days and last (C) for (39) days, all at constant temperature (±20) C^o .Balance model BL210S with sensitivity equaled to (10^{-4}) is used to measure the weight of samples. the mass gain recorded for all samples every (3) days. The relative mass gain calculated from equation (2) and the diffusion coefficient calculated from equation (3) for all samples. The charpy impact strength test was executed for samples before and after immersion in distilled water .the specification of charpy impact test instrument (AMITYVILLE.INC, New York) testing machine. Optical camera is used to picturing the shape of samples, and Nikon Japan Industry (10×) magnification optical microscope connected with digital camera with the computer is used to picturing the region of fraction.

Results and Discussion:

From the results in table (1) and figure (2) the relative mass gain for the samples increased with increasing the immersion time in the distilled water till reach it to saturation moisture mass (m∞) after that the relative mass gain decreased as shown in carve of sample C in figure (2).

Moisture diffusion in polymeric composites has shown to be governed by three different mechanisms. The first involves diffusion of water molecules inside the micro gaps between polymer chains. The second involves capillary transport into the gaps and flaws at the interfaces between fiber and the matrix. This is a result of poor wetting and impregnation during the initial manufacturing state. The third involves transport of

micro-cracks in the matrix arising from the swelling of fibers. [10_13] The water may occupy pre-existing space within the host material. This would be characterized by an increase in total mass with no overall volume change. Assuming that the pre-existing space was occupied by gas (e.g. atmospheric gas) this would result in an increase in density and no swelling.

One might expect this situation to occur for an amorphous material (such as epoxy resin) where water could occupy intermolecular spaces (possibly due to incomplete cross linking) and small voids from deficiencies in the manufacturing. [14].

The water may force its way into the material opening up nascent cracks and structural imperfections. This would be characterized by an increase in total mass with a corresponding increase in volume. Assuming that the density of the water is less than that of the host material, this would result in a decrease in density and concomitant swelling. One would expect this situation to occur for composites material if it is energetically more favorable for the water to occupy sites on the surface of the matrix. [14].

From the results in table (2) the diffusion coefficient decreased with increasing the immersion time this means the absorption resistance increased because of reaction between epoxy and (H_2O) through the interface making a separation between the epoxy and plates of glass fibers [15]. from the results in table (3) and fig(3) the impact strength decreased with increasing the time of immersion , this is due to : The effect of absorption of moisture leads to the degradation of fiber-matrix interface region creating poor stress transfer efficiencies resulting in a reduction of mechanical and dimensional properties. [16]

The pictures of samples as shown in figures (5-7) show the shape of samples before and after test and immersion in distil water .by observing the figures (9) and (10), which represent the region of fraction after the end of the test, where we find the crash of the binding material in this region, and also note the slip and break the fibers due to the stress as a result of hanging during the test.

Table (1) The Relative mass gain of samples with the time of immersion

Time immersion (day)	(M%) Relative mass gain of samples		
	M% of sample A	M% of sample B	M% of sample C
3	1.62	1.46	1.15
6	1.75	1.47	1.25
9	1.81	1.59	1.51
12	1.99	1.71	1.58
15	2.35	1.95	1.82
18		2.43	2.18
21		2.72	2.36
24		2.82	2.58
27		2.92	2.89
30			3.21
33			3.11
36			3
39			2.8

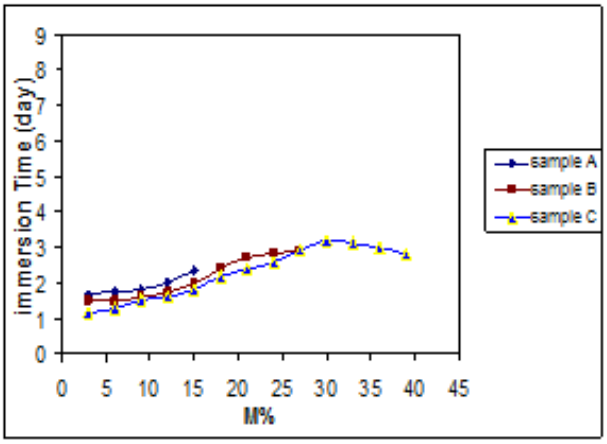

Figure (2) The Relative mass gain with the immersion time

Table (2) the diffusion coefficient D of the samples.

Sample	K day^{-1}	M∞	D m^2/day^2
A	0.06	2.35	$1.818*10^{-9}$
B	0.07	2.95	$1.570*10^{-9}$
C	0.08	3.21	$1.732*10^{-9}$

Table (4) the impact strength of the samples before and after immersion.

samples	Gc (KJ/M^2)	Time of immersion (day)
Sample without immersion	122.01	0
A	120.9	15
B	115.5	27
C	106.3	39

Figure (4) sample without test and immersion.

Figure (5) picture of tested sample without immersion.

Figure (6) picture of sample A

Figure (7) picture of sample B

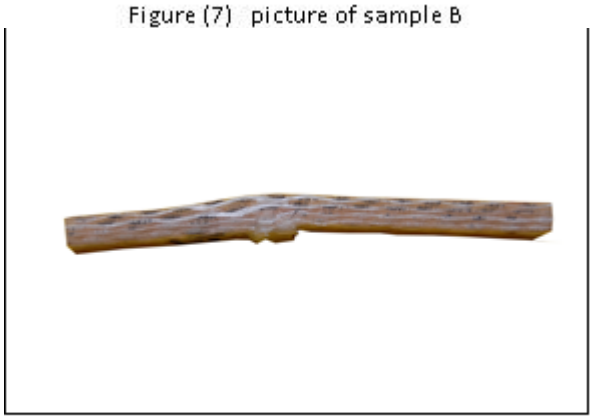

Figure (8) picture of sample C

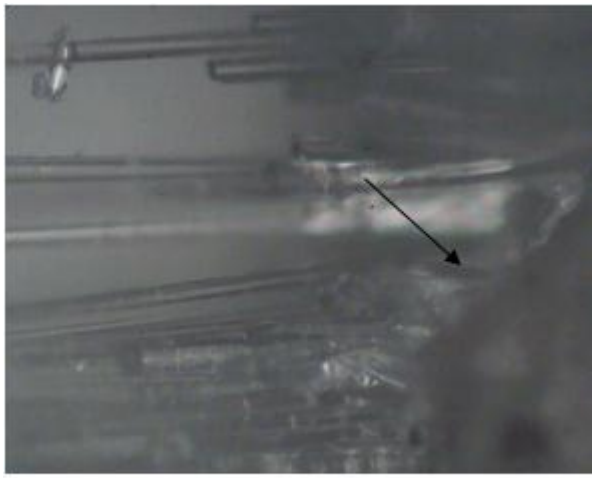

Figure (9) microscope Picture of sample B(×10)

Conclusion:-

1-The maximum mass gain was of the sample(C) till saturation (M_∞) after that the mass gain decreased.

2- The maximum diffusion coefficient (minimum absorption resistance) was for the sample (A) while

the minimum diffusion coefficient (maximum absorption resistance) was for the sample(C)

3- Increasing the time of immersion decreased the impact strength of the samples.

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تأثير امتصاصية الماء على قوة الصدمة لمتراكب الايبوكسي المدعم بالالياف الزجاجية

قيس عبد الله عباس

الخلاصـــة:تـم اسـتخدام طريقـة التصـنيع اليـدوي لتحضـير طبقـات مـن الايبوكسـي (EP) المدعمـة مـع ١٢ طبقـة مـن الأليـاف الزجاجيـة (٠° – ٩٠°)والمحاكة بشكل حصيرة وبكسر حجمي مقداره ٣٠% من ألياف التسليح . قطعت هذه الطبقات من متراكب الايبوكسي والألياف الزجاجية بالأبعاد القياسية لاختبار تأثير الصدمة لشاربي .ويهدف البحث الى دراسة تأثير امتصاص الماء على قوة الصدمة لمتراكب الايبوكسي المدعم –١٢ طبقة من الالياف الزجاجية ، وقد تم دراسة سلوك الانتشارية ومعامل الانتشار. وزعت العينات إلى ثلاث مجاميع وغمرت في الماء المقطر لفترات زمنية مختلفة .المجموعة الأولى غمرت لمدة ١٥ يوما، والمجموعة الثانية ٢٧ يوما والأخيرة ٣٩ يوما عند درجة حرارة ثابتة (± ٢٠).تم حساب الزيادة بالكتلة حيث سجلت كل ٣ أيام حتى الوصول إلى حالة التشبع (M∞) بعد ذلك لوحظ إن الربح بالكتلة انخفض. أظهرت النتائج أن قيمة معامل الانتشار القصوى (مقاومة الامتصاص الدنيا)كانت للعينة (A) ، في حين أن الحد الأدنى لمعامل الانتشار (مقاومة الامتصاص القصوى) للنموذج (C). تم دراسة قوة الصدمة للعينات قبل وبعد الغمر بالماء المقطر ولفترات زمنية مختلفة.وقد أظهرت النتائج ان قوة الصدمة تقل بزيادة زمن الغمر للعينات.