Journal of Engineering and Applied Sciences 13 (18): 7624-7629, 2018
ISSN: 1816-949X

762Study Effect of Reinforcement and Moisture on Impact Strength of Hybrid and Single Polymeric Composites

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Abstract: In this research study the effect of reinforcement and moisture on impact strength of hybrid and single composites for epoxy resin (Quickmast 105) type where used Javanese redwood flour and Russian whitewood flour and glass powder and rock wool fibers as support material by volume fraction (20%) for all prepared models. The results shows an increase in values of impact strength of all supported models (single and hybrid) at laboratory conditions where a hybrid supported material (EP+RWF+GP) achieved the highest value of impact strength (8.2 kJ/m^2) when the models submerged in normal water for different periods observed increase impact strength to all prepared models with increasing time of immersion except hybrid particulate composites that possessed low values of impact strength when the immersion (2 weeks) compared with the values in the laboratory conditions and then the impact strength values of these models rise with increasing time of immersion (4, 6, 8 week).

Key words: Polymeric composites, reinforcement, moisture, impact strength, fillers, models

INTRODUCTION

In recent years there has been growing interest in the characterization of inter penetrating networks polymer, great attention has been focused on enhancing their mechanical properties. mechanical characteristics are extremely important not only for scientific knowledge but also for modern technological applications. the polymeric composites received much attention by many researchers (Abdl-Hakem, 2003), the effect of ceramic fillers (kaolin and boxide) on the epoxy resin. The results showed improvement in mechanicals properties with increasing filler content and decreasing filler size (Abdl-Hakem, 2003). Mnati in 2005 studied the mechanical behavior for a particulate polymeric composite. She used epoxy as a matrix reinforced with particles of aluminum oxide and particles of glass with volume fraction of (30%). Better mechanical properties have been found for epoxy reinforced with alumina powder and hybrid composite material. Abdullah in 2007 studied the effect of adding aluminum powder of different sizes to polymeric matrix. The results showed that the addition of particles to the matrix improves to a great extent the mechanical properties.

MATERIALS AND METHODS

Theoretical side

Impact strength test: Impact strength test is one of the important tests used to study the behavior of materials under influence of fast forces, the type of impact test used in this research was charpy impact test which represents one of the types of three-point bending test but as kinetic type, the stress and effects of environment plays significant role in determining the impact strength of the material because the potential energy of the hammer change and there is a transformation of energy where work is done on the part that the impact was reached, shock test device includes transformation of energy and absorption and then dispersion, so, the absorbed energy determine the properties and features of the material located under impact loads because the impact energy represents the toughness which is the work done to break of model where the material which has high toughness requiring more energy in comparison with the material which has low toughness, Impact Strength (IS) can be obtained from the following Eq. 1 (Chawal, 1999):

$$\text{(Impact strength)} = \text{Break energy/Cross-sectional area of the model} \quad (1)$$

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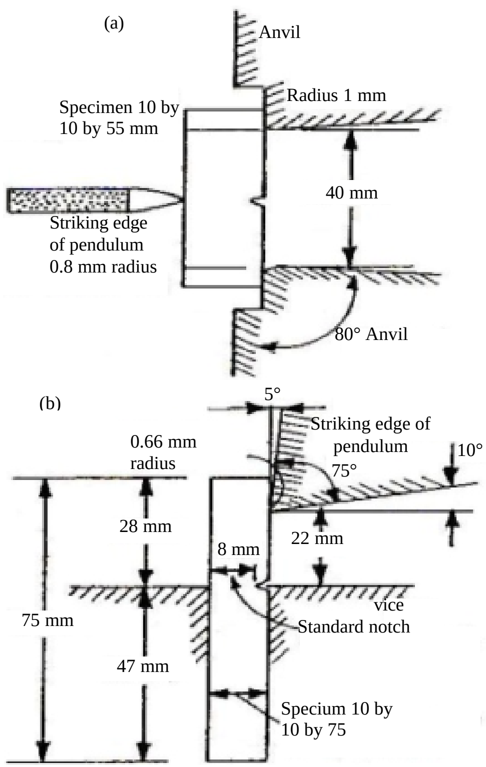

Fig. 1: The impact test; a) Charpy test and b) Izod test (Gupta and Gupta, 2005)

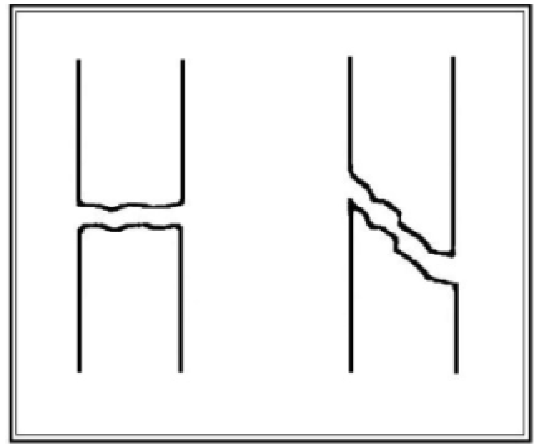

Fig. 2: The brittle fracture (Bolton, 1998)

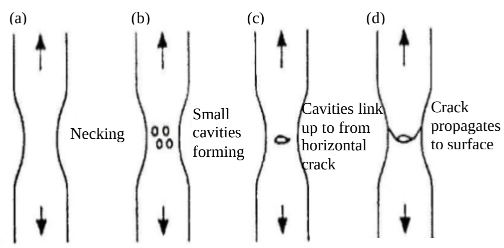

Fig. 3: a-d) The stages of ductile fracture

There are some polymers characterized by good strength but its performance is weak when subject them to impact test. Many researchers interested in impact test because there is a danger in that polymeric materials may be ductile under the influence of static stress but may seems brittle under the influence of fast stress (Chawal, 1999) where the sample in charpy impact test installed between two simple bases either in Izod impact test the sample be tightly installed between two bases as shown in Fig. 1. In some cases the sample is equipped with notch on the side exposed to tensile where the notch be a point for the concentration of stress in order to calculate less energy required to fracture (Gupta and Gupta, 2005).

Fracture edges after the test be very sharp because the stress is suddenly on the sample either if slowly, the fracture edges are less sharp (Bhatnagar, 2004), fracture defined as the bonds crash that bind of materials with each other due to the influence of an external force which leads to break the model into two or more portions configured a new surfaces during the body the fracture can be classified into two types:

Brittle fracture: Is one of the most dangerous types of fracture because it occurs suddenly without being preceded by visible the rmoplastic deformation it depends on the glass Transition degree (Tg) and the level of loading and stress condition and the properties of the material brittle fracture occurs in glass, ceramic and brittle polymers which possesses high hardness, material surfaces broken with this type of fracture characterized by shiny appearance and granulated as a result of the light reflection from the surfaces of individual crystals this is because the fracture has grains during the cracking of material over the levels of atoms, Fig. 2 shows the brittle fracture (Bolton, 1998).

Ductile fracture: This type of fracture does not occurs quickly and less serious than the first type where this fracture preceded by thermoplastic deformation in the surrounding area of acute notch edge and this leads alert to happen the fracture in the material, the ductile fracture surface characterized by rough referring that a significant plastic work had happened, Fig. 3 shows the stages of ductile fracture.

Experimental side

Materials: The matrix material used in this research is the epoxy resin (Quickmast 105) type which has impact resistance (2.1 kJ/m^2) which is one thermo setting resins and made by Ayla Construction Chemicals and with distinction from (dcp) English company, the epoxy which use in this study symbolize as (Ep) has distinguish properties from the rest of types its low viscosity allows to mixing with reinforcement materials until reaching to high homogeneous between the matrix material and reinforcement material, also has a high adhesion property where not getting shrinkage after solidification process where hardener (is a liquid has low viscosity and transparent color) add to the resin by (5:1) ratio interaction occur between them at room temperature where two types of wood flour used in this research, Russian White Wood Flour (WWF) with density (521.757 kg/m^3) and Javanese Red Wood Flour (RWF) with density (495.544 kg/m^3) both these types are fine particles with particles size (100-140 μm). Also, used Glass Powder (GP) of (Soda-lime glass) type with particles size (35 μm) with density (2480 kg/m^3) and Rock Wool fibers (RW) with density (0.7 g/cm^3) characterized by its green color were also used. These fibers are thermal insulators because of high thermal resistance up to (800°C) and characterized by high chemical resistance.

Samples preparation: Hand molding technique was used in the samples preparation at this stage, been manufacturing special mold for the casting process made of galvanized iron with dimensions (21×21 cm), then we have cleaning and drying process of mold then we have the mixing process according to the specific ratios where composite materials manufactured with volume fraction (20%) and by using Eq. 2-4 (Mahoon, 1988):

$$\psi = \frac{w_f}{w_c} \times 100\% \quad (2)$$

$$w_c = w_f + w_m \quad (3)$$

$$\phi = \frac{1}{1+\frac{1-\psi}{\psi}.\frac{\rho_f}{\rho_m}} \quad (4)$$

Where:

- Ψ = Weight fraction of reinforcement material
- ϕ = Volume fraction of reinforcement material
- ρ_m, ρ_f = Density of matrix and filler materials, respectively
- w_c, w_m, w_f = Weight of composite material, matrix material and filler, respectively

And then samples were chopped and according to standard specifications (ANSI/ASTM-D790) shown in

(a)

(b)

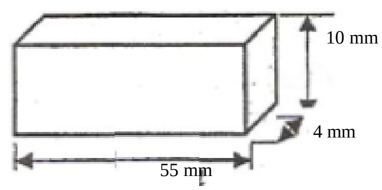

Fig. 4: a) Impact test device and b) Prepared models

Fig. 4 which shows pictures of models and impact test device manufactured by a company (Testing machines INC Amityville New York) where we have conducted a impact test for all models in laboratory conditions and at the immersion in normal water where they were attending five types of epoxy composite as follows: Epoxy supported with Javanese redwood particles (20%) only as single composite material (Ep+RWF) and epoxy supported with Javanese redwood particles (15%) and glass powder (5%) as hybrid composite material (EP+ RWF+GP).

Epoxy supported with Russian whitewood particles (20%) only as single composite material (Ep+W.W.F) and epoxy supported with Russian whitewood particles (15%) and glass powder (5%) as a hybrid composite material (EP+WWF+GP).

Epoxy supported with rock wool fibers (10%) and (5%) for both two types of wood particles as hybrid composite material.

RESULTS AND DISCUSSION

Impact test which used in this research is charpy impact test for different composites materials supported by three types of filler (three types of particles) Gawain Red Wood particles (RWF) and Russian White Wood particles (WWF) and Glass Particles (GP) and Rrock Wool fibers (RW). The charpy impact manner is from the tests that can be used to study the behavior of materials under influence fast forces where this test is represent one type of three points testes but as dynamic type, so, the increase test speed plays an important role in influencing on the mechanical properties of the material has received considerable attention by researchers because there is a danger where polymeric materials may be ductile under influence the static stress but may looks brittle under influence the fast stress (Hancox, 1981) and from the Eq. 1 calculated the impact strength at different conditions (laboratory conditions and when the immersion) and Table 1 shown impact strength values of all models.

From the results that were obtained for all prepared models in this research where the results shown an increase in impact strength for all hybrid and single composites at laboratory conditions and shown in Table 1and Fig. 5 where the addition of particles to epoxy resin which is one of brittle polymeric materials which has low impact strength (Kinloch *et al*., 1985; Broutman and Krock, 1974) operating these particles to increase the toughness of composites material because their presence leads to deflection of notch as the meet notch of the particles during the progress through the material will generate disability in movement by these particles which are barriers front of the notch and is works to install in particles centers in order to exceed the notch of these barriers and continue growth will change its shape and turns into a small secondary cracks trying, so, traffic between particles and this leads to an increase in crack surface and thus increasing the energy required to obtain fracture (Moloney *et al*., 1983).

As we found that the hybrid reinforcement material (EP+RWF+GP) possessed higher resistance to impact and then followed hybrid material (EP+WWF+GP) and then single materials (EP+RWF) (EP+WWF) where we note that the addition of Glass Powder (GP) to supported materials lead to increased resistance to impact any increase in the durability of composites material and this is consistent with the researcher (Owen,1979) where he noted that the glass powder gives strength to fracture and hardness of the polymeric composites (Owen, 1979) as well as consistent with the researcher

Table 1: Impact strength values at different conditions

Models	Impact strength (kJ/m^2) LC	2 weeks	4 weeks	6 weeks	8 weeks
(EP+RWF)	2.8	3.619	3.796	3.914	4.439
(EP+RWF+GP)	8.2	3.951	4.343	4.876	4.957
(EP+WWF)	2.7	3.584	3.536	3.655	3.789
(EP+WWF+GP)	6.2	2.855	3.901	6.812	7.278
(EP+RW+RWF+WWF)	2.5	2.501	2.771	2.931	3.433

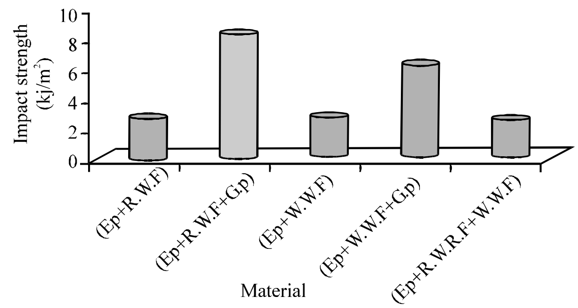

Fig. 5: Impact strength values of prepared models at laboratory conditions

who observed when addition glass particles to epoxy lead to an increase in fracture resistance (Kinloch *et al*., 1985). While hybrid reinforcement material (EP+RW+RWF+WWF) has less impact resistant for the supported models and this may be due to the mechanical interaction and internal friction between the two types of reinforcement and which contribute to non-stabilizing of the macro cracks and stimulates the growth of cracks that leads to decrease the break strength and then drop impact resistant and this was supported by the researchers (Pande and Sharma, 1984) and also may be due to possessing rock wool fibers very low density (0.7 g/cm^3) where it includes holes that act as weak points within the reinforcement material and be the center of stresses as well as this fibers work on increase the internal distance between the particles where the fracture energy of particulate composite materials is increasing when the decrease in the internal distance between particles (Beaumont and Young, 1977).

The results of impact test after the immersion of prepared models in normal water as shown in Fig. 6 and Table 1 where impact resistance of hybrid particulate composites (EP+RWF+GP), (EP+WWF+GP) down after two weeks of immersion compared with its value before the immersion and impact resistance for the itself composites increased with increasing period of immersion (4, 6, 8) weeks in the water where it may be due to the presence of Glass Powder (GP) within these composites materials which is ceramic particles where the ceramic particles characterized by the presence of pores that help

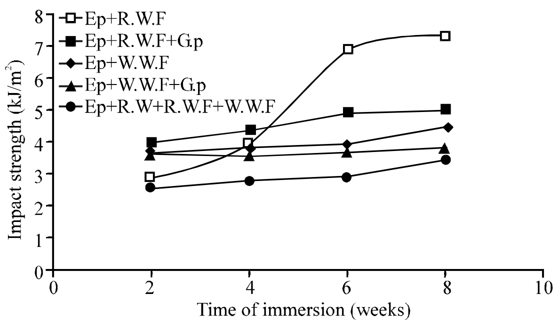

Fig. 6: Impact strength values of prepared models after immersion

to enter the water molecules into composite material causing weakness or damage in the interface between the matrix material and reinforcement material (Dhyae and Salman 2008; Razak, 2009) as well as decrease impact resistance at period immersion 2 weeks may be due to loss of adhesion and bond strength at interval surface between the matrix material and reinforcement material at this period as a result of entering the water to interface, made up what is known as swelling which generates internal stresses within the material there by to weaken (Comyn and Marom, 1985) the drop in impact resistance may be due to an increase of water molecules passers to the material which lead to a high rate of hydrolysis (increased deployment mechanism) as a result of the polymeric drift phenomenon that generate cracks in the composite material leads decrease impact resistance (Gary and Pawar, 1982).

But with the increase in immersion time shows that values impact resistant to all prepared single and hybrid models will increase where the reason for this increasing in fracture energy of models is that the particles of sodium chloride (NaCl) in water will forming another phase between matrix material and reinforcement material causing decrease in internal shear forces and this in role will increase the energy absorption at the interface region and the produces increase in the fracture strength of the composite material and this was supported by researchers (Gary and Pawar, 1982) and also may be due to the water absorption can lead to annealing of matrix material as a result of vander waals forces crash between polymer chains where lead to increase in movement of molecular chains and which in turn leads to the absorption of higher energy and increase impact strength (Singh *et al*., 2006) where the epoxy (matrix material) is sensitive to moisture because of the interaction that occurs between some polar-groups of polymer molecules and water molecules (Razak *et al*., 2009).

As well as by observing the results shown in the Table 1 shows that the hybrid composite material (EP+RW+RWF+WWF) supported with fibers and particles possessed lower impact resistance when immersion in water and this because of the low density and porous structure of rock wool fibers where these pores as weak points within the composite material and helps to enter water molecules into composite material which leads to reduced impact resistance compared with other models prepared (Beaumont and Young, 1977).

CONCLUSION

From this research, the following remarks can be concluded: The addition of different types from particles and fibers led tohighimpact resistance at laboratory conditions compared with un supported epoxy. Hybrid particulate composites possessed higher impact resistance in laboratory conditions compared withot her prepared models. The addition of rock wool fibers lead to a reduction in impact resistancetolowest value compared withot her supported models (laboratory conditions and immersion). Rising impact resistance values of all prepared models at the immersion except hybrid particulate composites at immersion period (2 weeks). Rising impact resistance fore a chprepared models with increasing the immersion time (2, 6 and 8 weeks).

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