Effect fire clay powder in epoxy- novolac composite

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Abstract:

In this work the mechanical properties and water absorption of epoxy composites reinforced with fire clay powder are investigated. The epoxy resin type Conbextra EP10 and Aphenolic novolac resin which made in (Al SAWARI COMPANY) and size (75 Mesh) with (hexa methylene tetra amine) (HMTA) as hardener in 15wt. %. were used as a matrix material. The reinforcement particulate materials are fire clay powder with size (105μm) and having weight fraction of 10%, 15%, 20%, 25% and 30%. The parameters such impact strength, shore D hardness, elongation test were carried out on the prepared samples after immersed in distill water in various time. Test results indicate that hardness, impact strength of the composite materials which immersion in water at different time is significantly higher than those of the matrix material. The enhancements in these properties are found to be directly proportional to the weight fraction of fire clay powder. The values of shore hardness 79.4 and 83.4 when the weight fraction 10% and 30% respectively after immersion seven weeks. At the same time the elongation of specimens were increased when the weight fraction of reinforcement increased but after immersion in different time the elongation of samples decreased for the same weight fraction of fire clay.

The fire clay powder has a positive influence on elongation of epoxy composite but the immersion led to negative influence on elongation. The immersion for all samples in water led to increasing the absorption.

Keywords: Fire clay, Epoxy, composites, Aphenolic Novola , absorption.

1. Introduction

Epoxy polymers are thermosetting polymers that are more and more used as matrices in composite materials. They are flexible polymeric materials characterized by the appearing of two epoxide groups or more in their molecular structure when cured, epoxies are amorphous and highly cross-linked, having unique characteristics, such as stiffness, hardness and relatively high strength [1].

Epoxy resin is commonly used for matrix material to development of advanced composite materials because of its following excellent properties: high electrical insulation, high strength, high adhesion to substrates, low shrinkage, low toxicity, low cost and high formability to various applications. However, from a mechanical perspective, epoxy polymers are a brittle fracture style. To modify and increase the properties of the brittle epoxy, adding rubber particles or inorganic fillers such as (kaolin, silica) [2, 3].

The characteristics of a polymer composite material depend on the nature, the shape of the reinforcement, the input amounts, the incorporation of reinforcement into matrix and finally, on the synthesis process [4].

The chosen of suitable a phenolic novolac resin as a binding system for added in the manufacture of a composite material is very important to achieving the desired properties such as mechanical and thermal properties in the final product. Phenolic novolac resin is a common synthetic resin that is used in a wide range of applications such as adhesives, paints and composites. It is a thermoset polymer and has two types, the resole type and the novolac type,
depending on the method of synthesis and the catalysts used [5].

These reinforcement such as ceramics, metal and polymers are done to improve properties of composite material is made by combining two or more materials to give a unique combination and superior properties that cannot be available in conventional monolithic materials [6, 7].

A composite is a heterogeneous material that combines the properties of its constituents to develop better properties than its parent components. At least one phase is mostly inorganic as dispersed phase [8].

The excellent dispersed inorganic fillers such as ceramic powder in polymer matrices and compatibility between interrupted phase & continuous phase are important to produce good rendering. Particulate filled polymers are used in very large quantities in all kinds of applications and despite the great interest in advanced composite materials[9].

The aim of this research was to investigate the effect addition powder of fire clay on hardness, impact resistance, elongation and absorption for the epoxy resin and novolac with the increment of weight ratio of powder, Results gained have been disputed and analyzed in experimental part.

The following equation can be used to calculate the impact strength (I. S.):

$$I.S = \frac{U_c}{A}$$

U_c: the fracture energy from Charpy impact device (Joule).
A: The cross- sectional area (m^2)

The elongation is given by equation:

$$\varepsilon = \frac{L - L_\circ}{L_\circ}$$

where:
ε = strain (elongation),
L = length at any point during the elongation (mm)
Lo =original length (mm).

The percentage gain (M_t)at any time, due to water absorption was calculated by:

$$M_t\% = \frac{W_w - W_d}{W_d} * 100$$

Where:
W_w: Weight of wet specimens.
W_d: Weight of dry specimens.

2. Materials and methods

Epoxy resin type Conbextra EP10 was used with Meta phenylene Diamine (MPDA) as hardener in this article. It is a liquid with moderate viscosity. When added the hardener in (3:1) ratio at room temperature to epoxy, it was converted to solid. This hardener is a light and yellowish color liquid.

Aphenolic novolac resin type made in (Al SAWARI COMPANY) was a solid material with a pink color and distinctive strong smell. It was crushing by (Mortar) and then milling and sieving to

obtain powder with size (75 Mesh). A phenolic- novolac resin used with (hexa methylene tetra amine) (HMTA) as hardener in 15wt.%. Ethyl alcohol is used to dissolve novolac with hardener by using electric mixer at 500 r.p.m for 15-20 min.

All samples in the paper were manufactured by hand layup technique. The epoxy with hardener is mixed using a glass rod until to be homogenous then Aphenolic- novolac resin with (hexa methylene tetra amine) (HMTA) (10wt.%) added and continuous to mix the mixture. Fire clay powder with granular size (105 µm) added into mixture (epoxy and novolac) with variation weight percentage (10, 15, 20, 25 and 30 wt. %) by shearing mixer at 500 r.p.m for 15 minutes. Good homogeneity between epoxy resin and fire clay powder will occur.

All specimens were immersed in distill water in different time (1, 3, 5 and 7) weeks. All samples were taken out, removed and wiped the distill water by filter paper to remove attached water

Charpy impact test involve the use of hammer strike that will be delivered to the sample until reaches to breaking point. Specimens of impact test have a dimension of (50*10*10) mm according to ASTM (IISO-179). The specimen is positioned in such a way that both of its ends are fixed in position and the strike is delivered to the middle part.

The tensile test of material was carried according to ASTM D 638-99 with a universal testing machine (ZWICK Co.) at constant rate (10mm/min) and room's temperature. Samples of tensile test have dimensions of (100*20*4) mm.

3. Results and discussions:

Hardness is considered one of the most important properties effect on the abrasion resistance of any material. In this paper, the hardness (Shore D) values of epoxy and 15 wt.% novolac composites reinforced with (10, 15, 20, 25 and 30) wt.% fire clay particles were obtained and compared with epoxy composite after all samples immersed in water.

The results show that the incorporation of fire clay powder into the epoxy resulted in a significant improvement in the hardness of the composites, this shown in figure 1. The value of hardness also increased when increasing the period of immersing in distills water due to the degree of bond between the fire clay and the polymer matrix, and the distribution of the powder in the matrix. The hardness increases after seven weeks from 0 to 20 wt. % from fire clay and then decrease at 25 wt. % due to affect the water at the bond between fire clay powder to return increase at 30 wt.%.

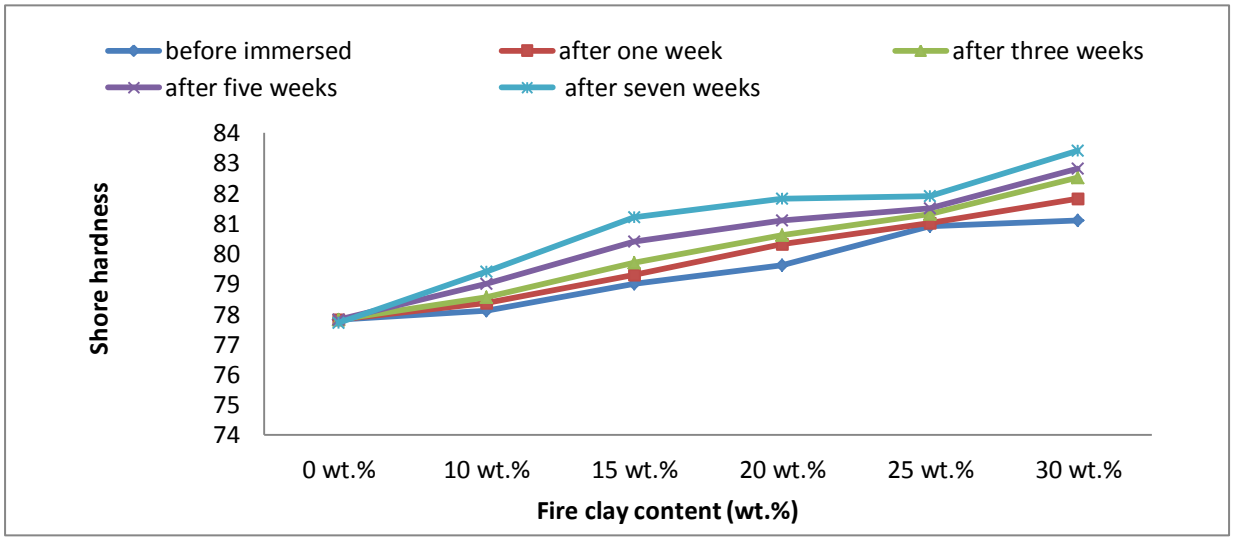

Figure 1: shore hardness of Epoxy composite in different weight fraction of Fire clay powder.

The impact strength of epoxy –fire clay powder composite as a function of fire clay content is presented in Figure 2. It is clear that the impact strength of epoxy composites increasing in value with the increases the fire clay content, also the immersion the samples in distill water enhancement the impact strength of samples. The increase in impact strength may be related to distribute the fire clay in the epoxy matrix [10].

The increasing in value of impact strength is happened due to the weaker bond between fire clay. The large amount of energy is absorbed by crack initiated at interface between the reinforcement and the matrix; this is due to the characteristics of the material content. Usually, the epoxy reduces the amount of energy absorbed.

Epoxy- fire clay are especially desirable for improved properties because of the large weight fraction and homogeneous dispersion of fire clay and huge interfacial area (and consequently strong interaction)between epoxy and fire clay .

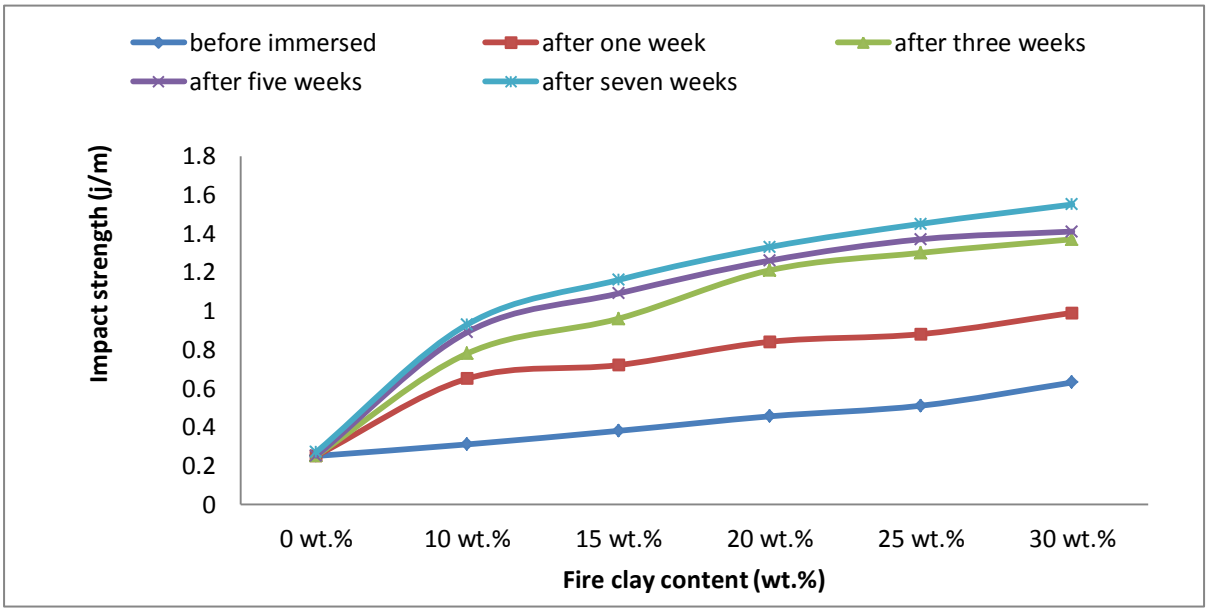

Figure 2: Impact strength of Epoxy composite in different weight fraction of Fire clay powder.

Figure 3 shown, compared to unfilled specimens, an increase of elongation at break are observed for filled epoxy- novolac resin. The elongation at break of epoxy-fire clay powder composite high increase from 12.2 % at 0 wt.% fire clay powder to 15.7 % at 30 wt.% fire clay powder before immerssion. Also, for all specimens the elongation was increased when the reinforcement increas at different period of immersion due to sufficient bonding between the particles of reinforcement also between the reinforcement and matrix . But at the same weight

fraction of fire clay, the elongation reduce when immersion in distill water. The process of submerging the samples in water leads to the dissolution of the bonds between the fire clay particles also between the reinforcement and matrix, the loads cannot transfer from end to another end this led to reduced the elongation of composite.

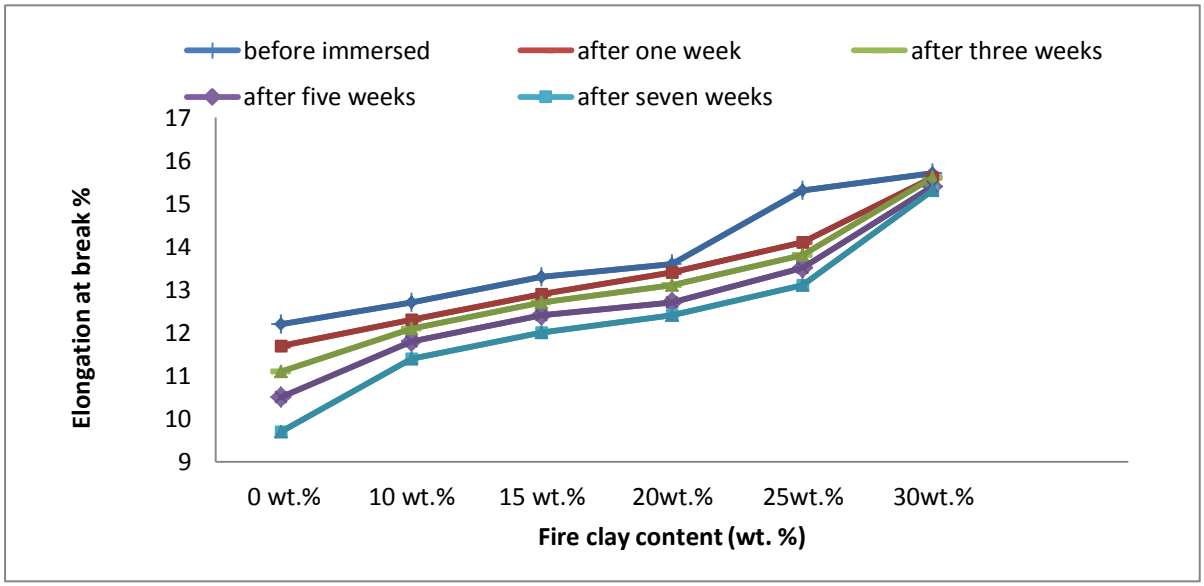

Figure 3: Elongation of Epoxy composite in different weight fraction of Fire clay powder.

The samples were taken out from water, wiped by filter paper to remove attached distill water on their surfaces. All specimens weighed by a accuracy balance (0.1 mg) after different periods (1, 3, 5, 7) week. The change in mass was measured compared with initial mass.

As shown in figure 4, the water absorption of epoxy – novolac-fire clay powder composite increased continuously week by week and also showed that a clear effect of increasing water absorption with increasing fire clay in the composites. The presence some clusters of fire clay was likely to be attributed to the many pores and led to increasing in water absorption.

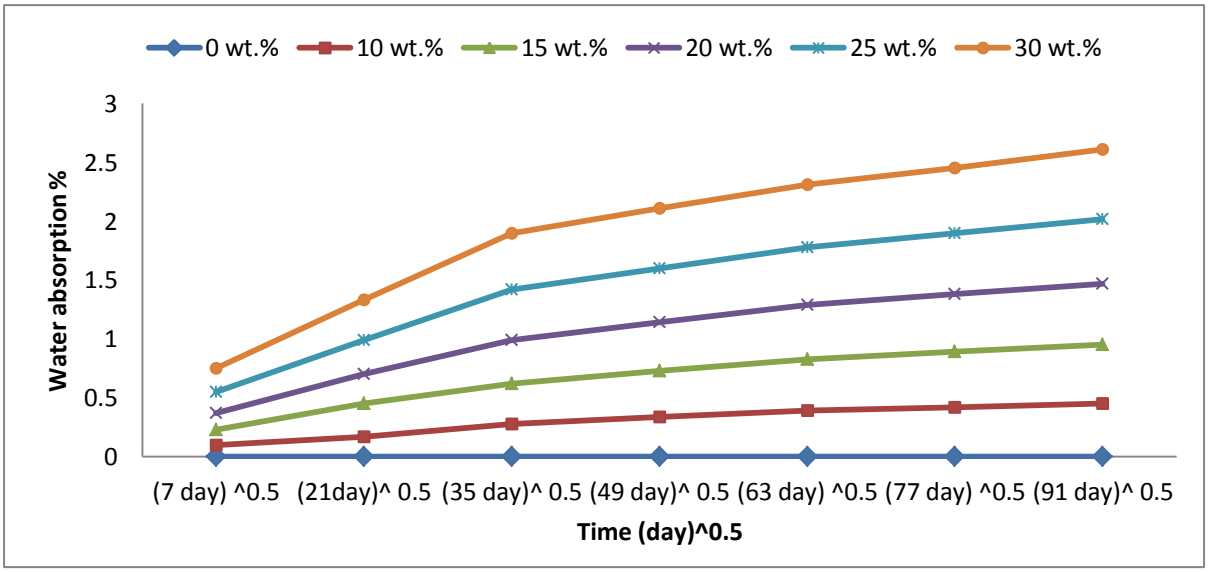

Figure 4: water absorption of Epoxy composite with time immersion.

4. Conclusions

The following conclusions can be made as a result of the experiments

1-Mechanical properties (Shore hardness, impact strength) of the fire clay powder filled epoxy - novolac composites improved with increase of filler content before and after immersion in distill water. The results obtained hardness of composite was increased from 77.8 at 0 wt. % to 81.1 at 30 wt. % of reinforcement before immersion. Also the hardness was increased after seven weeks of immersion in water from 77.7 at 0 wt. % to 83.4 at 30 wt. % fire clay powder.

2-The impact strength of epoxy composites increasing in value with the increases the fire clay content, also the immersion the samples in distill water enhancement the impact strength of samples.

3-Values of elongation at break for the epoxy composite with fire clay powder increases with the increase the fire clay particles.

4-The water absorption of epoxy – novolac- fire clay powder composite increased continuously week by week and also showed that effect of increasing water absorption with increasing fire clay in the composites.

5-References

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