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Thermal and mechanical study of polymeric composites prepared from epoxy with iron filings

Maysam K. Jassem Al-Atrash
Department of Chemistry, College of Education for Girls, University of Mosul, Mosul, Iraq
Corresponding author email: maysamkhaled1990@gmail.com

Ebtahag Z. Sulyman Al Halim
Department of Chemistry, College of Education for Girls, University of Mosul, Mosul, Iraq
Email: ebthalim@uomosul.edu.iq

***Abstract*---**Through this research, polymeric composites were prepared from Addition of epoxy resin with iron filings in certain weight ratios (0.5%,1%,1.5%,2%,2.5%,3%,4%,4.5%,5%) as a reinforcement material. The comparison was made between polymeric composites Before and after the cementing process , After a series of experiments, it was found that the best weight percentage was (1%),This addition was done at different temperatures (8,25,55) °C, The results when compared before and after the reinforcement process for the composites showed that the thermal conductivity the thermal conductivity increased after the strengthening process, for the mechanical properties, Impact test, Hardness and compressive strength, they increased at 25°C and increased at processing temperatures(8.55)°C.

***Keywords*---**epoxy, iron filings resin, hardness strength, compressive strength, impact strength, thermal conductivity.

Introduction

Composites materials are used in increasing quantities in various fields of industry such as automotive [1], defence [2, 3], transportation [4], aviation [5], marine [6], health [7, 8] and communication [9, 10]. Interpenetrating network composites is a subgroup of composites materials and in recent years there is a significant increase in research activity and publications in this area. High strength 7xxx series Al alloys are often called aeronautical materials due to their

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wide applications in aerospace field. Over the last decade, in order to meet the rapid development of large aircrafts, it has been desirable to fabricate large structural components using heavy forgings or thick plates[11-12], The polymer matrix to improve thermal [13–14] and electrical conductivity [15], and mechanical properties [16-19]. Mechanical properties of composite materials depend on the volume fraction of the fillers and additives such as metal or ceramic, on the form of them such as powder or fiber and on the interfacial compatibility [20] between the finer particles and the matrix. Various kinds of polymers and polymer matrix composites reinforced with metal particles have a wide range of industrial applications such as heaters, electrodes, positive temperature coefficient [21], and composites with thermal stability at high temperature [22]. These engineering composites are desirable due to their low density, high corrosion resistance, ease of fabrication, and low cost [23-24].

Experimental part

The materials used in the research:

First -the materials used

Base material

Epoxy is the base material from (Sikadur_32 normal) company, with a density of (1.5) kg / liter and a white color. As for the hardener Dark gray color (3_amino methyl-3,5,5,-tri methyl hexyl amine) The hardener is added to the epoxy in a ratio of (1:3) at room temperature to obtain the
samples required for molding

Reinforcing materials

Iron filings obtained from the local iron making plant were used.

Second -Procedure

Epoxy resin was used, then the hardener mentioned previously was added to it in a ratio of (1:3) to obtain a gelatinous substance at room temperature. The models were prepared by using the manual molding process before and after the reinforcement using different weight ratios of the reinforcing material. Iron filings (0.5% ,1.0%, 1.5%, 2.0%,2.5%,3.0%, 3.5% ,4.0% ,4.5%,5%), then placed the overlapping material in molds designated for each measurement according to the special specifications. After the casting process is completed, the material is left for 24 hours at different temperatures (8,25,55) C to complete the solidification and overlapping process. And the homogeneity that exists between the existing molecules.

Third -Sample preparation

Impact Test samples

The models in this test were prepared according to the American specifications (ASTM_D256_87). The groove angle is (45) degrees, in front of the grooving depth is 2 mm, and the dimensions are (10 * 10 * 55). Where the absorbed energy sufficient for the occurrence of the fracture is obtained in the charpy Impact Instrument, which is supplied by the (Tokyo kokiseizosho, LTD company.

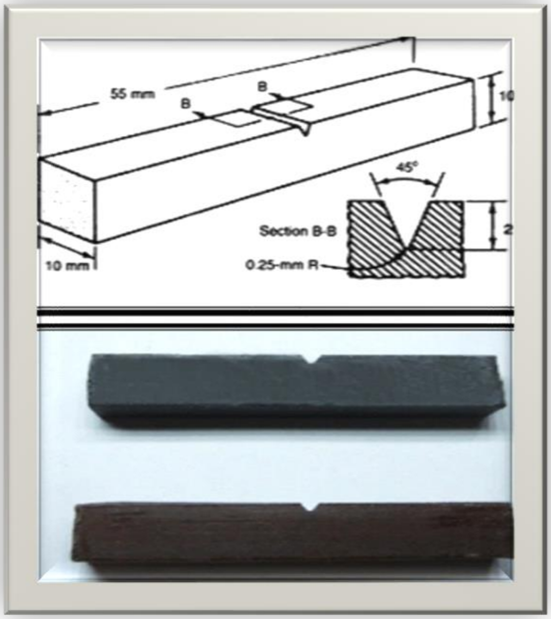

Figure (1) The shape and dimensions of the sample prepared for the impact strength test

Hardness test samples

Where the hardness device (Shore_D) type (Durometer Shore) Was used; Which was supplied by the German company "Wolpert", and was used to measure the hardness of samples of polymeric materials.

Figure (2) Hardness testing Machine

Compressive strength test samples

The samples for this test were prepared according to the required specifications (ASTM_D618), where a hydraulic piston (Testing Machine CO_LTD) was used, and it has a cylindrical shape according to the specifications supplied by (WOLPERT_Germany) company.

Heat conduction

Samples (11.23 cm) in diameter and (1 cm) in thickness were used in this test, as shown in Figure (3).

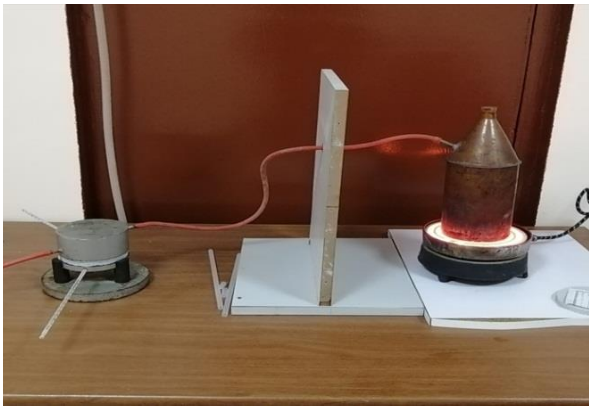

Figure 3: Thermal conductivity instrument

Results and Discussion

Impact strength

Impact strength is the ability of the material under the influence of a sudden load to resist breaking, and it is also a measure of the durability of the material, and the most durable materials show higher Impact strength [25]. To improve the impact resistance of polymers, plasticizers or improvers are added to polymeric resins such as rubber, fibers, mineral powders, etc. to give reinforcement to these resins, From the relationship below, the Impact strength can be calculated[26]:

$$I = \frac{\text{energy of fracture (J)}}{\text{area of cross section } (m^2)}$$

as shown in Table (1) and From Figure (4), it was found that the Impact resistance of epoxy is low due to its fragility, but the values of the Impact strength increase after strengthening it with Iron filings because iron improves this resistance because it bears the bulk of the Impact energy applied to the composite material [27].

Table 1: Impact strength values of epoxy with different weight ratios at 25°C

composites	Impact Strength KJ/M^2 at 25°C	composites	Impact Strength KJ/M^2 at 25°C
EP	5.759	EP+ Iron 3%	2.129
EP + Iron 0.5%	7.210	EP+ Iron 3.5%	1.234
EP+ Iron 1%	7.380	EP+ Iron 4%	0.943
EP+ Iron 1.5%	1.814	EP+ Iron 4.5%	0.822
EP+ Iron 2%	2.734	EP+ Iron 5%	0.774
EP+ Iron 2.5%	2.44		

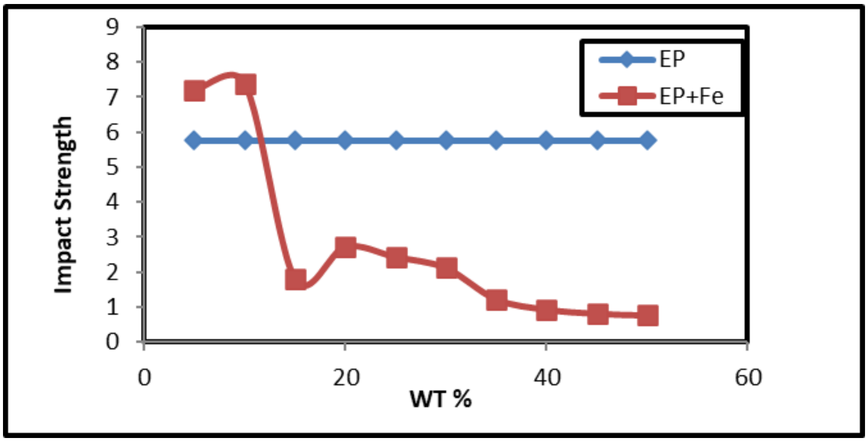

Figure 4: The Relation between Impact strength and weight ratios for Epoxy before and after reinforcement at 25° C

When treating polymeric compounds at temperatures (8.55) ℃, we find that the Impact increases When treating polymeric compounds at temperatures (8.55) ℃, we find that the Impact increases when the temperature decreases resen, the viscosity of the polymer increases and the movement of the polymeric chains is restricted, and the presence of Iron filings as an interlocking material is an additional factor restricting the movement of the polymeric chains, and the interlocking increases. Where the fillers work to distributing the stress on a larger volume of the polymer and thus preventing the growth of cracks and thus prevents its dissolution at low temperatures, It increases with the increase in temperature as a result of the relaxation of the bonds between the molecules of the material and its sliding movement, which gives it the possibility of absorbing part of the energy that leads to an increase in the energy needed to break [28], as shown in Table (2) and From Figure (5)

Table 2: Impact strength values of Epoxy at (8,25,55) °C before and after reinforcement

Temperatures°C	Impact strength PUE befor reinforcement	Impact strength PUE after reinforcement
8	3.388	4.702
25	5.759	7.380
55	5.057	6.444

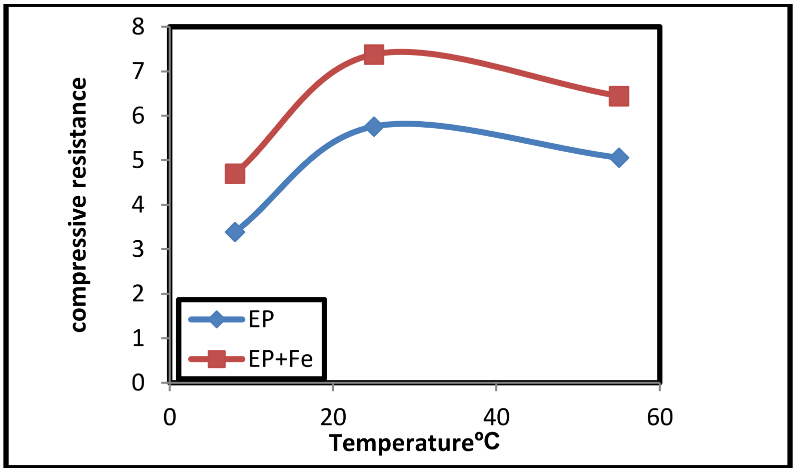

Figure (5) Relationship between Impact strength and Temperatures °C (8,25,55) before and after reinforcement

Hardness

The hardness property is one of the important surface mechanical properties, and it is defined as a measure of the deformation experienced by the material under the influence of external stress applied to it as a result of its exposure in general to scratching and burning by equipment that is harder than it while using it in various applied fields [29]. Reinforced with Iron filings The hardness values increase compared to non- Iron filings-reinforced Epoxy due to the physical affinity betweenIron filings and polymeric chains and highest value of hardness was obtian at the weight ratio 2% , as shown in Table (3) and From Figure (6). it is clear that the hardness value has increased after being reinforced with iron at a weight ratio of 1%. This increase indicates the adhesion of metal particles to the epoxy substance sufficient to increase the energy absorbed in polymeric compounds. [30]

Table 3: Hardness values of Epoxy with different weight ratios at 25°C

Composites	Hardness Strength at 25°C	Composites	Hardness Strength at 25°C
EP	115	EP+ Iron 3%	111
EP + Iron 0.5%	118	EP+ Iron 3.5%	109
EP+ Iron 1%	118.5	EP+ Iron 4%	108
EP+ Iron 1.5%	115	EP+ Iron 4.5%	106
EP+ Iron 2%	114	EP+ Iron 5%	105
EP+ Iron 2.5%	113		

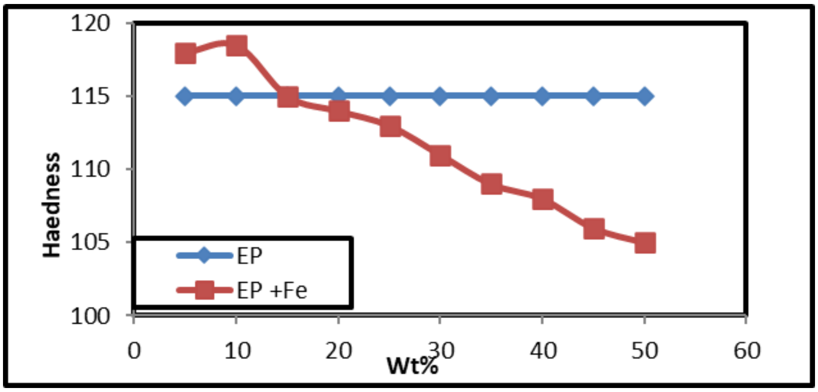

Figure 6: The Relation between Hardness and weight ratios for Epoxy before and after reinforcement at 25°C

When treating polymeric compounds at temperatures ℃ (8.55), we find that the Impact decreases when the temperature decreases in order to restrict the movement of the polymeric chains and thus cannot move, and also decreases with increasing temperature because A new type of vibrational motion connects the sides of the cube-shaped crystals - which appear solid - when heated. Which brings those atoms closer together, As a result, the atoms contract and get closer to each other [31], in Table (5) and Figure (6)

Table 4: Hardness values of Epoxy at (8,25,55) ℃ before and after reinforcement

Temperatures °C	Hardness Strength Ep befor reinforcement	Hardness Strength Ep after reinforcement
8	112	114
25	115	118.5
55	116	118

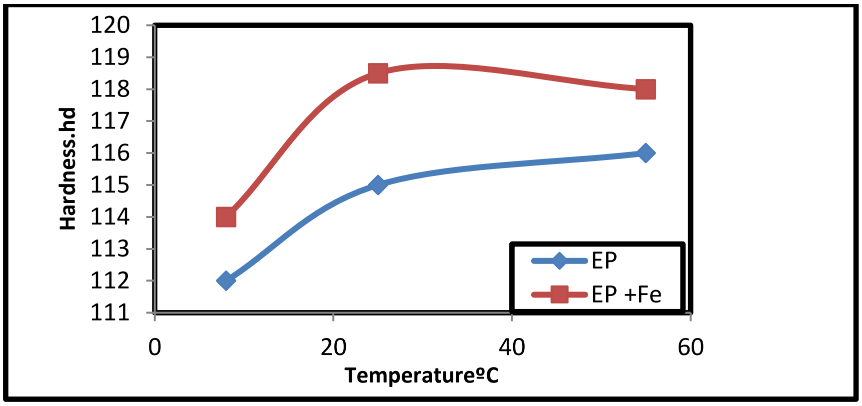

Figure 7: Relationship between Hardness.hd and Temperatures ℃ (8,25,55) before and after reinforcement

Compressive strength test

It expresses the greatest stress that a rigid material bears (the ideal state of a finite body in which deformations are considered) under vertical stress, and from the ratio of the load applied to the unit area of the section. It is the following equation [32]:

$$\text{Comps (MPa)} = \frac{\text{Force (N)}}{\text{Area (m}^2\text{)}}$$

We observation from Figures (8), (9) and Table (6),(7) increase the compressive strength of the composite material resulting from strengthening polymers with Iron filings, due to the efficiency of the bonding between the base material and Iron filings, as well as the distribution of the load imposed on Iron filings and this leads to an increase in the compressive strength [33-34]. At 25°C, but when processing the models at a temperature of 8°C, the compressive strength decreases, but at 55°C, the compressive strength increases. The reason is that with a decrease in temperature, the rate of crystallization increases, and thus decreases the compressive strength due to the restriction of the movement of the polymeric chains, but with an increase in the temperature, the compressive strength increases to increase the mobility of polymeric chains and increase the size qualitative.

Table5: Compressive strength values of Epoxy with different weight ratios at 25°C

Composites	Compressive Strength at 25°C	Composites	Compressive Strength at 25°C
EP	71.65	EP+ Iron 3%	76.433
EP + Iron 0.5%	60.50	EP+ Iron 3.5%	76.75
EP+ Iron 1%	76.19	EP+ Iron 4%	78.02
EP+ Iron 1.5%	66.87	EP+ Iron 4.5%	79.61
EP+ Iron 2%	73.248	EP+ Iron 5%	85.98
EP+ Iron 2.5%	74.84		

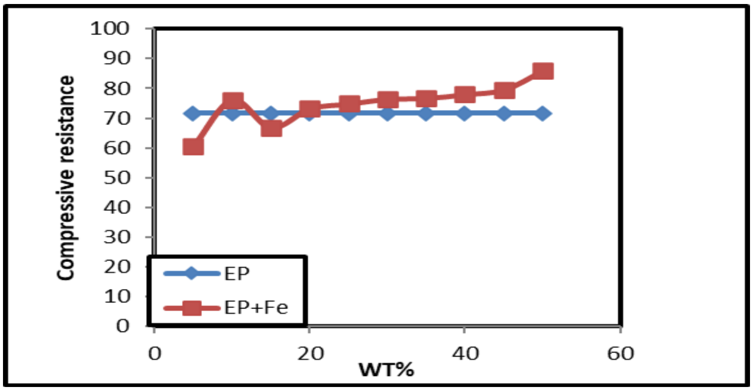

Figure 8: Relation between Compressive strength and weight ratios of Epoxy before and after reinforcement at 25˚C

Table 6: Compressive values of Epoxy at (8,25,55) ℃ before and after reinforcement

Temperatures °C	Compressive Strength Ep befor reinforcement	Compressive Strength Ep after reinforcement
8	68.47	77.77
25	66.878	76.19
55	60.509	62.500

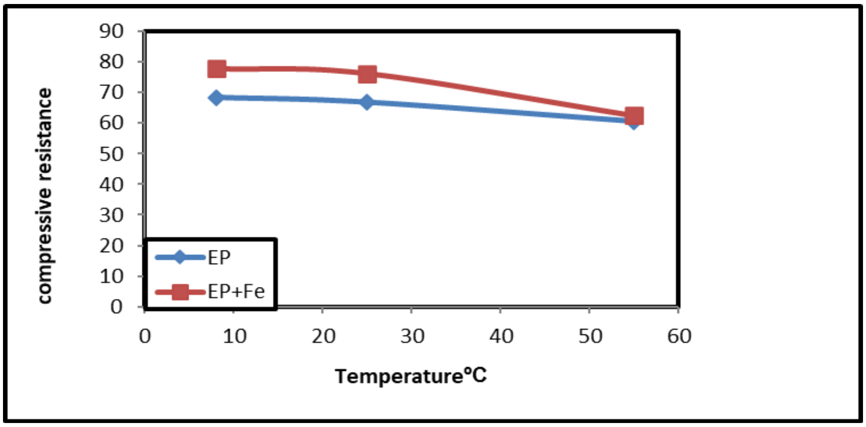

Figure 9: Relationship between Compressive and Temperatures ℃ (8,25,55) before and after reinforcement

Thermal Conductivity

Thermal conductivity is a measure of the material's ability to conduct heat. In insulating materials such as polymeric materials, heat is transmitted through a different mechanism than it is in other materials. As they are linked together by bonds [35-36], Thermal conductivity can be calculated using the law,[37]:

$$\lambda . \frac{1}{4} \pi D^2 \left(\frac{T_2 - T_1}{d} \right) = \text{mass of disc. CS. PN} \backslash \text{QN. } 1 \ / \ 60$$

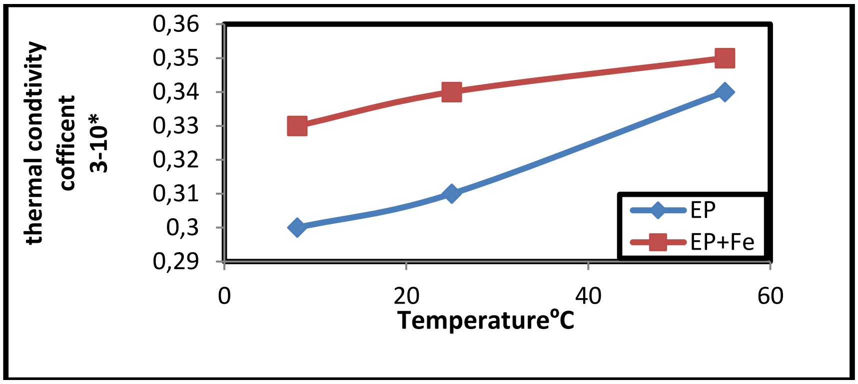

Figure10: Relationship between Thermal Conductivity and Temperatures ℃ (8,25,55) before and after reinforcement

We notice from Figure (10) an increase in the value of thermal conductivity after adding the reinforced material, because the reinforcement material has a higher thermal conductivity than the thermal conductivity of the base material,

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