# Study Of Some Mechanical Properties Of The Prepared Polymeric Composites Unsaturated Polyester With Gyrex Clay

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**Abstract**
Polymeric composites of unsaturated polyester resin were prepared as a base material, in addition to the gyrex clay as a supporting and strengthening material, and this was done by adding different weight percentages of gyrex clay. 25.55 ° C). Some mechanical and thermal tests were conducted.
It was found that the compressive and shock resistance increased, and the hardness decreased at a temperature of (55 ° C) after cementation, but increases at a temperature of (8 ° C) it was found through the results that the compressibility and hardness decreased, but the Impact increased after the cementation process, but at room temperature all properties increased Mechanical such as compressibility, impact and hardness. But the thermal conductivity decreased after the cementation process and for all the prepared samples.

**Keywords**: polymeric composites, unsaturated polyester, gyrex clay, Hardness, Compressive strength, impact strength, thermal conductivity.

## Introduction
The term composite materials is ancient, but modern technologies for various composite materials were not achieved until the twentieth century, especially after the discovery of polymers. As the period of World War II was a period of scientific and technical progress due to the need for modern technologies that required materials with good specifications such as strength, durability, low density, high hardness, temperature resistance, good thermal insulation properties, and the possibility of forming in different shapes and at a relatively low cost [1].
And as long as polymers are characterized as low-density materials, but they lack strength and durability, therefore, the creation of polymeric composite materials was the first step towards achieving those desired ideal properties [2]..
Superimposed materials are defined as heterogeneous materials consisting of mixing two or more materials, each material having different properties from the other, in order to obtain a new material with good properties [3]. The mechanical behavior of particle-reinforced composite materials depends on the base material, the support material, the interface, and the adhesion strength [4].
In addition, it depends on the size of the particles of the reinforcing material and the method of its distribution. Studies have developed on composite materials, especially polyester, which is considered a base material in composites as a result of its good mechanical properties and heat resistance. All these characteristics led to a variety of applications in which it is used [5].
The researcher [7] studied the development of the mechanical properties (Hardness test, tensile, elongation, flexural strength and compressibility) of unsaturated polyester with clay, and the results showed an improvement and increase in the mechanical properties.
The researchers studied [8] the mechanical properties and the effect of fiber endurance and alkaline treatment of sugar palm spinning with unsaturated polyester compounds reinforced with glass fibers in weight ratios of 50:50 with polyester. The results showed an increase in the mechanical properties after the reinforcement process.
The researcher [9] studied the mechanical properties of the polyester composite as a base material added to the reinforced materials of glass powder with different weight ratios. The shock value and the values (shock, hardness and compressibility) decreased with the increase in temperature.
The researcher [10] studied the composite materials and the unsaturated polyester base material reinforced with loofah fibers in order to improve the mechanical properties of the composite after treating the fibers with hydroxide. As for the researcher [11] she studied the mechanical and thermal properties of unsaturated polyester resin as a base material and reinforced with with dates particle and the percentage of (5 %)represents the greatest value for the modulus of elasticity for unsaturated polyester reinforced with grapes particle. The development of new polymer-clay composites has brought about advances in material chemistry in recent years. The clay solid can be used as a filler and is able to strengthen the polymer composition by hindering the free movement of its adjacent chains. Furthermore, it acts as an interfacial

adhesive between the filler and the polymeric chains[12].The main challenge is to achieve chemical compatibility between the polymer, filler, and slurry, in addition to the homogeneous dispersion of the slurry within the polymer matrix and the occurrence of an interfacial interaction between the fillers of the slurry layer and the polymer, and thus the polymer within the composite is determined by these interrelated features to form the properties of polymer/clay compounds such as strength [13], modulus of elasticity [14], and thermal stability [15].

**Experimental part**
**Materials used:**
**The matrix**:
The unsaturated polyester, which is of Turkish origin, has a density of (1.17) g / $cm^3$, which contains two types of materials that help in solidification, which is ethyl methyl ketone peroxide (as an initiator for the polymerization process, which is a colorless liquid). where samples suitable for manual molding can be obtained at room temperature. obtained after grinding and sifting by a 200-mesh sieve in the laboratory to obtain the granular size (75) µm. Suitable samples could be obtained for molding at room temperature.

**Reinforcing materials**:
Reinforcing materials (Gyrex clay that was sifted with a 200-mesh sieve) were used to reinforce the unsaturated polyester resin. The (It was obtained from the Zawita region (Tayat Bakhir), Dohuk Governorate.

**Procedure**
A sample was taken from the jerks clay, as it was in a solid form similar to sandstone, after which the grinding process was done by hand (mortar) using a sieve of size (75 micro) to obtain a very fine powder similar to powder for a better homogeneity process with the base material. Thus, the reinforcement and strengthening material became ready for use.
Unsaturated polyester resin was used as a base material, then the hardener was added to it (100:2) at room temperature to prepare samples of polyester as a reference material for comparison with the samples after the reinforcement that were prepared after adding the support material (gyrex clay) with different weight,
After that, the superimposed material is placed in special molds for each measurement based on the specifications of each measurement. After the completion of the casting process, the material is left for 24 hours at different temperatures (8, 25, 55) °C to complete the solidification process, homogeneity and overlap between the particles, and compare these models before After the consolidation process [16].

**The aim of the study:**
This study aims to prepare composite materials that show good resistance to shocks and high compressive strength, identify the behavior of polymeric materials under standard conditions, make a comparison between them and the polymeric material before reinforcement, and then study the mechanical properties (impact strength, hardness, compressive strength) for all samples before and after the reinforcement with gyrex clay powder.

**Preparation of samples:**
Three types of samples were prepared for the mechanical tests:

**Impact test samples:**
Impact test samples were prepared according to American Standard (256-87ASTM-D) with dimensions ($10 \times 55$ mm $^3$ $\times 10$) for the examination. The grooving depth in the models is (2 mm) with a notch angle of (45 °). The absorbed energy required for the occurrence of the breakage was obtained directly from the Charpy Impact Instrument provided by (Tokyo Koki Seizosho, LTD), Figure (1) Illustrates the shape and dimensions of the sample prepared for the impact strength testing.

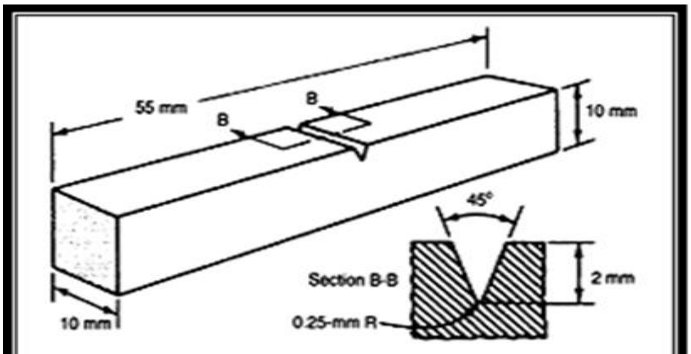


**Figure 1: The shape and dimensions of the sample prepared for the impact strength test**

**Figure 2: The sample used in the test**

**Hardness test samples:**
The hardness device (Shore-D) of the type (Durometer Shore) equipped by (WOLPERT-Germany) was used. As for the shape of the instrument, the device resembles a compass, and it was a needle located in the middle. The method of examination is by installing the device perpendicular to the sample to be examined and measured Where the needle is inserted into the surface of the material, after which it waits for 3 seconds, and then we take the hardness values recorded by the device, as shown in Figure (3),

**Figure 3: Hardness test instrument**

**Compressive resistance test samples:**
Compressive test samples have been prepared according to specifications (MSTM-D168) and are cylindrical in shape, where a hydraulic piston type (Testing machine, Co. LTD) is used.

**Figure 4: Shows the shape of the sample prepared for compressive resistance testing**

**Thermal Conductivity**

Models were used in this test with a diameter of (112.5 mm) and a thickness of (5mm), as shown in Figure 2. It is apparent from Figure 3 that five circular shapes of prepared samples were carefully designed to examine its thermal conductivities.

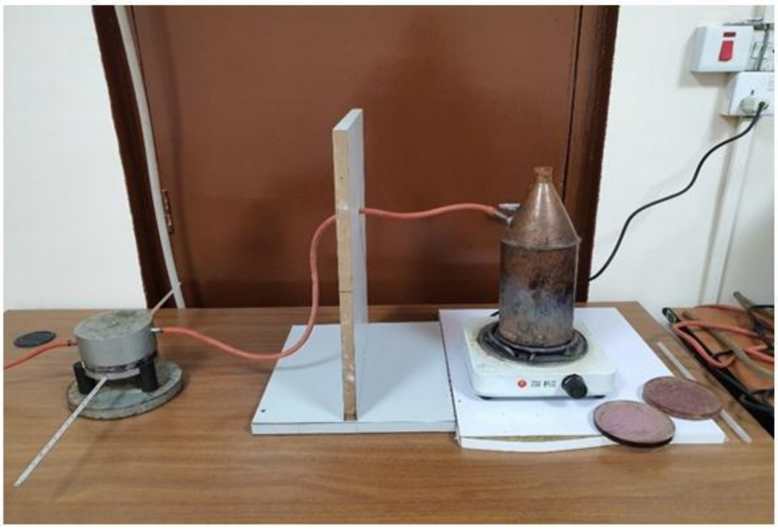

**Figure 5: Thermal conductivity instrument**

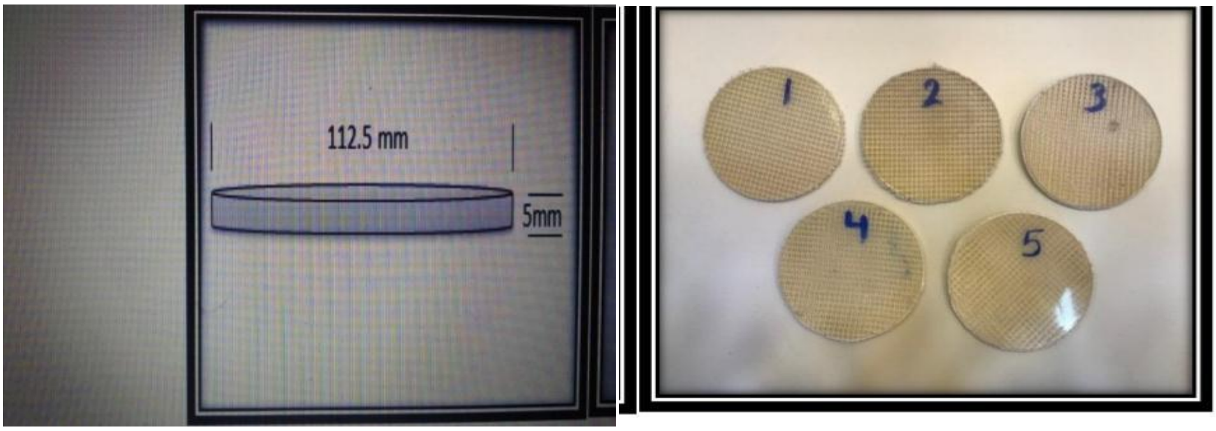


**Figure 6: The shape and dimensions of the sample for thermal conductivity test**

**Results and discussion**

**Impact strength (I.S):**

The Impact strength test is one of the scientific methods that give a correct indication in the descriptive form of the strength and resistance to fracture under the influence of stresses at high speed [17-18]. The Impact strength was calculated using the relation ship:

Impact strength (I.S) = Freature energyArea $(m)^2$

Impact strength is generally low for unsaturated polyester due to its fragility, but after strengthening with gyrex clay, we note that the Impact strength increases after strengthening at room temperature. This is because the fibers bear the greater part of the Impact energy applied to the Composite material, which improves this resistance and thus increases the Impact resistance, The highest value of Impact resistance was obtain at the weight ratio 30%, as shown Figure (7) and Table (1)

**Table 1: Impact strength and weight ratios values for unsaturated polyester before and after reinforcement at 25°C**

| C°Composite at 25 | Impact strength ($KJ/m^2$) | C°Composite at 25 | Impact strength ($KJ/m^2$) |
|---|---|---|---|
| UPE | 2.41 | UPE+GRX 35% | 5.8 |
| UPE + GRX 5% | 2.47 | UPE+GRX 40% | 6 |
| UPE + GRX 10% | 3.3 | UPE+GRX 45% | 6.7 |
| UPE + GRX 15% | 3.6 | UPE+GRX 50% | 7 |
| UPE + GRX 20% | 4.1 | UPE + GRX 55% | 6.5 |
| UPE + GRX 25% | 4.8 | UPE + GRX 60% | 5 |
| UPE + Gr 30% | 10.87 | | |

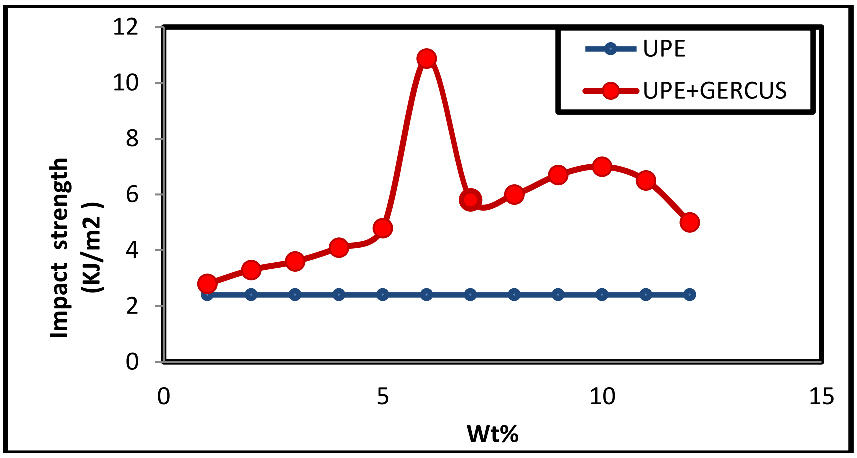


**Figure 7: Impact strength and weight ratios values for unsaturated polyester before and after reinforcement at 25°C**

It was noted that the process of strengthening by gyrex clay led to an increase in Impact strength in general, as the impact of the resins is low due to its fragility, but after strengthening it by gyrex, the shock value increased significantly and well. It works to prevent the growth of small cracks that occur as a result of trauma [19-20].

After that, three samples were taken at the weight ratio at which the highest results were recorded, which is 30%. These samples were left for 24 hours at different temperatures (8, 25, 55) °C, and then the impact was measured.

When treating polymeric compounds at temperatures (8.55) °C, we find that the Impact resistance decreases when the temperature decreases in order to restrict the movement of the polymeric chains and thus cannot move, but increases with the increase in temperature as a result of the loosening of bonds between the molecules of the material and the movement of the polymeric chains increases, which gives it the possibility of absorbing Part of the energy that leads to the distribution and spread of the energy needed to break in the form of mechanical decay [21-22], as shown in Table (2) and Figure (8).

**Table 2 Impact strength values of unsaturated polyester at (8,25,55) °C before and after reinforcement**

| **Temperature °C** | **Impact strength before reinforcement** | **Impact strength after reinforcement** |
|---|---|---|
| 8 | 4.83 | 4.86 |
| 25 | 2.41 | 10.86 |
| 55 | 4.85 | 5.13 |

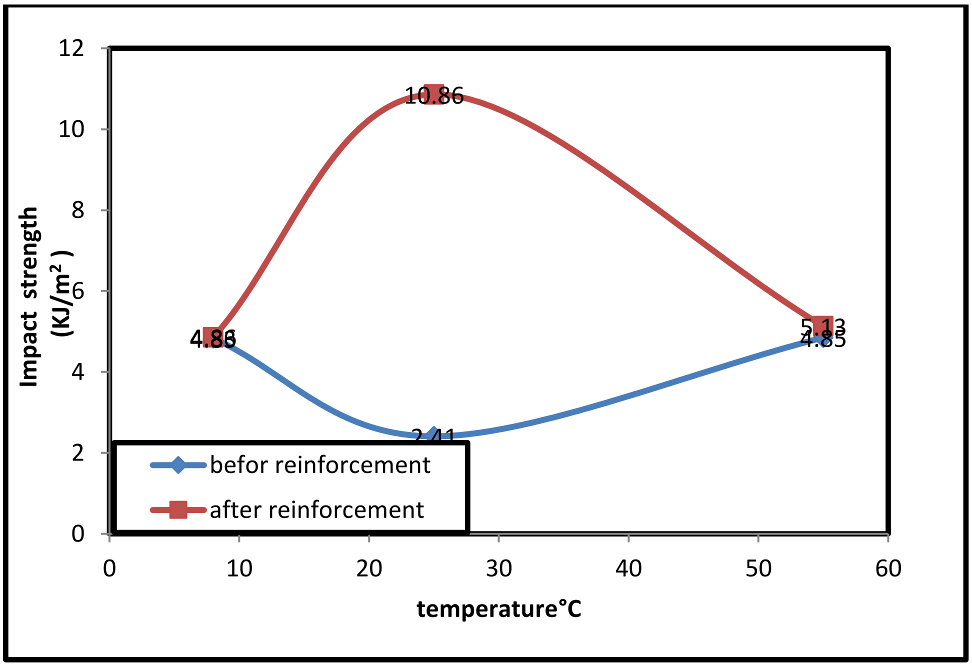


**Figure 8 :Relationship between Impact strength and Temperatures °C (8,25,55) before and after reinforcement**

**Hardness Test**

The hardness property is one of the important surface mechanical properties, as it is defined as a measure of the plastic deformation that the material can suffer from while it is under the influence of external stress applied to it as a result of its exposure in general to scratching and penetration by equipment that is more solid than it during its use in important applied fields, and that hardness is affected by several factors They are the temperatures, the methods of manufacturing the material, the time, and the manufacturing variables that were conducted on it [23].

**Table 3: Hardness values of unsaturated polyester before and after reinforcement at 25°C**

| Composite at 25C° | Hardness Shore-D ($Kg/mm^2$) | Composite at 25C° | Hardness Shore-D ($Kg/mm^2$) |
|---|---|---|---|
| UPE | 65 | UPE + GRX 30% | 55 |
| UPE + GRX 5% | 50 | UPE + GRX 35% | 56 |
| UPE + GRX 10% | 51 | UPE + GRX 40% | 56 |
| UPE + GRX 15% | 52 | UPE + GRX 45 % | 53 |
| UPE + GRX 20% | 52.5 | UPE + GRX 50% | 52.8 |
| UPE + GRX 25% | 54 | UPE + GRX 55 % | 51.9 |
| UPE + GRX 30% | 55 | UPE + GRX 60 % | 51.7 |

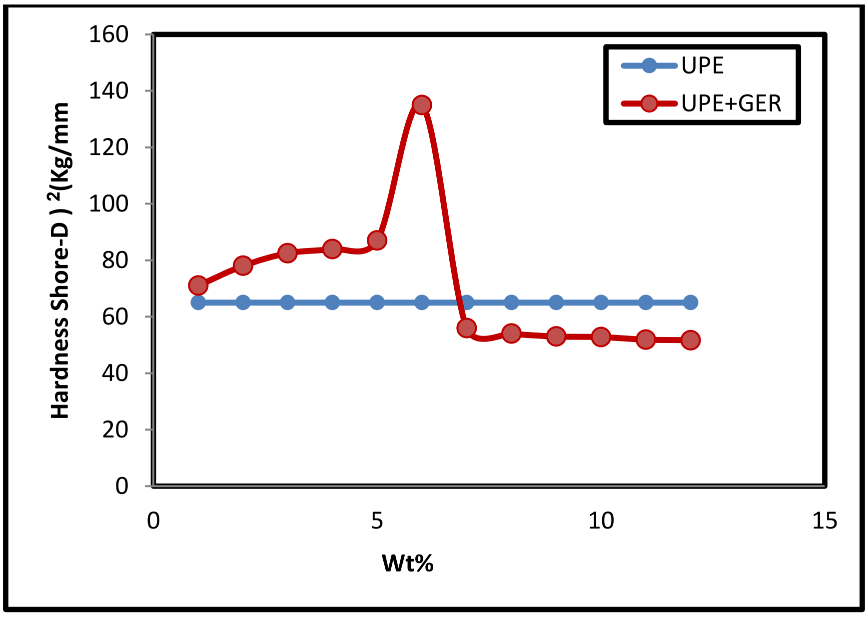


**Figure 9: Hardness values of unsaturated polyester before and after reinforcement at 25°C**

We notice from Table (3) and Figure (9) that the highest value of hardness is at 30% by weight, When heat treatment at temperatures (8, 55) ℃, it was found that the hardness values at 55 ℃ were lower than at 25 ℃, because the increase in heat leads to an increase in the ductility of the material due to the movement of the units and the loosening of the bonds between them and this leads to a decrease in the resistance to scratching and stitches But at 8 ℃ with a decrease in temperature, the polymeric chains become bound and cannot move, which leads to a weak resistance [24]. as shown in Table (4) and Figure (10).

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

| Temperature | Impact strength before reinforcement | Impact strength after reinforcement |
|---|---|---|
| 8 | 130 | 85 |
| 25 | 65 | 135 |
| 55 | 125 | 128 |

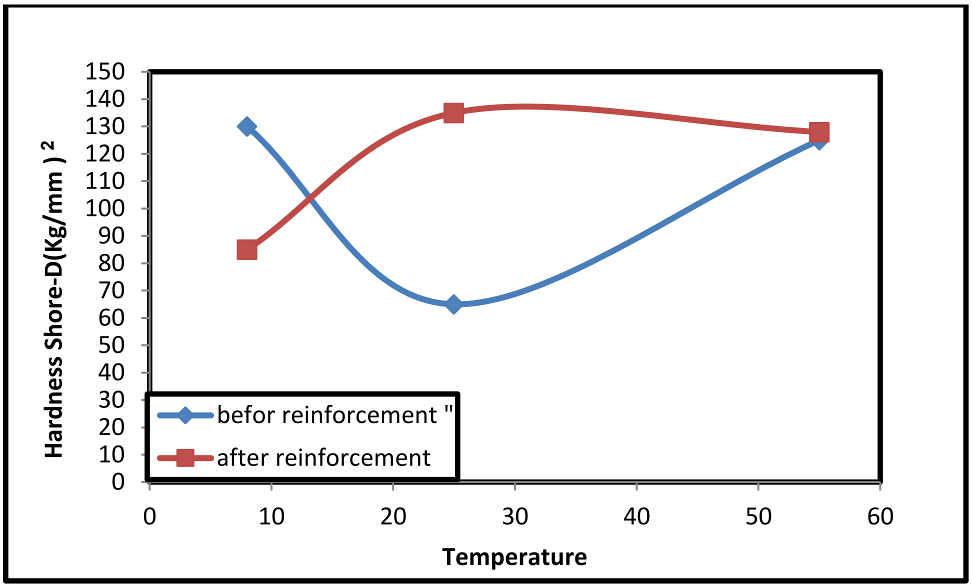


**Figure 10: Relationship between Hardness and Temperatures (8,25,55) °C before**

**Compressive Strength**

The compressive strength is the maximum applied effort that the polymeric material can bear while it is under the influence of the applied vertical pressure, and it can be calculated by the following equation

C (MPa) = Force (N) / Area ($m^2$)(

Compressibility is an important test because it leads to knowing the strength and endurance of the polymer because some materials are soft in the case of compression and brittle in the case of tension [25] , Shown in Table (5) and Figure (11) [26-27].

**Table 5: Compressive Strength values of unsaturated polyester before and after reinforcement at 25°C**

| Composite at 25C° | Compressive Strength (Mpa) | Composite at 25C° | Compressive Strength (Mpa) |
|---|---|---|---|
| UPE | 47.70 | UPE + GRX 30% | 22.3 |
| UPE + GRX 5% | 15.9 | UPE + GRX 35% | 23.1 |
| UPE + GRX 10% | 20.7 | UPE + GRX 40% | 23.5 |
| UPE + GRX 15% | 21.1 | UPE + GRX 45 % | 23.7 |
| UPE + GRX 20% | 21.6 | UPE + GRX 50% | 20 |
| UPE + GRX 25% | 21.8 | UPE + GRX 55 % | 19.8 |
| UPE + GRX 30% | 49.9 | UPE + GRX 60 % | 22.3 |

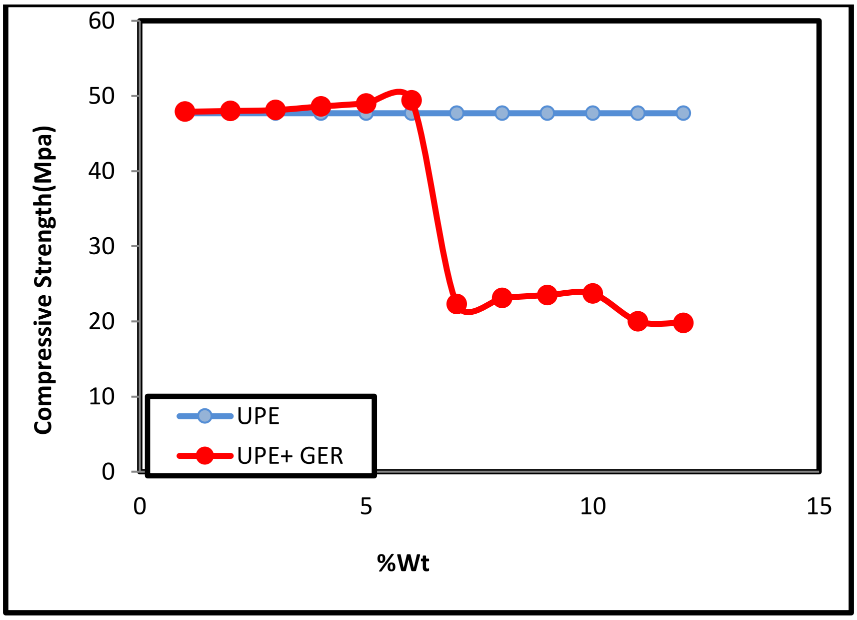


**Figure 11: Compressive Strength values of unsaturated polyester before and after reinforcement at 25°C**

When heat treatment at temperatures (8, 55) °C, it was found that the compressive strength values at 55 °C were lower than at 25 °C, because the increase in temperature leads to an increase in the ductility of the material due to the movement of the chains and the relaxation of the bonds between them and this leads to a decrease in the compressive strength But at 8 °C with a decrease in temperature, the polymeric chains become bound and cannot move, which leads to a weak resistance, and thus the compressive strength decreases [28-29]as shown in Table (6) and Figure (12).

**Table 6 :Compressive Strength values of unsaturated polyester before and after reinforcement at (8,25,55) °C**

| Temperature | Compressive Strength before reinforcement | Compressive Strength after reinforcement |
|---|---|---|
| 8 | 19.10 | 22.29 |
| 25 | 47.70 | 49.92 |
| 55 | 6.36 | 19.10 |

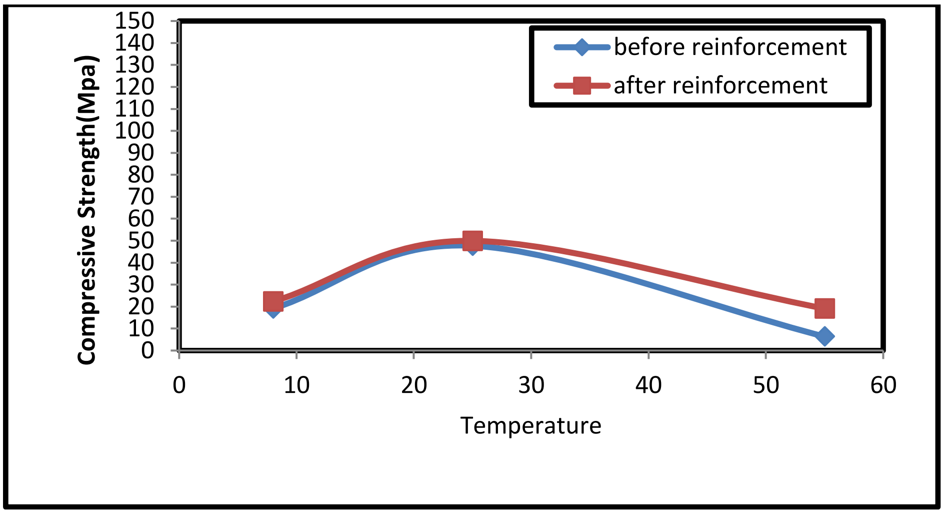


**Figure 12 :Compressive Strength values of unsaturated polyester before and after reinforcement at (8,25,55) °C**

We note from the above results that the compressive values of the reinforced polyester are higher than the unreinforced polyester values, due to the increased bonding between the polyester base material and the reinforcing material (gyrex clay) and also because of the distribution of the load on the on the sample.
We also note that the compressibility values are inversely proportional to the temperature, as they decrease as the temperature increases, especially at (55)°C, due to the weakness of the bonding strength between the polyester and the reinforcing material as a result of the increase in ductility at high temperatures, which leads to a weak resistance of the material to load [30-31] .

**Thermal conductivity**

It is defined as the spontaneous transfer of thermal energy through matter from a region with a high temperature to another region with a lower temperature than the previous one in pursuit of thermal homogeneity.
Heat conduction is the process of transferring thermal energy through the spread and microscopic collision of particles inside the body as a result of the thermal gradient. Conduction occurs in all forms of matter of weight such as solids, liquids, gases and plasma.
Through the research, it showed us that the thermal conductivity decreases with increasing temperature, because the polymers contain free electrons in the transfer of heat, where the thermal conductivity depends on the structural vibrations in its internal structure, as these vibrations decrease when adding fillers to the polymer, which hinder the vibration and thus the conductivity decreases.[32]
And that the reinforcement materials impede the vibration in the internal structure of the resin, and thus the values of the thermal conductivity coefficient decrease. [33]
The thermal conductivity can be calculated through the following equation:
ʎ=1/4ΠD2 (T2-T1/d)= mass of disc .CS.PN/QN*1/60)
whereas :-
d: thickness of the sample, measured in cm.
D: sample diameter, measured in cm.
Cs: specific heat capacity of the disk, measured in cal/gm
PN/QN: slope of the straight line
Mass of disc: the mass of the metallic disc, measured in gm
ʎ: coefficient of thermal conductivity (watt/m.°c)

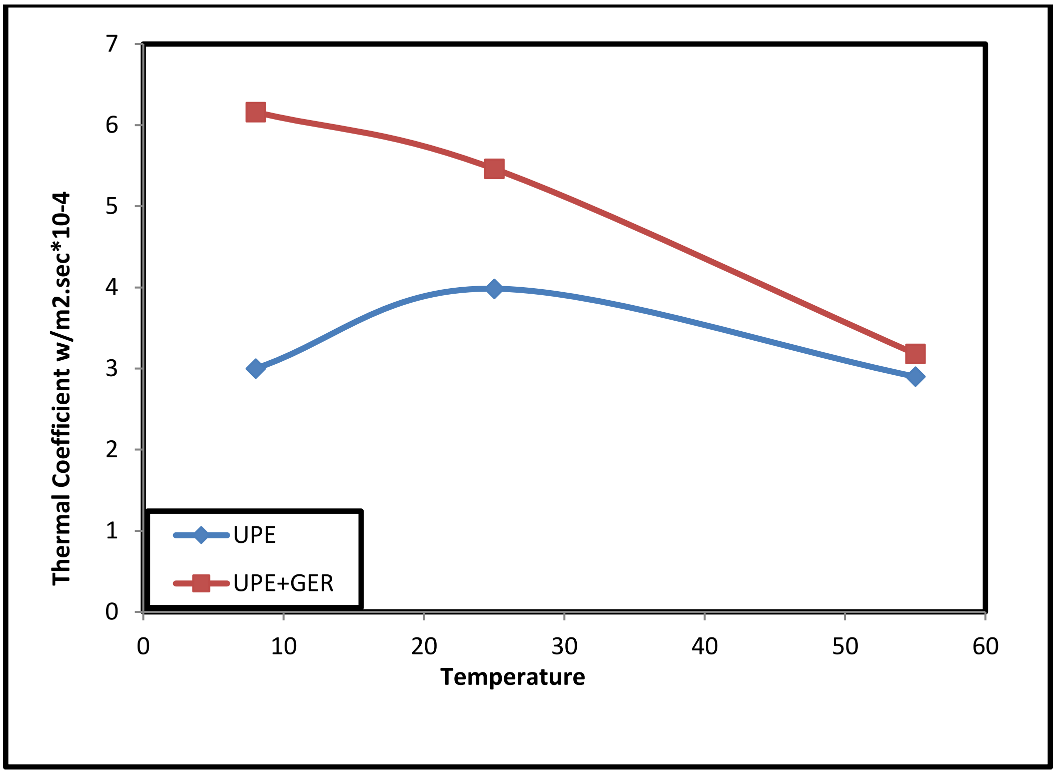


**Figure 13: Relationship between Thermal Conductivity and Temperatures (8,25,55) °C before and after reinforcement**

**Conclusions**

When adding gyrex clay as a support material to unsaturated polyester, which is considered the base material, a clear and good effect will appear on the mechanical and thermal properties, represented by:

1- Increasing the reinforcement percentage works to increase the mechanical properties at temperatures of 25 °C
2- Compressive, tensile, and shock values increased after reinforcement, while hardness decreased, either at temperatures (8, 55) °C.
3- The shock and tensile values increased after consolidation, while the increase was high and well noticeable at a temperature of 25°C when compared to temperatures (8, 55) °C, while the compressibility values decreased with the increase in temperature.
4- Low thermal conductivity of unsaturated polyester after reinforcement at room temperature and temperatures that were treated (8.55) °C.

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