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Study the Biaxial creep of continuous polymer fiber composites

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***Abstract*---**Creep is the slow continuous change in the dimensions of the engineering piece during the service. The study of the creep is one of the very important things in order to avoid the disasters that occur as a result of changing the dimensions. Since we are studying creep and its effect on engineering parts in various fields in which polymer or composite materials are used, and among these areas is the use of polymers and composite materials in dams, then we must choose polymeric materials carefully so that these materials must have special properties in terms of strength and rigidity. In order to meet the required requirements in terms of properties, we chose high-density polyethylene because it has several properties, including its high degree of urgency as well as high inter molecular force, but this material alone does not meet all requirements because the polymer alone is not considered a successful material. High-density carbon fiber and we got a composite material with excellent properties that are much better than high-density polyethylene alone. Practically, we have produced high-density polyethylene sheets by means of a two-screw extruder, and we have manufactured the composite material by incorporating carbon fibers into high-density polyethylene using an electro-thermal hydraulic press.

***Keywords*---**Biaxial creep, continuous polymer, fiber composites.

Introduction

Creep: The study of creep is one of the very important characteristics from an applied point of view. The importance of creep tests lies in knowing the change in mechanical properties as a function of time in addition to temperature (Groover, 2010). Crawl is meant as a gradual deformation process that occurs in its mixture with time due to a constant stress that will depend on the temperature

(Venkatesh and Harish, 2015). The approximate time during which the tires of a parked car can resist deformation due to static stress and air temperature as well as the case in engine structures and high temperature devices Theoretical basis that most metals and ceramic materials have high melting temperatures and therefore they begin to creep at much (Fundamentals, 2001).Higher temperatures from room temperature (Bannister et al., 2022). Figure 1: sample under effect creep bay water pressure. As for polymers, creep occurs at room temperature and since it is not crystalline in structure, and at a temperature higher than (T) it begins to crawl under the influence of a load (constant tensile stress) with the temperature remaining constant where the agitation with the time taken during the examination and the examination takes several hours or Days if the test is below a temperature less than (t) because the material is hard and brittle, and the duration increases for weeks if the material is reinforced with reinforcing materials, and the creep curve consists of strains in terms of the time taken as the deformation (elongation) passes through creeping stages, the first of which is instantaneous distortion A primary (transition) characterized by recovery when the load is removed, then followed by a secondary (steady) creep with a lower level that has a sticky or plastic behavior (a steady state) and this depends on the level of influential stress and temperat ure, and finally a third accelerated creep in fact represents a process characterized By the gradual deterioration that leads to the breaking of the material due to interfacial collapse of the crystal.

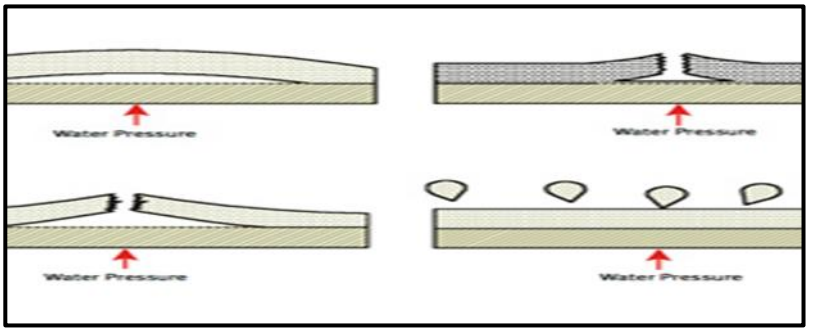

Figure 1. Sample under effect creep bay water pressure

Biaxial creep

One of the important matters in the practical aspect is that we must know that there is no creep of materials in one axis (in one direction), as if it is in the vertical direction only or only horizontally, since in fact the creep is in two or more directions under the influence of loads placed under more than one direction. Therefore, we will deal in our experience with this study of biaxial creep, because it is one of the real important issues facing composite materials in various industries, so that we are aware of what these composite materials face during service.

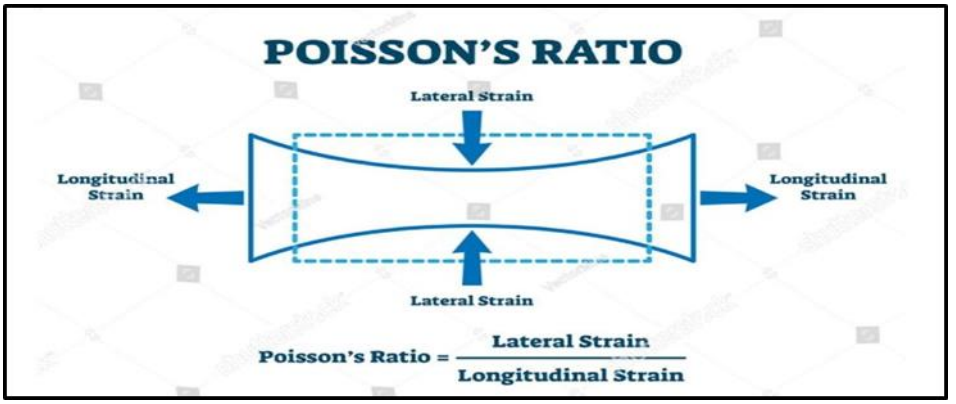

Figure 2. Illustrated the poisson ratio result the Biaxial strain (lateral and longitudinal)

The purpose of studying the biaxial creep of the continuous polymeric fiber composite. We study the biaxial creep in polymeric materials in order to predict the mechanical problems that the engineering part may encounter during the engineering service it performs , and thus allow us to avoid errors or Problems that may occur by choosing materials that have good features in terms of resistance to service conditions or choosing Suitable designs (Heller, 2022). The study of bi-axial creep is also involved in many important matters and designs that major countries and well-known institutions need, including the design of vehicles such as cars, trains, tractors and other basic means of transportation in people's lives in general, As well as the design of devices of various types, including air conditioning and machines that are used in land excavation and many important designs of devices used in people's daily lives (Strotebsky, 1977). Dangerous when the dimensions differ due to creep as the polymers are sensitive to work at high temperatures. Where problems of changing dimensions occur , such as changing the positions of screws , this problem is worth studying , especially in electrical parts and aircraft (Abbas, 2001).

The theoretical part

A-The polymeric materials used in the biaxial creep measurement experiment of the continuous fiber composite: High density polyethylene (HDPE) was selected and HDPE is considered a thermoplastic material as well as sime–crstainty. This material was carefully selected because it is characterized by special specifications suitable for experiment

1. HDPE has linear - chain structure.
2. High crystalline as well as high density
3. 3-The linear chain structure gives high intermolecular bonding forces
4. 4-HDPE also has high strength
5. 5- HDPE is hard and strong, which makes it suitable for working in composite materials and thus avoiding creep as much as possible.

High-density polyethylene was used in the engineering of dams and water resources, because it is considered a bio material. We also increased its uses by

strengthening it with carbon fibers. B-In our experiment, we will use carbon fiber to make a composite material
Carbon Fiber Plain Weave Fabric (Weave Example).

Figure 3. Unit 17 & 20 Abbey Business Park- Mill Road- Newtownabbey- Co. Antrim - BT36 7EE

What are carbon fiber composites (CFRP)? Carbon fiber reinforced composite materials, referred to as carbon fiber composite materials; refer to a fiber reinforced composite material using carbon fibers as the main structural component. It should be noted that the "P" in CFRP may represent not only a "polymer" but also a "plastic". In general, thermosetting resins such as epoxy resins, polyesters, or vinyl esters are often used in CFRP compounds. Although thermoplastic resins are also used in CFRP compounds, "carbon fiber reinforced thermoplastics" are often referred to as CFRTPs, which is the abbreviation for Carbon Fiber Reinforced Thermoplastics. When dealing with composite materials, it is important to understand the terminology and abbreviations for the substance. More importantly, it is important to understand the properties of FRP composites and various reinforcement materials, such as carbon fibres.

Advantages of composite materials reinforced with carbon fiber

1- Light weight
2- high strength

We manufacture a composite material consisting of HDPE Matrix in addition to carbon fibers that are used as a reinforcement material. It is known that high-density polyethylene is considered one of the biomaterials, so we can raise its mechanical uses in this field while preserving its properties. This point is very important.

Practical part

We will bring high-density polyethylene granules, which are dried for a period of not less than 24 hours, and put them in the double-screw extruder for the purpose of converting them into sheets. It suffers from shrinkage as soon as it comes out of the extrusion opening, so we used in our experiment high

temperatures of up to 180 degrees Celsius, where we were able to obtain a set of sheets.

Figure 4. HDPE granules

After that, the sheets will be taken and cut using a CNC laser in the form of a cross for the purpose of studying the creep through the biaxial creep experiment of the continuous polymeric fiber composite. The main purpose of these experiments is to be aware of the future of the engineering piece and the extent of its bearing the load during a period of time during service.

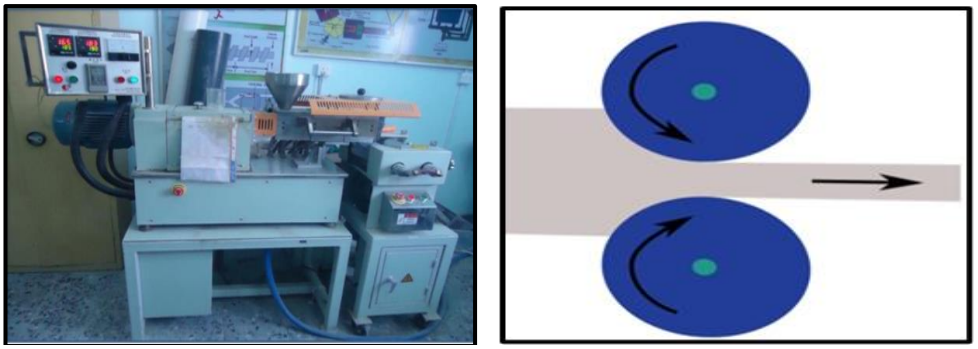

Figure 5. Twin screw extruder

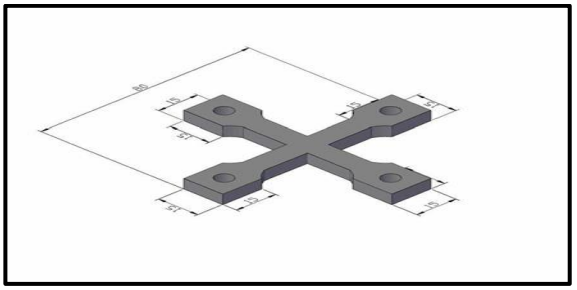

Figure 6. Rolling process

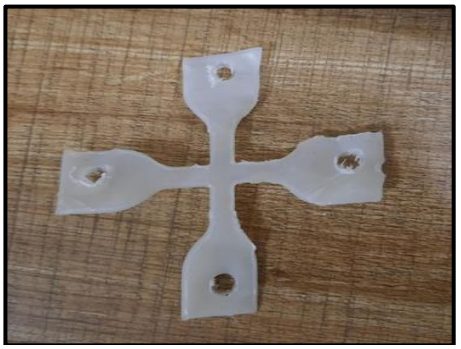

Figure 7. HDPE Sample cutting by lazer CNC

Composite material manufacturing

A device (hydraulic electric - thermal press) was used, because it was not possible to manufacture a composite material by means of the double screw extrusion device, because the HDPE material cooled quickly and this was demonstrated in practice. Therefore, the piston device was used where it was necessary to manufacture a special mold in order to withstand very high temperatures, where the HDPE material is placed in The bottom of the mold is in the form of a layer of granules, then carbon fibers are placed, then another layer of HDPE is placed, and the mold is closed. The device presses with a high temperature of up to 200 degrees Celsius. We note that the composite material is left to cool as the cooling rate has a role in its final properties, we then get sheets of the composite material

Figure 8. HDPE HDPE Reinforcement carbon fiber composite

Creep experience

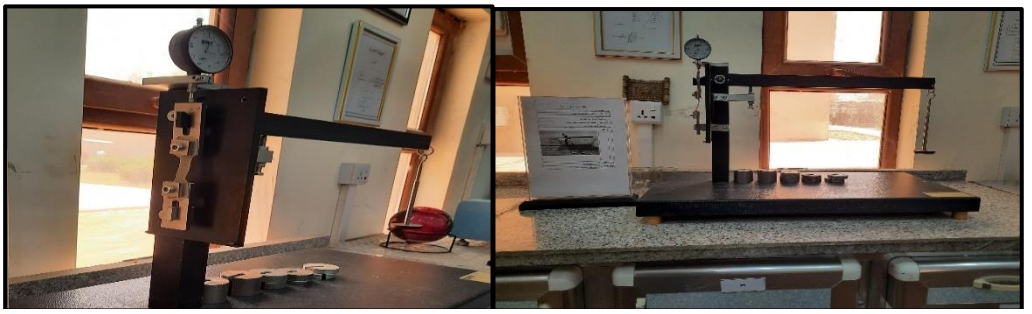

Figure 9. Uni creep device with a vertical axis only axis

We note from the previous pictures a uniaxial creep measuring device for polymeric materials, as it works on the basis of material creep in one direction, which is the vertical direction, where crawling is experienced by placing weights, which is a set of weights as if 3.5N or 5N are in place on the arm of the device. These weights It will affect the polymeric materials and pull them in the direction of shedding the load, and since the samples will begin to gradually expand and shorten in the middle until it reaches a point where the sample is cut into two parts there is no creep in one direction, we have modified the device and made it work in two directions, that is, it became bi-axial, through the manufacture of two arms, the first on which is placed the crawl scale, the weight and the weight to the side of the sample, and this arm consists of

1. Base based the arm has.
2. screw-shaped columns in order to be reduced or enlarged to suit the position of the sample.
3. A place to install the sample.
4. It contains a pulley to allow the porter's thread to move easily.

On the other side of this arm, another arm was made for installation

Figure 10. Shows a biaxial crawling device

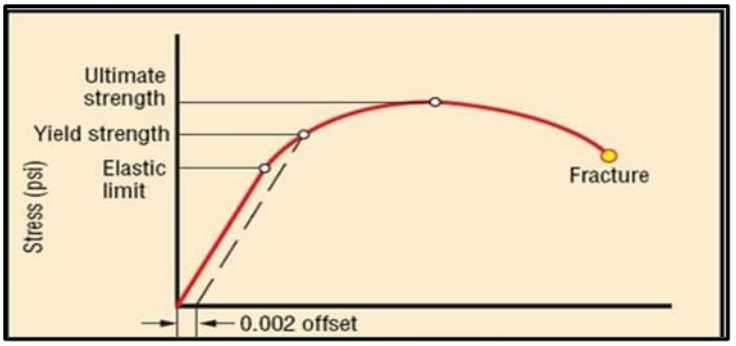

Figure 11. Material creep stages

Results, Discussion And Calculations

We will take the samples that we manufactured, which are in two parts:

1. HDPE samples
2. Samples of composite materials made of high density polyethylene and reinforced with carbon fiber.

We will first test the biaxial creep on HDPE samples only and they are as follows Creep test. HDPE

Time (min)	Elongation (mm)	Load 3.5N
1	0.1	3.5
2	0.13	3.5
3	0.16	3.5
4	0.19	3.5
5	0.21	3.5
6	0.25	3.5
7	0.29	3.5
8	0.33	3.5
9	0.37	3.5
10	0.40	3.5
11	0.44	3.5
12	0.49	3.5
13	0.53	3.5
14	0.58	3.5
15	0.65	3.5

We note that HDPE samples failed the biaxial creep test after a time of 15 minutes. The elongation is 0.65 mm for both axes.

Creep test to HDPE Reinforcement by carbon fiber composite

Time (min)	Elongation (mm)	Loud 3.5N
1	0.01	3.5
2	0.012	3.5
3	0.0135	3.5
4	0.015	3.5
5	0.0166	3.5
6	0.0178	3.5
7	0.0185	3.5
8	0.0194	3.5
9	0.022	3.5
10	0.024	3.5
11	0.0255	3.5
12	0.0268	3.5
13	0.0276	3.5
14	0.0284	3.5
15	0.0290	3.5

The durability of the composite material reinforced with fibers until the 15 minute and an elongation of 0.0290 mm until fracture. From this we conclude that the fiber-reinforced composite material endured for a period longer than HDPE alone by about three times and with a lower elongation rate due to the fiber reinforcement. Relying on this experience, it is possible to predict the future of the engineering piece during the service.

The tests used

1-hardness check
High density polyethylene 50.2
High density polyethylene and carbon fiber composite 55.7
2-Tension check

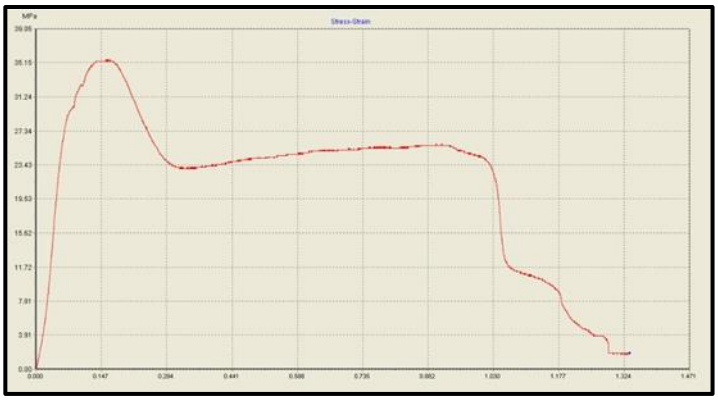

Figure 12. High density polyethylene tensile diagram

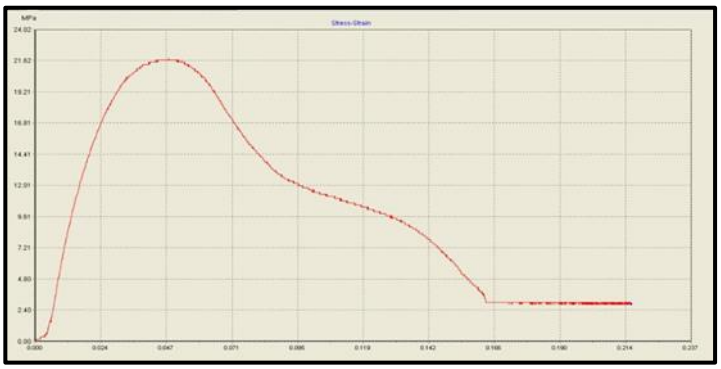

Figure 13. Tensile diagram of high density polyethylene composite materials reinforced with carbon fibers

1- We note through the previous forms of the most severe test that the high-density polyethylene sample expanded several times the composite material, because it has a high emotion if it is considered a ductile material, as the force quickly exceeded the elastic region, meaning that it cannot return to its previous form after this region and this What we notice is through the small area of the first concavity and then the sample continues to expand

and contract from the middle until it breaks, meaning that here these materials are weak and have undesirable properties.

2- In the second chart, we note that the shearing load did not easily exceed the elastic area. Also, the emotion of this material is low. Also, this composite material has endured the load for a long period of time, as we conclude that this material is tensile and therefore resistant to creep. This is a result of the way it is manufactured as well as the fibers inside strengthen it ،which is the most prominent characteristics of the composite material and this is what we practically concluded (Hadi and Aljanaby, 2022; Medhat and Aljanabay, 2022).

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