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Experimental Study of the Creep Behaviour of Nano-Composites Carbon Fibres

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Abstract. In this work, the effect of nano carbon black particles (N220) on creep behaviour of epoxy-fibres carbon composites was study. The nano composites were prepared with (2, 3and 4 wt %) of carbon black nanoparticles using ultrasonic wave bath machine dispersion method. The creep test was performed by using creep test rig for carbon- epoxy composite specimen with and without add carbon black nanoparticles. The volume fraction of this work (volume of carbon fiber to volume of composites specimen) was 30 %. The result show that, there is an improvement on the creep strain behaviour (10 %), (12.5 %) and (19%) for the specimen with nano carbon (2%), (3%) and (4%) wt % respectively.

Keywords: - Creep behaviour; Nano carbon particles; Carbon fibres; Composite materials.

1. Introduction

A combination of two or more materials lead to introduce a composite material is a macroscopic level, which is have properties between original materials [1]. The Composites materials used in many applications due to their properties such as environmental, structural, tribological, thermal, and electrical applications. The result consists of matrix phase and stiffer reinforcing phase. The composite material resulting has superior structural properties compare to either material constituent alone. Composites materials have a particle or fiber that is stronger and stiffer than the matrix phase and the fiber or particle carry the principal load members. The transfer load between fibers comes from matrix medium. The source of toughness of composite materials comes from matrix which is ductile more than the fiber. The matrix is protecting the fibers from damage of environmental after, during, and before processing of composite [2]. Nano composites are a type of materials consist of one, two, or more phases with Nano dimensions scale (2-D,1-D, and 0-D) are embedded in polymer matrix, ceramic, or metal. In general, the addition of the Nano phase scale to produce composite materials is to create a synergy between the basic constituents, such that meeting capable novel properties or expectations of design exceeding. The properties of Nano composite rely on variables arrange, the matrix material particularly, which can exhibit Nano scale size, shape, dimensions, loading, orientation, and degree of dispersion of the Nano interactions and scale second phase between the second phase and the matrix. For the purpose, most nanomaterials could be classified into four types: Metal materials based, Carbon materials based, Composite and Dendrimers materials carbon-based. The creep in materials science (cold flow) is the solid material moving tendency slowly or permanently deform under the mechanical stresses influence. It can be occurring due to exposure to high levels stress in long time which are less than the material yield strength. Creep is more occur in the materials when the heat is subjected on the sample for long time, and the creep is generally increases when the heat near the malting point. The deformation rate is a function of the properties of the material, exposure temperature and time, and the structural applied load Depending on the duration and magnitude the stress applied, the large deformation may become that a component cannot longer. As example, the creep of a blade in turbine will be cause the contact blade to the casing, led to failure in the blade of turbine. T. Glaskova and A. Aniskevich [1] studied the creep properties behaviour of epoxy/clay nanocomposite. The peculiarities of creep behaviour of clay / epoxy nanocomposite (NC) under moisture effect of are investigated. Experimentally, the viscoelastic properties of NC were study and moisture and filler effect were investigated. The results of creep tests and quasi static tensile uniaxial tests obtained were compared and the properties of matrix and effect of filler and moisture on NC was investigated. D.pedrazzoli et.al [2] used a fibers glass laminates reinforced with nano modified matrix epoxy to be investigated under creep and ramp, with a monitoring continuously of the damage and deformational behaviour through electrical measured device. A combination of nano carbon fibers (ncfs) and black carbon (bc), with a (bc\ ncf) ratio of 90\10 and a 2 wt.% amount of total filler, was used to prepare modified nano composite laminates by a hand lay-up method. Static tensile tests with creep and ramp highlighted conditions a damage and strain capability monitoring of the composites prepared, with the response dependency strong on the temperature of test and the level of load. Double wall carbon nanotube amino-modified (DWCNT-NH2) fiber carbon (fc) hybrid epoxy laminates nanocomposite was prepared using the fusion technique by Fawad Inam et.al [3]. For comparison, the nanocomposites epoxy\ DWCNT-NH2 and epoxy \fiber carbon micro composites were made. Using microscope scanning electron field emission analysis of the hybrid composites by Morphological was investigated. At low loadings a good dispersion of nanotubes carbon in epoxy (matrix) was found by a sonication- ultra method. Mechanical properties of the hybrid nano-micro-composites manufactured by a process of resin infusion included three-step, analysis of dynamic mechanical, weight -drop impact testing, and terlaminar toughness of bending mode. The addition of small CNT amounts (0.1,0.5, and 0.025 wt %) to resins (epoxy) for manufacturing of fiber carbon composites multi scale resulted in a maximum of enhancement in modulus of flexural by 35% flexural strength improvement, a 6% impact absorbed energy was improvement, and the inter laminar mode l toughness was decrease by 23%. The influence of the CNTS contents for different proportion of epoxy resin added into electrical conductivities and mechanical properties of composites is study, also the strength material tested under different environments temperature is investigated by Yi-Luen LI et. al [4] Moreover, the behaviour of creep for fiber carbon-epoxy resin composites tested with variables stress and temperature is also study to be analyzed. The resultant show that, the electrical conductivity and mechanical strength will be increase when the CNTS content added to the composites was increasing. In the influence of effect of temperature on specimen, because of different expansion coefficient among fiber, matrix and CNTS the matrix overexpansion caused by high temperature in crack during among matrix. The resistance of creep of thermoset nanocomposites is investigated by adding variables weight of graphite filler exfoliated, under constant loading a characterizer at different temperatures by Ahmed Almagableh et.al [5]. The response of creep of these nanocomposites was study using instruments (TA). The results show that, at some temperatures the nano-filler may reorientation of polymer chain and hinder slippage, in turn, gives resistance of creep for nanocomposites higher than the matrix. Poor resistance of creep for matrix was observed at a lower temperature, as compared to nano materials tested. behaviour of creep and tensile strength of a 2D carbon laminate composite (c\c) were investigated from 298K to 2773K temperature by Ken Goto et.al [6]. The tensile strength of the carbon composite was monotonically with test temperature increasing. in particular, at temperatures higher than 1873k significant improvement was observed. Nonlinear strain– stress cures were observed at low deformation rates in this temperature range. The nonlinearity source was concluded to be deformation of creep. The residual properties of the specimens and behaviour of creep for resin matrix and BFRP at elevated temperatures were investigated by Zhongyu Lu et.al [7]. The creep deformation is more larger than that at 25 °C. at elevated temperatures, With high temperature and combined loading. When the strain reached to 16% of ultimate strain, the rupture failure would be subject to the specimen. For the cases of 80 °C and 120 °C the behavior of creep of the matrices completely differently; the first increased with time, after that gradually decreased, while the second continuously increased, due to the temperature after and before the temperature of glass transition. Natália Pagnoncelli Lorandi et.al [8] used resin transfer molding vacuum assisted to obtain epoxy /carbon fabricated composites. Creep and dynamic mechanical analysis using Burger and Findley's methods - tests were used to find the composites viscoelastic properties, at static stresses (2, 5 and 10 MPa) and different temperatures (90, 60 and 30°C) Using Weibull parameters found from

creep curves the viscoelastic properties were also investigated. In general, the deformation was dependent on stress and temperature.
In this study, the creep behavior of the composite material was verified before and after the addition of the nano carbon at certain temperatures. Using three values of added nano carbon.

2. Experimental Work

2.1. Materials and Preparation of Specimens

In this work, epoxy resin of a trade mark (Euxit50KI) is a liquid of low viscosity resin as compare with other thermosets and it's converted to solid state by adding hardener (Euxit 50KII) at ratio of (1:3). The Carbon black (N220) used in this work was supplied from Korea Carbon Black company. Figure 1 illustrates nano Carbon black. The procedure of specimen's fabrication can be described as follow. Firstly, the weight of carbon black was calculated according to the required weight fraction (2, 3 and 4) wt % of epoxy resin. Nano carbon black manually mixed with epoxy resin for about 15 minutes at room temperature continuously and slowly to avoid bubbling during mixing until a homogeneous state of the mixture. Intermingling the mixture by ultrasonic ware bath machine [Ultrasonic ware bath machine (power sonic 410) model (LUC) (220V, SoH2 and 400W)] for twenty minutes to disperse the nano particles homogeneously. Figure 2 (A & B) shows the ultrasonic ware bath machine used in the present work. Adding of hardener to mixture with gentle mixing. The woven carbon fiber with epoxy resin specimens were tested. All specimens are manufacture by hand layup method with 30%volume fraction (volume of carbon fiber to volume of composites specimen). The specimens are then cut according to the ASTM-D2990 [9] and the grinding operations were applied for specimens to obtain the finish shape and dimensions of specimens. Final shape of creep specimen is shown in figure 3.

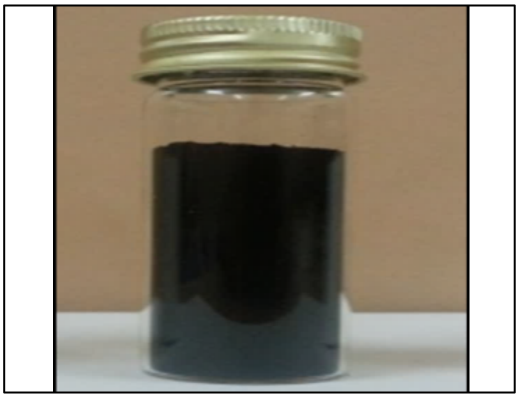

Figure 1. Nano Carbon black (N220).

a b

Figure 2. Ultrasonic Wave Bath Machine Dispersion.

Figure 3. Final shape of creep specimen according to the ASTM-D2990.

2.2 Creep test

The creep test consists of measuring the time dependent strain. The test rig required for the experimental work available in material testing laboratory \ Al- Mustansiriya University (materials Engineering) the test rig illustrate in Figure 4.

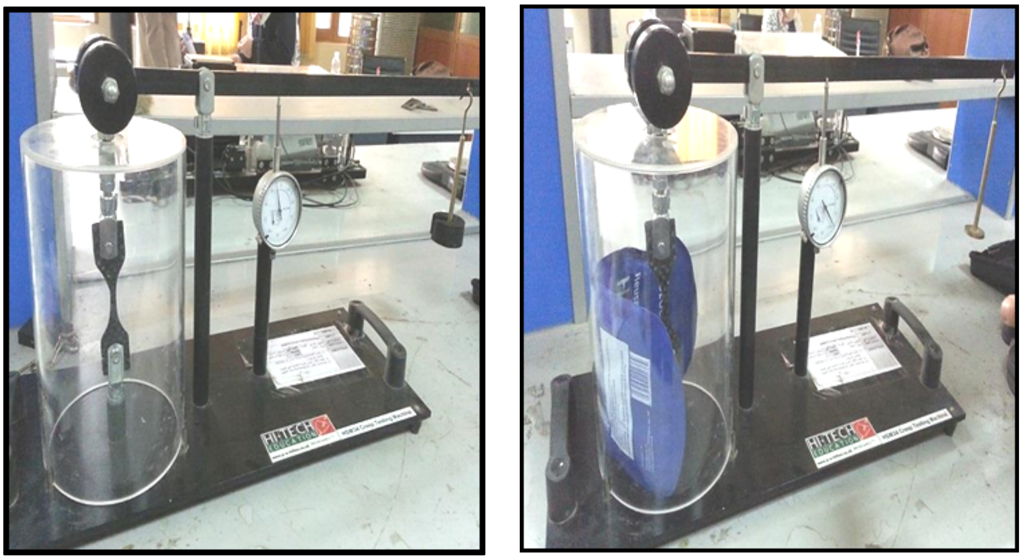

Figure 4. The creep test rig.

The steps for testing as follows:

• The specimen fixed in the creep testing rig (without nanomaterial) then used the specimens (with none material) as shown in Figure 5.

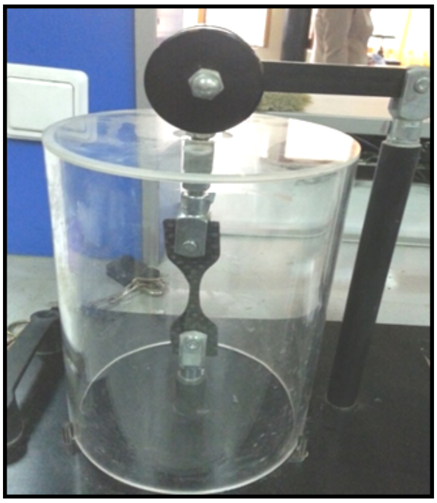

Figure 5. Specimen in the fixture.

• The force applied about (18N). (Constant Load)
• A hot thermal bag is placed around the sample this bag is heated by an oven in the laboratory about (250 C°) in Figure 6.
• After about (20 days) the elongation is measured by strain measuring system (dial gauge) as shown in Figure 7.

Figure 6. Hot thermal bag in the oven.

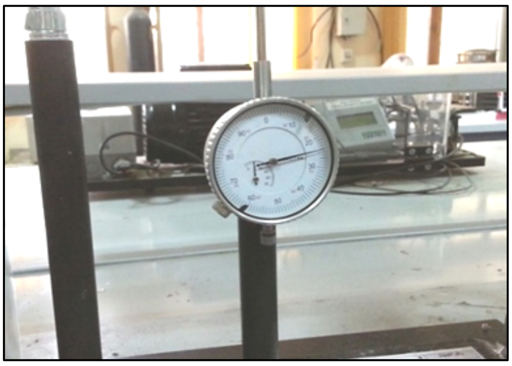

Figure 7. The dial gauge.

The procedure used to execute the creep test involves reading the deformation of the specimen after this, the strain of test specimen is calculated during the time interval by the following simple strain formula.

$$\varepsilon\ (t) = \delta\ (t) \setminus L \quad (1)$$

The initial strain is calculated from the initial deformation zero time.

3. Results and Discussion

The strain vs. time behavior is measured for two groups of materials, first group is woven carbon epoxy resin. In the second group using woven carbon epoxy resin with nano carbon (2, 3 and 4) wt % of epoxy resin. Figures 8, 9 and 10 show the effect of addition the nano carbon on the creep behavior (strain-time) relation, based on the experimental results it is observed that the addition of nano materials is improved the creep behavior of composite material (carbon-epoxy composite) this in evident by the low values of strain for the woven carbon-epoxy resin with nano carbon comparing with woven carbon-epoxy resin without nano carbon.

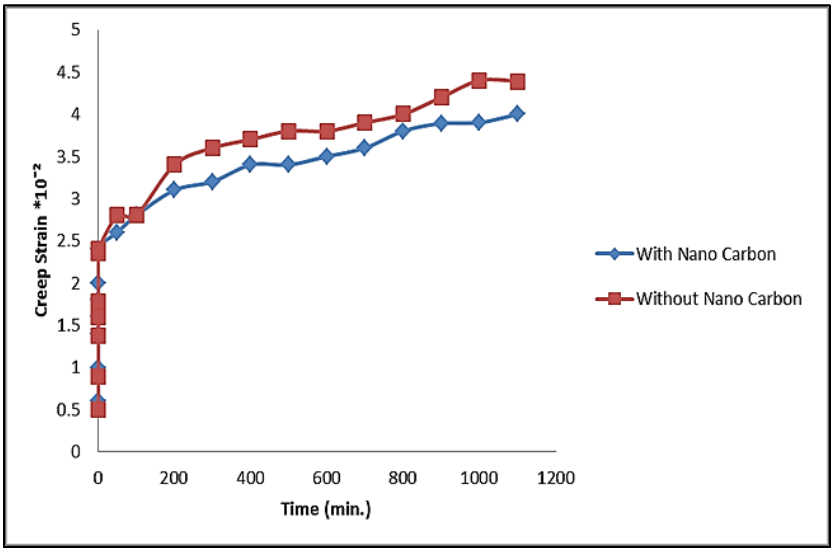

Figure 8. The variation of time with creep strain (2%) wt nano carbon with epoxy resin.

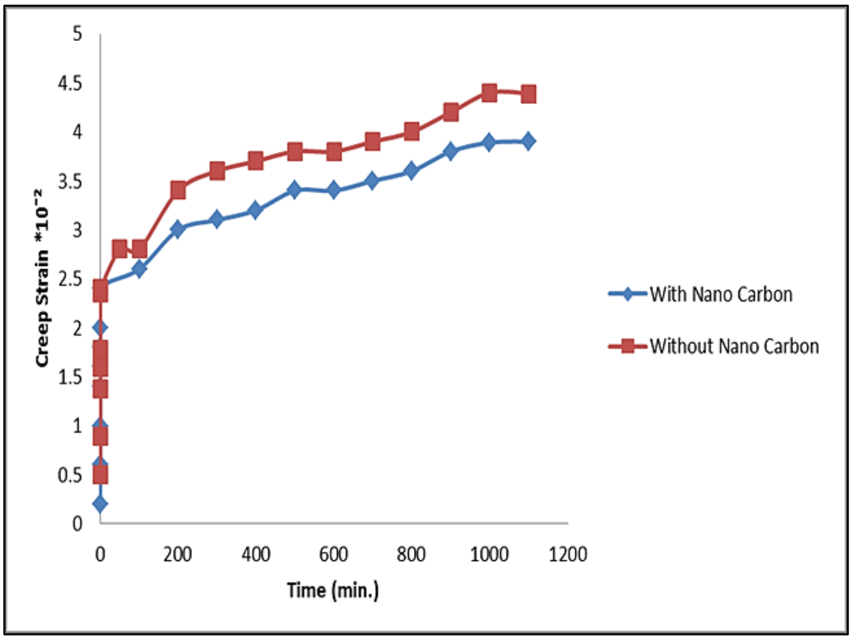

Figure 9. The variation of time with creep strain (3%) wt nano carbon with epoxy resin.

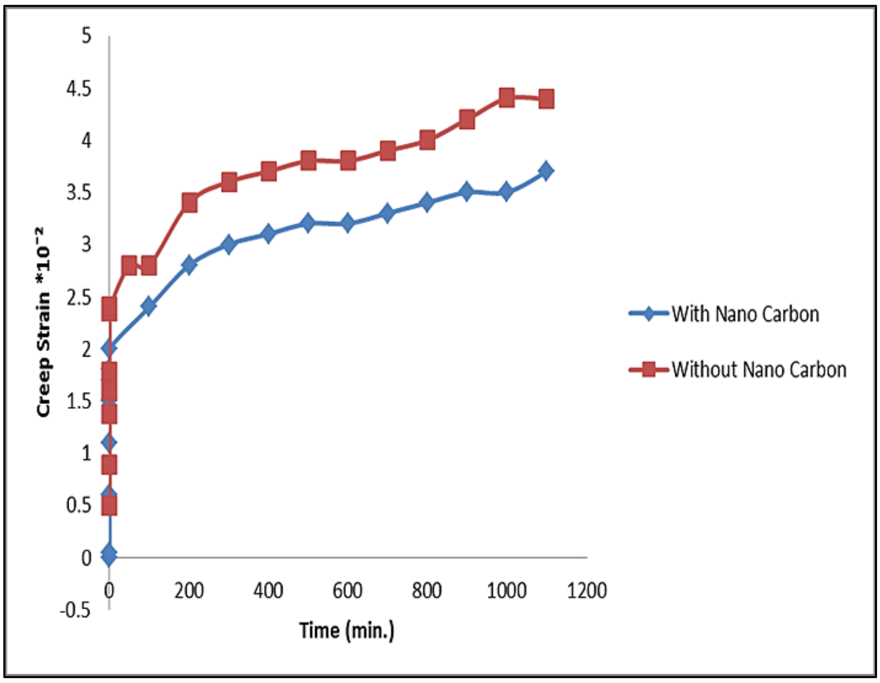

Figure 10. The variation of time with creep strain (4%) wt nano carbon with epoxy resin.

It can be seen from the above figure, there is an improvement on the creep strain behavior about (10 %), (12.5 %) and (19%) for the specimen with nano carbon (2%), (3%) and (4%) wt respectively. This indicate that when addition more weight of nano carbon to the epoxy resin lead to significant improvement on the creep behavior of composite material.

The maximum values of creep strain for the materials have been test listed in Table 1. It can be seen from this table that the maximum creep strain recoded for the specimen without nano carbon, while the value of creep strain has been decreased when adding nano carbon to the resin matrix.

Table 1. The values of maximum creep strain.

Wt of nano carbon	Max. creep Strain $*10^{-2}$	Time *(min.)*
Without	4.39	1100
2 %	4	1100
3 %	3.9	1100
4 %	3.7	1100

According to these evidences, it can say that adding the nano carbon maintains the structural bonding of the epoxy resin and Provides sufficient hardness to the carbon fiber used in the composite material.

4. Conclusion

Based on the experimental results, the maximum strain was observed in the specimen (woven carbon-epoxy resin without nano carbon), while, when adding nano carbon to the matrix, improvements in creep behavior were observed. This is due to the nano material improved the properties of composite material clearly by carbon fiber reinforcement as a result of the increased strength of the bonding structure of epoxy resin. Also, there is an improvement on the creep strain behavior about (10 %), (12.5 %) and (19%) for the specimen with nano carbon (2%), (3%) and (4%) wt respectively.

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