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Effect of industrial powder on mechanical properties of glass fiber reinforced epoxy composite

Aseel Basim Abdul-Hussein, Imad Saad Al-Hasani, Reem Alaa Mohamed

Materials Engineering Department, University of Technology

E-mail: dr.material@yahoo.com

Abstract

In the present study, composites were prepared by Hand lay-up molding and investigated. The composites constituents were epoxy resin as the matrix, 6% volume fractions of Glass Fibers (G.F) as reinforcement and 3%, 6% of industrial powder (Calcium Carbonate $CaCO_3$, Potassium Carbonate K_2CO_3 and Sodium Carbonate Na_2CO_3) as filler. Density, water absorption, hardness test, flexural strength, shear stress measurements and tests were conducted to reveal their values for each type of composite material. The results showed that the non – reinforced epoxy have lower properties than composites material. Measured density results had show an incremental increase with volume fraction increase and water absorption, hardness, flexural strength and shear stress results had show an incremental increase with volume fraction increase and with smaller particle size.

Key words
Density,
Water absorption,
Hardness,
Flexural Strength,
Glass fibers,
Composites.

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تأثير المساحيق الصناعية على الخواص الميكانيكية للمواد المركبة المدعمة بألياف الزجاج

اسيل باسم عبد الحسين, عماد سعدي الحسني, ريم علاء محمد

قسم هندسة المواد, الجامعة التكنولوجية

الخلاصة

تم في هذا البحث تحضير مواد متراكبه بواسطة طريقة القولبة اليدوية ودراسة خصائصها. تتكون المواد المتراكبة من راتنج الايبوكسي كماده اساس وبألياف الزجاج بكسر حجمي 6% وكذلك 3% و 6% مساحيق صناعية تدعيم من (كاربونات الكالسيوم $CaCO_3$, كاربونات البوتاسيوم K_2CO_3, كاربونات الصوديوم Na_2CO_3). تم اجراء فحوصات الكثافة وامتصاصية الماء، فحص الصلادة, مقاومة الانحناء و اجهاد القص للكشف عن قيمها لكل نوع من المواد المتراكبة. اظهرت النتائج ان الايبوكسي غير المقوى يمتلك خواص اقل من المواد المتراكبة. عند اجراء اختبارات الكثافة فان النتائج اظهرت بان الكثافة تزداد مع زياد الكسر الحجمي وامتصاصية الماء والصلادة ومقاومة الانحناء واقصى اجهاد قص بانها تزداد مع زيادة الكسر الحجمي مع اصغر حجم حبيبي.

Introduction

Composite materials are those containing two or more than two bonded materials whose mechanical performance and properties are designed to be superior to those of the constituent materials acting independently. One of the phases is usually discontinues, stiffer and stronger and is called reinforcement, whereas the less stiff and weaker phase is continuous and is called matrix [1]. Fig.1 shows a typical reinforcement geometric for composites [2].

A composite material is originally considered to be a combination of two materials but now this class of material is regarded as any combination which has particular physical and mechanical properties [3]. Many of common materials are metals, alloys, doped ceramics and polymers mixed with additives. Favorable properties of composite materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, and improved wear resistance [4].

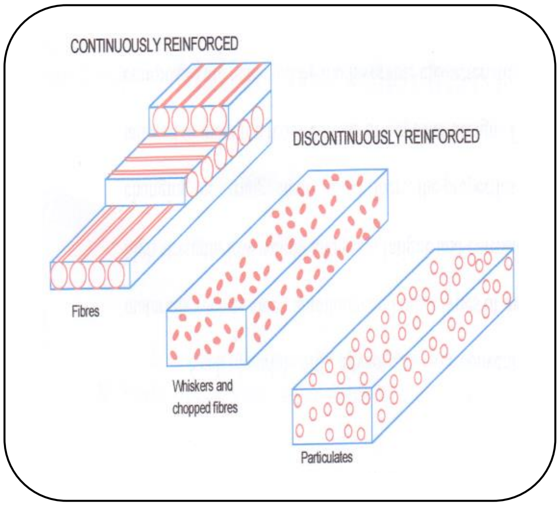


Fig.1: Typical reinforcement geometric for composites [2].

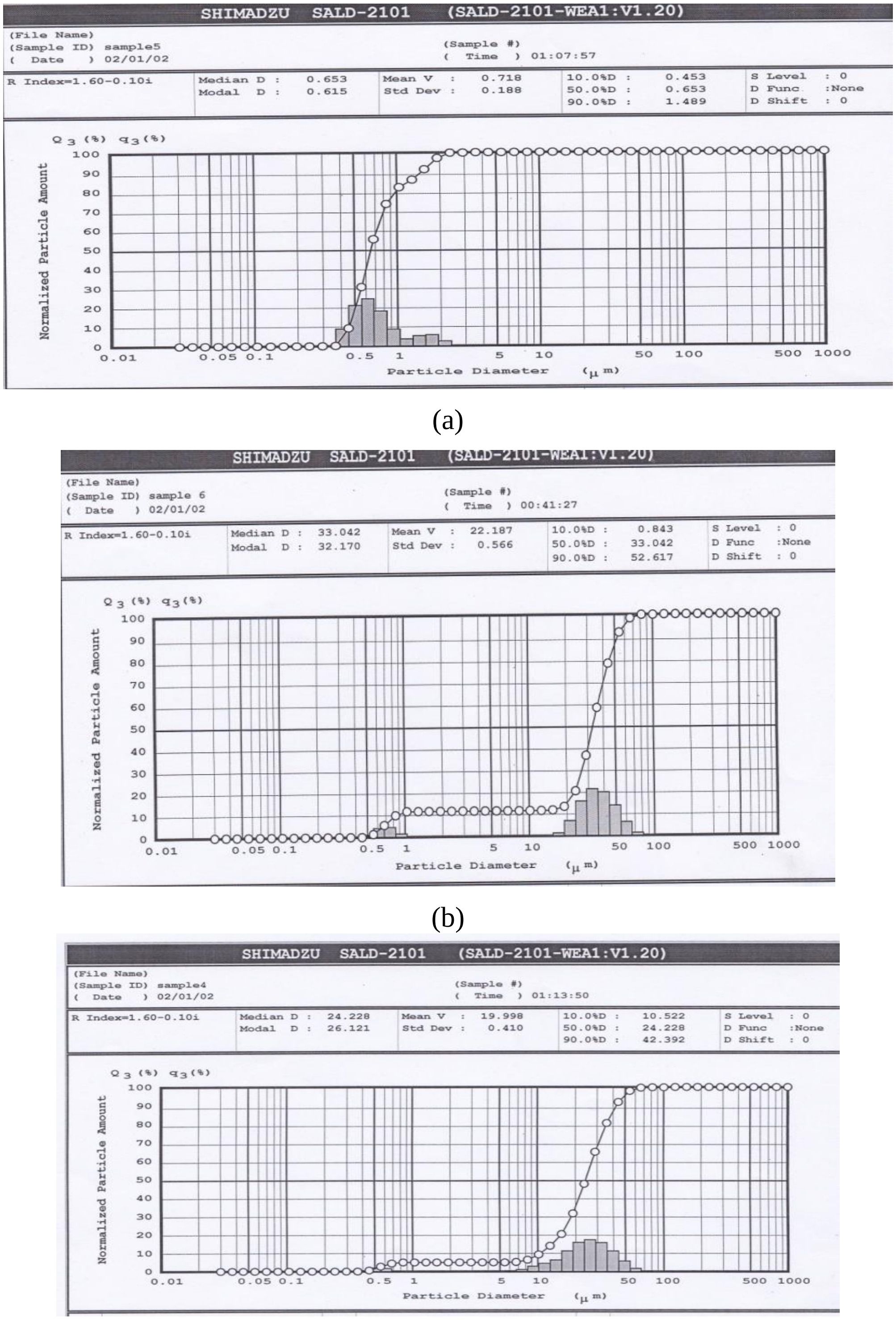
There are many studies about composite materials. Mukul and Sachin have studied Composites materials are used in almost of the industrial and commercial fields in aircraft, ship. Their most attractive properties are the high strength-to-weight ratio. Materials added to the matrix help improving operating properties of a composite. Study targeted to investigate the tensile strength of glass fiber and epoxy resin based composite with $CaCO_3$ as a filler [5].

Fouad, El-Meniawi and Afifi have studied the solid particle erosion behavior and wear mechanism of commercial epoxy based unidirectional glass fiber reinforced plastics (GFRP) composites were investigated. The erosion experiments have been carried out using irregular silica sand (SiC) particles (150±15 μm) as an erodent. The erosion losses of these composites were evaluated at various impingement angles (30°, 60° and 90°) with the change of both of erosion time and pressure [6].

Falak et al have studied the properties and behavior of particles on (glass, carbon, and Kevlar fiber) reinforced polyester composites. The effect of alumina (Al_2O_3) and silicon carbide (SiC) particles ceramic polyester composites are investigated at different additive ratios as 0.2, 0.4, 0.6, 0.8 and1.0% volume fraction. Comparative analysis show that the bending distortion, Hardness, and Impact resistance are affected by the type and content of filler particles, where both impact and Hardness is increased with increasing volume fraction specially in case of 0.5% volume fraction for both filler particles and decreased for bending distortion specially in case of glass fiber/ polyester at 0.5% volume fraction for both filler particles [7].

Experimental work

The basic materials used in the preparation of research samples consisting of glass fibers (Woven E- Glass Fiber) from the Tenax company, England, and epoxy resin Quickmast (105) base as the matrix from the (Don Construction products) Made in Jordan in the form of transparent viscous liquid at room temperature which is a thermally hardened polymers (Thermosets) with a density of 1.3 gm/cm^3. The mean of powder was used for Calcium Carbonates (0.71 µm), Potassium Carbonates (22.18 µm), and Sodium Carbonates (19.99 µm) as shown in Fig.2. All the required moulds for preparing the specimens were made from glass with dimensions of 150×150×5 mm. The inner face of the mould was covered with a layer of nylon (thermal paper) made from polyvinyl alcohol (PVA) so as to ensure no-adhesion of the resin with the mould.



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(File Name)
(Sample ID) sample5                  (Sample #)
(  Date    ) 02/01/02                (  Time  ) 01:07:57
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                     Modal  D :  0.615   Std Dev  :  0.188   50.0%D :  0.653   D Func   :None
                                                             90.0%D :  1.489   D Shift  : 0
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(a)

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(File Name)
(Sample ID) sample 6                 (Sample #)
(  Date    ) 02/01/02                (  Time  ) 00:41:27
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                                                               90.0%D :  52.617   D Shift  : 0
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(b)

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(  Date    ) 02/01/02                (  Time  ) 01:13:50
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                     Modal  D :  26.121   Std Dev  :  0.410    50.0%D :  24.228   D Func   :None
                                                               90.0%D :  42.392   D Shift  : 0
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(c)

Fig.2: (a) Particle size of $CaCO_3$, (b) Particle size of K_2CO_3, (c) Particle size of Na_2CO_3.

1 Industrial material

1-1 Calcium carbonate

Is a chemical compound whose chemical formula is $CaCO_3$. Calcium carbonate is the active ingredient in agricultural lime, and is usually the principal cause of hard water. It is commonly used medicinally as a calcium supplement or as an antacid, but excessive consumption can be hazardous [9]. Preparation of calcium carbonate used in industry is extracted by mining or quarrying. Pure calcium carbonate (e.g. for food or pharmaceutical use), can be produced from a pure quarried source (usually marble) [10]. Calcium carbonate is widely used medicinally to prevent and to treat calcium deficiencies or gastric antacid. It may be used as a phosphate binder for the treatment of hyperphosphatemia (primarily in patients with chronic renal failure). It is also used in the pharmaceutical industry as inert filler for tablets and other pharmaceuticals; Calcium carbonate is used in the production of toothpaste [9].

1-2 Potassium carbonates

Potassium carbonate occurs in wood ashes the chemical formula is K_2CO_3. It is one of the first known salts of potassium and was used historically in recovering metallic potassium. The Compound has numerous potential applications. However, in most cases the Cheaper and equivalent sodium carbonate is used. An important application of potassium carbonate involves making specialty television glass. Other applications are in pottery; soaps and liquid shampoos; process engraving and lithography; to depress the freezing point of water in fire.

1-3 Sodium carbonates

Sodium Carbonate occurs in Industrial as monohydrate in the mineral thermonatrite the chemical formula is Na_2CO_3. It also occurs naturally as the mineral Natrona or natrite in its decahydrate form. Sodium carbonate is one of the most important salts of sodium, used in manufacturing several other sodium salts. Other major uses are in manufacturing glass, soaps and detergents, pulp, and paper. Also, it is used for washing textiles and wool, in cleaning preparations, for bleaching linen and cotton, in water treatment, and in photography. Sodium carbonate is used as an emetic. Sodium carbonate solution cleanses skin and softens skin rashes. The salt is a common laboratory reagent with wide applications in analytical chemistry [13- 14].

To find the element of the Industrial material we use chemical composition analyzer (ICP-OES optical emission spectroscopy, chemical analysis machine, south kored, light source – high speed measurement it gives the measurement 1 to 2 minutes with high resolution), as shown in Table 1.

Then we use X-Ray Diffraction (XRD) to find crystalline phases for the Industrial materials as shown in Fig. 3.

Fig.(3-a) X-Ray Diffraction pattern confirmed that (Ca_2CO_3) powder. High intensities of Sharpe peaks could be obtained indicating a high Crystalline in the synthesized powder. All peaks could be indexed to a Rhombohedra structure (Calcite) [15].

Fig.(3-b) X-Ray Diffraction pattern confirmed that K_2CO_3 powder .High intensities of Sharpe peaks could be obtained indicating a high Crystalline in the synthesized powder. All peaks could be indexed to a Hexagonal structure [16].

Fig.(3-c) X-Ray Diffraction pattern confirmed that (Na_2CO_3) powder. High intensities of Sharpe peaks could be obtained indicating a high Crystalline in the synthesized powder. All peaks could be indexed to a monoclinic structure [17].

Table 1: (a) Chemical composition of the $CaCO_3$, (b) chemical composition of the K_2CO_3, (c) chemical composition of the Na_2CO_3.

a		b		c	
Material	**Ca_2CO_3 (Content in %)**	**Material**	**K_2CO_3 (Content in %)**	**Material**	**Na_2CO_3 (Content in %)**
$CaCO_3$	97.5%	K_2CO_3	97%	Na_2CO_3	98.5%
$MgCO_3$	0.87%	$MgCO_3$	0.71%	$MgCO_3$	0.89%
SiO_2	0.30%	SiO_2	0.25%	SiO_2	0.50%
Al_2O_3	0.14%	Al_2O_3	0.21%	Al_2O_3	0.17%
Fe_2O_3	o.12%	Fe_2O_3	0.15%	Fe_2O_3	o.15%
Na_2O	< 0.08%	Na_2O	< 0.07%	CaO	< 0.09%
K_2O	< 0.04%	Cao	< 0.05%	K_2O	< 0.05%
T.O.C.	0.025%	T.O.C.	0.031%	T.O.C.	0.027%
Absorption H2O	0.18%	Absorption H2O	98.6%	Absorption H2O	99.19%

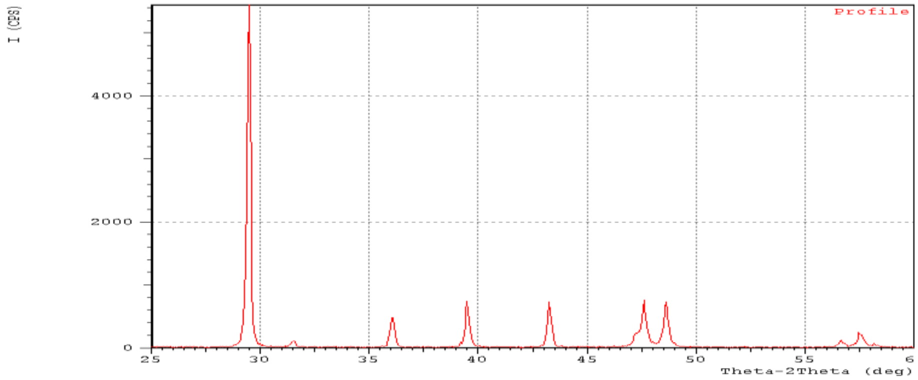


Fig.3: (a) The X- Ray diffraction of $CaCO_3$.

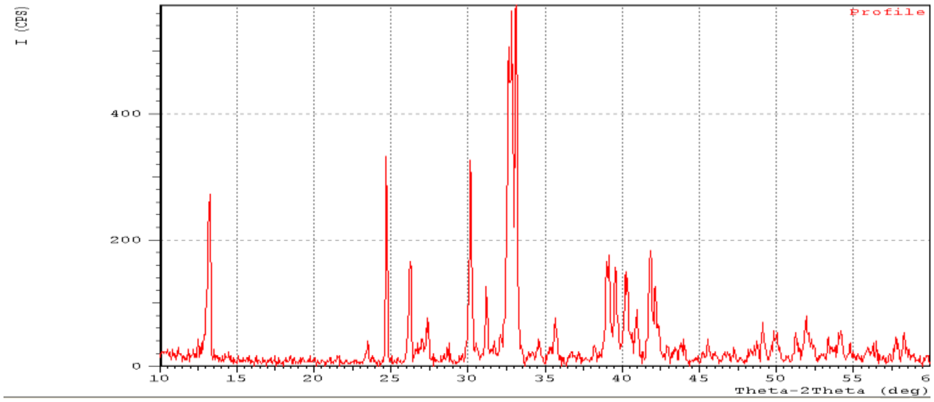


Fig.3: (b) The X- Ray diffraction of K_2CO_3.

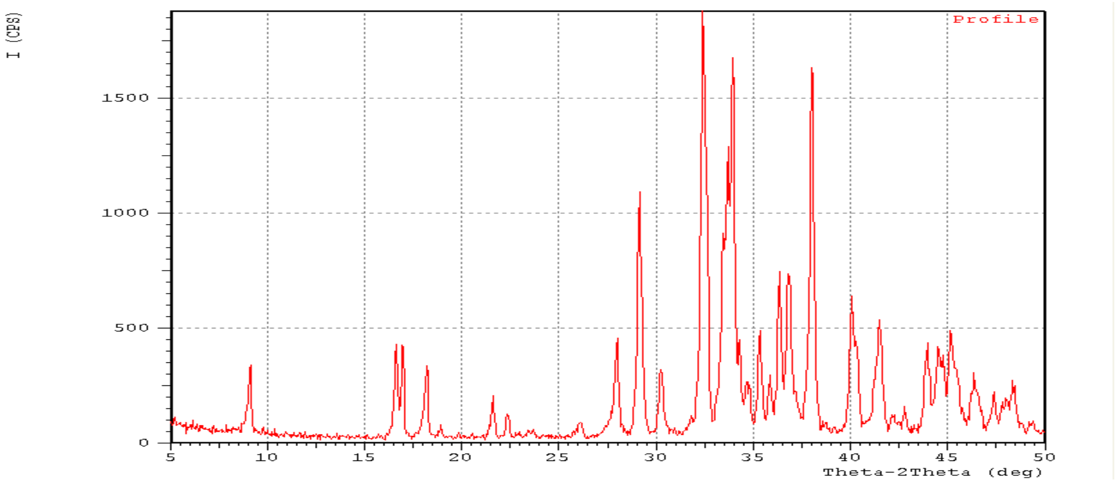


Fig.3: (C) The X- Ray diffraction of Na_2CO_3.

Preparation of composites

The composites samples were prepared from epoxy reinforced with glass fiber of 6% volume fraction, and powder of industrial Calcium Carbonate $CaCO_3$, Potassium Carbonate K_2CO_3 and Sodium Carbonate Na_2CO_3 with volume fraction of 3% and 6%. The method used in the preparation of the samples in this research is the Hand lay-Up Molding because it is simple to use and can make different shapes and sizes of composites.

Physical tests

1. Density measurements

1.1. Calculated theoretical density

The following role of mixture (ROM) formula is used to calculate the density of the composite.

$$\rho_c = \rho_m V_m + \rho_r V_r \qquad (1)$$

1.2. Measured density

This test is performed according to (ASTM C 373) standard. The samples were cut into a diameter of 40 mm and a thickness of 5 mm the measured density (ρ_t) is calculated from the method of immersion in water using the following relationship [18]. Fig.4 shows the prepared specimens for this test [19].

$$\rho t = (Wd / Ws - Wn) * D \qquad (2)$$

where:

ρt: Measured density or bulk density (gm/cm^3).

D: Density of distilled water (1 gm/cm^3).

Wd: dry weight of sample (gm).

Wn: weight of the sample, a commentator and submerged with water (gm).

Ws: weight of the sample is saturated with water (gm).

1.3 Water absorption

This test is performed according to (ASTM D 570) standard at room temperature [20]. Samples have been cut into a diameter of (40mm) and a thickness of (5mm). The mechanism of water absorption is explained to be the direct uptake and flow of water by capillary and transport along the reinforcement-matrix interface [21]. Water absorption percentage is calculated using (Archimedes base) according the following formula [22]:

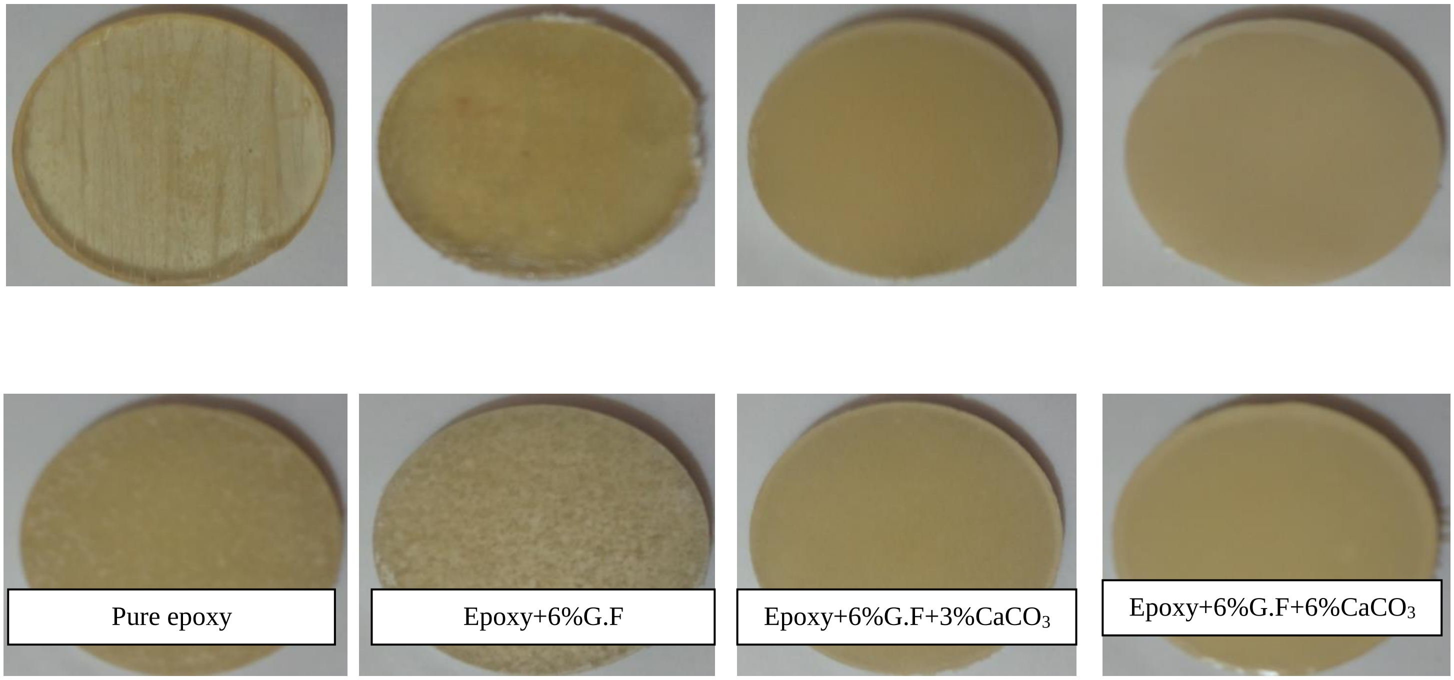
$$M(\%) = \frac{(mt - m_o)}{m_o} \times 100 \qquad (3)$$

where

M (%): water absorption percentage.

m_o: mass of specimen before immersion (g).

m_t: mass of specimen after immersion for seven days (g).



Pure epoxy

Epoxy+6%G.F

Epoxy+6%G.F+3%$CaCO_3$

Epoxy+6%G.F+6%$CaCO_3$

Epoxy+6%G.F+3%k_2CO_3

Epoxy+6%G.F+6%k_2CO_3

Epoxy+6%G.F+3%Na_2CO_3

Epoxy+6%G.F+6%Na_2CO_3

Fig.4: Prepared specimens [19].

Mechanical test

1. Hardness test measurement

This test is performed by using hardness (Shore D) and according to (ASTM DI-2240) standard at room temperature. Samples have been cut into a diameter of 40mm and a thickness of 5mm[23].

For each specimen five hardness measurements were taken and the average hardness is calculated.

2. Flexural strength and shear stress test

This test is performed according to M 1031 at room temperature applied load (0-45 KN) by using the machine type Laryee, Chinese made Samples have been cut into the dimensions (100*10*5) mm. Fig.5 shows standard specimens for this test [23]. The flexural strength and maximum shear stress are calculated according to the equations [24- 25].

$$F.S = \frac{3PL}{2bd^2} \tag{4}$$

$$\tau = \frac{3P}{4bd} \tag{5}$$

where

F.S: flexural strength (MPa).

P: force at fracture (N).

L: length of the sample between Predicate (mm).

b:thikness(mm).

d:width(mm).

τ:maximum shear stress (MPa)

P: force at fracture (N).

b:thikness (mm).

d:width (mm).

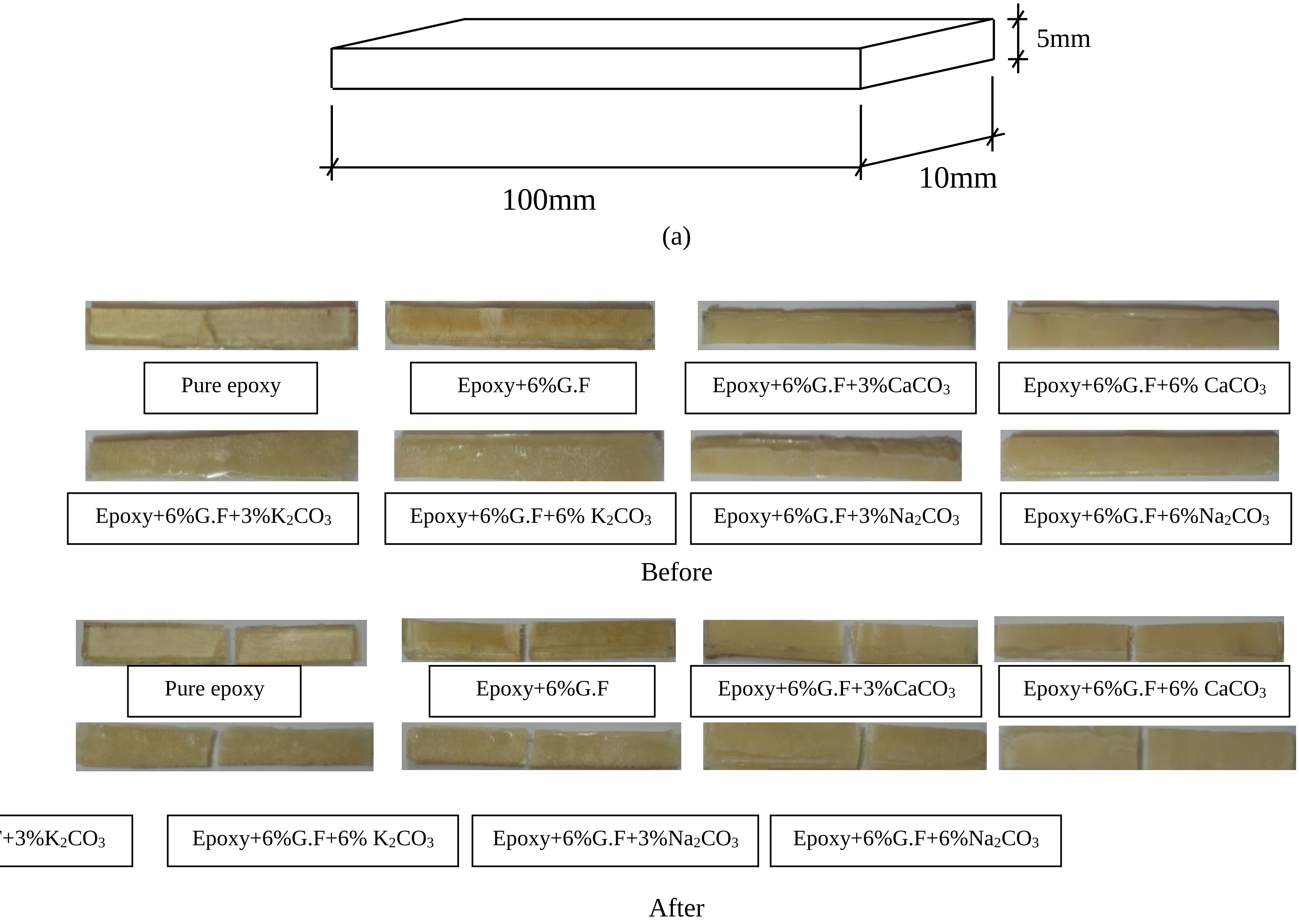


Fig.5: (a) Flexural strength standard specimen [26], (b) Experimental specimens before & after test.

Results and discussion

1. Density

Density is a material property which is of prime importance in several weight sensitive applications. Thus, in many such applications polymer composites are found to replace conventional metals and materials primarily for their low densities. Density of a composite depends on the relative proportion of matrix and the reinforcing materials. There is always a difference between the measured and the theoretical density values of a composite due to the presence of voids and pores. These voids significantly affect some of the mechanical properties and even the performance of composites [27]. Table 2 shows the values of density for the prepared (pure epoxy, epoxy +6% glass fiber and Industrial) composites. From the Table 2 it is observed all value of the composites density values are calculated theoretically from weight fraction using rule of mixtures by Eq.1 and are not equal to the experimentally measured values. This difference is due to presence of voids and pores in the composites. The observation shows that more voids are found in the composites with the addition of fiber as well as filler material [28- 29].

Figs.6 and 7 show the measured and theoretical densities for epoxy +6% glass fiber with pure epoxy composites. In Fig.6 can be seen the higher measured density has been found to be for the specimen epoxy +6%G.F then specimen pure epoxy, density of composites increases when the reinforcement is increases due to the glass density is more when compared to pure epoxy density [30].

Figs. 8 and 9 show the measured and theoretical densities for Industrial composites. In Fig. 8 can be seen the higher density has been found to be for the specimen epoxy +6%G.F+6% $CaCO_3$ due the $CaCO_3$ powder have density higher than Na_2CO_3 powder and K_2CO_3 Powder. When comparing the value of measured density of industrial with measured density of (pure Epoxy) can be seen higher than because the additions of reinforcement ($CaCO_3$ powder, Na_2CO_3 powder and K_2CO_3 Powder) that have higher density comparing with density of pure epoxy [29].

Table 2: Density of the prepared composites.

Types of composite	**Measured density (gm/cm^3)**	**Theoretical density**
Epoxy +6% Glass fiber	1.226	1.376
(Industrial Composites)		
Epoxy+6%GF+3% $CaCO_3$	1.272	1.419
Epoxy+6%GF+6% $CaCO_3$	1.320	1.461
Epoxy+6%GF+3% K_2CO_3	1.228	1.410
Epoxy+6%GF+6% K_2CO_3	1.283	1.444
Epoxy+6%GF+3% Na_2CO_3	1.255	1.414
Epoxy+6%GF+6% Na_2CO_3	1.299	1.451

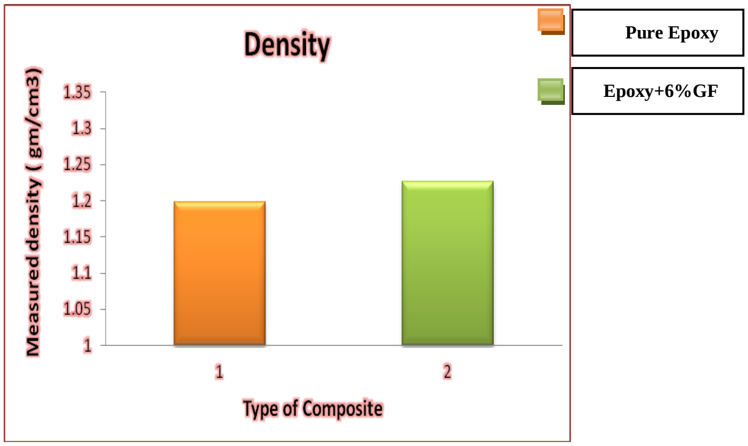


Fig.6: Measured density of Epoxy +6% glass fiber composites and pure epoxy.

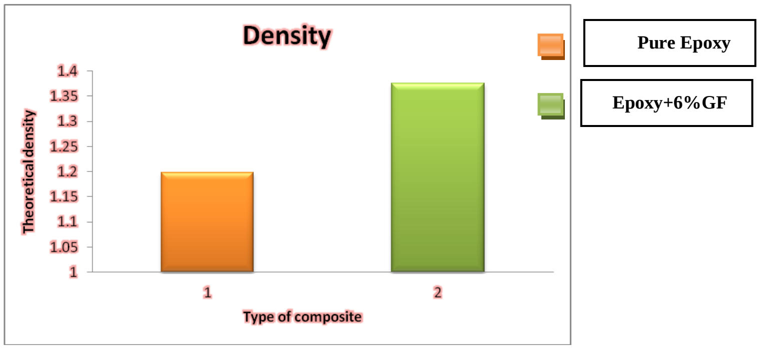


Fig.7: Theoretical density of Epoxy +6% glass fiber composites and pure epoxy.

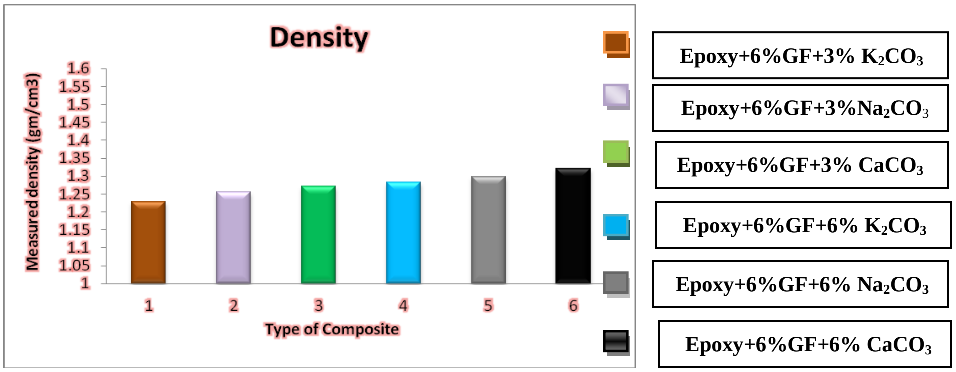


Fig.8: Measured density of industrial composites.

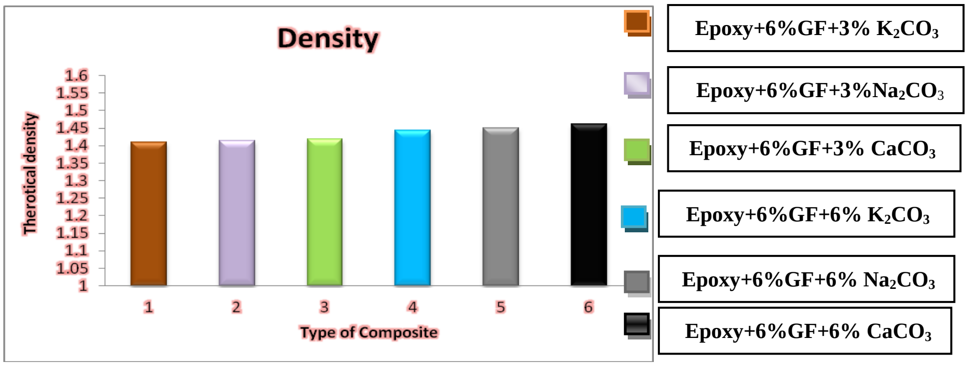


Fig.9: Theoretical density of industrial composites.

2. Water absorption

Some studies revealed that mechanical properties such as toughness and resistance will fall after exposure of the specimen to moisture, or after absorption specific quantity of water and the reason for this, is that the moisture has a role in breaking the interface between the matrix material and the reinforcing material and by reducing the adhesion between the matrix material and the reinforcing material, or the reinforced material may absorb greater amounts of water, causing swelling of the matrix material and therefore separation in the matrix material will be expected and the detoriation of the interface in the composite material will happen and this leads to decreasing in transfer of stress to the filler material thus leading to decrease in toughness and resistance will be decreased [31]. Table 3 shows the values of water absorption for the prepared pure epoxy,

epoxy +6% glass fiber and Industrial composites.

Fig.10 shows the water absorption of epoxy +6% glass fiber composites with pure epoxy. In Fig.10 can be seen the specimen epoxy +6%G.F have higher water absorption than specimen (pure epoxy), the increasing water absorption percentage with increasing volume fraction of fiber depends on the rule of mixture theory where fiber have a higher water absorption percentage than specimen pure epoxy [32]. The water absorption attacked the fiber-matrix interface, causing de-bonding of the fiber and the matrix. The failures of the composite materials were due to voids [33].

Fig.11 shows the Industrial composite have give higher water absorption percentage than specimen pure epoxy and specimen epoxy +6% glass fiber composites. the higher water absorption percentage of industrial composite has been found to specimen epoxy +6%G.F+6% K_2CO_3 while the specimen epoxy + 6%G.F+6% $CaCO_3$ have lower than specimen of Na_2CO_3 and K_2CO_3 at the volume fraction (6%) of glass fiber and (6%) volume fraction of filler particles (industrial powder), and the specimen epoxy +6%G.F+3% K_2CO_3 have higher water absorption percentage while the specimen epoxy + 6%G.F+3% $CaCO_3$ have lower than specimen of Na_2CO_3 and K_2CO_3 at the volume fraction (3%) of glass fiber and (3%) volume fraction of filler particles (industrial powder).

In this work the specimens of composite material filled with larger particles show a higher water absorption percentage when compared with the specimens of composite material filled with small particles because the saturation level of fillers matrix composition influenced by agglomeration that will affect the water absorption percentage of the composite material[31].The mean particle size of the K_2CO_3 is 22.18 µm while mean particle size of the $CaCO_3$ is 0.71 µm and mean particle size of the Na_2CO_3 is 19.99 µm.

Table 3: Water absorption of the prepared composites.

Types of composite	Water absorption (%)
Pure Epoxy	0.128
Epoxy +6% Glass fiber	0.201
(Industrial Composites)	
Epoxy+6%GF+3% $CaCO_3$	0.210
Epoxy+6%GF+6% $CaCO_3$	0.240
Epoxy+6%GF+3% K_2CO_3	0.236
Epoxy+6%GF+6% K_2CO_3	0.268
Epoxy+6%GF+3% Na_2CO_3	0.220
Epoxy+6%GF+6% Na_2CO_3	0.250

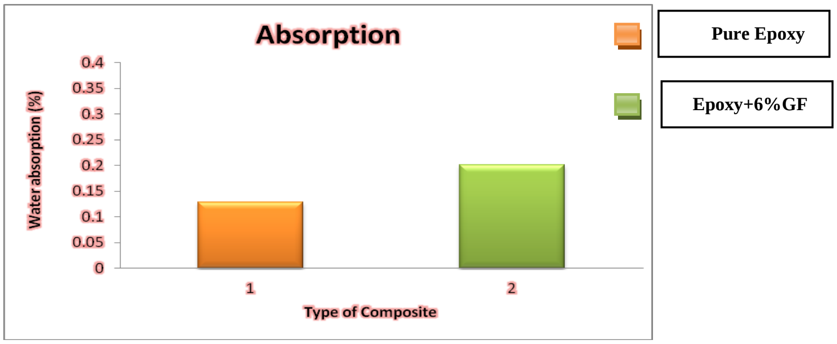


Fig.10: Water absorption of Epoxy +6% glass fiber composites and pure epoxy.

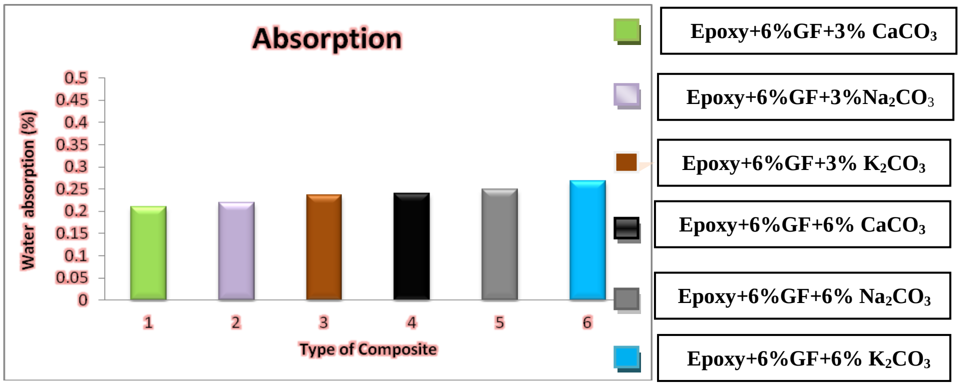


Fig.11: Water absorption of industrial composites.

3. Hardness shore (D)

Hardness test type (Shore (D)) was carried out on pure Epoxy before and after glass fiber and powder fillers were added and the average of five readings in each case was taken to obtain higher accuracy results. Table 4 shows the values of hardness for the prepared (Pure Epoxy, Epoxy +6% glass fiber and Industrial) composites.

Fig. 12 shows that there is clear a pronounced effect of the addition of 6% glass fiber volume fraction percents on the hardness of the material. Increase in fiber content leads to a increase in the hardness, this may be due to the fact that the hardness is generally considered to be a property of the surface therefore this behavior of hardness is expected. The addition of the fiber leads to an increase in the elasticity and a decrease in the matrix surface resistance to the indentation [34- 35], thus specimen Epoxy +6%G.F) have higher hardness than (specimen (Pure Epoxy). Fig. 13 shows that there is clear a pronounced effect of the addition of 6% glass fiber with 3%and 6% volume fraction from (industrial powder) percent on the hardness of the material. It can be seen that the hardness increases with increasing volume fraction. Adding the filler particles will raise the materials hardness due to increasing in material resistance against the plastic deformation[36]. Result had revealed that the hardness of pure epoxy alone was 76.4 shores D compared to maximum value (83.5) at volume fraction of 6% and particle size of $CaCO_3$ is 0.71 µm. the reason of the increase in hardness is that $CaCO_3$ contains an elements harder than the pure epoxy that lead to an increase in hardness [36]. These results become match with our work because the $CaCO_3$ have particle size smaller than $Na_2CO_3$and K_2CO_3.

Table 4: Hardness of the prepared composites.

Types of composite	Hardness Shore (D)
Pure Epoxy	76.4
Epoxy +6% Glass fiber	78
(Industrial Composites)	
Epoxy+6%GF+3% $CaCO_3$	81.8
Epoxy+6%GF+6% $CaCO_3$	83.5
Epoxy+6%GF+3% K_2CO_3	81
Epoxy+6%GF+6% K_2CO_3	82
Epoxy+6%GF+3% Na_2CO_3	81.5
Epoxy+6%GF+6% Na_2CO_3	83.1

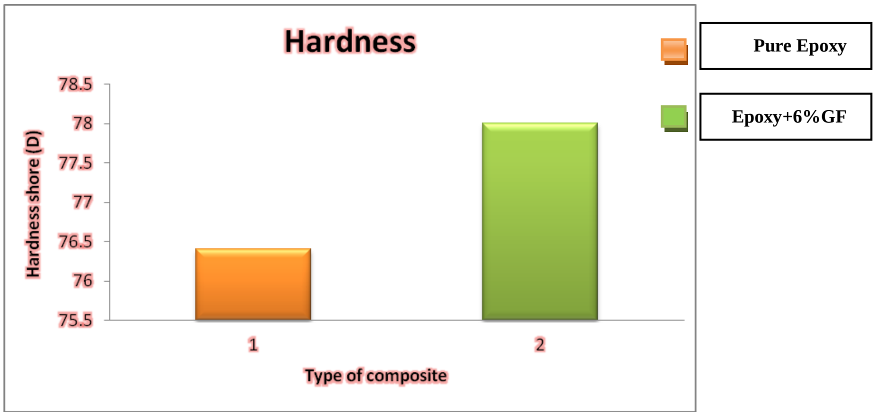


Fig.12: Hardness shore (D) of Epoxy +6% glass fiber composites and pure epoxy.

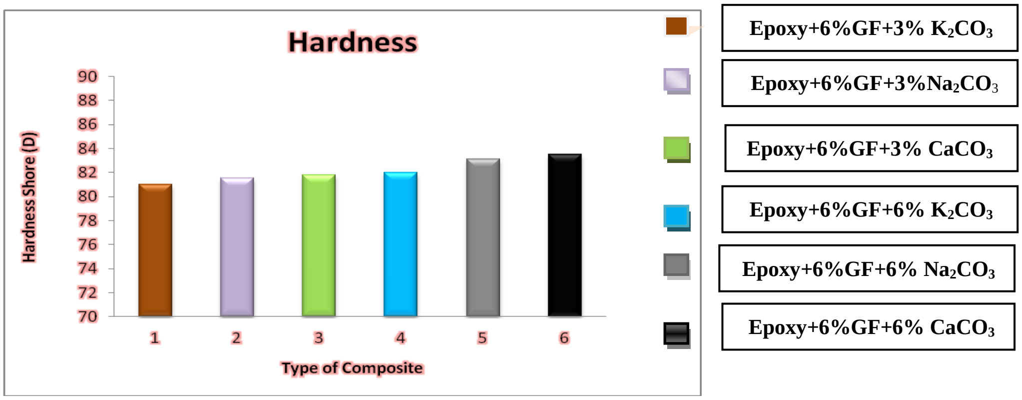


Fig.13: Hardness shore (D) of industrial composites.

4. Flexural strength

Table 5 shows the values of flexural strength for the prepared (pure epoxy, epoxy +6% glass fiber and Industrial) composites.

Fig.14 shows that there is clear a pronounced effect of the addition of 6% glass fiber volume fraction percents on the flexural strength, where specimen (epoxy +6%glass fiber) have higher flexural strength than specimen (pure epoxy) due the addition of 6% volume fraction of glass fiber.

Fig.15 shows that there is clear a pronounced effect of the addition of 6% glass fiber with 3% and 6% volume fraction from (Industrial powder) percents on the strength of the material. It can be seen that the flexural strength increases with increasing volume fraction and decreasing of the particle size. Flexural strength of pure reference epoxy was 149 MPa then an increasing had observed with increasing in volume fraction till it reached to its maximum value of 265MPa by the addition of 6% glass fiber and volume fraction of 6% of $CaCO_3$ with particle size of 0.71µm, these results become match with our work because the $CaCO_3$ have particle size smaller than Na_2CO_3 and K_2CO_3, and that consider with our suggestion in that bonding strength between epoxy and reinforcing material is high. This is attributed to the homogenous dispersibility and reinforcing-ability of the $CaCO_3$ powder in the epoxy/glass fiber composites [32].

Table 5: Flexural strength of the prepared composites.

Types of Composite	Flexural Strength (MPa)
Pure Epoxy	149
Epoxy +6% Glass fiber	170
(Industrial Composites)	
Epoxy+6%GF+3% $CaCO_3$	223
Epoxy+6%GF+6% $CaCO_3$	265
Epoxy+6%GF+3% K_2CO_3	197
Epoxy+6%GF+6% K_2CO_3	231
Epoxy+6%GF+3% Na_2CO_3	208
Epoxy+6%GF+6% Na_2CO_3	243

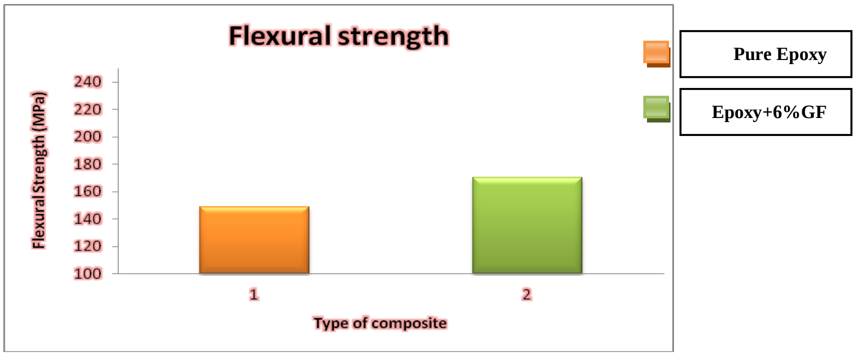


Fig.14: Flexural strength of Epoxy +6% glass fiber composites and pure epoxy.

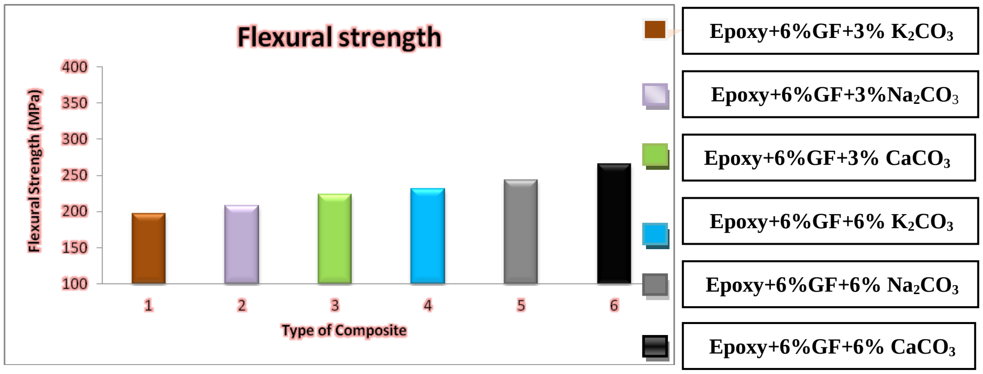


Fig.15: Flexural strength of industrial composites.

5. Shear stress

Table 6 shows the values of Shear Stress for the prepared (pure epoxy, epoxy +6% glass fiber and Industrial) composites.

Adhesive between matrix and reinforcing material has a large effect in giving the maximum shear stress specimen that load to increase shear stress of particle reinforced epoxy to a higher amount than that of epoxy specimen alone as shown in Fig.16 due the addition of 6% volume fraction of glass fiber [36], which the specimen Epoxy +6% glass fiber +6% $CaCO_3$ composite material had a maximum shear stress of 6.39MPa. by the addition of 6% glass fiber and volume fraction of 6% of $CaCO_3$with particle size of 0.71 µm these results become match with our work because the $CaCO_3$ have particle size smaller than Na_2CO_3 and K_2CO_3, as shown in Fig.17.

Table 6: Shear stress of the prepared composite.

Types of Composite	Shear Stress (MPa)
Pure Epoxy	4.65
Epoxy +6% Glass fiber	5.76
(Industrial Composites)	
Epoxy+6%GF+3% $CaCO_3$	6.01
Epoxy+6%GF+6% $CaCO_3$	6.39
Epoxy+6%GF+3% K_2CO_3	5.85
Epoxy+6%GF+6% K_2CO_3	6.15
Epoxy+6%GF+3% Na_2CO_3	5.96
Epoxy+6%GF+6% Na_2CO_3	6.23

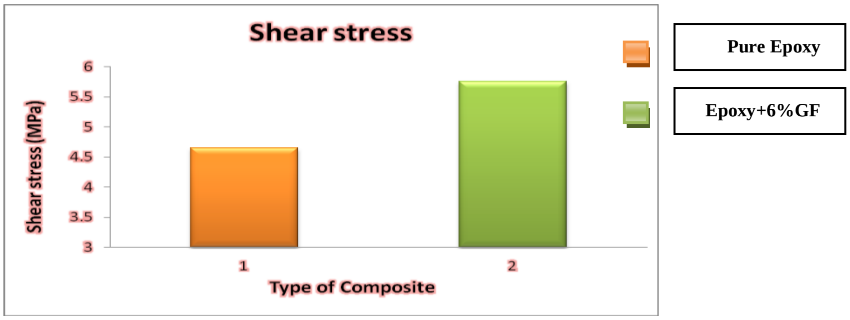


Fig.16: Shear stress of Epoxy +6% glass fiber composites and pure epoxy.

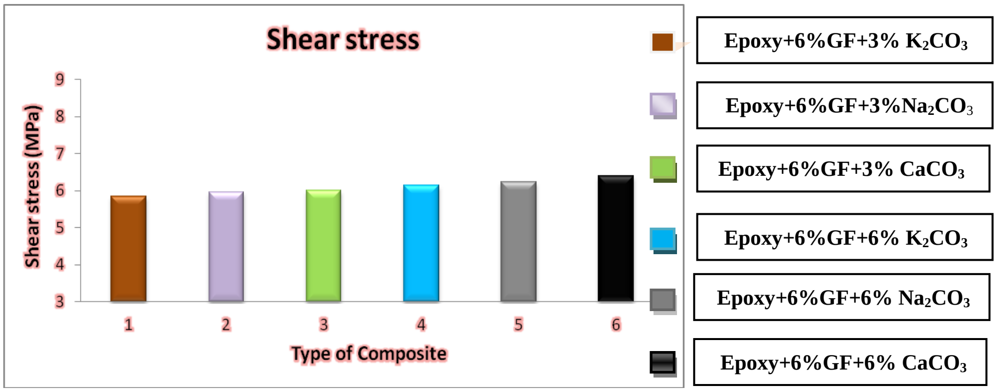


Fig.17: Shear stress of industrial composites.

Conclusions

1. Non –reinforced pure Epoxy has lower physical and mechanical properties than (epoxy+6%glass fiber) composites and Industrial composites.
2. The values of measured density are lower than that of the theoretical ones.

Industrial composite with 6% glass fiber and 6% Industrial powder have the higher density when compared with other composites. Industrial composite with epoxy +6% glass fiber +6% $CaCO_3$ has the maximum density of 1.320gm/cm^3 when compared with other composites.

3. The values of water absorption of specimen pure epoxy lower than specimen epoxy +6% glass fibers. Industrial composite with 6% glass fiber and 6% Industrial powder have the higher water absorption when compared with specimen pure epoxy and specimen epoxy +6% glass fibers composites. Industrial composite with epoxy +6% glass fibers +6% K_2CO_3 has the maximum water absorption of 0.268 %.
4. Result shows that the best hardness value was 83.5 shore D, Flexural strength (265MPa) and maximum Shear Stress (6.39MPa) at volume fraction of 6%glass fiber with 6% $CaCO_3$.

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