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Manufacturing and Studying The Mechanical Properties of Composite Materials reinforcing By Powders .Part I: Metallic

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***Abstract*— This paper presents experimental studying about manufacturing composite materials reinforcing by metallic powders. Manufacturing technical method based on lay-up for two methods that mixing and spraying technique. E-glass fiber type: EEMC chopped strand mat with (ISO 3374 g/m2) which were calculated by using product code with polyester resin which it was used in manufacturing of the composite materials while metallic powder was used metallic oxide Fe_2O_3 (hematite powder). All the manufacturing specimens were conducted to mechanical tests such as tensile test, Brill hardness test, impact test and bending test.**

Schematic diagram of fiber configurations of manufacturing laminate composite material of chopped strand mat of lay-up method with metallic of thicknesses design are ts=3.125mm,3.2mm at mixing and spraying technique respectively.

According to resulting, it can be observed that there is no clearly different between mixing and spraying technique of hematite powder Fe2O3 by the same type of fibre (E-glass/Chopped) where they were 81.12 MPa and 82.47MPa of mixing and spraying respectively. Also, it can be seen the failure strain were εf=69.5% and εf=70.51% of mixing and spraying respectively for tensile test. experimental results of hardness can be observed that there is slightly increased between mixing and spraying technique of hematite powder (Fe2O3) is H.B 32, 31 respectively. experimental results of toughness can be shown to be clearly increased for spraying than the mixing technique of the hematite powder (Fe2O3) values are 289.9J, 286.67J respectively. The pure bending stress of samples was observed to be increase with hematite powder (Fe2O3) 190.87MPa at spraying technique and 163.84MPa at mixing technique.

It has fund that composite materials reinforcing with metal powder have good mechanical properties usefully to repair defected metal pipes which are used in oil and gas industry with minimum effective cost and boats, ships, and tanks. Maximum tensile failure strength of Fe_2O_3 and strain ratio are 82.47MPa,70.51% at spraying technique. The maximum compression failure strength of Fe2O3 and strain ratio are 97.66MPa,4.62% at spraying technique. The maximum value of hardness was observed at mixing technique of (Fe_2O_3) 32 H.B. The maximum energy of fracture value was about 289.9J of Fe_2O_3 at spraying technique. The maximum flexible stress of Fe_2O_3 is 190.87MPa at spraying technique.

Keywords— ***composite materials; E-glass/chopped; metallic powders; lay-up technique; mixing method; spraying method; mechanical properties.***

I. Introduction

The study of mechanical properties is an important criterion in selecting materials and studying the behavior of materials and the effect of mechanical forces in different conditions, as it is of great importance to know the suitability of these properties in design and manufacturing **[1]**. The superimposed material is known in different ways and the simplest is the merging of two or more materials with different properties because the result of new properties is completely different from the basic components. Strong and rigid Composite materials can be divided into: **[2]** Natura natural such as wood and synthetic synthetic such as copolymers **[3]**.

Polymers are divided into: thermoplastic polymers such as nylon and thermosetting polymers such as unsaturated polyester resin **[4]**. Unsaturated polyester resin is widely used in industry because it has many good physical and mechanical properties, as it is characterized by its dimensional stability, good bonding ability with other materials, as well as its ease of formation (it does not need pressure and heat) and its low cost **[6,5]**.

Polymeric materials can increase their resistance against cracking by adding particles of certain materials, and fillers, which are called fillers. The nature of these particles, such as their size and concentration, are of great importance to the amount of durability acquired by the polymer **[7]**.

The polymeric material resulting from particle reinforcement is called particle reinforced composite material. Reinforcement occurs in these materials when the particles act as obstacles deforming the base material during loading, and these particles are usually in several forms, including spherical, scale, needle, or thread. These particles improve the mechanical properties of the base material **[8]**.

Fillings can be divided according to their effectiveness into the following sections **[9]**: Active fillers: They are the fillers that play a major role in strengthening elastic materials and rubber, and the addition of these effective fillers below the glass transition reduces fragility. Inactive fillers: These fillers are used to reduce the cost of the material and to improve polymeric products in terms of shape and size. These fillings work on a reasonable increase in volume, and thus the ratio of the filling to the material is very important. These fillings can be organic such as nylon and rayon, or inorganic such as glass and carbon.

In view of the light weight and good thermal and electrical insulation of the composite materials, the urgent need to use them in many fields, such as civil and military, has increased. The desired goal is to use it in many applications **[10-12]**.

Many scientific researches studies the effect of metal powders and particles on composite materials. **[13]** They prepared hybrid composite materials with a polymeric basis by hand lay-up method, and the composite materials were prepared from unsaturated polyester resin as a material supported by fiberglass matting type (E-GLASS) with a fixed volume fraction (10%) and minutes Graphite as a first group of samples and a second group of samples reinforced with Kevlar matting fibers 49 instead of glass fibers The research included studying the effect of the selected volume fraction (20%, 15%, 10%, 5%, 0%) for graphite particles with a mixture of different molecular sizes The range of 106 µm -25 µm on the properties of the prepared composite materials, a set of mechanical tests were conducted at room temperature, including tensile, compression, impact, flexural strength, shear stress and hardness. The hardness increases with the increase in the volume fraction of graphite particles, and the values of the modulus of compressive elasticity, flexural strength, and shear stress increase at low volume fractions of graphite particles for both samples of the two groups, while the values of impact resistance decrease with the increase in volume fraction of graphite particles. For both samples of the two groups, the results also showed that the values of tensile stress, tensile modulus of elasticity, modulus of compressive elasticity, impact resistance, and fracture strength were higher for the hybrid composite materials reinforced with graphite particles and Kevlar fibers than the values of their counterparts reinforced with glass fibers instead of Kevlar fibers, while it was observed that the compressive strength values The hardness, flexural strength, and shear stress are higher for the hybrid composite materials reinforced with glass fibers and graphite particles than the values of their counterparts reinforced with Kevlar fibers instead of glass fibers. **[14]** They studied the effect of adding alumina particles on the mechanical properties of a composite material based on unsaturated polyester reinforced with discontinuous glass fibers with three different weight fractions (wt 3, 5, 7%). Mechanical tests were carried out for the samples, such as impact, hardness and bending tests, and from the results it was found that the mechanical properties improved with the increase of the gravimetric fracture. The energy absorbed by fracture gave the best results for the samples reinforced with glass fibers and alumina particles compared with the samples reinforced with glass fibers only with the same weight fractions. **[15]** in this study, feather and copper powder were used to reinforce the polyester material to produce a composite material. Mechanical tests such as flexural strength and impact test were carried out for the polymeric material reinforced with feathers and copper powder, and it was found that the maximum bending resistance of the copper-reinforced polymeric material (powder and chip) is (85.13 Mpa) and (50.08 Mpa) respectively, while the highest energy absorbed in the impact test For the polymeric material reinforced with copper (powder and chip), it is (0.85 J) and (0.4 J), respectively. **[16]** in this research, they used titanium and alumina powders with different weight ratios to produce a superimposed material. Several mechanical tests were conducted, namely wear, impact, compressive strength and Brinell hardness test for unsaturated polyester reinforced with titanium and alumina powder with weight ratios (10, 15%). %, 5%, 0%), and the wear rate decreased by increasing the weight percentage of the reinforcing material, as it decreased from 28 to 8 g/cm and from 28 to 5 g/cm for polyester reinforced with alumina and titanium, respectively. The highest values of impact strength were recorded at 10% and were 14 and 12 KJ/m^2 for the models reinforced with titanium and alumina. Also, the compressive strength recorded the highest values at 10% by weight, and it was 229 MPa and 180 MPa for alumina and titanium, respectively. As for the hardness, it was found that its value increased with the increase of the weight percentage of the reinforcing particles, and it was the highest value at the strengthening percentage of 15% with a value of 15 and 12 HBN for each of the samples reinforced with titanium and alumina particles, respectively. The unsaturated polyester reinforced with alumina particles showed higher resistance to wear and compression, while the polyester reinforced with titanium particles gave higher impact resistance and hardness than those given by the models reinforced with alumina particles.

Recently, that some researchers are interested about this point.**[17]** were studied α-Al_2O_3 whisker reinforced Cu-graphite matrix composites were prepared by spark plasma sintering. Results showed that the surface modification of α-Al_2O_3 whiskers with sodium dodecyl sulfate solution can improve its dispersibility, and the composites obtained are basically completely dense. The composite with 1.0 wt% α-Al_2O_3 whisker has the best performance. By analyzing microstructure and fracture morphology of the composites, it is determined that the strengthening mechanisms are mainly fine grain strengthening, particle strengthening and load transfer. Simultaneously, the fracture type is brittle fracture. **[18]** were prepared the hybrid Metal Matrix Composites (MMC's) iron-based reinforced with 0, 1, 2, 3 and 4% volume fraction of constant mix (80% Al_2O_3 and 20% ZrO_2) by means of powder metallurgy and investigate the mechanical properties of these hybrid Composites. The best mechanical properties were obtained at (97% Fe + 3% (80% Al_2O_3 + 20% ZrO_2) among all reinforcement volume fractions and the composites has properties of 61%, 37% and 7% more than the matrix properties for compression strength, hardness HRC and radial crushing strength respectively.

In this paper is intended to introduce the composite manufacturing method for studying mechanical properties of type the E-glass/chopped. This needs to carry out experimental study to investigate the strength stress, hardness, toughness, and stress-strain characteristic for composite material. The experimental study will be based on manufacturing techniques by lay-up to prepare specimens. The composite manufacturing material will be fiber E-glass/chopped reinforced with metallic powder and polyester resin. All the manufacturing specimens will conducted to mechanical tests such as tensile test, Brill hardness test, impact test and bending test.

II. THEORETICAL SET-UP

A. Supply Manufacturing Materials

The manufacturing materials (Fiber E-glass) were supplied by Libya Glass(LG). Resin and hardener were produced from Libya Glass(LG) of Fiber glass and Chemical Industries and Trading. In addition, types E-glass were product code that chopped strand mat (EEMC 450-1000/1250/1270).

Powders as hematite (Fe2O3) were supplied from the Libyan Iron and steel Company (LISCO) and chemistry analysis as shown in Table I.

TABLE I Chemistry analysis of hematite powder

Fe-Metallic	Fe-Total	FeO	SiO2	CaO	Al_2O_3	MgO	P
13.91%	68.86%	0.86%	2.33%	0.79%	0.46%	0.58%	0.046%

B. Models of specimens

The Fig.1 shows a schematic diagram of fiber configurations of manufacturing laminate composite material of chopped strand mat of lay-up method with metallic powders of thicknesses design is $t_s = 3.125mm$ at mixing technique of metallic . Also, thicknesses design is $t_s = 3.2mm$ at spraying technique.

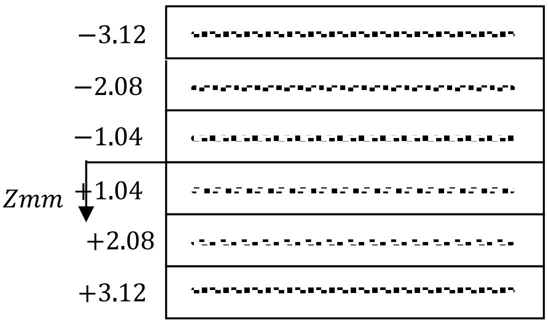

Fig.1-a

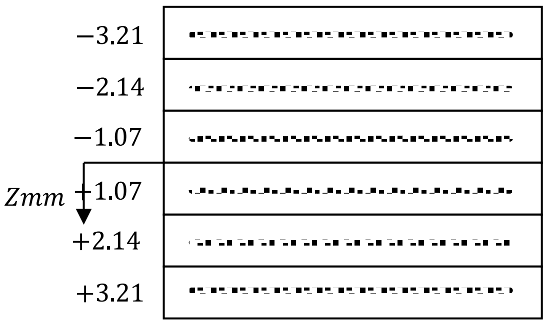

Fig.1-b

Fig. 1 Schematic diagram of chopped mat ply (symmetric).(a) Mix technique of metallic powder at $t_s = 3.125mm$.(b) Spraying technique of metallic powder at $t_s = 3.2mm$.

C. Composites Material and Powders Characterization

Table II illustrates that basic information about using materials as fibers, resins, and powders in order to manufacture. These are such as weights, cross areas, and quantities.

TABLE II Characterization of Using Materials.

Characterization	Fiber	Polyester	hematite (Fe_2O_3)
Cross area	$400mm \times 400mm$		$\leq 0.5mm$
weight	$70mg$	1076g	210g
Size		$800ml$	$100ml$
Ratio powders to polyester			19.5%

D. Tests Set-Up and Experimental Methods

1) Manufacturing of E-glass/polyester Composite Laminate

In order to determine the mechanical properties of the composite material which will be used to compare between two technique methods of powders (spraying and mixing), a quasi-isotropic composite laminate chopped mat with dimension of 400mm×400mm was fabricated using hand lay-up method **[19]**.

a) Manufacturing Composite Laminate by Spraying Technique

The **Fig 2** shows that starts scenario of hand lay- up method by preparing working table, then cutting the E-glass fiber to limited dimension with chopped mat fiber and putting a first layer on a smooth working table then wetting it by a polyester resin with spraying the powder is 20 ml at each lamina or ply during six plies of composite material that using a small roller to vacuum air as shown in **Fig.3** Cut the second layer of chopped mat fiber and put it on the first layer and wet it again by polyester resin with spraying the powder at the same quantity until all the resin impregnate in to the fiber. Repeat this procedure with six plies up to get the required thickness as shown in **Fig 3**. In the last layer make sure all the air voids are removed. Put a smooth sheet on the last layer and weight it by using a suitable balance. Leave the wetted laminate to cur e at room temperature for 1 to up five days. This mechanism was applied to hematite powders.

Fig.2-a Photograph of preparing working table

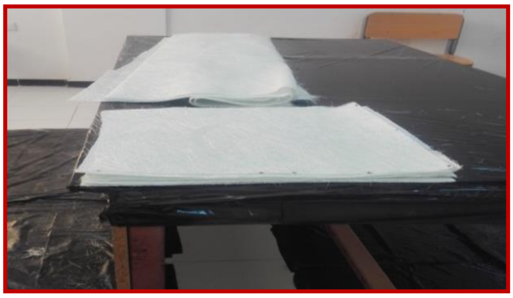

Fig.2-b Photograph of cutting the Copped/E-glass fiber to limited dimension

Fig.3-a

Fig.3-b

Fig.3-c

Fig.3-d

Fig.3 photographs the manufacturing steps of spraying technique .**(a)** mixing 800ml polyester with 8ml hardener. **(b)** mechanism spraying 20ml hematite Fe_2O_3 on lamina. **(c)** the small roller to remove air voids. **(d)** Leave the wetted laminate to cure at room temperature about five days.

b) Manufacturing Composite Laminate by Mixing Technique

Start scenarios of hand lay- up method by preparing working table, then cutting the E-glass fiber to limited dimension with chopped mat fiber and putting a first layer on a smooth working table as shown in **Fig.2** then wetting it by mixing 100 ml powders with polyester resin at each lamina or ply during six plies of composite material that using a small roller to vacuum air as shown in **Fig.4**. Cut the second layer of chopped mat fiber and put it on the first layer and wet it again by mix powder with polyester resin. Repeat this procedure with six plies up to get the required thickness as shown in **Fig. 4**. In the last layer make sure all the air voids are removed. Put a smooth sheet on the last layer and weight it by using a suitable balance. Leave the wetted laminate to cure at room temperature for 1 to up five days. This mechanism was applied to hematite powders.

Fig.4-a

Fig.4-b

Fig.4-c

Fig.4-d

Fig.4-e

Fig.4-f

Fig.4-g

Fig.4. photographs the manufacturing steps of mixing technique.**(a)** preparation quantity of polyester.**(b)** add the hematite powder into polyester.**(c)** mixing contents together for homogeneous.**(d)** putting mixing on fiber layer by lay-up method. **(e)** distribution resin reinforcing hematite powder on all laminas and remove air voids.**(f)** Leave the wetted laminate(mould)to cure at room temperature. **(g)** covering mould by sheet as general mechanism of manufacturing.

2) Determination of Tensile Strength for Composite Laminate

In order to determine the tensile strength of the composite laminate, fives samples were cut from the previous laminate according to the test method of composite laminate by **[20]** as illustrated in section **D-1**. The dimension of the specimen is shown in the **Fig.5**. Each specimen was equipped by small rectangular aluminium sheets at its ends for machine grips. The samples must be carefully aligned in test machine jaws to avoid induced sample bending. All samples geometrically similar (L=150mm, e=50mm, w=25mm, t=depend on method technique as illustrated in section **II-B** as shown in **Fig 6**.

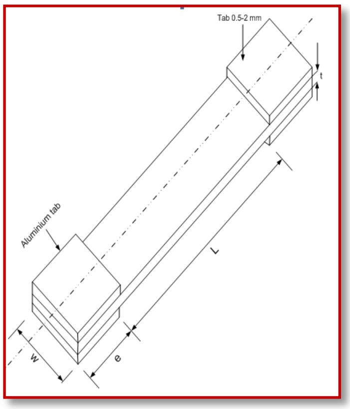

Fig.5 schematic diagram of tensile test specimen

Fig.6 photo of specimens the tensile test

The first step of the test is fixed the specimen into the test rig as shown in **Fig.7**and then the load increments uniformly by constant rate, then recording the load with strain data by load indicator and strain meter respectively, until failure.

Hence, the tensile strength for plain specimen is given by **[21]**:

$$S_T = \frac{P}{w \times t} \quad (1)$$

Where

e: Length of end tabs.
t: Measured thickness of specimen.
w: Measured width of specimen.
L : Free length.
P: Load at failure.
S_T: Tensile strength.

Fig.7 photo of specimen fixed in the rig

3) Determination of Hardness for the Composite Laminate

In order to determine the hardness of the composite laminate, five samples were cut from the previous laminate according to the test method of composite laminate by **[22]** as illustrated in Section **D-1**.The dimension of the chopped mat specimen is diameter $\emptyset 40\ mm$ with d d in section **II-B** as s

Fig.8 photo of specimens the hardness test

The first step the specimen is fixed into Rockwell's Hardness rig as shown in **Fig.9**. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale.

Fig. 9 photo of specimen fixed in the rig

4) Determination of Toughness for the Composite Laminate

In order to determine the toughness of the composite laminate, five samples were cut from the previous laminate according to the test method of composite laminate by **[22]** as illustrated in Section **D-1**. The dimension of the chopped mat specimen is $55\text{mm} \times 10\text{mm}$ with designing thickness as illustrated in section **II-B** as shown in the **Fig.10**.

Fig. 10 photos of specimens the toughness test.

The first step of the test specimen is fixed into Charpy machine the rig as shown in **Fig.11**. The Charpy impact test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of composite material reinforcing metallic powder toughness. The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of composite material. The energy transferred to composite material can be inferred by comparing the difference in the height of the hammer before and after the fracture (energy absorbed by the fracture event).

Fig. 11 photo of specimen fixed in the rig.

5) Determination of Bending for the Composite Laminate

In order to determine the toughness of the composite laminate, five samples were cut from the previous laminate according to the test method of composite laminate by **[22]** as illustrated in Section **D-1**. The dimension of the chopped mat specimen is $160\text{mm} \times 15\text{mm}$ with designing thickness as illustrated in section **II-B** as shown in the **Fig.12**.

Fig. 12 photos of specimens the bending test.

Bending tests are conducted by placing a length of material across a span and pushing down along the span to bend the material until failure. Bending tests reveal the elastic modulus of bending, flexural stress, and flexural strain of a material. 3-Point bending involves placing the material across a span supported on either ends of the material and bringing down a point source to the center of the span and bending the material until failure while recording applied force and crosshead displacement as shown in **Fig.13**. The 3-point description comes from the two points of support at the ends of the material and the one point of deflection brought down to the middle of the material.

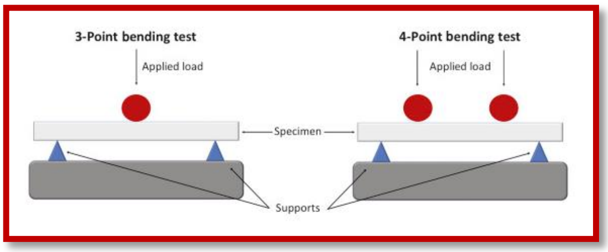

Fig. 13 photo of specimen fixed in the rig **[23]**.

Bending test was carried on composite material reinforcing metallic powders samples with a 400N load capacity in accordance with **ASTM D790 (2014)** standard. Load and deflections of the specimen at failure were recorded and equations **2** and **3** were used to determine the flexural strength and flexural modulus of the material.

$$\sigma_f = \frac{3PL}{2bt^2} \quad (2)$$

$$FM = \frac{PL^3}{4bt^2D} = E * t \quad (3)$$

Where:
σ_f = the Flexural strength in (MPa).
P = maximum force at failure (N).
t = thickness of the laminate (mm).
L= length of the laminate (mm).
D= Deflection of the laminate (mm).
E= yang module (MPa)
FM= Flexural Modulus (N/mm).

III. RESULTS AND DISCOUSION

A. *Experimental Resulting of Tensile Test*

Table III show the experimental modelled axial stress-strain test as described in section **D-2** for the quasi-isotropic composite laminate reinforcing hematite powder which was used to the manufacturing. It can be demonstrated that the experimental resulting at mixing and spraying technique of hematite powder (Fe_2O_3) are slightly increased to spraying technique of failure strength and strain, where they were $81.12\ MP_a$ and $82.47 MP_a$ of mixing and spraying respectively. Also, it can be seen the failure strain were $\varepsilon_f = 69.5\%$ and $\varepsilon_f = 70.51\%$ of mixing and spraying respectively. It can be observed that there is no clearly different between mixing and spraying technique of hematite powder Fe_2O_3 by the same type of fibre (E-glass/Chopped) which it is used during the manufacturing. While **Table IV** show the experimental resulting of compression test at mixing and spraying technique of hematite powder (Fe_2O_3) are clearly increased to spraying technique of failure strength, where they were $51.54\ MP_a$ and $97.66 MP_a$ of mixing and spraying respectively. Also, it can be seen the failure strain were $\varepsilon_f = 4.24\%$ and $\varepsilon_f = 4.62\%$ of mixing and spraying respectively. It can be observed that there is clearly different between mixing and spraying technique of hematite powder Fe_2O_3 by the same type of fibre (E-glass/Chopped).

TABLE III Experimental Resulting of Tensile Test

Composite Material (E-glass/Chopped mat) Reinforcing Powders	Spraying Technique			Mixing Technique		
	Failure Strength $S_f MP_a$	Failure Strain $\varepsilon\%$	Total thickness $t_T mm$	Failure Strength $S_f MP_a$	Failure strain $\varepsilon\%$	Total thickness $t_T mm$
Hematite Powder (Fe_2O_3)	82.47	70.51	6.4	81.12	69.5	6.25

TABLE IV Experimental Resulting of Compression Test

Composite Material (E-glass/Chopped mat) Reinforcing Powders	Spraying Technique			Mixing Technique		
	Failure Strength $S_f MP_a$	Failure Strain $\varepsilon\%$	Total thickness $t_T mm$	Failure Strength $S_f MP_a$	Failure strain $\varepsilon\%$	Total thickness $t_T mm$
Hematite Powder (Fe_2O_3)	97.66	4.62	6.4	51.54	4.24	6.25

B. *The Experimental Results of Hardness*

Table V shows the experimental results of hardness as described in section **D-3**. It can be observed that there is slightly increased between mixing and spraying technique of hematite powder (Fe_2O_3) is H.B 32, 31 respectively by the same type of fibre (E-glass/Chopped) which it is used during the manufacturing.

TABLE V Experimental Resulting of Hardness Test

Composite Material (E-glass/Chopped mat) Reinforcing Powders	Spraying Technique	Mixing Technique
	Hardness H.B	Hardness H.B
Hematite Powder (Fe_2O_3)	31	32

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C. The Experimental Results of Toughness

Table VI shows the experimental results of toughness as described in section **D-4**. It can be observed that increased energy value of hematite powder Fe_2O_3 of mixing and spraying technique. It can be shown to be clearly increased for spraying than the mixing technique of the hematite powder Fe_2O_3 values are $289.9J$, $286.67J$ respectively by the same type of fibre (E-glass/Chopped) which it is used during the manufacturing.

TABLE VI Experimental Resulting of Toughness Test

Composite Material (E-glass/Chopped mat) Reinforcing Powders	Spraying Technique	Mixing Technique
	Energy of Fracture E(J)	Energy of Fracture $E(J)$
Hematite Powder (Fe2O3)	289.9	286.67

D. The Experimental Results of Pure Bending Stress

Table VII shows the experimental results of bending as described in section **D-5**. The pure bending stress of samples was observed to be increase with hematite powder Fe_2O_3 $190.87MP_a$ at spraying technique. While it can showed to decreased with hematite powder Fe_2O_3 $163.84MP_a$ at mixing technique.

TABLE I Experimental Resulting of Bending Test

Composite Material (E-glass/Chopped mat) Reinforcing Powders	Spraying Technique					Mixing Technique				
	σ_f MPa	FM N/mm	P N	b mm	S mm	σ_f MPa	FM N/mm	P N	b mm	S mm
Hematite Powder (Fe_2O_3)	190.8	N/A	430	13.2	9.35	163.84	N/A	400	15	7.047

E. Failure Mode

Two modes of failure were observed namely; the fiber breakage mode and delamination mode. The fiber breakage mode was exhibited by most of tensile specimens. **Fig. 14** show photograph of tested specimens. Tensile test was carried out on manufacturing specimens with chopped mat of mixing and spraying technique. It was observed that the entire specimens failed by fiber breakage mode near its ends and also specimens in its centre of one mixing and spraying .

The delamination mode is illustrated in **Fig.15**. It was observed that the specimens failed at chopped mat of mixing and spraying technique to impact test.

Fig. 14 photograph of failed specimens by tensile test.

Fig. 15 photograph of failed specimens by impact test.

IV. Conclusion

- The study showed that, composite materials reinforcing with metal powder have good mechanical properties usefully to repair defected metal pipes which are used in oil and gas industry with minimum effective cost and boats, ships, and tanks.
- Maximum tensile failure strength of Fe_2O_3 and strain ratio are $82.47MPa, 70.51\%$ at spraying technique.
- The maximum compression failure strength of Fe_2O_3 and strain ratio are $97.66MPa, 4.62\%$ at spraying technique.
- The maximum value of hardness was observed at mixing technique of Fe_2O_3 32 H.B.
- The maximum energy of fracture value was about 289.9J of Fe_2O_3 at spraying technique.
- The maximum flexible stress of Fe_2O_3 is $190.87MPa$ at spraying technique.
- Fibre breakage and delamination were observed in failed specimens.

Future Work

we are going to continuous this work about " Manufacturing and Studying The Mechanical Properties of Composite Materials reinforcing By Powders .Part II: ceramic" after publishing this work for comparing with part II.

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