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Investigation of Mechanical Properties of Slag Reinforced Polymer Composites

Tirumala Krishna.M[1], Dr. Mahesh Mallampati[2], Dr. Bejagam Naga Raju[3]
[1]*(Asst Professor ,Dept of Mechanical Engineering, Guntur Engineering College, Yanamadala, Guntur, AP)*
[2]*(Asso Professor&HOD ,Dept of Mechanical Engineering, Guntur Engineering College, Yanamadala, Guntur, AP)*
[3]*(Asso Professor, Dept of Mechanical Engineering, St.Mary's Integrated Campus, Hyderabad, Telangana)*

Abstract: *Most basic and common attractive features of composites that make them useful for industrial applications are low cost, low weight, high specific modulus; renewability and biodegradability .Huge amount of minerals are released from the industries as waste materials which cause serious environmental problems. By appropriate usage of these industrial waste physical and mechanical properties of the conventional polymer materials will be enhanced*
The objective of present work is to use this industrial waste i.e. Slag as particulate filler material to the epoxy and polyester matrix composites by molding technique with different weight fractions 0%, 5%,10%, 15%, 20% to study the mechanical behavior of reinforced polymer composite material. The percentage weight of slag for different specimens are calculated under different tests like, tensile, bending and impact for obtaining the result. The conclusion helps us to predict the mechanical behavior of various constituents of Slag had resulted in better mechanical properties. The composite can be regarded as a useful light weight engineering material. And also the manufacturing cost of the composite can be reduced considerably by adding Slag as fillers to the matrix. Future work will investigate the methods for improving the mechanical properties further.
Keywords: *Iron wastage (Reinforced Slag), Unsaturated polyester and Epoxy resin, Mechanical Properties, Tensile Strength, Tensile Modulus, Flexural strength, Flexural modulus, Impact Strength.*

I. Introduction

Previous studies have shown that it is possible to use waste dust from power industry as filler in polymer composite materials based on thermo setting polymers as unsaturated polyesters and epoxy resins. However, it was found that the waste impacts negatively some strength characteristics of the resultant composites, most probably because of poor adhesion on the “polymer/filler” interface borderlinez [1]. To improve the strength characteristics of composites is through polymer matrix modifying. It is well known that a large part of thermosetting polymers, like polyester and epoxy resins, have been widely used for polymer composites containing disperse and/or fibrous additives. Many of these composites have been applied as construction materials in the building, automotive and other industrial activities. Unsaturated polyester resin (UPR) has been used as a polymer matrix in compositions. The use of UPR in composite materials is limited by its brittleness and relatively high volume shrinkage [2]

Composite materials: Composite materials are engineering materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure.

II. Classification

(a) Metal Matrix Composites (MMC):
Metal Matrix Composites are composed of a metallic matrix (aluminum, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.
(b) Ceramic Matrix Composites (CMC) : Ceramic Matrix Composites are composed of a ceramic matrix and embedded fibers of other ceramic material (dispersed phase).
(c) Polymer Matrix Composites (PMC): Polymer Matrix Composites are composed of a matrix from thermo set *(*Unsaturated Polyester (UP), Epoxy (EP)*)* or thermoplastic *(*Polycarbonate (PC), Polyvinylchloride, Nylon, Polystyrene) and embedded glass, carbon, steel or Kevlar fibers dispersed phase thin the finished structure.

Details of Experimental:
The specimens prepared are subjected to 3 types of tests
1) Tensile test – Uni axial tensile test
2) Bending test – 3-point flexural test
3) Impact test – V- notched impact test

Fig1. Composites before testing

III. Tensile Test

Equipment for Tensile Test:

A 2 ton capacity - Electronic tenso meter, METM 2000 ER-I model (Plate II-18), supplied by M/S Microtech, Pune, is used to find the tensile strength of composites. Its capacity can be changed by load cells of 20Kg, 200Kg & 2000 Kg. A load cell of 200 Kg. is used for testing composites. Self-aligned quick grip chuck is used to hold composite specimens. A digital micrometer is used to measure the thickness and width of composites.

Testing Procedure:

The electronic tenso meter is fitted with load and extension indicators, which has a least count of0.01 kg and 0.01 mm, respectively. The tenso meter is fitted with a fixed self-aligned quick grip chuck and other movable self aligned quick grip chuck to accommodate the specimen. The specimen was held in fixed grip and the movable grip is manually moved until the specimen is held firmly without slackness. At that instant, the deflection meter is adjusted to read zero, when the load on the specimen is zero. The speed reduction pulleys are chosen such that a crosshead speed of 2mm/min. is applied on movable grip. Then the electric motor fitted to tenso meter is started. Starting from zero, at every 0.2 mm extension the load indicated is noted until the specimen breaks. At the end of the test, the final load and deflection are also noted from the electronic indicator display. For each specimen the type of failure and any other such observations pertaining to failure are noted. The tests are conducted at 28^0 c and 50 % relative humidity in the laboratory atmosphere. Five identical specimens are tested for each slag content in the specimen. The rate of loading is selected such that the testing time of each specimen varied between 2 to 5 minutes.

IV. Bending Test:

The bending test is conducted on the specimen using the same machine

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular across section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress.

Testing procedure:-
(a) The specimen is placed such that the supports at 15 mm from both the end of the specimen.
(b) Load is applied at the centre of the specimen.
(c) By increasing the load the deflection at centre is note down.

V. Impact Test

An analog Izod/charpy Impact tester supplied by M/S International Equipments, Mumbai (photo), was used to test the Impact properties of fiber Reinforced composite specimen. The Equipment has four working ranges of impact strength and are 0-2.71 J.0-5.42 J,0-10.84 J and 0-21.68 J, with a minimum resolution on each scale of 0.02 J, 0.05 J, 0.1 J and 0.2 J respectively .Four scales and corresponding hammers (R1,R2,R3,R4) are provided for all the above working ranges.

TESTING PROCEDURE:

(a) The specimen is placed b/w the two grippers of the machine.
(b) At the centre of the specimen" V "groove is provided with an angle of 45°.
(c) After placing the specimen in position the pendulum is released from the top portion of the machine with high force.
(d) The specimen breaks into two pieces and the reading is noted.

VI. Results And Discussion

Tensile Strength Vs % Weight of Slag for Epoxy and Polyester

The tensile strength versus percentage weight of Slag is shown in the fig . There is an increase in the graph which reached a maximum value at 20 %. The value of tensile strength at 5% weight of particulate for epoxy is 34.16 MP and for polyester is 31.14MPa there is an increase in the tensile strength at 10% weight of particulate to a value of 26.66MPa as comparing with polyester value of 34.37Mpa. The increment in the tensile strength has later increased at 15 % weight of particulate to an amount of 37.946MPa.Thae tensile strength at 20% weight of particulate to an amount of 30.16Mpa.

Tensile Modulus Vs % Weight of Slag for Epoxy and Polyester

The tensile modulus reached maximum value at 15% and minimum value at 5%. The value of tensile modulus of epoxy at 15% weight of Slag is 790 MPa. and that of polyester is410MPa. The tensile modulus value Decreased at 5% weight of Slag to a value of 427MPa and for polyester is 556 Mpa. There is again an increase in the value 10% weight of Slag to a value of 554.41 MPa.

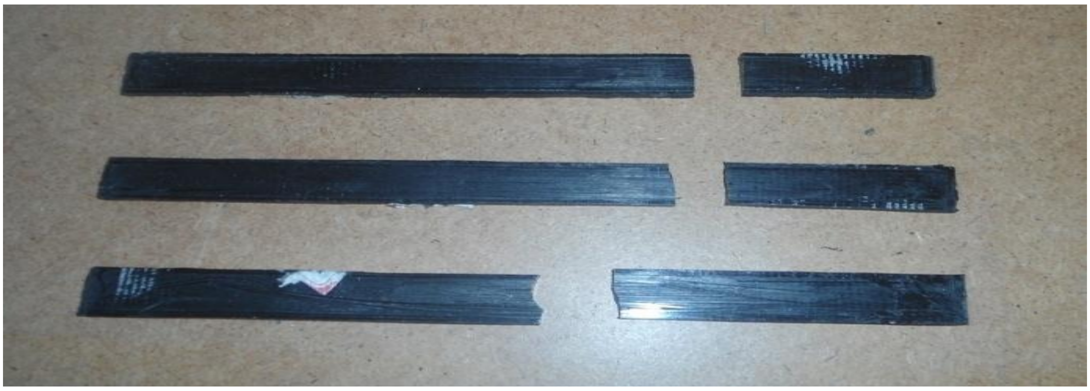

Fig- composites after tensile test

Flexural Strength Vs % Wt of Slag for Epoxy and Polyester

The flexural strength reached a maximum value at 15%. The flexural strength at 15% weight of slag for epoxy is 86.8 MPa and for polyester 93.39 Mpa . The flexural strength minimum at 10% weight of slag is 50.49 Mpa. And for polyster 76.86MPa

Flexural Modulus Vs % Weight of Slag for Epoxy and Polyester

The flexural modulus versus percentage weight of Slag is shown in the figure. The flexural modulus is maximum at 20% i.e. 1275 MPa for epoxy and less for polyester at 20% i.e 76.22MPa. The flexural modulus is minimum at 10% that is 665.54MPa and for polyster 224.54MPa.

Fig -composites after bending test

Fig composites after impact test

Impact Strength Vs %Weight of Slag for Epoxy and Polyester

The impact strength decreased gradually to 10%. The impact strength at 20% weight of Slag for epoxy is 0.0022Nm/mm^2.and for polyester is 0.0052 Nm/mm^2. The impact strength is 0.002Nm/mm^2 at 10%.

VI. Conclusions

The main objective of this investigation is to gauge the possibility of industrial waste i.e. slag is an alternative filler material in a polymer matrix. Following conclusion are made from the investigation

- ➢ The Tensile strength of slag for epoxy resin is 37.94MPa % is higher than compared to the value of polyester.
- ➢ The Tensile Modulus of Slag for epoxy resin at 15 % is 790 Mpa is less than compared to the polyester is 410 Mpa.
- ➢ Flexural strength of pure resin is 146.03 Mpa for epoxy is higher than compare to the value of polyester is 86.43 Mpa.
- ➢ The flexural modulus is maximum at 20 % is 1275 Mpa.
- ➢ The impact strength of the pure specimens 0.0017 Nm/mm^2 at epoxy is less than that of polyester is 0.022 Nm/mm^2.The value is increased by mixing the percentage of slag .The impact strength is maximum at 20 % is 0.0076 Nm/mm^2.

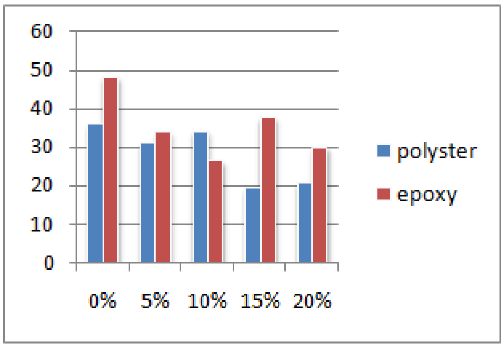

Fig2 tensile strength

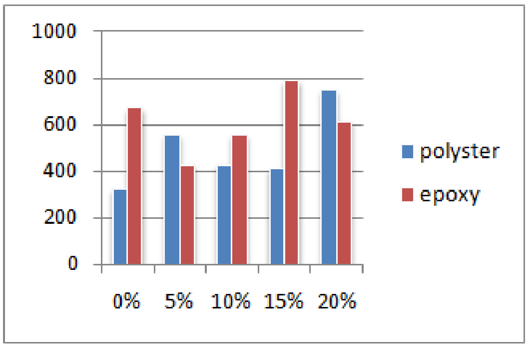

Fig3 tensile modulus

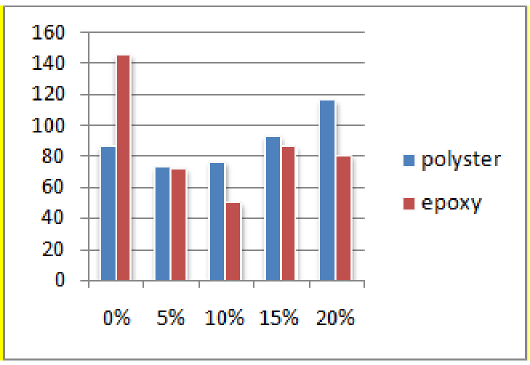

Fig4 flexural strength

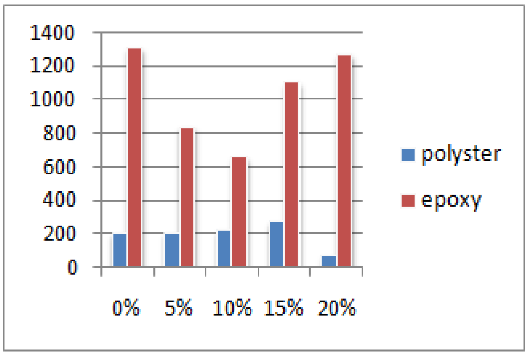

Fig5 flexural modulus

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Tirumala Krishna.M   Dr Mahesh Mallampati   Dr Bejagam Naga Raju