Mechanical Properties of Polyester Matrix Composites
Reinforced with Waste Marble Particles

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Abstract. In this study a preparation of composite materials with a polyester base reinforced by low cost industrial waste and weight fraction from of powder (1,3,5,7,9) % wt of marble particles prepared by manually technique. Mechanical properties have been studied and discussed. The results showed that the new composite materials supported by marble particle gave high results in resistance to hardness, bending and tensile strength compared to the based matrix. This is due to the presence of marble particle, which reduces the concentration of stresses of the base material, and as a result reduces the growth of cracks on the base material. Therefore, the mechanical properties increase with adding of the reinforced particles.

Keywords: Polyester resin, marble particle, mechanical properties, composite.

1. Introduction
Composite material is formed by combining two or more materials together which were combined physical interaction and do not react chemically [1]. The constituents are combined in such a way that they keep their individual physical phases and do not form a new chemical compound [1]. That is why a composite is considered to be any multiphase material systems that exhibit greater properties of composite than both of constituent phase [2]. This criterion has motivated the researchers to develop the composite materials over all the world. Composites involve of two phases, which is called reinforcement, embedded in continuous phase, which is called matrix. The boundaries between the two phases are called interface. There are three major types of composite materials which are metallic, polymeric or can even be ceramic [3,4]. Polymers are considered one of the most important challenges
by adding a quantity of filler with different weights. Adding particles of filling material improves the performance of the overlapping material in industrial and structural applications and gives good properties. The most important goal of the new is to recycle waste, so in this research, marble powders were used as a filling material in polyester [5,6]. Borsellino et.al. [7] concluded the effect of composite materials reinforced with marble powder by various weight fractions on the many properties for the composite with different matrix materials (epoxy and polyester resins). It was concluded that adding marble powder by 60% to epoxy gives superior properties of the material. Raffi Mohammed et al. [8] studied the effect of adding marble powder as a filler material to the epoxy on mechanical properties such as tensile strength, young modulus, compression strength and impact strength of the composites. All these properties of the composite with 5% of marble powder were the best among all of composites. Husaini et al, [9] determined the tensile and hardness strength which consisting of resin and marble powder in order to obtain the highest values of the compositions of the composite material. High mechanical properties were obtained from yield strength, modulus of elasticity and hardness. The best compositions values for the composites were 60/40 and 70/30. Subhrajit Ray et al., [10] investigated the materials with superior properties of importance were used in the industrial use of superimposed polymeric based materials reinforced by waste of industrial materials in its place of ceramic materials which were highly cost. Where used glass fiber epoxy with different weight content of marble powder. It was observed that the mechanical properties of hybrid composites have been enhanced compared using the non-reinforced material.

The aim of the current study to estimate the using of recycled materials which are waste marble particles as a filler in the polyester. This is for the purpose of improving mechanical properties and obtaining the best percentage of marble particles addition to the composite material with different weight fraction.

2. Materials and procedures

2.1 Material and Equipment:

2.1.1 Materials

Unsaturated polyester resin (UPR) used as the matrix. The resin is a liquid transparently viscosity which is hardened in thermally at room temperature called (Thermoset) polymer. In table 1. illustrations the specifications of polyester resin.

| Density (gm/cm³) | Tensile strength (MPa) | Thermal conductivity (w/m.c) |
|------------------|------------------------|----------------------------|
| 1.225            | 70.3-103               | 0.17                       |

Marble powders are added to polyester resin as reinforced materials. The waste marble powders were collected from different processing such as (shaping and polishing), then the powders sieving by a fine sieve. Fig. (1) shows the marble powders which are using.
2.1.2 SEM and EDS of Marble Powder

Figure 2) shows the SEM marble wastes were grinded in the mill and then sieving. polyester matrix was combined with marble wastes at different weight fraction.

The EDS analysis was used for detecting the element composition of the marble waste powder, which X-ray spectra are existing by energy in keV on the x-axis and the number of counts on the y-axis as observed in figure (3).
2.1.3 Composite preparation

The test specimen preparation by using unsaturated polyester resin reinforced with different weight percentages (1,3,5,7,9) % of the marble powder unsaturated polyester resin. The materials were mixed at room temperature gradually for voiding bubbly in mixture with adding the hardener material. Then all the mixture was pouring in the mold.

The mold used in the research is made of cast iron, as shown in the figure (4). The mixture was lifting in the mold for (24) hours at room temperature to cure.

2.2 Impact Test:

For polymeric impact testing were used Izod test. This test is performed according to (ISO-180) and the standard sample is shown in (Fig. 5) at room temperature.
2.3 Hardness Test

Shor hardness test was done agreeing to (ASTM D 2240) at room temperature. Figure (6) shows a standard sample for hardness test. Seven measurements of hardness were made at different positions the specimens to determine the average value.

![Figure 5. Samples of Impact test](image)

**Figure 5.** Samples of Impact test

![Figure 6. Hardness test specimen.](image)

**Figure 6.** Hardness test specimen.

2.4 Flexural (Bending) Strength Test:

The bending strength performs for characterization of a fundamental constituent which exposed a perpendicular loading for the axis section. Bending strength signifies the fracture and were used the three-point test (ASTM D790). In (Fig. 7) demonstrations bending strength test.
3. Results and Discussion

3.1 Impact Strength

Impact strength were increased by increasing weight faction of marble powders as shown in figure (8). This is due to the fact that the quantity of powder was good distribution within the matrix, which that lead good interface and reinforcement [8].

3.2 Micro Hardness

From figure 9 it can be notice from the hardness examination the effect of adding marble powder to the polyester. The addition of 9% of marble powder had been shown a maximum hardness of 0.38 HV among the all of the composites. This is due to the absence of voids and pores which were increased the hardness value [11].
3.3 Tensile strength
The results of the tensile test shown in Figure 10. The marble powder additives that were increased the tensile strength value compared to the polyester matrix. As a result, resistance to interfacial bond increased between marble powder and polyester matrix. As the marble powders were reduced of the stress concentration the base material during the load tensile test. As a result, the tensile strength increased by increasing the weight fraction of the marble powders due to good interface between marble and matrix. So indicates lower porosity in composite structures.
4. Conclusions
1- The impact energy for the prepared composite materials were increased by increasing the weight fraction of marble powders. The optimum value of marble powders was at 9% wt.
2- The hardness of composite material increases with increase in weight fraction percentage of Marble (hardness and impact).
3- The prepared composite was improving mechanical properties by using (9% wt.) of marble powder.
4- The use of recycled marble powder has been assignment effect in improving the mechanical properties of the polyester.

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