Investigations on Mechanical Properties of Basalt Powder filled Vinyl Ester Composites

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Abstract The current research work deals with the addition of basalt powder on the characteristics of vinyl ester resin composites. The vinyl ester was modified by basalt powder in the amount of 5%, 10% and 15% by weight. The impact of basalt powder on the performance, such as tensile strength and flexural strength was analyzed. The consequence of powder addition on the impact strength of the fabricated materials was also examined. From the results obtained the basalt powder has an encouraging outcome on the strength of the fabricated composites.

1. Introduction
The characteristics such as good strength, easily available, easy to manufacture makes composites as a popular material in the field of Engineering. Since it is success in the field of aerospace, it became widely used in domestic, marine, structural, electronics and almost all emerging areas [1-22]. Also, the wonderful characteristics of composites such as lightweight, low economic and its stiffness properties suggest its suitability in replacing the conservative existing materials [23-46]. Danuta Matykiewicz et al. [47] proved that basalt powder can be effectively utilized as a receptive modifier for the epoxy resin. They suggested that the structure of this powder may be changed by its constructive interface with existing matrices. Abusahmin et al. [48] improved the characteristics of abrasion resistance of polyester by the addition of basalt powder. They evaluated the consequence of impact properties of flax fibre with basalt powder reinforced polyester composites [49]. Barczewski et al. [50] investigated the influence of the basalt powder content on the thermo-mechanical stability of novel polypropylene-based composite materials measured in static and vibrant test conditions.
Basalt powder is considered as low-cost waste filler because high quantities of this material are created during the crushing of basalt rocks. Since no separate manufacturing routes are not required. Very few papers are published as basalt powder as filler in the polymer composites. The wear resistance capability of basalt powder made successful in polyethylene [51] and polyester [52] resin. Mentioned characteristics of basalt powder make them a suitable substitute for the existing filler. Thus, the basalt powder is the best option as filler for many industrial fields and different applications of this powder have been extensively studied [53-55]. In most of the articles, the basalt powder was efficiently used in both thermosetting and thermoplastic resin. But the improvement of the performance of vinyl ester resin by the addition of basalt powder has not been covered yet.

The aim of the present work is to examine the outlook of adopting basalt powder as filler in a vinyl ester matrix. These powders, if put to correct weight ratio, will definitely add to the growth of the mechanical properties and will open up new avenues.

2. Materials and methodology

The vinyl ester resin (4508) having a density of 1.11-1.21 g/cm3 and modulus 2.6–4 MPa was used as the matrix material. Methyl ethyl ketone peroxide (MEKP), cobalt naphthenate and N, N-dimethyl aniline were used as catalyst, accelerator and promoter, respectively. These are added to increase the curing process of the composites. Basalt powder of approximately 50-60 microns was purchased from go green products- Chennai.

2.1 Manufacturing technique

Among the different composite manufacturing process hand layup method was used for the preparation of basalt powder-filled composites. Addition of basalt powder was mixed vinyl ester resin and mechanically stirred to spread the powder throughout the resin. Then the hardener was added in the resin to facilitate the curing process. The resin/hardener mixture was taken in the ratio of 10:1 as suggested by suppliers. Similarly, powder was added for another remaining two weight percentage of basalt powder. In order to spread the powder to all the areas of resin, the plate was compressed using compression moulding machine during curing.

2.2 Mechanical tests

The mechanical properties such as tensile strength, Young’s modulus and percentage strain were determined on an Instron universal testing machine (UTM, UK). The test was conducted at a crosshead speed of 10 mm/min. The UTM was fitted with a load cell for measuring the load applied on the specimen. The computer recorded the load and corresponding deflection. The tension specimens were prepared as per ASTM standard. The load and corresponding deflection until the failure of the specimen were recorded. The tensile strength and the tensile modulus were computed.

3. Results And discussion

Figure 1 displays the effect of tensile strength due to basalt powder filled in composites. The tensile strength of unfilled VE resin is 42 MPa and the value gradually increases to 125, 144, and 139 MPa upon addition of 5, 10, and 15 wt.% basalt in the VE matrix. Upon further increase in the reinforcement of basalt to 15 and 20 wt.% in the VE matrix, the tensile strength decreases to 139 and 108 MPa, respectively. However, the impact of basalt filler addition is significant up to 10 wt. %. The tensile strength of the composites increases up to 10wt% powder loading. The performance of the composites was attained when the filler weight ratio attains to 10 wt%. The tensile strength of filled composites increases up to 15%. The further addition of powder does not cause any noteworthy improvement in tensile strength. The output result of tensile strength is similar to the result of mechanical characteristics of chopped basalt fibre reinforced poly (butylene terephthalate) composites.
Figure 1. Effect of basalt powder in tensile strength

Figure 2 displays the effect of flexural strength due to basalt powder filled in composites. As expected, the flexural strength was not influenced considerably by the existence of little quantity of fillers because the stress field of the bulk material occurs only in the immediate neighbourhood of the fillers. Since the stresses in the composite are nearby exaggerated by the occurrence of the filler, it may be imagined that the composite breakdown by first breaking at the highly stressed regions and rapidly increase the voids with the help of the additional stresses persuaded by the diminution of the cross-sectional area. Hence there was no significant improvement occurred in the case of flexural strength of filled composites. This might be due to the loose cumulative of fillers which begin to form in the composite as the filler percentage was amplified.
Figure 3 displays the effect of impact strength due to basalt powder filled in composites. From the tested composites, the impacted area is not easily noticeable unless the impact energy is very close to penetration. However, basalt powder resists the impact load acting on it and increases with the increase in weight percentage. Based on the test results, the improvement of the properties are due to the presence of additional plasticizing properties of the basalt powder. A similar result has also obtained by Dobiszewska et al. [56].

![Figure 3. Effect of basalt powder in impact strength](image)

### 4. Conclusions

In this work, the effects of basalt powder at different weight percentage on tensile, flexural and impact characteristics of composites were analysed. Based on the output of the tensile test outcomes, basalt powder confirmed its reinforcing outcome when the filler weight percentage reached to 10wt%. The flexural strength increased as the basalt powder enhance up to 10wt% in the resin. The impact strength of the filled composites increases by the increased amount of weight percentage.

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