Effect of Silicon Dioxide (Sio2) On Physical and Mechanical Properties of Vinyl Ester Composite

Gurkirat Singh[1], N.K Batra[2], Ramesh Chand[3]
[1] Research Scholar, Mechanical Engineering Department, M.M University, Mullana, India
[2] Mechanical Engineering Department, M.M University, Mullana, India
[3] Mechanical Engineering Department, M.M University, Mullana, India

Abstract - The effect of addition of silicon dioxide (SiO_2) filler in different weight percentages on physical properties, mechanical properties, of aramid fiber-reinforced vinyl ester composites has been investigated. Physical and mechanical properties, i.e., hardness, tensile strength, and flexural strength, are determined with the change in filler content to notice the behavior of composite material subjected to loading..The results show that the physical and mechanical properties of SiO_2-filled aramid fiber-reinforced vinyl ester composites are better than unfilled aramid fiber-reinforced vinyl composite. Whereas adding too much (more than 20 wt. %) SiO_2 content results in decrease of hardness, tensile strength and flexural strength of the composite.

Keywords: physical and mechanical properties, vinyl ester, aramid fiber, silicon dioxide.

1. INTRODUCTION

These days' polymer composite materials are gaining more importance because of their significantly different physical and chemical properties. These qualities make composite material unique from individual components as these composites are formed by combining materials together to form an overall structure that is better than the sum of the individual component. The materials provide excellent mechanical and tribological properties combined with the low specific weight and high resistance to degradation in order to ensure safety and reliability. The composite material may be preferred for many reasons over individual components; common examples include materials are stronger, lighter or less expensive compared to traditional materials. A number of these applications are tribological components such as gears, cams, bearings and seals, where the self-lubrication of polymers is of special advantage [1-3]. One of the features that make polymer composites so promising in industrial applications is the possibility of tailoring their properties with special fillers.

Vinyl ester resins were first introduced commercially in early 1960's [4]. Today they are one of the most important Thermo settings Materials. Vinyl ester resins have been widely recognized as materials with excellent resistance to a wide variety of commonly encountered chemical environments. Vinyl ester resins are used to fabricate a variety of reinforced structures [5-8] including pipes, tanks, scrubber and ducts. They are the prime candidates for use in composite for transportation and/or infrastructure. Vinyl ester is a hybrid form of polyester resin which has been toughened with epoxy molecules within the
main molecular structure. Vinyl ester resins offer better resistance.

Aramid fibers are a class of heat-resistant and strong synthetic fibers. They are used in aerospace and military applications, for ballistic rated body armor fabric and ballistic composites, in bicycle tires, and as an asbestos substitute [9-10]. The name is a portmanteau of "aromatic polyamide" . They are fibers in which the molecules are highly oriented along the fibers axis, so the strength of the chemical bond can be exploited.

Silicon dioxide, also known as silica (from the Latin ilex), is a chemical compound that is a dioxide of silicon with the chemical formula SiO_2. Silica is most commonly find in nature a quartz, a well as in various living organism , silica is one of the most complex , and most abundant families of materials , existing both as several minerals and being produced synthetically[11-15]. Notable example includes fused quartz, crystal, fumed silica, silica, and aerogels. Applications range from structural materials to microelectronics to components used in the food industry. Silicon dioxide is obtained by mining and purification of the resulting mineral. Quartz comprises more than 10% by mass of the earth's crust. It I also produced, almost always via the processing of quartz, synthetically on very large scale [15-19]. The present investigation is to check the effect of silicon di- oxide in vinyl ester reinforced aramid fibre composite.

II. EXPERIMENTAL DETAILS

A. Material

In this investigation effect of silica powder on vinyl ester aramid fiber reinforced composite has been studied. The vinyl ester resin is supplied by Northern Polymer Pvt. Ltd. New Delhi. Aramid fiber has been used as reinforcing material in vinyl ester composites. The filler material used in this study is silicon dioxide (SiO_2) with different weight percentages (0wt%, 5wt%, 10wt%, 20wt% and 30wt %) .

B. Composite fabrication

In present investigation composite material is fabricated by hand layup technique. Two layers of aramid fibre is cut in to 250*250 mm was used for the preparation of specimen. A measured volume of vinyl ester is taken and hardener is mixed in the ratio of 20:1 and silicon dioxide is added in different percentage ranges from 0-30%. Firstly the acetone is sprayed on the inner side of mould to avoid the bonding of mould and material. Pour the required amount of mixture in to mould. Wait for the mixture to settle down and put a layer of aramid fibre again pour the measured amount of mixture and repeat the procedure till we get two layers of aramid fibre in between three layers of the mixture. Then leave the mould for drying at least for one day to get perfect samples. After the mould is completely dried, the composite material was taken out of mould and rough edges were nearly cut and removed as per ASTM standards.

Sr. No	Nomenclature of sample	Area mm2	Tensile Strength (KN/mm^2)	% Elongation	Flexural Strength (KN/mm^2)	Density Kg/m3 (10^{-3})	Hardness Shore 'D'
1.	Vinyl ester + Aramid 0% silica	109.95	0.02	0.45	0.010	6.49	46
2.	Vinyl ester + Aramid 10% silica	137.99	0.03	0.71	0.011	10.90	56
3.	Vinyl ester + Aramid 20% silica	164.74	0.06	2.00	0.013	7.168	58
4.	Vinyl ester + Aramid 30% silica	167.52	0.04	1.06	0.010	6.395	48

RESULT AND DISCUSSION

The addition of any filler material in a composite had a great effect on mechanical properties[ ]. In present study comparison of unfilled composite against filled composite with different wt. % of filler material has been studied. Various tests to calculate the mechanical properties i.e. tensile strength, flexural strength, hardness, % Elongation have been performed. The result in detail has been discussed as follows:

Effect on tensile strength

The term tensile strength refers to the amount of tensile (stretching) stress a material can withstand before breaking or failing. Figure 2 shows the graph of tensile strength versus SiO_2-filled aramid fiber-reinforced vinyl ester composite. Tensile strength increases from 0.02 KN/mm^2 to 0.06 KN/mm^{2}by adding SiO2 content from 0 to 20 wt. % .whereas further increase in SiO2 content results in decrease in the value of tensile strength .This is because filler particles act as a barrier in transferring stress from one point to another, and an increase in SiO2 content beyond 20 wt. % results in the increase of transfer of stresses from one point to another.

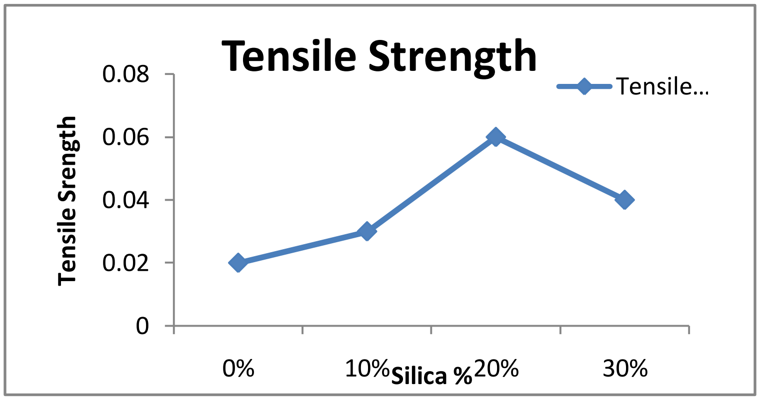

Figure 1: Effect of silica percentage on tensile strength

Also as the fiber/filler content increases, the bonding surface area increases and hence bonding strength decreases. Due to insufficient amount of bonding between three different constituents, the loads may not effectively be transferred from one end to another and hence there is reduction in tensile strength of the composite. Tensile strength of aramid fiber-reinforced vinyl ester composite improves significantly with the addition in the percentage of fiber/filler reinforcement.

Effect on flexural strength

The term flexural strength of a material is defined as its ability to resist deformation under the load. Figure 3 shows the graph how flexural strength varies with addition of different % of filler material (SiO_2). Up tothe addition of 20 wt. % of Silicon dioxide filler material flexural strength rises from 0 .01 KN/mm^2 to 0.013 KN/mm^2 afterwards it decreases. When the specimen is placed on two support points and load is applied from the top of the specimen, then the specimen is subjected to bending and the top layer is subjected to compressive loading, whereas the bottom layer is subjected to tensile loading. When the bonding between the fiber/filler and the matrix is increased, a flexural strength increases and strong bonding transfers loads from one end to another resulting in the increase in flexural strength of the specimen, whereas when the percentage of fiber/filler exceeds the required percentage, then the surface area increases, while the weight percentage of the matrix decreases: therefore, the bonding strength decreases, and loads cannot be effectively transferred from one part to another resulting in the decrease in the flexural strength of the composite.

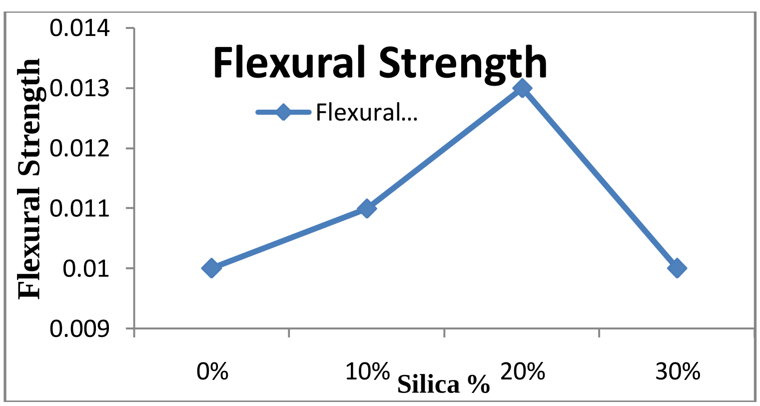

Figure 2: Effect of silica percentage on flexural strength

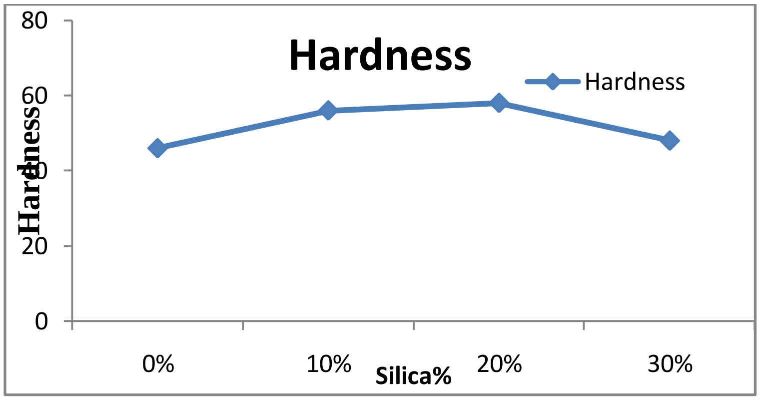

Figure 3: Effect of silica percentage on hardness

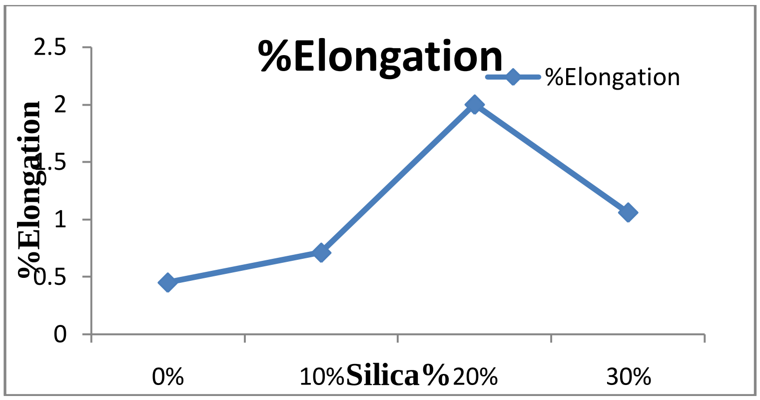

Figure 4: Effect of silica percentage on percentage elongation

Effect on hardness

Hardness is a property to resist deformation, indentation or penetration by mean such as abrasion, drilling, impact loading and scratching. Hardness increases up to addition of 20wt% filler material in composite and further addition of filler material reduces the hardness of a composite. The increase in the value of hardness are attributed to the fact that as the density of composition increases due to filler particles introduced between the fibre and the matrix, the compression value of the specimen decreases and hardness increases. Addition of a small volume fraction of SiO_2 can significantly improve the hardness and wear resistance of the composites. With the addition of SiO_2 filler content, the filler particles (SiO_2) fill in the gap between the fibre and the matrix and form a more dense structure and hence hardness increases.

Effect on % Elongation

% Elongation is the percentage increase in original length of a specimen as a result of tensile force being applied to the specimen. Figure 4 shows the graph of % elongation versus SiO_2-filled aramid fiber-reinforced vinyl ester composite. Above graph depicts that the % elongation increases from 0 to 20 wt. % SiO2 content and also % elongation has a direct relation with tensile strength. So % elongation increases up to 20wt, % and further increase in SiO_2 content results in decrease in the value of tensile strength and % elongation.

CONCLUSION

1. Tensile strength increases from 0.02 KN/mm^2 to 0.06 $KN/mm^2$by adding SiO_2 content from 0 to 20 wt. % .whereas further increases in SiO_2 content i.e. 30 % results in decreases the value up to 0.04 KN/mm^2 .
2. Flexure strength increases from 0.01 KN/mm^2 to 0.013 $KN/mm^2$by adding SiO_2 content from 0 to 20 wt. % .whereas further increases in SiO_2 content results in decrease in the value of flexural strength.
3. The value of hardness and percentage elongation also shows the same trends as in the case of tensile and flexural strength.

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