Ultra Sonic Wave Propagation Properties of GFRP Hybrid Composite with Nano Fillers

[1]Mohd. Minhajuddin Saif, [2]Dr. D.V. Ravi Shankar and [3]Dr. M. Manzoor Husain.
[1]Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Hyderabad-500085.
[2] Professor & Principal, TKR College of Engineering and Technology, India
[3]Professor & Director of Admissions, Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Hyderabad-500085
Email – [1] Saif1688@gmail.com

Abstract: *In the present study, ultrasonic velocity measurement was used to find the young's modulus and other wave propagation properties of hybrid multifunctional composite materials. The hybridization was based on addition of different nano particle with different weight percentages. The ultrasonic wave velocity in all the materials decreases as well as the Young's modulus is also decreasing with the addition of nano particles. The attenuation coefficient in all the specimen is increasing with the addition of nano particles in glass fibre reinforced polymer[GFRP] composite.*

Key Words: *ultrasonic velocity, GFRP, attenuation coefficient, nano particles.*

1. INTRODUCTION:

In this present era, the demand and usage of FRP composites was increasing in rapid manner. The applications of these composites are not limited to a field, but it is widely spread over to various arena. The field of applications includes automotive, sporting goods, aerospace, structural, cryogenic vessels, solar panels and oil and gas pipelines. Incorporation of nano-fillers into the polymer matrix has been an active area of research around the world. Reproduction of the distinct behaviours of nano-fillers in the polymer matrix is one of the crucial objectives to achieve better mechanical, electrical and/or thermal properties. Various researchers have studied on the mechanical performance of GFRP composites and incorporation of different nano-fillers [3–5] at various environments and loading conditions [6–8]. These new materials consisting fiber and nano particle are referred as hybrid composite. The elastic properties of these hybrid fiber reinforced composite are needed to be predicted and characterized also. So non destructive technique is very important for such a study. In most of the air craft application these technique are used for laminate after fabrication.[9-10]. There is also increasing attenuation coefficient being given to determine the relationship between attenuation and mechanical properties as they may be due to same reason[11-12]. In this study, three different nano particles were selected that are MWCNT, Nano Silica, Nano Iron oxide. The weight percentages use was 0.1%, 0.2%, 0.5%, 1.0%. Young's modulus of all of the laminates was found out using ultra sonic pulsed transmission technique. Other parameters such as adiabatic compressibility, attenuation, acoustic length were also calculated.

2. MATERIALS AND METHOD:

The nano polymer composite was prepared from 66% of unidirectional glass fibre and 34% of chopped stand on weight basis having 600 GSM thick size. Lapox L12 resin is used as polymer with K6 as hardner. The fillers of nano particles were used in this experimental work are nano silica, multi wall carbon nano tube(MWCNT) and nano iron oxide .

The outer diameter of MWCNT is 30-50 nm and inner wall is 15-20 nm. The length of MWCNT was found to be 10-15 µm. The bulk density and specific area of MWCNT are 0.21 g/cm^3 and 110 m^2/g. MWCNT used were 99.8% pure. Nano silica used is of 50 nm size and spherical in shape. Nano silica has a specific surface area of 110-120 m^2/g and bulk density of 2.4 g/cm^3 which has purity of 99.9%. Iron oxide used is also of 50 nm size, and has specific surface area of 30 m^2/g and bulk density of 5.242 g/cm^3 with a purity of 99.9%.

The fabrication was done by hand layup method. The size of the mould used is 325x300mm^2. The mould is of two part and made up of mild steel for good thermal conductivity and to avoid deformation under thermal loads due to exothermic reaction of resin. The inner surface of mould that is both top and bottom moulds are well coated with wax polish which act as releasing agent. Four layers of E-glass fibers are used and each layer is of size 250 mm x250mm.

With each nano particles four sample are fabricated by varying their weight percentage with respect to resin as 0.1%, 0.2%, 0.5% and 1%. For good improvement in strength even dispersion of nano particles is necessary. To achieve this nano particles were stirred and mixed with mechanical stirrer and ultrasonic bath. The nano-particles and resin was stirred mechanically and then this mixture was kept in ultrasonic bath for 1 hour. Using this mixture laminates were fabricated. The thirteen laminates were fabricated using polyester resin. The content of glass fiber is maintained constant. The four different weight percentage of samples with each nano-particle and one with neat resin (without nano particles). From the laminate disk with 1.5 cm diameter was cut and used in ultra sonic pulsed transmision technique. The ultrasonic pulsed through-transmission technique, as described by McMaster, 8 involves the measurement of the velocity of sound through a material. A pulse of 1MHz is applied to the transmitting transducer in between which materials is kept. The time between an initial or undelayed pulse and a delayed pulse is measured with digital oscilloscope of 100 MHz, and this time used to calculate velocity. The young's modulus (E) is calculated by the relation $E= \rho V^2$. Where ρ is the density and v is the velocity of sound. The densities of specimen are found out using Archmedes' principle. The liquid used is xylene. The attenuation (α) was calculated using Y coordinate of digital sonicator. First the value of I_0 is calculated Y coordinate of oscilloscope without any sample. The value of I is found as the difference in y coordinate in of digital oscilloscope with sample. Then $\alpha= \frac{\ln(\frac{I_0}{I})}{x}$ gives the amount of sound absorbed by samples.

3. DICUSSION AND RESULT:

Figure 1 show the relation between velocity of sound and laminate hybridize with different weight concentration of nano particles. There is a decrease in velocity of sound was absorbed for all type of nano particle. In MWCNT hybrid composite reduction of velocity of sound was gradual. The reduction in nano iron oxide hybrid and MWCNT hybrid composite is almost same for 0.1% wt. in nano silica type there is sudden variation with 0.1 % wt itself, after that it is gradual.

The figure 2 gives the relation between Young's modulus and weight concentration of different nano particles. The young's modulus of the entire specimen reduced with the increase in weight concentration of nano particles. The reduction of E with the addition of nano particles are as follows:

a) 72% in MWCNT hybridized specimen.
b) 66% with Nano iron oxide hybridized specimen and
c) 31% with Nano Silica hybridized specimen.

The behaviour of particles with respect to concentration is similar to that of velocity of ultrasonic sound in material.

Figure 3 show how the attenuation is changing with weight concentration of nano particles. In silica there is sharp increase in attenuation was observed for 0.1% of weight concentration. After this a gradual increase was absorbed. In MWCNT and nano ironoxide the behaviour was intial decreasing and then increasing order.

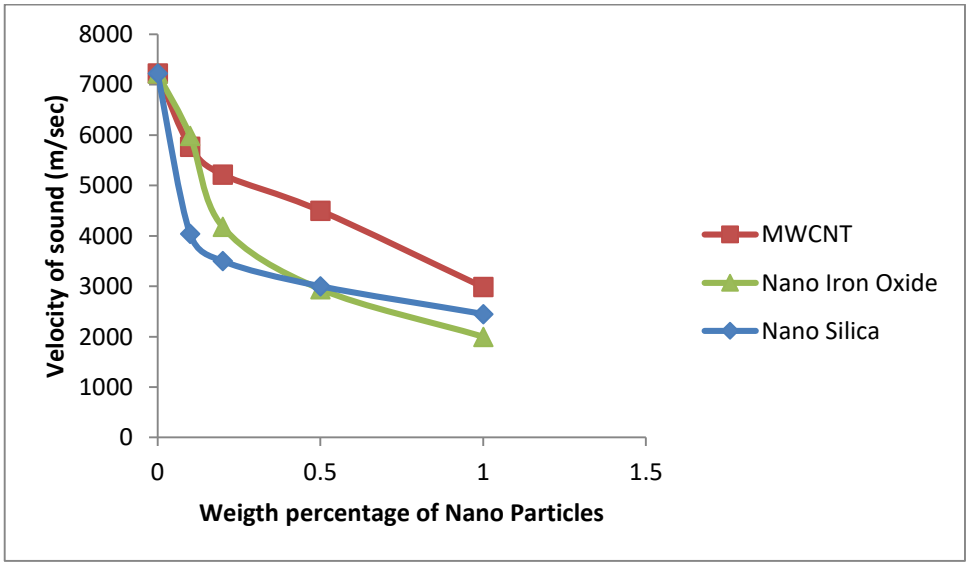

Fig 1. Weight concentration of different nano particles vs Velocity.

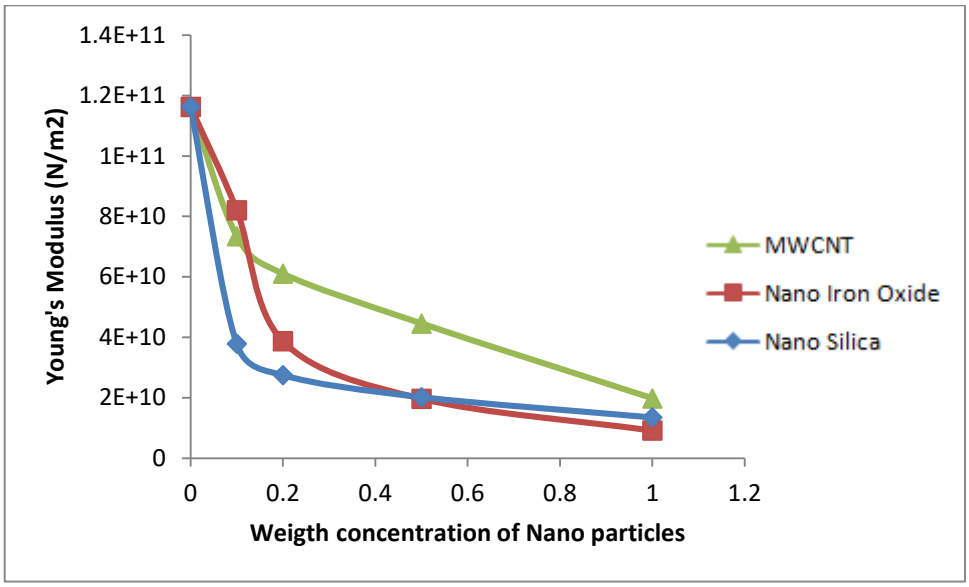

Fig 2. Weight concentration of different nano particles vs Young's Modulus

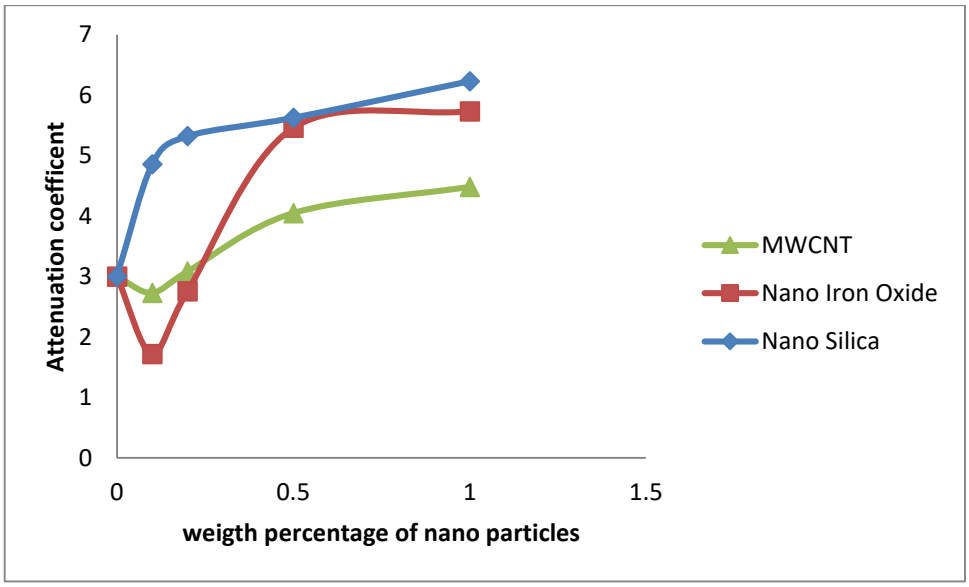

Fig 3. Weight concentration of different nano particles vs Attenuation.

4. CONCLUSION:

Based on the result obtained from the above mentioned experiment the following results are drawn.

1) With the addition of nano filler the velocity of sound in materials as well as the young's modulus of the entire specimen decreases.
2) In silica with the addition of 0.1 wt% in GFRP their is sudden drop of velocity and young modulus is observed. Later also there is decrease in young's modulus but its variation is small compared to first variation.
3) In MWCNT the decrease in young's modulus is gradual. Were as in Nano ironoxide the decrease in young' modulus is gradual till 0.2 wt% and then a linear variation is absorbed.
4) Attenuation coefficient of all the specimen in creases with the addition of Nano fillers.
5) Maximum attenuation coefficient is absorved in silica and minimum in MCNT samples.

REFERENCES:

1. Haupt P, Lion A, Backhaus E. On the dynamic behavior of polymers under finite strains: constitutive modeling and identification of parameters. Int J Solids Struct 2000;37:3633–46.

2. Ehlers W, Markert B. A macroscopic finite strain model for cellular polymers. Int J Plast 2003;19:961–76.
3. Abu-Abdeen M, Elamer I. Mechanical and swelling properties of thermoplastic elastomer blends. Mater Des 2010;31:808–15.
4. Fu SY, Lauke B. Analysis of mechanical properties of injection molded short glass fibre (SGF)/calcite/ABS composites. J Mater Sci Technol 1997;13:389–96.
5. Sumita M, Tsukihi H, Miyasaka K, Ishikawa K. J Appl Polym Sci 1984;29(5):1523–30.
6. Sumita M, Tsukumo Y, Miyasaka K, Ishikawa K. J Mater Sci 1983;18(6):1758–64.
7. Sumita M, Shizuma T, Miyasaka K, Ishikawa K. J Macromol Sci Part B Phys 1983;22(4):601–18.
8. Jiang L, Lam YC, Tam KC, Chua TH, Sim GW, Ang LS. Polymer 2005;46(1):243–52
9. Stone, D.E.W and B. Clarke Non-Destructive Testing 1975:137-145.
10. de Almieda, S.F.M and Z.S.NNeto, Composite Structure, (28)139-148
11. Jones, B.R. and DEW,Stone Non-Destructive Testing 9:71-79
12. Jeong, H. and D.K. Hsu , Journal of composite material 31(3):276-292.