Investigation of Mechanical Behavior of Alfa and Gamma Nano-Alumina/Epoxy Composite Made By Vartm

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ABSTRACT
In this paper, the mechanical properties (flexural and tensional modulus and strength) are investigated by manufacturing Epoxy/Glass Nano-composite samples with different Nano-particle wt% (Nano-Alumina) to find optimum conditions. The alpha and Gamma grade of Nano alumina were added to the epoxy system with the weight percentage of 1, 2, 3, 4, 5 and 6. The experimental results show that the maximum flexural stiffness in Alfa and Gamma Nano-alumina composite is related to 6 wt% and 4 wt% samples, respectively. And the highest tensional stiffness in Alfa and Gamma Nano-alumina composite is related to 4 wt% and 5 wt% samples, respectively. Also the highest toughness for Alfa and Gamma Nano-composites is observed for 4 wt% and 3 wt% samples and in the same way Nano-alumina in grade Alfa with 1 wt% and Gamma with 3 wt% have highest failure strain.

Keywords: mechanical properties, flexural and tensional behavior Nano-Alumina, Alfa and Gamma grade.

1. INTRODUCTION
Composite materials having specific strength (strength to weight ratio) and specific stiffness (stiffness to weight ratio) higher than traditional materials such as metals are used widely in industries such as military, aerospace and ballistic applications where weight is important. Developing in Nano-technology and using in polymer composite materials has created promising progress towards the production of new materials for structural applications. More researches in hybrid and polymeric Nano-composites reinforced with fibers are done to improve the mechanical, thermal, optical and electrical properties [1, 2]. Gojny et al. [3] have focused on a comprehensive review of the effect of Nano-fillers on fracture toughness of epoxy resins and related micro-mechanisms. They studied hardening mechanisms in two
dimensional levels: 1. deformation mechanisms such as micro cracks in Agglomerates, stretching in the plastic deformation area and so on, 2. Nano-mechanical mechanisms such as the separation between levels, push out and cracks bridging in the presence of carbon nanoparticles. Gilbert et al. [4, 5] and Timmerman et al. [6] showed that the fracture toughness can be improved by adding metal and clay nanoparticles. Yasmin et al. [7] have reported an increase of about 80% in elastic modulus while adding 1 to 10 wt% cloisite®30B in epoxy. Also, Lin et al. [8] are reported a 30 percent increase in impact resistance while using 50 wt% cloisite®30B in epoxy resin. Rice et al. [9] used an organic silicate as reinforced in epoxy/carbon and by adding 2 wt% Nano-filler observed 12% improvement in hardness than pure epoxy. Ghabazi et al. [10] investigated the influence of cutting speed (rpm), feed rate (mm/min), and tool diameter (mm) on the uncut fiber and delamination damage of a type of composite sandwich structures including PVC foam, Trapezoidal corrugated sheets and faces made of E-Glass/polyester made by VARTM process. Shokuhfar et al. [11] have investigated the stiffness and pressure behavior of aluminum/glass short fiber Nano-composite made by the mill and hot-press. The density and mechanical properties such as stiffness and compressive strength of the Nano-composite is investigated with 1, 3 and 5 wt% of short glass fibers. Compressive strength and stiffness in samples with 1 to 3 wt% is increased but it is decreased in sample with 5 wt% due to an intensive decline in the density. The compressive strength of Nano-composite with aluminum alloy and pure aluminum matrices were analyzed and the results showed more reinforcement in the pure aluminum matrix.

2. EXPERIMENTS

2.1. Material

Nano-composites have been used in this study consisted of epoxy/glass fiber reinforced with Nano-alumina particles. In this study, the Nano-alumina with a purity of 98 percent and in two alpha and Gamma phases produced by Esfaraien steel is used. The resin system is including of Diglycidyl Ether of Bisphenol A (DGEBA) with the trade name of EPON 828 as the epoxy base and a polyoxypropylene diamine with molecular weight of 400 gr/mol and the trade name of JEFFAMINE D-400 as the hardener produced by huntsman Co. also, the glass fibers as used in this research have 2D-dimensional woven texture by 200 gr/m² surface density.

The following is a brief process of making the Nano-composite samples.

1- At the first, the alpha and Gamma phase of Nano-alumina powder is heated with temperature 80 C for 150 minutes and 120 C for 150 minutes inside an oven.

2- To produce the samples, the first Nano-alumina particles with 1, 2, 3, 4, 5 and 6 wt% relative to the total weight of the resin is mixed mechanically. The mixture is heated to temperature of 50 °C in the oven and then it is mixed by Epyon 818 set (mixer) with 1800 rpm speed during 10 minutes (Fig. 1). Finally, the mixer is stirred using an ultra-sonication Set for 30 minutes at temperature 40C with power $kw/cm^2$ and amplitude 5 $\mu m$ (Fig. 2).
3- The mixture is poured into a beaker with a capacity of 700 cc and at the room temperature and ready to vacuum process.
4- separator layer is applied on the die.
5- The perform is consisted of 12 glass fiber layers with dimension 20*30 cm, a Dacron fabric layer and a distribution (Fig. 3).
6- Providing and connecting of hydraulic system, sealing adhesive and vacuum bags, it is ready to resin injection.
7- The system is connected to a vacuum pump and the injection is applied with vacuum pressure -0.8 bar (Fig 4).

Tensile test (Fig. 5) is carried out according to ASTM-D-3039 at 0.5 millimeters per minute rate of loading and bending tests (Fig. 6) is applied according to ASTM-D-6272 with 2 mm per minute rate of loading.
According to Figures 7-10, it is derivable that the maximum flexural stiffness in Alfa and Gamma Nano-alumina composite is related to 6 wt% and 4 wt% samples, respectively. And the maximum tensional stiffness in Alfa and Gamma Nano-alumina composite is related to 4 wt% and 5 wt% samples, respectively. Also the highest toughness for Alfa and Gamma Nano-composites is observed for 4 wt% and 3 wt% samples and in the same way Nano-alumina in grade Alfa with 1 wt% and Nano-alumina in grade Gamma with 3 wt% have highest failure strain. On the other hand, increasing of Nano-particles wt% lead to Agglomeration of particles and the location of these Agglomeration points have potential to stress concentration and result in mechanical properties reduction.
Investigation of Mechanical Behavior of Alfa and Gamma Nano-Alumina/Epoxy Composite Made By Vartm

M. Farahani, et al.

Fig 10: variation of tensional modulus Vs wt% of Alfa and Gamma nano-alumina

3. CONCLUSION

1. In this research, the influence of alpha and Gamma grade nano-alumina on the mechanical properties of glass/epoxy have been studied empirically. Generally, the following results are derivable:
2. Maximum ultimate strength in Alfa and Gamma Nano-alumina composite is related to 4 wt% and 2 wt% samples, respectively.
3. Maximum failure strain in Gamma and Alfa Nano-alumina composite is related to 3 wt% and 1 wt% samples, respectively.
4. Maximum failure strain in Gamma and Alfa Nano-alumina composite is related to 5 wt% and 4 wt% samples, respectively.
5. The highest toughness for Alfa and Gamma Nano-composites is observed for 4 wt% and 3 wt% samples, respectively.
6. The flexural stiffness for Alfa and Gamma Nano-composites is observed for 4 wt% and 6 wt% samples, respectively.

4. REFERENCES

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