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The study of behavior of epoxy matrix composites reinforced Glass fiber against impact loads with low energy

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***Abstract*—The study of composites Impact behavior is of high importance, Due to high sensitivity of these types of composites against impact loads. In this research the reaction of carbon fiber reinforced polymer (CFRP) composites against impact loads with different energy values has been examined. Therefore, using vacuum assisted resin transfer molding. (VARTM) the desired composites manufactured in 700*700 mm dimensions and were cut in accordance with ASTM D7136 standard using water jets. The cut samples were impact loads at different energy levels. The test results were illustrated contact force-time curves as energy-time and velocity-time curves for different energy levels. In this study, Profile energy method was used in order to obtain penetration and perforation threshold energy. Finally key parameters of low energy impact such as maximum absorbed energy, maximum speed, and test duration time were compared for different energy levels. According to results the penetration threshold energy and perforation threshold energy values of carbon fiber reinforced polymer (CFRP) composites are 60 and 80 joules respectively. According to the results by increasing the energy level to penetration threshold point the amount of absorbed energy also increased and reached its maximum level. After reaching to this point the absorbed energy is reduced with increasing impact energy.**

***Index Terms*— carbon fiber, composite, epoxy matrix, impact energy**

I. INTRODUCTION

Composite materials during their manufacturing and using are affected by impact loads with different energy [1]. These impact loads may occur due to very normal daily encounters or tools falling on objects made of composite materials. Even low energy impact loads may cause damage to the external and internal structure of composites that are not even visible to the eye. But the damages in the internal structure of the material may decrease the mechanical characteristics of the material and cause irreparable damages during operation. Therefore, the study of the reasons of formation of such damages and analyzing them in order for confronting the consequences and decreasing the damages is very crucial and important. The glass fibers use in the polymer composites structure in aerospace, marine and automotive industries is greatly expanded due to very high mechanical properties such as elasticity modulus and high tolerance which is due to low density, high strength and elasticity modulus of these fibers.[2] In addition to their high mechanical properties, these composites because of good thermal properties of glass fibers such as high thermal conductivity, high thermal stability have acceptable thermal properties. Hassur and his colleagues[3] conducted a research which experimentally examined low velocity impact behavior for to different composite materials including carbon fiber reinforced polymer (CFRP) composites and glass fibers. They investigated the effects of fibers' texture type on composite's low velocity impact behavior and relatively compared behavior of composites with two different textures including simple woven and twill woven composites. According to the results, the twill woven composites have better impact behavior compared to simple woven composites. Datta and his colleagues[4] have carried out a research on the behavior of composite materials in a low-speed impact test in which they have examined the effects of Sample thickness on the amount of energy absorbed by the polymer composite samples reinforced with glass fibers and maximum contact force. . Mitrovsky and his colleagues[5] have done a research that examined the effects of the projectile form on the composite behavior. Withangham and colleagues[6] to explore the factors that affect the behavior of the composite impact examined the effects of residual stresses in composite on these materials low-velocity impact behavior. According to the results, residual stresses in the composite structure reduces the contact force and absorbed energy in composite. This study examined the behavior of carbon fiber reinforced polymer (CFRP) composites at different energy level and in order to compare the behavior of these types of composites, key parameters of composites such as maximum contact force, energy- time, velocity- time curves have been examined at different energy levels. In addition, the contact force-time curves, energy-time and velocity-time curves were compared at different energy levels and composite behavior was studied at different energies.

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II. COMPOSITE STRUCTURE

The type of composite used in impact test is simple woven composite and as illustrated in figure 1, in this kind of composite there are two wefts and one warp and this way of weaving has been repeated for the whole reinforcing system.

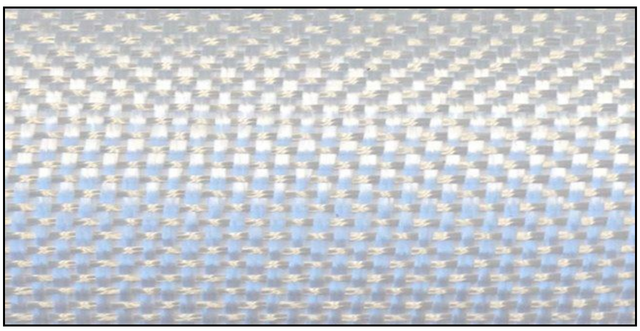

Figure 1: glass fiber weaving mode

In this method, Woven laminate fabrics cut in the same size and layed on separator layer of vacuum assisted resin transfer molding machine and diffusion facilitator and epoxy layer and vacuum layer put over them and using sealant tapes were completely isolated from the environment and were under the pressure of 1.1 atmospher. during the production process in due to the vacuum created by a vacuum pump on the other other side Epoxy from a Volvo enters into the isolated space and by passing through the composite leyers causes the symmetric distribution of matrix between the fibers. The schematic figure of This type of composite manufacturing shown in Figure 2.

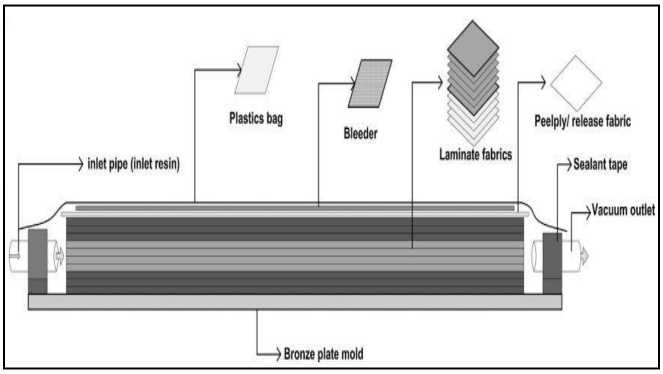

Figure 2: schematic figure of composite manufacturing using Vacuum Assisted Resin Transfer Molding[7]

Fiber volume fraction versus matrix in composite structure is 55.5 percent to 44.5 percent and the number of layers of the composites is 10. Composite plates were made with dimensions of 550 × 550 mm square and in order to provide impact test samples, the cutting operations of samples was performed using water jet based on the ASTM D 7136 standard in dimensions of 80 × 80 mm. The samples encoded after cutting operations and were prepared to conduct impact tests with different energy levels.

III. . Low velocity Impact

Low velocity impact test was performed according to ASTM D7136 standard using the pull-down weight machine. This device was connected to an automatic measurement software which can perform the test at different energy levels and record the data on test results such as contact force, absorbed energy, and projectile deflection and speed considering the time. The machine's load-bearing capability is about a 42.4 k/N and the fixture-pneumatic whole diameter which holds the sample is 76.2 mm. in this study profile energy method was employed to determine the composite breaking threshold energy and samples were tested under different energy level impacts. And the Penetration and Perforation threshold determined using trial and error procedure.

IV. Discussion

One of the important parameters requires before the beginning of the main tests to perform the impact is to measure the penetration and perforation threshold energy. This energy is determined using energy profile method. In this method the desired material samples are hit by projectile with different energy levels that start from low values. The purpose of this step is to determine the perforation and penetration threshold energy. Penetration threshold energy is the amount of energy that projectile penetrate into the sample and therefore the total amount of projectile energy is absorbed by the sample. In this case, the amount of energy absorbed equals with impact energy, and energy point position will be on equal energy line. The minimum energy required for the projectile to perforate through the sample is referred to as threshold perforation energy. Energy profile diagram for the epoxy matrix composite reinforced with carbon fibers is illustrated in Figure 3.

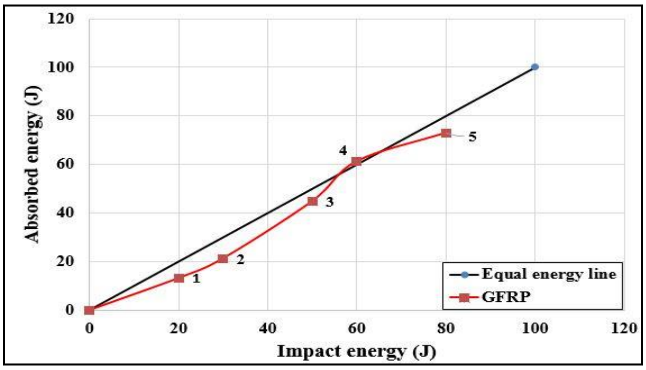

Figure 3: energy profile of carbon fiber reinforced polymer (CFRP) composites

In this study, five tests with different energy levels were carried out to obtain perforation and penetration threshold energy. The first 3 tests were performed at 20, 30, and 50 joule energy level. These tests indicated that the impact energy was not sufficient to pierce the sample and the projectile after hitting the sample and giving some energy to it rebounds from its surface. In this case, the energy point position is under the equal energy line. When the impact energy increases to 60 joules, as illustrated on figure 3, the energy point positon will be on equal energy line and the total amount of projectile energy will be absorbed by the sample. This amount of energy is referred to as penetration threshold energy. With increasing impact energy to 80 joules, after the collision projectile perforates and passes through the sample. In this case which indicated as the energy point 5, the absorbed energy by the sample is lower than the impact energy. Contact force-deflection Diagram of composite samples behavior under 20, 30, 50, 60 and 80 joules low velocity impact energy illustrated in Figure 4.

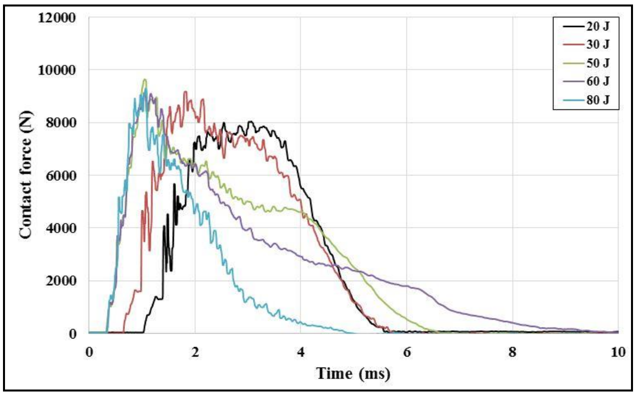

Figure 4: contact force-time diagram of glass fiber reinforced composites in different energy

According to the force-time curves shown in Fig. 5 with increasing the impact energy the maximum force values also increases. However, with increasing impact energy, time the peak time of maximum energy reduces and reaches its lowest level at 80 joules of energy. Another effect of increasing the impact energy can be the shift of force- time curve from symmetric mode which shows the increase in Propagation and delamination energy against the Initiation energy in composite structure. This index is referred to as Ductility index.

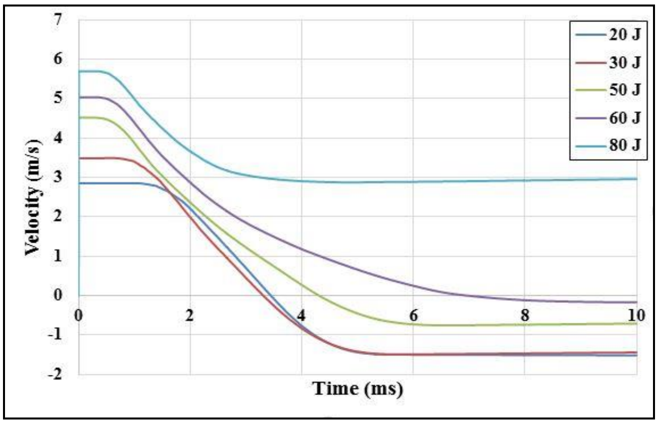

Figure 5: shows the velocity-time diagram of carbon fiber reinforced polymer (CFRP) composites in different energy

Considering the velocity-time curves the increased initial velocity impact is evident by increasing the amount of energy. According to the curves the projectiles rebound mode occurs at energy values of 20, 30 and 50 Joule. Thus, the projectile velocity changes direction and moves to negative values at these energy levels which shows the rebounding mode. At 60 joules of energy the velocity curve with a slight amount of tolerance is tangent to the horizontal axis at the end of the curve which shows the projectile velocity is zero and the penetration mode occurs. As evident in velocity diagram at 80 joules of energy, after hitting the sample the projectile passes through it with the velocity of 3 meter per second. Maximum force values for impact with different energy have been compared in figure 6.

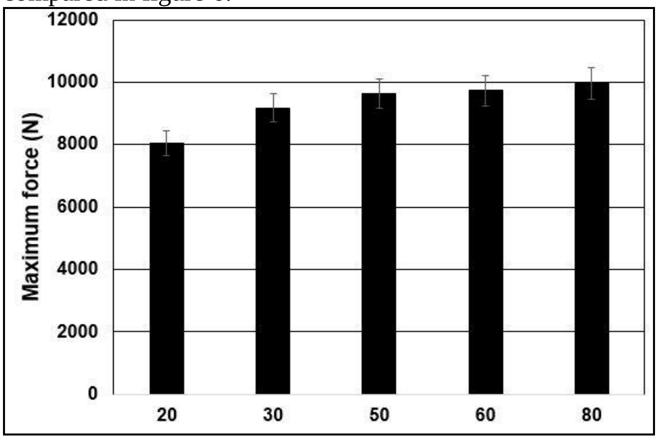

Figure 6: shows the maximum amount of contact force with different energy

In general, as is evident from Figure 6 with increasing amount of impact energy the maximum contact force between the projectile and sample increased. With the impact energy of 20 joules the amount of contact force is about 8040 newton and as the impact energy increases to 30 joules of impact energy of 30 joules the contact force increases by 14.18 percent and reaches to 1010 Nm. With the continuing increase of impact energy to 50 and 60 joules, which is referred to as penetration threshold, the contact force between the projectile and sample increases by 5.093 percent that will be 11100 and 11321 Newton respectively. With increasing impact energy to 80 joules, which is perforation threshold, contact force increases by 2.37 percent and reaches 12038 Newton. Maximum deflection values for different energy levels are compared.

V. Conclusion

In this paper the behavior of twill woven composite with 2/2 glass fibers against low energy impact loads were examined. The penetration and perforation threshold energy values obtained by profile energy method which are 60 and 80 joules respectively. Based on the results the impact energy is inversely proportional to the time of occurrence of maximum force and with increasing energy the peak time reduces. The force-time curve of these composites are unsymmetrical and the amount of energy used to destruct the sample was more than the initiation energy needed for destruction.

The amount of absorbed energy in penetration mode that occurred at 60 joules of energy is the maximum amount and roughly equals the impact energy. However in perforation mode the absorbed energy is less than the impact energy. With increasing impact energy, the impact velocity of the projectile with sample also increases and reaches its maximum at 80 joules of energy. With increasing impact energy to penetration threshold level, the absorbed energy increases and reaches its peak at 60 joules. Absorbed energy starts to reduce after penetration threshold point. With increasing impact energy the maximum contact force between sample and projectile increases and reaches its optimum at 80 joules.

References

[1] T. Czigany, Special manufacturing and characteristics of basalt fiber reinforced hybrid polypropylene composites: Mechanical properties and acoustic emission study, Composites Science and Technology, Vol. 66, No. 16, pp. 3210-3220, Dec, 2006

[2] S. H. Han, H. J. Oh, H. C. Lee, S. S. Kim, The effect of post-processing of carbon fibers on the mechanical properties of epoxy-based composites, Composites Part B-Engineering, Vol. 45, No. 1, pp. 172-177, Feb, 2013.

[3] M. V. Hosur, M. Abdullah, Studies on the low-velocity impact response of woven hybrid composites, Composite Structures, Vol. 67, No. 3, pp. 253–262, 2005.

[4] S. Datta, A. V. Krishna, R. M. V. G. K.Rao, Low velocity impact damage tolerance studies on glass/epoxy laminates – effects of material, process and test parameters, Journal of Reinforced Plastics and Composites, Vol. 23, No. Journal of Reinforced Plastics and Composites, pp. 327–345, 2004

[5] T. Mitrevski, I. H. Marshall, R. Thomson, The influence of impactor shape on the damage to composite laminates, Composite Structures, Vol. 76, pp. 116–122, 2006.

[6] B. Whittingham, I. H. Marshall, T. Mitrevski, R. Jones, The response of composite structures with pre-stress subject to low velocity impact damage, Composite Structures, Vol. 66, pp. 685–98, 2004.

[7] I. D. G. A. Subagia, Y. Kim, L. D. Tijing, C. S. Kim, H. K. Shon, Effect of stacking sequence on the flexural properties of hybrid composites reinforced with carbon and basalt fibers, Composites Part B-Engineering, Vol. 58, pp. 251-258, Mar, 2014. English