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Comparative study on repeated impact response of E-glass fiber reinforced polypropylene & epoxy matrix composites

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ABSTRACT

In this study, E-glass fiber reinforced composites have been manufactured with two types of resin, polypropylene and epoxy (Thermoplastic and Thermoset) and they have been subjected to the low velocity single and repeated impacts and effect of resin type on the impact response of composites are investigated. Impact energies were chosen as 20 J, 50 J, 80 J and 110 J for single impact tests while 50 J was chosen for repeated impact tests. Comparisons between the results of 110 J single and 50 J repeated impacted specimens were performed. As a result of the study it is concluded that the resin type is a crucial parameter for the repeated impact response of the composites.

1. Introduction

Requirements have changed with technological developments. Sometimes, traditional materials are insufficient to meet these requirements. Especially, in marine applications, wind turbine blades and space craft, it is desired to have light weight in addition to high strength. Having high strength and low density properties, fiber reinforced composites have been widely used in many engineering applications including military, marine industries and aerospace engineering. However, these materials are exposed to different loads and harsh conditions. In example, accidental impact (in transporting etc.), runway debris, wave impact and tool drop at maintenance. These kinds of loadings may result in some kind of damages such as delamination, fiber breakage and matrix cracking.

There has been many studies reported about transverse impact loading but these works commonly focused on the effect of composite plate's thickness, orientation impactor type or fiber type and also some environmental conditions [1–5]. Zhang et al. [6] researched the effect of voids on the residual tensile strength after impact and they found that, with the same impact energy, the dent depth increased with increasing void contents. Likewise, repeating impacts could cause void formation in the composite structure and this formation decreases the residual strength of the composites. In thermoplastic matrix composites, void formation, which occurs from impact loading, could less than thermoset composites. De morais et al. [7] conducted a study on the effect of the laminate thickness on the resistance of carbon, glass and aramid fabric composites to repeated low energy impacts and they obtained results for the different fiber reinforced composites which were correlated with the characteristics of the used fibers and fabrics. Atas et al. [8] investigated repeated impact response of woven E-glass/epoxy composites with various thicknesses. Duc et al. [9] studied damping capability of thermoset and thermoplastic composites reinforced with flax fiber fabric and compared the effects of matrix on damping properties. They used epoxy, polypropylene and polyactide as matrix material. They found best damping properties in flax fiber reinforced semi-crystalline polyactide. Lu et al. [10] studied the synergistic effect of self-assembled CNF and boron nitride (BN) nanopaper on the electro-activated shape memory effect. They finally introduced BN to improve the thermal conductivity and large dissimilarity of the nanocomposite for enhanced heat transfer and electric-activated shape recovery. Erkendirci and Haque [11] compared the penetration resistance behavior of glass/polyethylene composites with the baseline glass/epoxy composites and they showed that the force–displacement behavior of HDPE composites differs from the baseline SC15 epoxy

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Table 1
Mechanical properties of thermoset and thermoplastic composites.

	E_1 (GPa)	V_{12}	G_{12} (GPa)	X_T (MPa)
Thermoset	19.2	0.18	3.1	370
Thermoplastic	13.4	0.23	2.6	245[a]

[a] Represents tensile strength at yield.

composites. Shyr and Pan [12] studied impact resistance and damage characteristics of different composite laminates and they used different fabrics, thickness and impact energy levels as parameters. Fotouh et al. [13] performed cylic loading tests on the naturalfiber–reinforced thermoplastic composites and they were developed a model which predicts the fatigue behavior of these composites. Vieille et al. [14] studied the impact behavior of woven ply carbon fiber reinforced thermoplastic and thermosetting composites comparatively. They found that epoxy laminates experienced larger delamination than thermoplastic laminates and thermoplastic laminates showed better impact performances. Richardson and Wisheart [15] proposed a review of low velocity impact response of composite materials. They defined major impact –induced damage modes (matrix damage, delamination, fiber failure and penetration). Finally they proposed toughened resins or thermoplastics can reduce matrix dominated damage and they showed that post impact performance is related to the major damage.

In this study, E-glass fiber reinforced composites have been manufactured with two types of resin, polypropylene and epoxy (Thermoplastic and Thermoset) and they have been subjected to the low velocity single and repeated impacts and effect of resin type on the impact response of composites are investigated.

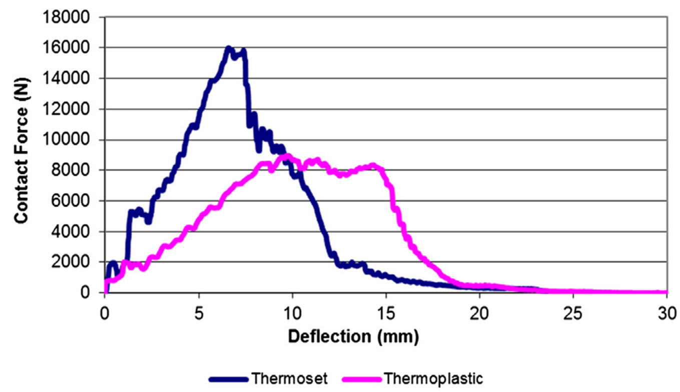

Fig. 2. Contact force/Deflection diagram for 110 J impact energy.

2. Material and methods

This study focused on the effect of resin type on the impact response of composite plates therefore it's important to choose proper (impact resistant) reinforcement material. E-glass and carbon fibers are the most common form of reinforcing fiber used in polymer matrix composites. However carbon fiber reinforced composites are delicate to impact loadings. In this point of view E-glass fiber chosen for reinforcement and resin type impact behaviors are examined. Composite plates with thermoset matrix were produced by using vacuum infusion method. Composite plates with thermoplastic matrix, however, were produced by hot press method with using prepreg fabrics. Both plates were manufactured in $[0/90]_{10s}$ orientation with using 300 gr/m^2 areal density of E-glass fiber. Epoxy and its hardener were used for thermoset,

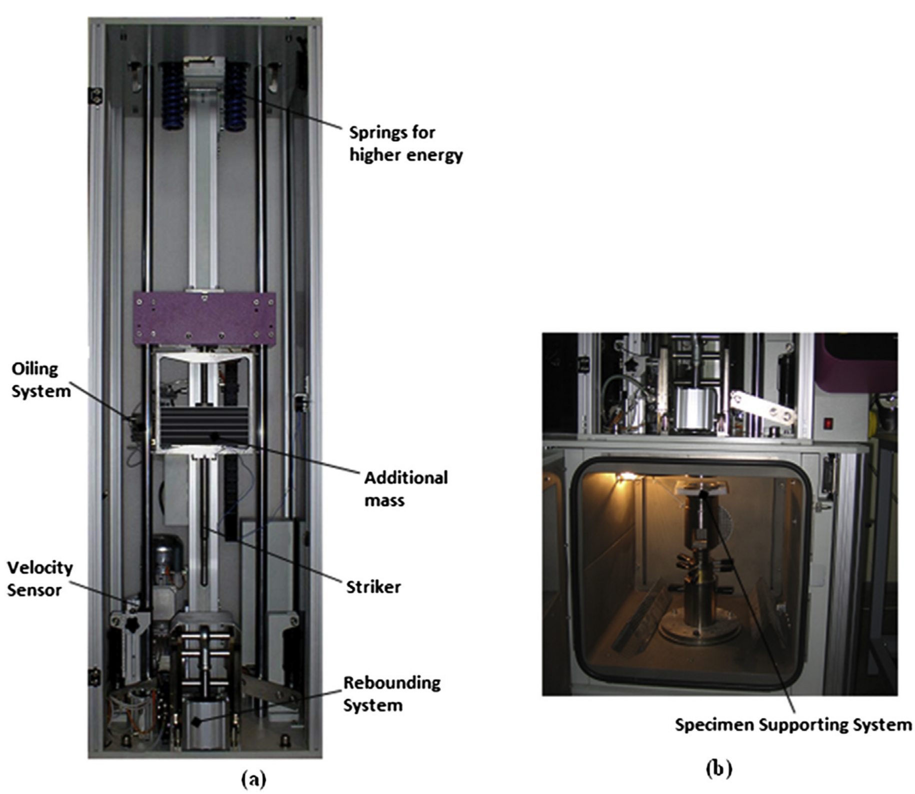

Fig. 1. Fractovis Plus drop weight test machine.