

Velocity Impact Properties of Hybrid Laminate Composites

Ibrahim Mohammed

Department of Aerospace Engineering,
Air Force Institute of Technology, Kaduna

ABSTRACT

The paper present the velocity impact properties of fibre-metal laminate (FML) composites of a sandwich natural (flax and kenaf) and synthetic (carbon) with a thin sheets of aluminium alloy T3-2024. The paper investigates the velocity impact properties of the hybrid composite and compared the results of the two composites. Mould of 400 mm x 400 mm was used to fabricate the samples of the composites by hand lay-up method. The fabricated composites undergo a velocity impact test by using a gun tunnel. The result of the properties test shows the velocity impact strength for low and high-velocity, with kenaf composite having the highest percentage of 22.72% and 19.91% than flax composite respectively. Likewise in specific perforation energy and absorb energy it is greater by 29.87% and 16.07 respectively. In Conclusion, the result indicates that the hybrid composites can be used to replace the synthetic in the near future.

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INTRODUCTION

Different types of fibres both synthetic and natural fibres were used for a long time in so many industries, this results for different researched on these fibres, Natural fibres were used due to its availability, cost, environmentally friendly and weight; also, some natural fibres has equivalent properties with some synthetic fibres, but some factors such as strength and water absorption hinders its performance. Therefore the needs for hybridization arises (Mohammed *et al.*, 2018). The synthetic fibres yield a composite with an excellent impact, thermal and mechanical properties (good stiffness and strength); also, resists crack fatigue growth, but most of it were costly, itching during fabrication

process (Prabhakaran *et al.*, 2013; Sivakumar *et al.*, 2017; Souza *et al.*, 2011).

For more than six-decade fibre reinforced composites were been used in different industries for the structural development, these types of the composite were developed to replace steel and other metals due to the deficiency of some properties in them that includes strength and stiffness, weight, corrosion and thermal resistance. The composite of carbon and glass fibres reinforced plastic (CFRP and GFRP) has better mechanical, thermal and impact properties in terms of strength, stiffness and impact strength, but has a limitation in terms of localised impact loading and load bearing characteristics (Hancox, 1981; Matthews & Rawlings, 1999; Mohammed *et al.*, 2017). The carbon and glass fibres where

Corresponding author: Ibrahim Mohammed

✉ ibrahimmuhd1980@gmail.com

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in different forms such as woven, pre-preg, but the carbon fibre is stronger and lighter than glass-fibre, while in terms of health issues glass fibre is more harmful than carbon fibre, it irritates skin and causes rashes if touch. These two composites when used in a structural member reduce the weight of the component, withstand damage tolerance for a high specific time and in turn reduce fuel consumption by increasing the fuel efficiency. Also, the composites withstand a high temperature with low thermal conductivity.

Different types of FML composites were fabricated and used in different components such as in aerospace and automobile industries; some of the composites (ARALL) have the drawback of brittleness that limits its application on the primary structures, but later the FML composites with boost properties (CARALL and GLARE) were developed and yield a positive result in producing a good mechanical properties components, which are mostly been used in aerospace industries for producing the cabin and external components (Jumahat *et al.*, 2015; Li & WU, 2017; Sadighi *et al.*, 2012; Sinmazçelik *et al.*, 2011).

This research study of the FML composite consists of a natural fibre (flax and kenaf), a synthetic fibre (carbon fibre), and sheets of aluminium alloy 2024-T3 that are used at the front and rear face of the reinforced composites bonded together using an epoxy resin/hardener. The study is to investigate and compared the velocity impact properties of the fabricated composites gun tunnel testing machine.

MATERIALS AND METHOD

The materials used in fabricating the composites were a sheets of Aluminium alloy 2024-T3 kenaf, flax and carbon fibres.

Two sets of five samples each were fabricated using kenaf as natural fibre, carbon as synthetic fibre and a sheets of aluminium alloy for the first composite and flax as natural fibre, carbon as synthetic fibre and a sheets of aluminium alloy for the second composite with the same number of layers bonded with epoxy resin polymer matrix (epoxy). Both composites has aluminium alloy at the front and rear face of it, The front sheet follows by a carbon fibre then 1 kenaf plies, 2 carbon fibres, 1 kenaf plies, and a carbon fibres; the something applies to second composite that uses flax instead of kenaf. Figure 1 shows the layering pattern of the composites.

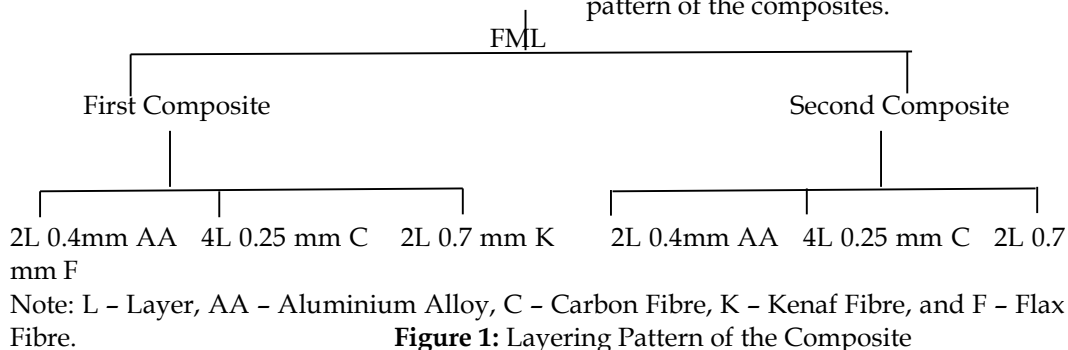


Figure 1: Layering Pattern of the Composite

Corresponding author: Ibrahim Mohammed

✉ ibrahimmuhammad1980@gmail.com

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Five samples from each composite were cut 100mm x 100mm x 4mm for the velocity impact test. The high and low-velocity test was conducted, whereas the high velocity of 205 ± 1 m/s impact penetrates all the FML composites while the two plates withstand a low velocity of 20 ± 1 m/s impact. Helium gas was used as the fluid that fired a flat cylindrical mild steel projectile of 8mm diameter, 4.5g

mass and 13 mm length. The plate of 100mm x 100mm was clamped in a steel support bolted in steel block where only 75mm x 75mm was exposed. In the experiment high-speed video camera was used to record the time, distance travelled, impact and residual velocity, the spotlight was also used to light the chamber box and a gun tunnel system was used in the experiment. as shown in Figure 2.



Figure 2: Impact velocity Test Rig

RESULT AND DISCUSSION

The velocity impact properties result of all the composites considered in this investigation was presented in this section. The test results for high velocity of 205 ± 1 and low velocity of 20 ± 1 of the average of five samples from each composite were presented in this section. The test was conducted to find

the residual velocity after impact, impact resistant, absorption energy and specific perforation energy of each composite for the high and low velocities. The result of the impact and residual velocities were presented in Figure 3.

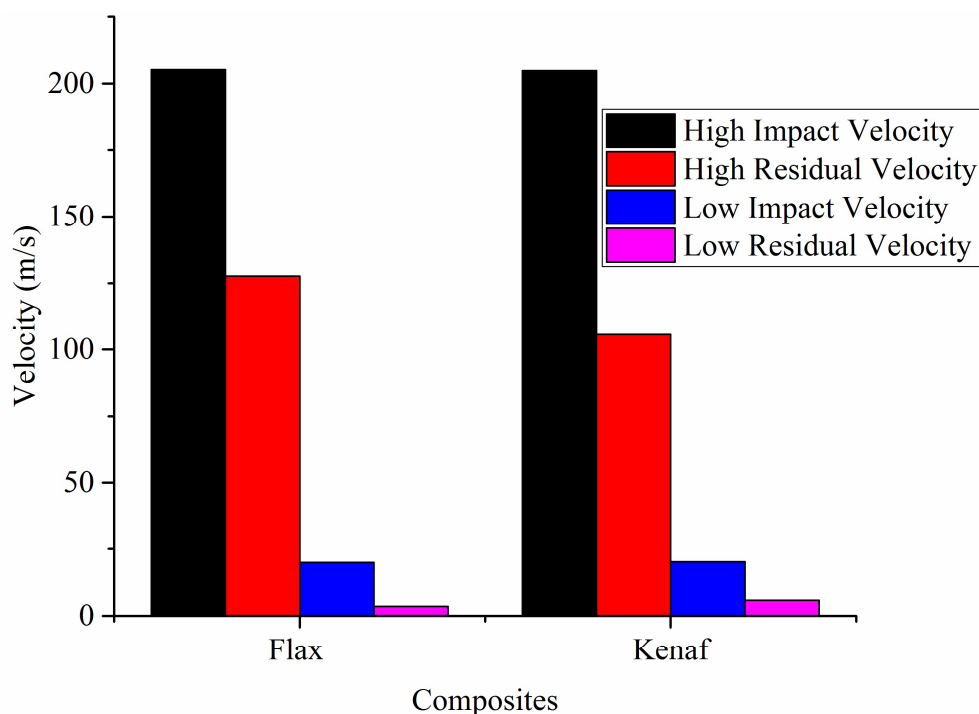


Figure 3: Impact and Residual of High and Low Velocities

After impact for high velocity, the debris is pulled out of the two composites from the rear and front face of it, the samples of the composites delaminates and break by making a hole at the point of impact that shows no any stress is acting on the area, this is in agreement with result reported by Day and Rodrigez (1998); and Mohammed *et al.*, 2017.

The frictional force impacted on the composites affected the absorption energy of the two composites under study that resulted in much delamination on the composites, this was also reported by Babu *et al.* (2006), the penetrated composites produces different structure at the rear face of each composite as observed in Mohammed *et al.* (2017). As the

projectile impacted on the sample the crack on the samples grows through the matrix till it reaches the inter-laminar area, at this point the samples failed as reported by Hammond *et al.* (2004), therefore each composite absorb and dissipated energy due to the impact as also reported in Santhosh *et al.* (2014). Figure 4 shows the energy absorbed during the impact of the high and low velocity which was obtained using equation (1) as:

$$E_{Abs} = \frac{1}{2}mp (V_i^2 - V_r^2) \quad (1)$$

Where mp = Mass of Projectile, V_i = Impact Velocity, V_r = Residual Velocity and E_{Abs} = Absorb Energy.

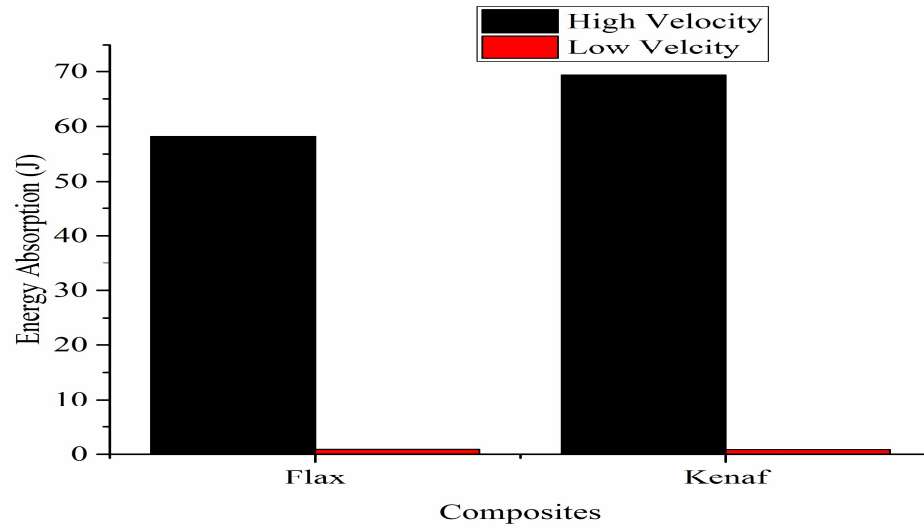


Figure 4: Energy absorption of the two composites

The impact energy was obtained as the fibre was pulled out from the composite, therefore, energy was dissipated and the difference between the impact and residual energy resulted in the impact energy. Therefore the impact strength was calculated using equation (4) and the specific perforation energy for high velocity by using equation (5) as:

$$I_s = \frac{QI}{A} \quad (4)$$

$$spe = \frac{P.E \times A}{W} \quad (5)$$

Where I_s = Impact Strength, QI = Impact Energy, A = Area of the Plate, spe = Specific Perforation Energy, $P.E$ = Potential Energy and W = Weight of the plate.

Table 1 shows the calculated values of the impact strength of high and low velocities and the calculated specific perforation energy of the high velocity.

Table 1: Impact Strength and Specific Perforation Energy

Composites	Impact Strength x 10 ⁻³ (kJ/m ²)		Specific Perforation Energy (Jm ² /kg)
	High Velocity	Low Velocity	
Flax	1.77	1.02	10.8
Kenaf	2.21	1.32	15.4

From all the values obtained in this properties test, clearly it shows that kenaf composite withstands more impact loading than the flax composite, but both composites withstand the low-velocity impact, which clearly shows

that these types of composite could be used in a different component that is subject to low impact velocity without failing.

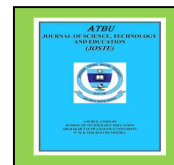
CONCLUSION

Corresponding author: Ibrahim Mohammed

✉ ibrahimmuhammad1980@gmail.com

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Based on the result obtained from the velocity impact test of the composites, the main aim of the research was achieved. From the results, the composite shows resistive properties as such it can be used in some structural components. It is clearly seen that a kenaf composite and flax composite has almost the same value in terms of impact and residual high and low velocities, but differs slightly in terms of energy absorption. Likewise, the kenaf component has higher impact strength and specific perforation energy for both low and high velocities. Therefore in the near future hybrid composites can be used in various composite.

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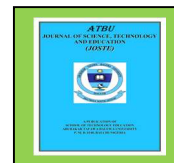
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Corresponding author: Ibrahim Mohammed

✉ ibrahimmuhd1980@gmail.com

Department of Aerospace Engineering, Air Force Institute of Technology, Kaduna.

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