Mechanical behaviour of Kevlar fibre matrix composites manufactured through hand-lay process

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ABSTRACT--*In the current days, composite serve as a essential role in the aircraft, structural automotive, marine and electronics and so on. Composite are being employed in the aircraft to obtain much efficiency. The main benefits of our experimental work is to augment the impact resistance, hardness and strength-weight ratio of the material which is going to be produced through the combination of Kevlar (K) and Nylon (N), E-glass (EG) fibers using pairing method. The fabrication of the polymer matrix composite is done by conventional hand-lay (CH) approach. Polyester (SKR 2501) resin alongside with HY951 hardener is used as the binding element throughout the layer. This experimental work deals with producing, mechanical characterization of a hybrid (K+N+K) composite and also the comparison of it with the (EG+K+EG) based composite. Experimental outcome reveals the hybrid synthetic composite has outstanding properties under impact and tensile loading.*

Keywords--*Synthetic fiber, Mechanical properties, Hand-lay method, Kevlar, Nylon.*

I. INTRODUCTION

1.1 Composites

Novel composites materials show desirable chemical, tribological and mechanical properties like superior strength, outstanding specific modulus and higher corrosive protection. Light weight matrix based composite materials have multipurpose applications in structural and automobile factories owing to their remarkable characteristics like superior tribological and corrosion protection [1-30]. In the recent decades, Fiber-reinforced polymer (FRP) composites are widely used in design due to relatively low-density and reliable tailoring capability to provide the required strength and stiffness. Numerous possible material combinations, unique self-lubrication capabilities and low noise make the FRP composites as a better substitute over conventional metallic materials for tribological application [31, 32]. The importance of polymeric composite in tribological application made some lots of research which are already been published on various types of polymers and fibers. Synthetic fibers like Kevlar is extensively employed in several composites applications especially in the fields' aviation, army equipment's and commercial, ballistic rated body armour fabric and ballistic composites owing to heat-resistant characteristics, distinctive combination of superior toughness, extra high tenacity and modulus and thermal stability.

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Synthetic fibers are employed as filler material for numerous industrial applications. Realistic applications are switch boxes, dashboards, door panels and etc. In this research study, two types of synthetic fibers (Kevlar, E-glass) and their hybridized combinations such as (i) (K+N+K) and (ii) (EG+K+EG) were used in woven mat form to be reinforced with polyester matrix.

II. MATERIALS AND METHODS

2.1 Hardener and Resin

Polyester resin is utilized to provide superior binding characteristics between the natural fibre layers to form the matrix. The polyester resin utilized at normal atmosphere temperature is SKR 2501. HY951 hardener is utilized to augment the interfacial adhesion and toughness of the composite. A polyester resin and the hardener mixture of 10:1 is utilized to succeeded augment matrix composition. Figure. 1. exhibits the polyester resin.

Figure. 1. Polyester resin

2.2. Kevlar

The prime ingredient of the composite material is Kevlar fiber fibers which are tough, possessing high tensile strength, Good resistance to abrasion, Good resistance to organic solvents, Non-conductive, No melting point, Low flammability, Good fabric integrity at elevated temperatures as well as elasticity. Figure 2. reveals the Kevlar fiber.

Figure. 2. Kevlar fiber

2.3. Glass fiber

Glass fiber is a material involving of numerous extremely fine fibers of glass. It is advanced when thin strands of silica glass are extruded into various fibers with small diameters. It is weightless, extremely sturdy and durable. Figure.3. reveals the lightweight glass fiber. Figure 4. reveals the flow chart of the fabrication process.

Figure. 3. Glass fiber

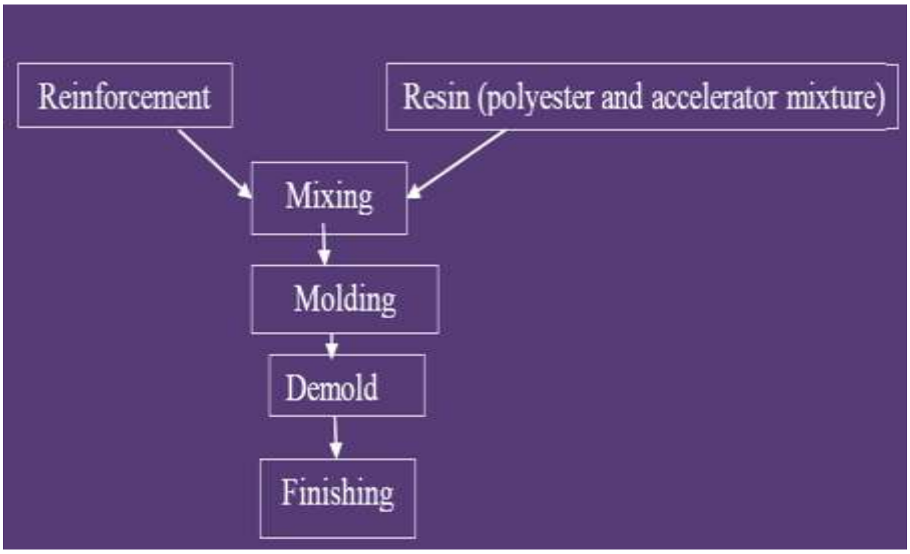

Figure. 4. Flow chart of the fabrication process

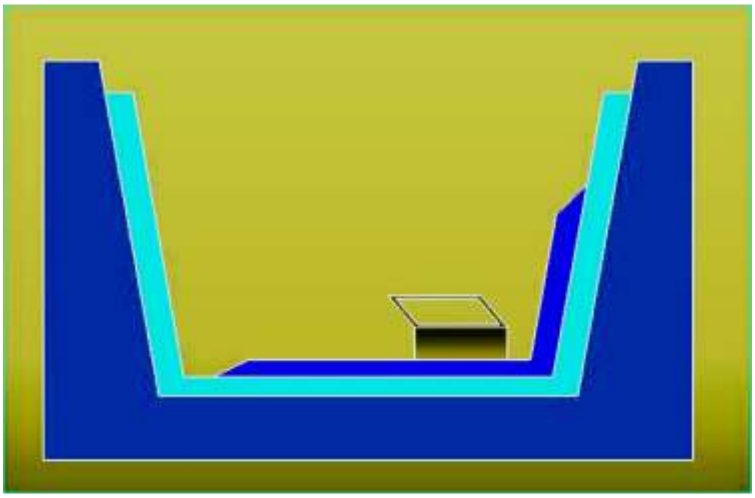

Figure. 5. Schematic diagram of hand layup process

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2.4.Fabrication of composites

Figure. 5. reveals the schematic diagram of hand layup process. In this present research work, the hybrid composite samples were made through three layers. Two samples manufactured in various layer orientation, Trial1 (K+N+K) 1st layer Kevlar fiber is placed on the Wooden board brushed polyester resin onto the Kevlar fiber. 2nd layer Nylon (loose form) fiber is placed then polyester resin is brushed. Lastly again Kevlar fiber is to be placed on the wooden board. Now, apply the load which is directly proportional to the thickness of the composite laminate plate then curing with 24 hours. Conclusively, progressively eliminate the load, the produced plates are machined 20cm x 20cm dimensions and below 6 mm thickness. Similarly the above techniques to follow via preparing the Trial 2 Kevlar and E-glass based composites (EG+K+EG).

III. RESULTS AND DISCUSSIONS

3.1 Tensile test

Figure 6. illustrations the tensile test sample. The tensile behavior analysis test results exposed in Figure.7. The tensile strength of the K+N+K composites and EG+K+EG composites are in the range of 168 MPa and 191 MPa respectively. From the experimental outcome exposed that the superior tensile strength is attained for EG+K+EG composites followed through K+N+K composites.

Figure 6. Tensile test sample

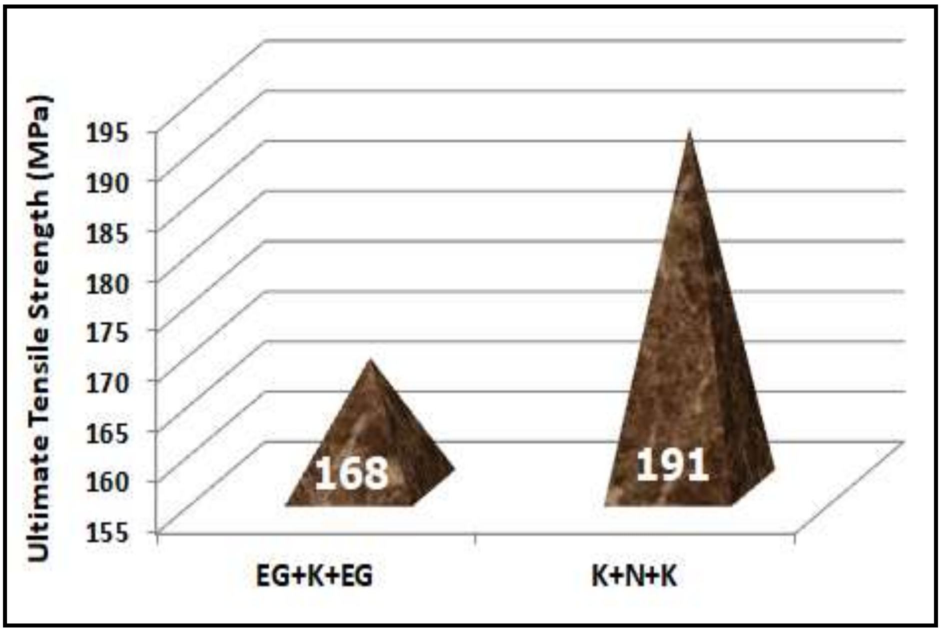

Figure. 7, Tensile strength of the composites

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3.2 Impact test

Figure 8. illustrations the Charpy impact test sample. The toughness analysis test results exposed in Figure.9. The impact strength of the EG+K+EG composites and K+N+K composites are in the range of 9.7 Joules and 8.4 Joules respectively. From the impact test trials exposed that the superior toughness is attained for K+N+K composites followed through EG+K+EG composites.

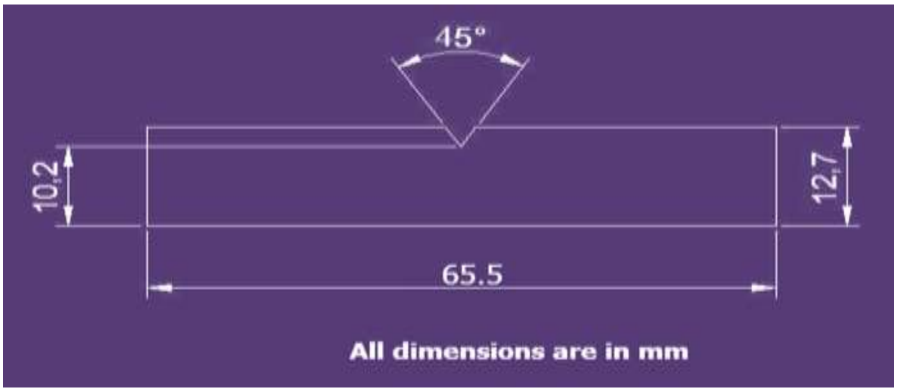

Figure 8. Charpy Impact test sample standard dimesnion

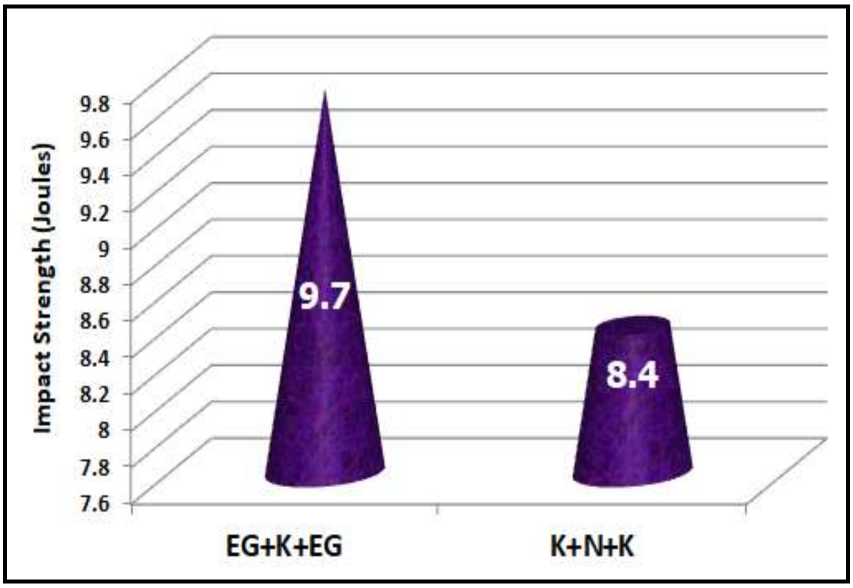

Figure. 9. Impact strength of the composites

IV. CONCLUSIONS

On the basis of this present investigation, the following conclusions are drawn:

1. The impact strength of the EG+K+EG sample is 9.7 Joules which is greater than that of K+N+K with 8.4 Joules.

2. The tensile strength of K+N+K (191 MPa) sample is comparatively augment than (168 MPa) of EG+K+EG sample.

REFERENCES

1. S.Deng, L.Ye, Y.W.Mai, Influence of fibre cross-sectional aspect ratio on mechanical properties of glass fibre/epoxy composites, Tensile and flexure behavior, Composite Science and Technology. 59 (1999) 1331-1339.
2. R.N.Raja, S.J.Kokan, R.Sathyanarayanan, S.Rajesh. V.M.Manickavasagam, B.Vijaya Ramnath, Fabrication and Testing of Abaca Fibre Reinforced Epoxy Composites for Automotive Applications. Advanced Materials Research. 718-720 (2013) 63-68.
3. P.Gurusamy, S.Balasivanandha Prabu, R.Paskaramooorthy, Prediction of Cooling Curves for Squeeze Cast Al/SiC_p Composites Using Finite Element Analysis, Metallurgical and Materials Transactions A, 46 (2015) 1697- 1703.
4. V. Mohanavel, M.Ravichandran, S.Suresh Kumar, Tribological and mechanical properties of Zirconium Di-boride (ZrB_2) particles reinforced aluminium matrix composites, Materials Today Proceedings, 21 (2020) 862-864.
5. V.Mohanavel, Mechanical and microstructural characterization of AA7178-TiB_2 composites, Materials Testing, 62 (2020) 146-150.
6. V.Mohanavel, M.Ravichandran, Influence of AlN particles on microstructure, mechanical and tribological behaviour in AA6351 aluminum alloy, Materials Research Express, 6 (2019) 106557.
7. V.Mohanavel, K.Rajan, M.Ravichandran, S.Suresh Kumar. M.Balamurugan, C.Jayasekar, Physical and tribological behaviour of dual particles reinforced metal matrix composites, Lecture Notes in Mechanical Engineering, (2019) 339-347.
8. V.Mohanavel, S.Suresh Kumar, K.Mariyappan, P.Ganeshan, T.Adithiyaa, Mechanical behavior of Al-matrix nanocomposites produced by stir casting technique, Materials Today Proceedings, 5 (2018) 26873-26877.
9. Vinayagam Mohanavel, Synthesis and evaluation on mechanical properties of LM4/AlN alloy based composites, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, (2019). DOI: 10.1080/15567036.2019.1647313
10. V.Mohanavel, K.Rajan, S.Suresh Kumar, A.Chockalingam, A.Roy, T.Adithiyaa, Mechanical and tribological characterization of stir-cast Al-SiCp composites, Materials Today Proceedings, 5 (2018) 1740-1746.
11. V.Mohanavel, K.Rajan, S.Arul, P.V.Senthil, Production, Microstructure and Mechanical behavior of AA6351/TiB_2 composite synthesized by direct melt reaction method, Materials Today Proceedings, 4 (2017) 3315-3324.
12. V.Mohanavel, S.Suresh Kumar, T.Sathish, T.Adithiyaa, K.Mariyappan, Microstructure and mechanical properties of hard ceramic particulate reinforced AA7075 alloy composites via liquid metallurgy route, Materials Today Proceedings, 5 (2018) 26860-26865.
13. V. Mohanavel, M. Naveen Kumar, K. Magesh Kumar, C. Jayasekar, N. Dineshbabu, S. Udishkumar, Mechanical behavior of in situ ZrB_2/AA2014 composite produced by the exothermic salt-metal reaction technique, Materials Today Proceedings, 4 (2017) 3215-3221.
14. V. Mohanavel, K. Rajan , S. Sureshkumar, G. Vijayan, M.S. Vijayanand, Study on mechanical properties of graphite particulates reinforced aluminium matrix composite fabricated by stir casting technique, Materials Today Proceedings, 5 (2018) 2945-2950.

15. V. Mohanavel, M. Ravichandran, Experimental investigation on mechanical properties of AA7075-AlN composites, Materials Testing, 61 (2019) 554-558.
16. V. Mohanavel, P. Periyasamy, M. Balamurugan, T. Sathish. A review on mechanical and tribological behaviour of aluminium based metal matrix composites, International Journal of Mechanical and Production Engineering Research and Development, (2018) 473-478.
17. V. Mohanavel, A. Chockalingam, S. Suresh Kumar, R. Praveen Kumar. Characterization of mechanical properties of aluminium/fly ash composites fabricated through stir casting process, International Journal of Mechanical and Production Engineering Research and Development, (2018) 377-382.
18. V.Mohanavel, M. Karthick, D.L. Belginpaul, Fabrication and development of aluminum alloy AA6063-titanium carbide composite prepared by in situ method, International Journal of Applied Engineering Research, 10 (2015) 12475-12481.
19. V. Mohanavel, K. Rajan, S. Suresh Kumar, S. Udishkumar, C. Jayasekar, Effect of silicon carbide reinforcement on mechanical and physical properties of aluminum matrix composites, Materials Today Proceedings, 5 (2018) 2938-2944.
20. V. Mohanavel, M. Ravichandran. T. Sathish, S. Suresh Kumar, M.M. Ravikumar, S. Mahendiran, L. Yeshwanth Nathan, Tribological and mechanical behaviour of composites fabricated via compo casting, stir casting and in situ casting – An overview, Journal of Balkan Tribological Association, 25 (2019) 342-352.
21. V.Mohanavel, E.ArunKumar, P.Kumar, N.Devaraj, K.Praveenkumar, Investigating on mechanical behavior of aluminium metal matrix composite, International Journal of Applied Engineering Research, 10 (2015) 22918-22920.
22. V.Mohanavel, E.ArunKumar, M.Lokesh Kumar, P.Kumar, Evaluation of mechanical properties of AA6360 aluminum alloy–B_4C–Al_2O_3 metal matrix composites (MMCs), International Journal of Applied Engineering Research, 10 (2015) 753-756.
23. V.Mohanavel, E.ArunKumar, P.Kumar, N.Devaraj, Effect of boron carbide addition on impact behavior of AA6360/Al_2O_3 hybrid composites fabricated by stir casting method, International Journal of Applied Engineering Research, 10 (2015) 341-344.
24. R. Praveen Kumar, P.Periyasamy, V. Mohanavel, Microstructure and mechanical properties of MG/WC composites prepared by stir casting method, International Journal of Mechanical Engineering and Technology, 2018, Vol. 9(10), 1504-1511.
25. V.Mohanavel, S.N. Sundar, R. Poongothai, S. Suresh Kumar, V. Sivaraman, Experimental and FEA evaluation of AA2014/TiC composites, International Journal of Recent Technology and Engineering, 8 (2019) 5636-5639.
26. B. Stalin, M. Ravichandran, S. Arivukkarasan, V. Mohanavel, International Journal of Mechanical and Production Engineering Research and Development, (2018) 329-336.
27. V.Mohanavel, R. Poongothai, S. Suresh Kumar, N.J. Lavanya, S. Gowrishankar, Compression strength and tensile fracture analysis of aluminium matrix composites made via stir casting method, International Journal of Recent Technology and Engineering, 8 (2019) 2815-2819.

28. R.Praveen Kumar, P.Periyasamy, V. Mohanavel, M.M. Ravikumar, Mechanical and tribological behavior of mg-matrix composites manufactured by stir casting, International Journal of Vehicle Structures & Systems, 11 (2019) 117-120.
29. P.Gurusamy, S.Balasivanandha Prabu, R.Paskaramooorthy, Influence of processing temperatures on mechanical properties and microstructure of squeeze cast aluminum alloy composites, Materials and Manufacturing Processes, 30 (2015) 367-373.
30. P.Gurusamy, S.Balasivanandha Prabu, R.Paskaramooorthy, Interfacial thermal resistance and the solidification behavior of the Al/SiCp composites, Materials and Manufacturing Processes, 30 (2015) 381-386.
31. T.Raja, P.Anand, Evaluation of thermal stability and thermal properties of Neem/Banyan reinforced hybrid polymer composite, Materials Performance and Characterization, 8 (2019) 481-490
32. T.Raja, P.Anand, Testing and evaluation of tensile and impact strength of Neem/Banyan fiber-reinforced hybrid composite, Journal of Testing and Evaluation, 1 (2019), 647-655.