EFFECT OF STACKING LAYERING SEQUENCE OF NATURAL FIBER/ARAMID FABRIC REINFORCEMENT ON A HYBRID EPOXY MATRIX COMPOSITE SUBJECTED TO HIGH ENERGY BALLISTIC IMPACT

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Abstract - Natural lignocellulosic fibers (NLFs) have been, successfully, used as a reinforcement for polymer matrix composites in several engineering applications in the past couple of decades. Their inherent characteristics such as biodegradability, renewability, and abundance make them appealing for sustainable materials. However, it is also well-known that synthetic fibers surpass NLFs in mechanical and thermal properties, even though their production and disposal usually are associated with CO2 footprint. Combining these fibers as a hybrid reinforcement in polymeric materials shows promise for synergically joining their best characteristics to produce superior multifunctional materials and structures. This research investigates the development of hybrid composite systems aiming their application against high-energy ammunition. Different stacking layering sequences consisting of an NLF fabric and Aramid fabric are proposed to reinforce an epoxy matrix composite. NLF/Aramid hybrid laminated composites were fabricated through hand lay-up techniques by arranging NLFs and Aramid fabrics in different layering sequences. To assess the ballistic resistance of the proposed configurations, a standing-alone target against 7.62 mm high-energy ammunition tests were performed. The influence of the stacking sequence was determined in terms of absorbed energy, limit velocity, and V50 parameters. Macro and microscopic analyses were performed to determine the primary failure mechanism in the proposed structures. Statistical analyses were performed to evaluate the results obtained. It was shown that both the stacking sequence and the strike face, i.e., whether NLF or Aramid face, display a significant difference in the measured parameters. This study is part of an exploration of the potential application of the hybrid composite in high-velocity impact applications.

References

1. F.S. Luz; F.C. Garcia Filho; M.S. Oliveira; L.F.C. Nascimento; S.N. Monteiro. *Polymers* ***2020**, 12, 1920.* https://doi.org/10.3390/polym12091920
2. U.O. Costa; F.C. Garcia Filho; T.G. Del-Rio; J.G.P. Rodrigues; N.T. Simonassi; S.N. Monteiro; L.F.C. Nascimento. *Polymers 2023*, *15*, *2460*. https://doi.org/10.3390/polym15112460
3. J. Naveen; M. Jawaid; E.S. Zainudin; M.T.H. Sultan; R.Yahaya. *The Journal of The Textile Institute 2019, 110:8, 1179-1189.* https://doi.org/10.1080/00405000.2018.1548801
4. R. Yahaya; S.M. Sapuan; M. Jawaid; Z. Leman; E.S. Zainudin. *Materials and Design 2015, 67, 173–179*. http://dx.doi.org/10.1016/j.matdes.2014.11.024

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