Effect of Temperature on the Mechanical Performance of Woven Carbon Epoxy Composites Under Dynamic Compression

Rohit Kumar*†[1], Muddu Rahul Bharadwaj[1], Palak Bhagoria[1], and Vikrant Tiwari

[1]Indian Institute of Technology Delhi – India

Abstract

Carbon woven composites, with their high strength-to-weight ratio, are used in aerospace, automotive, and other civil structure applications, making temperature effects important. The current study investigates the mechanical performance of carbon woven composites under varying temperatures, with a particular emphasis on their dynamic compression behaviour. Compression moulding was employed to make rectangular panels of 4 mm carbon-epoxy woven composite. For dynamic compression investigations, cylindrical specimens were made through the thickness direction utilizing water jet cutting. The split-Hopkinson pressure bar arrangement for reproducing high strain rate compression studies at temperatures ranging from -40∘C to 70∘C yielded significant results. Analysis of various mechanical properties, including elastic modulus and ultimate strength, revealed a dependence of the material on strain rate within the specified temperature range. Increased temperature reduces composite compressive strength by 20% at 70∘C relative to ambient temperature. At -40∘C, the strain rate sensitivity factor may rise by around 10-15%, increasing compressive strength at sub-zero strain rates, while leading to brittle and catastrophic failure modes.
Deformed specimen fracture surfaces were examined using a DVM6 digital microscope. The epoxy matrix becomes soft at high temperatures, causing ductile failure with fibre pull-out, polished matrix surfaces, and enhanced delamination. The matrix's load-transfer efficiency is reduced by fibre exposure on fracture surfaces due to decreasing binding strength. The epoxy matrix becomes brittle at low temperatures, causing acute fractures and clean fibre ruptures. However, this reduces durability and increases catastrophic failure.

*Speaker
†Corresponding author: rohitnituk001@gmail.com