

Impact behaviour of microwave-assisted compression moulded HDPE/kenaf and HDPE/MWCNT composites

A thesis

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Candidate's declaration

This is to certify that the thesis entitled “**Impact behaviour of microwave-assisted compression moulded HDPE/kenaf and HDPE/MWCNT composites**”, submitted by me to the Indian Institute of Technology Mandi for the award of the Degree of Master of Science (by Research) is a bonafide record of research work carried out by me under the supervision of Dr. Sunny Zafar and Dr. Himanshu Pathak. The content of this thesis, in full or in parts, have not been submitted to any other institute or university for the award of any degree or diploma.



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Declaration by the Thesis Supervisor

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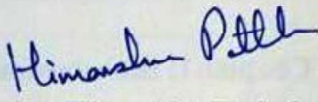

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Abstract

The present work deals with a novel manufacturing route, microwave-assisted compression moulding (MACM), for fabricating high-density polyethylene (HDPE) based composites. In the present work, 20 wt.% of reinforcement in the form of kenaf and multi-walled carbon nanotube (MWCNT) was used to fabricate HDPE/kenaf and HDPE/MWCNT polymer composites. The mechanical characterizations of the microwave processed composites were carried out in terms of the uniaxial tensile test at different strain rates, multi-step stress relaxation, flexural and impact test. The uniaxial tensile test revealed that the tensile modulus of four-layered HDPE/kenaf polymer composite was 35.2% higher than that of HDPE/MWCNT polymer composite. The HDPE/MWCNT polymer composite showed elastic modulus a minimum of 1.25 GPa and a maximum of 4.7 GPa when tested at different strain rates. The energy absorbed by the HDPE/kenaf polymer composite (1.055 J) was 81.12% higher than the HDPE/MWCNT polymer composite (0.582 J).

Thereafter, the experimentally obtained properties have been utilized in crashworthiness testing of HDPE composites with respect to the aluminum alloy (Al5022) due to their comparable specific energy absorption. Finite element method (FEM) based ANSYS 16.0 package has been utilized to predict comparative crashworthiness strength of composites. Numerical results were obtained for full, offset and oblique frontal impact of the automobile body panel. Crashworthiness of the automotive body panel has been investigated on the basis of the deformation of the bumper, kinetic energy of the body panel and the reaction force of the target body. Although the directional deformation of the HDPE/kenaf and HDPE/MWCNT composites is higher than the aluminum alloy (Al5022), they have a considerably lower value of deceleration and reaction force during the impact period.

Nomenclature

ACRONYMS

ASTM	American Society for Testing and Materials
DSC	Differential scanning calorimetry
HDPE/MWCNT	High-density polyethylene/multiwalled carbon nanotube-polymer
HDPE/kenaf	High-density polyethylene/kenaf fibre reinforced polymer
MACM	Microwave-assisted compression moulding
NFRC	Natural fibre reinforced composite
NaOH	Sodium hydroxide
SEA	Specific energy absorption
PP	Polypropylene
PE	Polyethylene

SYMBOLS

Vector quantities

\mathbf{B}	Body force
Γ	Boundary
$\boldsymbol{\sigma}$	Cauchy stress tensor
\ddot{U}_i	Component of nodal acceleration (i=1,2,3)
\dot{U}_i	Velocity at nodal point (i=1,2,3)
U_i	Component of nodal displacement (i=1,2,3)
F_i	Component of nodal force (i=1,2,3)

S	Stiffness matrix
Scalar quantities	
E	Young's modulus of the polymer composite
e	Volume expansion of the material
E_f	Flexural modulus of the polymer composite
G	The shear modulus of the polymer composite
K	The bulk modulus of the polymer composite
Δk	Change in kinetic energy of body panel
L	Span length of the specimen
m	Mass of the body panel
m_n	Nodal mass
N	Shape function
P	Maximum applied load
s	The slope of the secant of the load-displacement curve
T_g	Glass transition temperature
T	The thickness of the specimen
t	Duration of impact
W	Width of the specimen
ρ	The density of polymer composite
ρ_p	Density of polymer
ρ_r	Density of reinforcement
V_p	The volume fraction of polymer
V_r	The volume fraction of reinforcement

U_0	The initial velocity of the body panel
U_t	The final velocity of the body panel at time 't'
δ	Deflection of the specimen in the flexural test
a	Deceleration of body panel
Ω	Domain
σ_f	Flexural stress of the polymer composite
ε_f	Flexural strain of the polymer composite