Review

Accelerated Microwave Curing of Fibre-reinforced Thermoset Polymer Composites for Structural Applications: A Review of Scientific Challenges

Chinedum Ogonna Mgbemena, Danning Li, Meng-Fang Lin, Paul Daniel Liddel, Kali Babu Katnam, Vijay Thakur Kumar, Hamed Yazdani Nezhad

PII: S1359-835X(18)30362-2
DOI: https://doi.org/10.1016/j.compositesa.2018.09.012
Reference: JCOMA 5181

To appear in: *Composites: Part A*

Received Date: 8 June 2018
Revised Date: 31 July 2018
Accepted Date: 10 September 2018

Please cite this article as: Ogonna Mgbemena, C., Li, D., Lin, M-F., Daniel Liddel, P., Babu Katnam, K., Thakur Kumar, V., Yazdani Nezhad, H., Accelerated Microwave Curing of Fibre-reinforced Thermoset Polymer Composites for Structural Applications: A Review of Scientific Challenges, *Composites: Part A* (2018), doi: https://doi.org/10.1016/j.compositesa.2018.09.012

Accelerated Microwave Curing of Fibre-reinforced Thermoset Polymer Composites for Structural Applications: A Review of Scientific Challenges

Chinedum Ogonna Mgbemena[1,2], Danning Li[1], Meng-Fang Lin[1], Paul Daniel Liddel[1], Kali Babu Katnam[3], Vijay Thakur Kumar[1] and Hamed Yazdani Nezhad[1,*]

[1]Enhanced Composites and Structures Centre, School of Aerospace, Transport and Manufacturing, Cranfield University, MK43 0AL, UK

[2]Department of Mechanical Engineering, Federal University of Petroleum Resources, Effurun, Nigeria
[3]School of Mechanical, Aerospace and Civil Engineering, University of Manchester, M13 9PL, UK

**Corresponding author: h.yazdani-nezhad@cranfield.ac.uk, Tel.: +44 (0)1234750111*

Abstract

Accelerated curing of high performance fibre-reinforced polymer (FRP) composites via microwave heating or radiation, which can significantly reduce cure time and increase energy efficiency, has several major challenges (e.g. uneven depth of radiation penetration, reinforcing fibre shielding, uneven curing, introduction of hot spots etc). This article reviews the current scientific challenges with microwave curing of FRP composites considering the underlying physics of microwave radiation absorption in thermoset-matrix composites. The fundamental principles behind efficient accelerated curing of composites using microwave radiation heating are reviewed and presented, especially focusing on the relation between penetration depth, microwave frequency, dielectric properties and cure degree. Based on this review, major factors influencing microwave curing of thermoset-matrix composites are identified, and recommendations for efficient cure cycle design are provided.

Keywords: microwave curing, thermosetting polymers, depth of penetration, dielectric constant, fibre-reinforced polymer composite

Nomenclature

Parameter	Definition
f	Microwave radiation frequency
$f(\alpha)$	Cure kinetics model function
k	Curing rate constant in Arrhenius expression
v_p	Microwave speed in polymer
t	Time (duration)
A	Material constant (frequency factor) in Arrhenius expression
C_{ijkl}	Material constant matrix
D_p	Depth of microwave penetration
E	Activation energy in Arrhenius expression
$\bar{E}$	Electric field intensity
E^*	Conjugate of electric field strength
H	Concentration level
P_{av}	Average power
Q	Microwave energy
R	Gas constant (=1.987 cal K^{-1} mol^{-1} or 8.314 J K^{-1} mol^{-1})
T	Absolute temperature in Kelvin (K)
T_c	Cure temperature
T_g	Glass transition temperature
α	Degree of cure
ε_{ij}	Strain tensor
ε_0'	Permittivity of free space (8.8514×10^{-12}F/m)