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Quasi-static compressive response of compression molded Glass microballoon/HDPE syntactic foam

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ABSTRACT
Quasi-static compressive behavior of different density glass microballoon (GMB) reinforced high density polyethylene (HDPE) syntactic foams are investigated in the present work. Reducing the weight of thermoplastic components has been always a high priority in transportation, aerospace, consumer products and underwater vehicle structures. Despite continued interest in developing lightweight thermoplastic syntactic foams, they have not been studied extensively for quasi-static response with focus on wall thickness and volume fraction variations. Compression molded GMB/HDPE sheets are subjected to 0.001, 0.01 and 0.1 s^{-1} strain rates. Compressive modulus of foams is higher compared to neat HDPE. Increasing strain rates and decreasing filler content increases yield strength for all the foams investigated compared to neat HDPE. Yield strain and energy absorption of GMB/HDPE foams increases with an increasing strain rate and wall thickness. Specific modulus and strength of GMB/HDPE foams are superior and are comparable to neat HDPE. GMB/HDPE foam achieved high stiffness to weight ratio making them suitable for wide variety of applications. Theoretical model based on differential scheme predicts a good estimate of elastic modulus for all the type of GMB/HDPE foams. Finally, property map is exhibited to present comparative studies with existing literature.

Keywords: Syntactic foam, glass microballoon, HDPE, quasi-static compression, Porfiri-Gupta model.

INTRODUCTION

Contribution of inorganic solid fillers towards growth of the thermoplastic industry is phenomenal. Initially fillers are introduced to replace expensive resin with primary objective of cost reduction [1]. Researchers over time explored filler usage in providing tailored unique properties to these plastics alongside functional benefits. Fillers modify thermal, mechanical, magnetic, electrical and surface properties [2]. They can also act as fire retardants [3] and processing aids and stabilizers [4]. More than one property is modified by fillers in most of the cases. Solid fillers are having higher density than the neat resin making plastic components to gain weight substantially. Advent of glass microballoons (GMBs) in 1960s changed the scenario the way lightweight materials are designed and developed [5]. Making lightweight thermoplastics parts has been a high-priority in industries like handheld electronics, sports, aerospace, transportation and leisure. GMBs find numerous applications in variety of applications in automotive sector including sheet, thermoplastics and bulk molding composites, structural foams, plastisols and auto body fillers. GMBs are promising candidate materials in developing lightweight thermoplastic composites with price advantage without compromising mechanical properties [6]. Several benefits imparted by GMBs include higher modulus, dimensional stability, heat distortion resistance, reduced thermal conductivity and dielectric