3D Printing in Material Engineering: Tailoring Thermal Conductivity in Composite Plastics Through Engineered Air Gaps

Fernando Cervantes-Alvarez[1, C], Adriana Paola Franco Bacca[2], Caridad Valés-Pinzón[1], Miguel Ángel Zambrano-Arjona[1], Jorge Alejandro Tapia-González[1], Juan José Alvarado-Gil[2, S] and Rubén Arturo Medina-Esquivel[3]

[1]*Facultad de Ingeniería, Universidad Autónoma de Yucatán, Mérida, Yucatán, Mexico*
[2]*Física Aplicada, CINVESTAV, Unidad-Mérida, Mérida, Yucatán, Mexico*
[3]*Física Aplicada, Universidad Autónoma de Yucatán, Mérida, Yucatán, Mexico*
fernando.cervantes@cinvestav.mx

This study presents a method for fabricating composite materials with tailored thermal properties, utilizing fused deposition modeling (FDM) 3D printing with carbon fiber reinforced PETG filament and precise engineering of air gaps. This research assesses how modifications in the configuration and scale of the engineered air gaps embedded within the composite matrix influence its thermal diffusivity and conductivity. By implementing a modified Armstrong method, we conducted a detailed examination of the thermal diffusivity in these composites. This adapted method enabled a precise evaluation of FDM 3D printed materials' thermal transport properties. In this study, the objective was on the generation of samples featuring specifically tailored air gaps, designed with CAD software, and produced using FDM 3D printing technology. This approach allowed for the exact formation of the engineered air gaps, finely adjusting the thermal characteristics of the composites. The findings suggest that strategic manipulation of air gaps at a micro-scale is a powerful method for crafting materials with specific thermal attributes. This investigation paves the way for producing advanced composite materials for applications that demand precise control over thermal conductivity and diffusivity, including thermal insulation systems, thermoelectric devices, and electronic thermal management materials. This work emphasizes the essential contribution of 3D printing and computational design in the field of materials development, setting a new standard for precision and customization in materials technology.