DESIGN AND CHARACTERIZATION OF THERMALLY HIGH CONDUCTIVE COMPOSITES

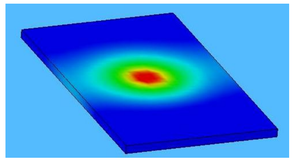
J. Schuster (University of Applied Sciences Kaiserslautern), D. Heider and K. Sharp (3TEX)

University of Delaware . Center for Composite Materials

INTRODUCTION

Design Parameters for Composites

- Stiffness (Deformation)
- Strength (of layers)
- Impact behavior
- Toughness
- Density
- Wear
- Price
- …



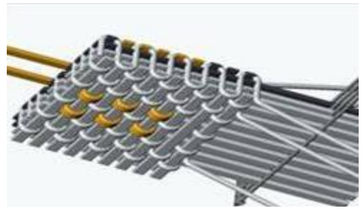
Thermal conductivity?

Main Goal:

Improvement of out-of-plane thermal conductivity of composites by a factor of at least 10 to obtain an additional design parameter

OBJECTIVES

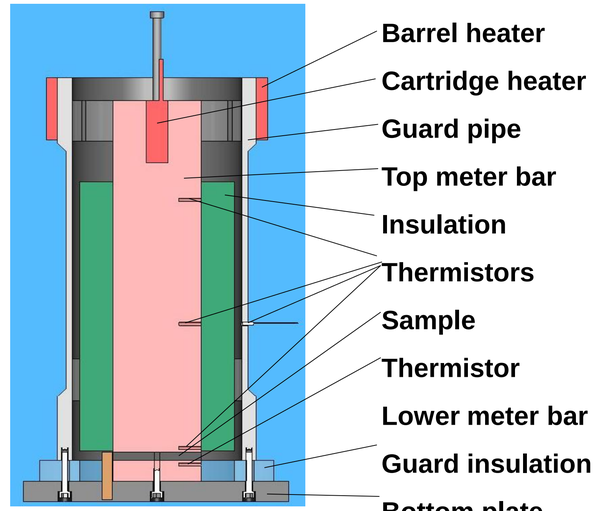
Intention: Use of 3D-oriented textile preforms



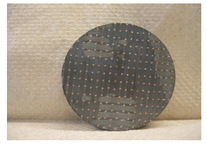
$K_{C\text{-}fiber}$ = 320 – 900 W/(m K)
$K_{composite}$ = 0.6 W/(m K)
$K_{Aluminium}$ = 166 W/(m K)
K_{Copper} = 390 W/(m K)

- Creation of a suitable measuring device
- Production of samples with varying z-fiber content
- Determination of thermal conductivity
- Analytical description for design purposes

CONDUCTIVITY MEASURING CELL

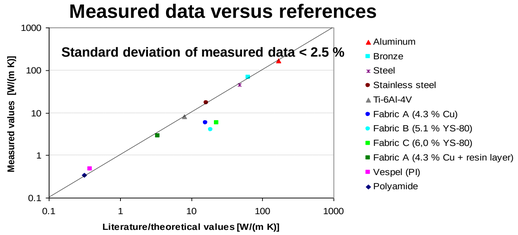


RESULTS



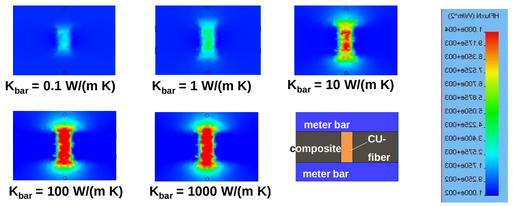
Sample:
Thickness 10 mm
2" diameter
4.3% Cu-fibers

Measured data versus references

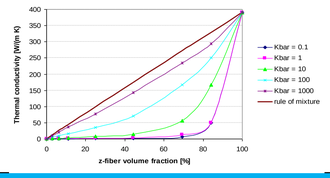


Out-of-plane thermal conductivity has been improved by a factor >10 compared to laminated composites

SAMPLE HETEROGENEITY



Influence of meter bar material



MODEL

In-plane properties of z-fibers => simple rule of mixture

$$K_{11} = K_{lfiber}\,\nu_{fiber} + K_{matrix}\,(1-\nu_{fiber})$$

Out-of-plane properties of x-,y-fibers

$$K_{33} = K_{matrix} + \frac{K_{matrix}\,(K_{lfiber}-K_{matrix})\,\nu_{x-,y-fiber}}{K_{matrix} + \frac{(1-\nu_{x-,y-fiber})\,(K_{lfiber}-K_{matrix})}{2}}$$

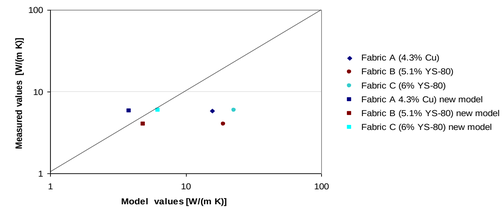
Combined in terms of parallel connection

$$K_{33composite} = K_{z-fiber}\,\delta_{z-fiber}\,\eta_{KMat}\,\eta_{Dens} + (1-\delta_{z-fiber})\,K_{out-of-planex,y}$$

$$\delta_{z-fiber} = \frac{\nu_{z-fiber}}{\nu_{x-,y-fiber}} \qquad \eta_{KMat} = \left(1 - \frac{1}{K_{meterbar}}\right)^{1-\nu_{z-fiber}}$$

$$\eta_{Dens} = \frac{d_{fiber}}{D_{fiber}} = \frac{d_{fiber}}{d_{fiber}\sqrt{\frac{\pi}{4\,\nu_{z-fiber}}}} = 2\sqrt{\frac{\nu_{z-fiber}}{\pi}}$$

MODEL VALIDATION



ACKNOWLEDGEMENTS

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