Finite Element Material Model for the Prediction of the Thermal Conductivity of Highly Filled Polymers

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Abstract

Advanced polymer composites are increasingly used in the development of efficient and resource-conserving applications which require a high thermal conductivity. To optimize the thermal properties of the composites, fillers are added into the matrix material. To predict the effective thermal conductivity of the composites, several theoretical and empirical models have been presented [1-5]. To enhance the prediction of the influence of various fillers on the effective thermal conductivity a 3D finite element based material model is presented. Thereby, different properties of the filler such as filler geometries, filler proportions, filler size distributions and filler orientations can be taken into account.

To evaluate the model, specimens of polyphenylensulfid (PPS) with cuboid aluminum silicate (AlSi) fillers are injection-molded. The filler fraction is gradually increased up to the processing limit. The filler-dependent thermal conductivity is determined by different measuring methods and compared with the prediction from the material model. The results show that the prediction with the material model matches the measurements very well. Therefore, it is assumed that the developed material model can be used for the reliable virtual development of new highly filled thermally conductive polymer composites.

Using the model first studies have been conducted to establish guidelines for the development of advanced polymer composites.

Image

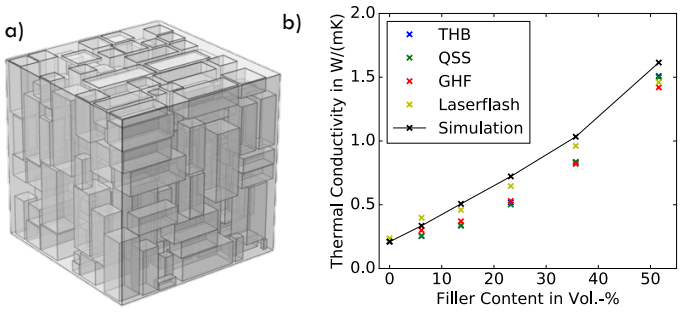


Figure: a) 3D finite element material model of PPS/AlSi with 60 Vol.-% filler content, b) simulated and measured filler-dependent thermal conductivity of PPS/AlSi

Recent Publications

1. Progelhof R. C., Throne J. L., Ruetsch R. R. (1976) Methods for Predicting the Thermal Conductivity of Composite Systems: A Review, Polymer Engineering and Science 16:615-625
2. Hongyun Chen et al. (2016) Thermal conductivity of polymer-based composites: Fundamentals and applications, Progress in Polymer Science 59:41-85
3. Ich-Long Ngo, S.V. Prabhakar Vattikuti, Chan Byon (2017) A modified Hashin-Shtrikman model for predicting the thermal conductivity of polymer composites reinforced with randomly distributed hybrid fillers, International Journal of Heat and Mass Transfer 114:727–734
4. Hill R. F., Strader J. L. (2007) Rudimentary Finite Element Thermal Modeling of Platelet-filled Polymer-Ceramic Composites, IEEE Transactions on Components and Packaging Technologies 30:235-241
5. Ich-Long Ngo, Sangwoo Jeon, Chan Byon (2016) Thermal conductivity of transparent and frexible polymers containing fillers: A literature review, International Journal of Heat and Mass Transfer 98:219-226



Biography

Jochen Gaiser is a PhD student at the University of Applied Sciences Karlsruhe and is conducting research on measuring and simulation methods for the determination of the thermal conductivity of highly filled polymers. The aim of his work is to ensure the reliable design of thermally stressed injection-molded components.

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Notes/Comments: