Efficient Simulation of Short Fibre Reinforced Composites

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Lightweight structures became more and more important over the last years. In the development of these structures, fibre reinforced materials play an important role. One special class of fibre reinforced components, are short fibre reinforced composites, produced by injection moulding.
To avoid expensive experiments for testing the behaviour of these materials under several loads, an effective simulation is necessary. Therefore, material models are needed, which describe the specific behaviour.

In this talk, we will present how the material properties of short fibre reinforced composites and the arising stresses within can be described in the case of linear thermoelasticity. For this, we use the stress-strain-relation

$$\sigma = \mathfrak{C} : (\varepsilon - (\theta - \theta_0)\mathbf{T}),$$

with a fourth order material tensor $\mathfrak{C}$, a second order thermal expansion tensor $\mathbf{T}$, the temperature difference $(\theta - \theta_0)$, and the second order linearised strain tensor ε.
For the description of these properties, we start with the expressions for transversely isotropic material, where the tensors $\mathfrak{C}$, $\mathbf{T}$, and, thereby, σ depend on a function $p(x)$, with

$$p : \Omega \to \{y \in \mathbb{R}^3 \mid \|y\|_2 = 1\}.$$

Here Ω is the domain, where our computation is done. Therefore, $p(x)$ can be understood as the direction of a fibre inserted in point x of a mechanical component, which is described by Ω. So, a transversely isotropic component can be understood as a fibre reinforced structure the fibres of which are perfectly aligned along the given direction $p(x)$.

Now, in the case of short fibre reinforced composites the function $p(x)$ is not longer known exactly. Therefore, it has to be supposed as random. The only given information are the first moments of the distribution of $p(x)$, obtained by a simulation of the injection moulding process of this component. So, we show how the material properties and the arising stresses can be generalised from the transversely isotropic case using these moments.

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