Multiphysics Modeling of Heat Transfer During Fiber Drawing

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Abstract

The process of cold drawing a fiber over rollers is analyzed in this work to predict the temperature rise due to the heat generated during plastic deformation of the fiber. Experimental measurements on prototypes indicated an unacceptable temperature rise of greater than 100 F requiring identification of process modifications to reduce the temperature rise to an acceptable level.
A computational model of the submerged drawing process was constructed using COMSOL Multiphysics®. The model includes the deformation of a moving fiber submerged in a tank that contains water circulated by a pump. Plastic deformation due to the mechanical loading of the fiber and a heat source due to this plastic deformation is included and the conjugate heat transfer problem between the moving fiber and the cooling water is solved. Due to asymmetry in the practical application, the modelling process consists of a planar model to generate plasticity and a three-dimensional model to represent the fluid flow. This approach enabled the development of a computationally efficient solid-mechanics model that accurately modeled the fiber thickness while also solving for fluid flow over the length scale of the tank.
Figure 1 shows the equivalent plastic strain generated during the mechanical deformation of the fiber as it is drawn over the rollers. Plastic deformation generates heat and increases the temperature of the fiber, Figure 2. Three-dimensional modelling of fiber cooling due to conjugate heat transfer is shown in Figure 3.

Figures used in the abstract

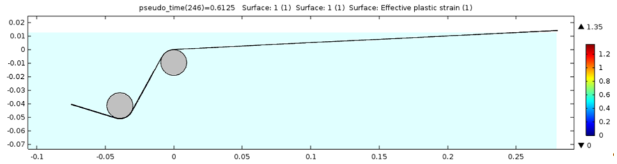

Figure 1: Two-dimensional model of plastic deformation of fiber due to mechanical load