Simulative Approach for Predicting the Heating Behavior of Elastomers in the Solid-State Microwave Heating Process

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Sinopsis

The increasing demand for energy efficient vulcanization of rubber extrusions requires the optimization and further development of existing processes. Microwave vulcanization allows the energy required for this process to be coupled directly into the material via dielectric losses. Microwave heating requires the polarity of the rubber so that the electromagnetic wave can cause the polar components of the material to vibrate. These vibrations cause internal friction, resulting in an increase in the temperature of the rubber compound. In this research project, microwaves were used to heat a rubber strand placed in a specially prepared waveguide. This method offers advantages over conventional methods, such as hot air vulcanization. A key advantage is that the energy is coupled directly into the material, resulting in low losses. In contrast to hot air vulcanization, where the air must first be heated, the heating of the material also takes place within the product to be heated. This results in a significant increase in energy efficiency, reaching up to 90 %. In addition, internal heating provides a more homogeneous heat distribution in the rubber strand compared to external heating by hot air vulcanization.



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To predict the heating behavior of rubber in the microwave process, a simulative model is created in the multiphysics simulation environment CST Studio Suite®. The model describes the microwave heating behavior of rubbers based on the thermodynamic and electromagnetic material data of the rubber compound. This simulation is known as a bi-directional simulation, so that temperature-dependent variables such as dielectric loss and thermal conductivity can be considered. The model is used to analyze parameter variations of the electromagnetic wave frequency, waveguide geometry, and strand orientation in the waveguide. Finally, optimized settings for the real process are recommended.

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