SL 5.8

Phenomenological Model to Predict Carbon Black Dispersion in a Batch Mixer

V. Collin and E. Peuvrel-Disdier
Ecole des Mines de Paris
Centre de Mise en Forme des Matériaux, UMR CNRS / Ecole des Mines de Paris N°7635
BP207, 06904 Sophia-Antipolis, France

Carbon black is commonly used as a reinforcing filler for rubbers. In order to play this role, the carbon black initially in the form of pellets (millimeter size) must be dispersed down to the aggregate size (a few tens of microns) and well distributed in the matrix. This operation is usually performed in a batch mixer. The size and spatial distribution of the filler particles in the matrix determines the quality and properties of the rubber part. A good prediction of these properties implies a good modelling of the complex flow in the mixer and the spatial and temporal evolution of the pellet size distribution during mixing. The last point necessitates a good knowledge of the dispersion mechanisms which is not the case. Dispersion occurs via two main mechanisms which are erosion and rupture. These mechanisms can be induced by the collision between pellets and/or by the hydrodynamic stress subjected to the pellet by the flow of the surrounding matrix. In the case of carbon black pellets dispersed in an elastomer under shear conditions, we showed that rupture is governed by a critical shear stress which depends on the pellet size and that erosion is well represented by a linear variation of the eroded volume with time.

In this work, we propose to use these criterion and law for dispersion to build a phenomenological model to predict the pellet size reduction during mixing. The model couples the physical description of the rupture and erosion mechanisms determined in the case of isolated pellets and a simple description of the flow field in the mixer (maximum shear rate in the milling zone and mean shear rate in the rest of the chamber). The different hypotheses of the model and its limits will be discussed. Although phenomenological, the model allows to evaluate the impact of various parameters (mixing ones or parameters characteristic of the carbon black mix) on the dispersion process.

This work is part of a project supported by the European Community in the framework of the "Competitive and Sustainable Growth" program. The authors wish to thank all the partners including ThyssenKrupp Elastomertechnik, Michelin, Snecma Propulsion Solide, Optigrade-TechPro, Polyflow, Cesame (U.C. Louvain) and T.U. Lodz for their collaboration in this project.