Elongational viscosity and polymer foaming process

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Strain hardening in elongational melt viscosity is necessary in the production of high quality polymeric foam. Strain hardening in the rheology of polymer melts is related to the molecular structure of the polymer and it is greatly enhanced by the presence of long chain branches on the main chain. The relation of rheology with structure has been the subject of extensive studies and reliable theories exist that can be used to describe the viscosity in simple elongational flows as a function of time and strain.[1]

Foaming is an example of a process that employs mainly extensional flow. In the present work this process is used to illustrate the capabilities of the theoretical predictions for the effects of long chain branching on the chain. The simulation uses an approximate but accurate numerical method and aims to assist the foam manufacturers to opitimise their process and produce low density and high cell integrity closed cell insulation foam.

The method is also applied to the description of bubble growth within a polymeric fluid that undergoes a crosslinking reaction (vulcanisation). The (single) bubble growth is initiated by the explosive decomposition of a grain of the foaming agent. The vulcanisation reaction results initially in evolving changes in the relaxation spectrum of the polymer and the degree of branching. Both of these can change the elongational viscosity of the melt. The changing viscoelasticity of the melt influences the growth rate of the bubbles and their final size. At the end of the process, when the crosslinking is complete, the growth of the bubbles stop and the reduction of the density ends.

The density and the properties of the final foam depend on the foaming agent and the foaming agent grain size. The relaxation spectrum of the polymer, its branching structure and the vulcanisation reaction kinetics are important material parameters. Equipment optimisation parameters include the extrusion temperature and the length/temperature profile of the oven.

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[1] G. Vogiatzis, C. Tsenoglou and A.D. Gotsis, Simple constitutive modelling of nonlinear viscoelasticity under general extension, J.Non Newt.Fl.Mech., **138** (2006) 3343