ABSTRACT

The submitted doctoral dissertation presents the development of rigid melamine-formaldehyde foams for use in thermal insulation applications.

The introduction includes the historical development and the basic theory of polymer foam processing. It further includes a description of the cellular structure and its influence on the properties of polymer foams. This is followed by an overview of foaming agents and melamine-formaldehyde foams. Patents and the basic theory of the synthesis of melamine-formaldehyde resin, which is necessary for the production of rigid melamine-formaldehyde foams, are presented. The basic theory of highly efficient thermal insulation materials is given. This chapter includes description of heat transfer through thermal insulation material with detailed analysis of individual heat transfer modes to the overall thermal conductivity under atmospheric and vacuum conditions. The development of a numerical method for non-stationary heat transfer is also given.

The experimental part presents the synthesis of melamine-formaldehyde resin and the production process of rigid melamine-formaldehyde foams. The methods used for foam characterization are described. Initial and boundary conditions are specified and assumptions used to set up the model to describe non-stationary heat transfer. Results and discussion include characterization of rigid MF foam in terms of average cell size, description of the effect of formulation (proportion of foaming and emulsifying agent and catalyst) on its density, and effective thermal conductivity and compressive strength as a function of density. Furthermore, the results of determining the individual contributions of the heat transfer methods (radiation, conduction through the polymer matrix and conduction through air) to the effective thermal conductivity are given. The results of the calculation of non-stationary heat transfer through a panel of rigid MF foam are presented. At the end, there is a description of the safety aspect of the production of rigid MF foams and the possibility of their recycling.

Key words: rigid melamine-formaldehyde foam, effective thermal conductivity, non-stationary heat transfer, compressive strength