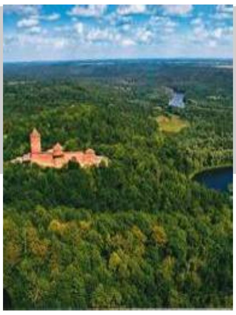
BALTIC POLYMER SYMPOSIUM 2015

PROGRAMME AND PROCEEDINGS



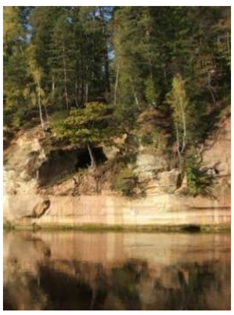
Sigulda, Latvia, September 16-18

Institute of Polymer Materials

Riga Technical University

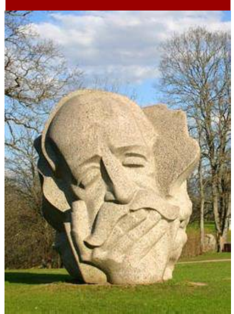
Latvian State Institute of Wood Chemistry

Riga Technical University



Institute of Technical Physics

Riga Technical University



GENERAL SPONSOR

TENAX Grupa, SIA TENACHEM

Riga Technical University
Institute of Polymer Materials

BALTIC POLYMER SYMPOSIUM
2015

Sigulda, Latvia

September 16-18

PROGRAMME AND PROCEEDINGS

RIGA
2015

Scientific Committee
International Advisory Board

Chairman
Prof. Martins Kalnins (Latvia)
Vice-chairman
Prof. Leonids Ribickis (Latvia)

Members
Prof. Juozas Vidas Grazulevicius (Lithuania)
Prof. Ricardas Makuska (Lithuania)
Prof. Andres Krumme (Estonia)
Prof. Andres Öpik (Estonia)
Prof. Talis Juhna (Latvia)
Dr. Janis Zicans (Latvia)

Organising Committee

Chairman
Dr. Janis Zicans
Secretary
M.Sc. Tatjana Ivanova

Members
Prof. Juris Jansons
Prof. Valdis Kokars
Prof. Skaidrite Reihmane
Prof. Remo Merijs Meri
Dr. Bruno Andersons
Dr. Marcis Dzenis

BUILDING OF CURING KINETIC MODELS FOR A SIMULATION OF PULTRUSION PROCESSES

P. Akishin[1], E. Barkanov[1], N. L. Miazza[2] and S. Galvez[2]

[1]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[2]AIMPLAS, Paterna, Spain

Pultrusion process is a continuous and efficient process producing composite profiles with a constant cross-section. During pultrusion, the fibre reinforcements are saturated with the resin in a resin tank and then continuously pulled through a heated die by a puller. Inside the die, the resin gradually cures and solidifies to form a composite part with the same cross-section profile as in the die. After exit from the die the finished product is cut to the desired length by saw integrated to the pultrusion tool. An effective set up of pultrusion process is not possible without a numerical analysis of the technological process when the curing kinetic model for a matrix material should be developed separately.

Curing of thermoset resin is an exothermal chemical reaction, where the curing kinetic is characterized by the degree of cure. Using differential scanning calorimetry (DSC) results, the degree of cure is determined as the ratio of the amount of heat evolved during the reaction up to present time to the total heat of reaction. Traditionally dependencies of the degree of cure on time are approximated by using the Arrhenius relationship multiplied by a simple mathematical function that depends on the resin properties and varies with the resin reaction model.

Physical parameters of the Arrhenius relationship - activation energy and frequency factor are determined by using an experimental data. In this case at least 3 DSC tests at different heating rates (usually 1…10°C/min) are required. There are many methods for a determination of Arrhenius relationship's parameters. The most widely applied are the Kissinger method [1] and ASTM E 698 procedure [2] based on the Ozawa method. As a simple mathematical function, *n*-th order, Prout-Tompkins [3] and Kamal-Sourour models [4] are more frequently used for a formulation of the curing kinetic models. The ordinary least squares method is applied in this case to approximate the experimental curves of the degree of cure and to determine non-physical coefficients of a simple mathematical function.

The proposed methodology for a building of the curing kinetic models was validated by using DSC tests results presented in paper [5] and was realized as the Microsoft Excel tool. The best precision was obtained with the Kamal-Sourour model but the *n*-th order model gave the worst result. Finally the developed methodology was applied successfully for a building of the curing kinetic models of resins with high microwave absorption properties to be used in the advanced pultrusion processes.

The authors gratefully acknowledge the support of European Commission, FRAMEWORK 7 program, contract no. NMP2-SL-2013-609149, project "Development of an Innovative Manufacturing Process for the In-Line Coating of Pultruded Composites (COALINE)".

References

1. *Kissinger H. E.* Reaction kinetics in differential thermal analysis // National bureau of standards - 1957. – Vol. 29, No. 11 – p. 1702–1706.
2. ASTM E 698. Standard test method for Arrhenius kinetic constants for thermally unstable materials.
3. Prout E. G., Tompkins F. C. The thermal decomposition of potassium permanganate // Transactions of the Faraday Society – 1944. – Vol. 40 – p. 488-498.
4. *Kamal M. R., Sourour S.* Kinetics and thermal characterization of thermoset cure // Polymer engineering and science - 1973. – Vol. 13, No. 1 – p. 59–64.
5. Non-isothermal kinetic methods. Wokbook and laboratory manual / Ed. by *Arkhangel'skii I.V.* – Berlin: Edition Open Access, 2013. – 73 p.

Index of authors: