



UNIVERSITY OF MISKOLC
Faculty of Materials Science and
Engineering



Kerpely Antal Doctoral School of
Materials Science and Technologies

Rheology of Polymer Processing

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SUBJECT DESCRIPTION

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Rheology of Polymer Processing

Reorder of the Subject

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Target Group of Subject

The subject is offered to all students of Kerpely Doctoral School. The well-trained student performing research work in the field of polymer technology can obtain specifically useful rheological knowledge by acquiring the curriculum of subject.

Language of Subject

Hungarian or English

Purpose of Subject

The purpose of subject is that the students can learn the fundamentals of polymer melt rheology and the rheological properties of the different plastic materials as well as they can study the tools necessary for determining the rheological characteristics. In addition to the theoretical knowledge, the students can acquire the practice of measurement technology as well by means of the capillary rheometer. Moreover the injection moulding as the rheological approximation of the modern polymer shaping technology and the simulation of shaping appear also as targets in the subject-material.

Methodology of Subject

The students will be trained in the framework of contact-hours in traditional way without prescribing the upper limit of the number of students. During the course, two topics will be detailed in the framework of the so-called „board-presentation” by expounding the theory and the basic relationships of the topics. The draft of topics will be given to the students as work-help divided into two large topics by head-words. In addition to the topics, the checking questions and the compulsory literature will also be given to the students in order that they can learn the topics and they can preliminary check their level of training during the education. There will be a possibility for the personal meeting six-times; the period of each meeting is 5 hours. In addition to the lectures, the questions arising from the side of students will also be discussed during the contact-hours.

Topics of Subject

Topic No. 1

Fundamentals of polymers rheology

Representation of the rheological index numbers and the scientific field of rheology. Rheology of Newtonian fluids. Flow curves of polymer melts of pseudoplastic and dilatant behaviour. Flow of the Newtonian fluid in the capillary. Relationship between the

complete rheological curve and the shaping velocity. Dependence of viscosity on the deformation velocity. Pressure drop as a consequence of the shear of plastic melt. Significance of Hagen Poiseuille relationship. Fundamentals of capillary rheometry. The correction of pressure drop according to Bagley. Pressure drop during the flow into the mould-cavity. The theoretical relationships of Rabinowich and Weissenberg correction. Capillary rheometric measurement practice by using polymer raw material. Calculation tasks: Determination of the kinematic and dynamic viscosity. Determination of the apparent viscosity from complete rheological curves. Simple rheological models. Representation of the Oswald de Waele model. Representation of Carreau equation describing the rheology of structure-viscous melt.

Checking questions:

1. Why is the Bernouli equation called an energetic equation? Where does a pressure drop develop in the die channel and what is the quality of this pressure drop?
2. What is the rheological fundamental law of Newtonian fluids? What is the Reynolds number and the pipe friction factor?
3. What is the construction of Newtonian melt rheological model? What is the explanation of dynamic and apparent viscosity?
4. What is the Oswald-de Waelle model of plastic melt?
5. What is the fundamental equation of the structural or structure-viscous plastic melts?
6. Does the viscosity of polymer melt decrease or increase as a function of increasing the temperature? What is the Arrhenius diagram?
7. How does the Newtonian fluid flow in the capillary?
8. What does the concept of expansion stream mean?
9. What kind of rheometrical methods do you know for determining the apparent viscosity? What is the significance of Bagley correction?
10. Why is the Weissenberg correction applied?

Compulsory literature concerning Topic No. 1:

- 1, Zehev Tadmor, Costas G. Gogos: Principles of Polymer Processing, 2nd Edition ISBN: 978-0-471-38770-1 July 2006 Wiley
- 2, Stanley Middleman: Fundamentals of Polymer Processing, (ISBN13:780070418516) McGraw-Hill Companies 1977.

Topic No. 2:

Rheology of shaping of polymers by means of injection moulding

Structure of plastic materials and their influence on the rheology of injection moulding. Polymeric raw materials suitable for injection moulding. The process and equipment of injection moulding. Fundamental die-constructions. Cycle diagram of injection moulding. Injection moulding on the p-v-T plane. Index-numbers which are important from rheological aspects in the plastic industry. The flow of plastic melt following the power law in the die channel. Heat-transport process during shaping of the different plastic materials. Dependence of viscosity on the temperature. Dependence of viscosity of polymer melt on the pressure. The amount of energy necessary for producing different plastic products and for maintaining the individual technological lines. Following the technological process of injection moulding by a finite-element simulation program. Virtual injection moulding, simulation of injection. Operational principle of finite-element simulation programs and the relationships of their calculation. Representation of Cross-WLF model used by the simulation programs. Computer simulation of the process of injection moulding by using the MOLDFLOW M-P-I program.

Checking questions:

1. What kind of rheological elements does an injection mould consist of? What is the task of the individual rheological elements?
2. How can the mould cavity be filled up? What is the gate freezing? Why is the afterdraft necessary? How much time is necessary for the afterdraft?
3. Determine the concept of injection work. How do the thermal conditions change in the die cavity?
4. What kind of rheological model is used during an injection moulding simulation program?
5. What kind of rheological parameters shall be known for using the injection moulding simulation program?

The compulsory literature of Topic No. 2:

1. Jay Shoemaker: Moldflow Design Guide, HANSER Publishers, Munich 2006
2. Menges-Mohren: How to make injection molds, Verlag, München 2004
3. Oswald, Turn, Germann: Injection molding handbook, Hanser2001.

Offered Literature concerning the subject

4. Robert A. Mallot Plastic Part Design for Injection Molding: Hanser München 1994
5. Howard A. Barnes: A Handbook of Elementary Rheology, Wirral, England 2000.

Fulfilment of Subject, Exams

Oral exam.

Complex exam-questions concerning the Subject

1. How does the viscosity of melt of polymeric material depend on the characteristics of structure and environment?
2. What kind of rheological models shall be applied for describing the pseudo-plastic behaviour of polymers?
3. How does the polymer melt flow in the melt channel and in the die cavity? What kind of enveloping surface is necessary to cover the velocity profile in the flux tube?
4. What means are available for determining the viscosity and shear-sensitivity of polymers? List some types of rheometers and explain their measurement principles.
5. What are the theoretical fundamentals of finite element injection moulding simulation? What kind of models are applied by the simulation for calculating the filling of cavity and thermal condition? What kind of results can be obtained by simulation?