DESCRIPTION FOR THE GENERAL PUBLIC

Dynamic development of material science and manufacturing new, advanced polymeric materials, e.g. polyblends, filled polymers and polymer composites, requires new processing methods. Experiences gained in this field are fundamental for mathematical modeling of polymer processing. The models generalize the results of experimentation and are the basis for development of computer aided engineering tools for polymer processing design. Polymer processing industry is twice as large as polymers industry. It clearly shows an importance of the polymer processing branch to compare with the polymeric materials sector. The wood plastics composites (WPC) market has grown very substantially in the last years. These composites, usually with a content of 40-60% wood flour, have been used in many areas of economy, to replace wood, e.g. as a building material. The main advantage of WPC over wood is its higher resistance to decay. The most commonly used wood plastic composites are the wood/HDPE, wood/PP and wood/PVC resins. Worldwide WPC production is still growing and will reach about 4 million tonnes in 2015. The basic technology of processing of wood plastic composites is extrusion, which is essential in the polymer processing industry because of fundamental use in the compounding processes, eg. filling, reinforcing, mixing and granulation. The extrusion process of wood plastics composites differs substantially from conventional polymer extrusion. It results from the different rheological behavior of these highly filled materials, the thermally unstable nature of wood, etc. State of the art in rheology and processing of wood plastic composites is rather weak. It is generally established that WPC are non-newtonian, pseudoplastic and viscoelastic materials, and exhibit yield stress and wall slip. There is not any model of WPC extrusion around the world. The mechanism of material melting and flow is also unknown. It is expected this mechanism is different from melting and flow of conventional, neat polymers, like PP, PS. Therefore, a research project has been formulated on modeling for single screw extrusion of WPC. On the basis of experimental study a physical model of the process will be proposed, and the first global mathematical and computer model will be developed, and validated experimentally. The main objective of the project is a development of the global mathematical model of the single screw extrusion of WPC, and finally the computer model of the process. The model will involve solid material transport, melting of the material and flow of the molten material. The model will be integrated with the die melt flow models, and this will allow to simulate the extrusion process for various screw and die configurations. The model will make it possible to predict process behavior based on the operating conditions, screw and die geometry, and material properties This will be a basis for development of the CAD/CAE tools of high industrial importance. Experimental studies of the extrusion process of composites based on the PP and HDPE resins, with a content of 30-70% wood flour, using screws of different configurations, are fundamental for the project. Melting of the material and filling of the screw channel will be investigated, as well as pressure, temperature and power consumption will be measured. These will enable to understand the mechanism of melting and flow of WPC in the extruder, and validate the model. The applied technique is a direct observation of the composite samples taken off from the screw extruder, after stopping the machine, and rapid cooling (screw pulling-out technique). Based on a physical model of the process, using equations of motion and energy (continuum mechanics) and appropriate rheological model of the material (developed on the basis of rheological measurements (including effect of wall slip and yield stress), mathematical models of the studied phenomena will be developed (elementary models) and then will be combined in a global model by integrating with the die melt flow models. Global modeling for single screw extrusion of wood plastic composites requires a new approach to computation comparing with modeling of extrusion of conventional plastics. The melting mechanism and material transport are different, the flow is viscoplastic with wall slip and yield stress. The computation algorithm searches the material flow rate which results from an operation of the extruder/die system. The terms of this operation designate an operating point of the extruder which defines the extrusion rate and extrusion pressure. The operating point is determined in a special iterative procedure. Modeling of WPC extrusion is a pioneering research. There is not known any model of the WPC extrusion around the world. Modeling concepts and numerical procedures developed in the project will be applied for process modeling of other composites and filled materials exibitting wall slip and yield stress. The results of the project will find an application in various areas of science and technology: processing of WPC composites and other polymer composites and filled materials, compounding processes in the polymer industry (e.g. mixing, reinforcing, filling, pelletizing), development of new polymeric materials (polyblends, composites, filled polymers), material recycling of polymers, and food processing (materials rheologically similar to polymeric materials).