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Rheological properties of polymer composites with wood filler

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Summary of the doctoral dissertation

„Rheological properties of polymer composites with wood filler"

In the literature part, a brief description of rheological properties of polymer materials in a molten state, including the rheology of filled polymers was presented. The theoretical foundations of capillary rheometry, possible measurement errors and methods of their correction were discussed. Laboratory capillary rheometers (*off-line*) and a literature review concerning rheometric tests using processing equipment such as extruders and injection moulding machines for polymer materials (*in-line*) were presented. The last section of the literature part contains information on wood-polymer composites (WPC) with a description of their rheological properties.

The main research hypotheses were formulated both on the basis of own preliminary tests and literature analysis:

1. The content and size of wood filler particles has a decisive impact on the rheological properties of wood-polymer composites based on polypropylene, wherein the above-mentioned effect decreases with the increase in shear rate.

2. It is possible to perform efficient and reliable rheological measurements under real processing conditions by injection method using a capillary rheological head with a simple design.

One research objective of the study was to determine the rheological properties of wood-polymer composites based on polypropylene in a wide range of shear rate using capillary rheometry. Another research objective was to determine the impact of rheometric corrections (Rabinowitsch correction, Bagley correction and wall slip velocity) on uncorrected values of rheological properties and an attempt to mathematically describe the results obtained using selected rheological models.

The application objective of the study was to determine the rheological properties of wood-polymer composites at high shear rates, or those that occur during industrial injection moulding processes. This requires the development and verification of the correct operation of an innovative stand for determining rheological properties using an industrial injection moulding machine for processing polymer materials.

The description of the research methodology contains a detailed description of the determination of rheological properties of wood-polymer composites using capillary rheometry. In this section, the methodology for determining the volume content of wood flour in WPC under the conditions of the conducted rheological measurements was also described.

In the experimental part, experimentally determined rheological properties of polypropylene composites with wood flour of various particle sizes were discussed. The content of WF in the composites was 10%, 30% or 50% by weight. Among others, the Rabinowitsch and Bagley corrections and the wall slip velocity were determined. In addition, the analysis of reduced viscosity based on the Krieger-Dougherty equation was conducted. Rheological characteristics of WPC in the range of uncorrected shear rate from 10 s^{-1} to 912 s^{-1} were determined using a capillary rheometer. In the study, an innovative head for the determination of rheological characteristics of polymer materials at high values of shear rates adapted to work with an injection moulding machine, was applied. Its use allowed for the tests conducted in the range of uncorrected shear rate from 19098 s^{-1} to 101859 s^{-1}.

Based on the conducted analysis of test results, it has been demonstrated that with the increase in shear rate, the content and size of wood flour particles has a smaller effect on rheological properties of wood-polymer composites.

After exceeding a certain limit value of shear rate, WF has no significant effect on the viscosity of wood-polymer composites. It was also found that rheological properties of WPC in real injection process conditions can be determined only on the basis of in-line measurements.