Abstract

Processing of mouldable fibre reinforced thermoplastics has been established in industrial manufacturing over the past years. So far laminar semi-finished materials, so-called glass mat reinforced thermoplastics (GMT) were used primarily. Competing with these materials are long-fibre-reinforced granulates (LFG) which are melted and homogenised in a plastifying extruder. Long-fibre-reinforced thermoplastics manufactured directly from plastic and fibres are a relatively new group of materials. This material is processed in a plastifying extruder and subsequently pressed similar to LFG or GMT materials.

Parts made of these thermoplastic materials are characterised by high complexity and functionality. Their application is usually found in light to moderately stressed components. The high degree of automation of the manufacturing process is to be particularly emphasised. Dependent upon processing method and degree of automation lot sizes of up to 2,000 items per tool and day can be achieved.

This thesis is a contribution to the investigation of flow behaviour of fibre-reinforced thermoplastic moulding compounds. Main objective was the process integrated analysis and mathematical description of the moulding compound propagation during the process as well as the fibre orientation of these moulding compounds.

In addition, the flow behaviour of different compression moulding compounds with differing geometry was described using mathematical models. Analysis by means of video camera represents a new method which allows examination of oblong compound parts in particular. Application of this method clearly reduces the amount of testing required in comparison to multiple pressing tests. Flow factors determined in the different test series are mostly dependent upon material and process (e.g. fibre length of semi-finished product, compound geometry). These factors have to be determined individually in order to estimate the flow behaviour and to be considered in flow simulation programmes.

The models described represent input parameters needed for a simulation software on the one hand and are a useful tool for processing on the other hand.

To investigate the flowability of compression moulding compounds a model for determination of viscosity values was deduced in an additional work step. This model fulfils the demand for a quick and simple testing procedure. In a model based on Navier-Stokes the viscosity can be derived by means of a circular plate tool of any diameter, whereby proof of a parabolic flow profile is achieved during moulding. An influence of fibre orientation on viscosity could not be found so that fibre orientation can be neglected in future viscosity measuring and computer simulations for moulding force. The results prove that the flow model represents a simple and applicable instrument for material manufacturers and processing plants. Thus, for the first time, different thermoplastic semi-finished materials can reliably be compared and the required input parameters for simulations can be determined as well.

Although the mechanical characteristics of the different moulding compounds were already determined during extensive studies, each type of compound is examined again in separate component suitability checks for serial production. This is due to the lack of knowledge of the flow behaviour like e.g. development or final state of fibre orientation and the fact that reliable viscosity data for a simulation of the different material groups is not available. Because of these deficits component production with moulding compounds was delayed in the past.

Therefore, the connection between fibre orientation and mechanical characteristics was specifically examined in this thesis, based on X-ray photographs which were used to determine the fibre orientation and thus calculate the rigidity. The procedure is excellently suitable to drastically reduce the amount of testing prior to serial production and to determine the rigidity of component segments that are not suitable for mechanical testing due to their geometry.

Extensive mechanical examinations could prove that there is not only a correlation of the mechanical properties with the theoretically obtained values but also that with constant manufacturing parameters as well as unchanging material combinations an examination of the component can be abandoned.

An example of application describes the flow behaviour and the reinforcement effect of thin-walled ribbed components and compares it with parts made of GMT which particularly shows the high potential of plastified moulding compounds. Again correlation with fibre orientation are derived in mechanical investigations of components and characteristic differences within the group of thermoplastic compression moulding materials are pointed out.

The special benefit of this work for processing plants and manufacturers of thermoplastic moulding compounds is emphasised by sample applications with real components as well as by computer simulations.