HIGH SENSITIVE DETECTION OF MELTFLOW INSTABILITIES DURING EXTRUSION OF POLYMER MELTS

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During the extrusion of polymer melts, i.e. polyethylene (PE), visible surface instabilities can appear if the applied strain rate exceeds a critical value. These surface instabilities are called meltflow instabilities and they show a shear rate dependent behaviour (see i.e. [1, 2]). By their appearance the meltflow instabilities can be classified as, i.e. shark-skin, stick-slip or melt-fracture. In addition to the visible instabilities are pressure fluctuations appearing inside the die; those fluctuations seem to correlate with the meltflow instabilities.

The relation between pressure fluctuations and meltflow instabilities was preliminary investigated for PE melts via a commercial capillary rheometer (Göttfert Rheotester 2000) with a unique die set up and advanced data analysis [3, 4]. The unique setup has now been transferred to a lab size single screw extruder (Brabender extruder 10/25D with Labstation).

As for the capillary rheometer unique slit dies have been manufactured. These special slit dies are containing high sensitive piezoelectric pressure transducers to record the time dependant pressure. The setup included a fast data acquisition (100 kHz). Advanced data acquisition methods (oversampling [5]) were used to improve the signal to noise ratio and allowed a pressure resolution of $\Delta p \sim 10^{-4}$ bar at a mean pressure of $p_{mean} \sim 500$ bar. The time resolution is typically in the range of $\Delta t \sim 10^{-3}$ s, enabling us to measure pressure oscillations up to 500 Hz. For the analysis of the pressure fluctuations Fourier-transform (FT) and autocorrelation function were utilized. From this analysis it is possible to distinguish between the different meltflow instabilities and smooth extrudate, as shown in fig. 1. A smooth extrudate, fig 1.a, shows no material dependent peaks. For the polymer melt with visible meltflow instabilities the FT-spectrum (fig. 1.b) gives a broad characteristic and material dependent peak at about 48 Hz.

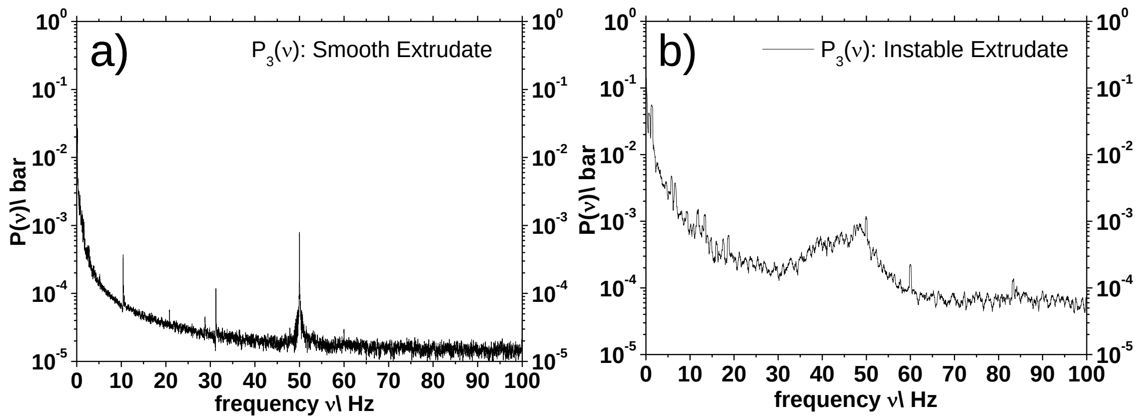

Fig. 1 –The FT of the time dependent pressure of a nearly smooth extrudate is shown in a), at T = 130 °C and $n_{rot} = 10\ min^{-1}$. The FT of the time dependent pressure in b) is for an extrudate with a visible meltflow instability; experimental conditions T = 140 °C and $n_{rot} = 45\ min^{-1}$

The characterisation of melt flow instabilities on the extruder via the new set up is sufficiently done and the preliminary results are promising for a useful application in terms of process optimization and process control. For this purpose the FT analysis seems to be the most promising method of detection of melt flow instabilities, due to the clear appearance of significant peaks. An improved slit die for the online measurement of the first normalstress difference is currently in our workshop under construction.

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