Application Note
LR-60

Correlation between Mixer Tests and the Extrusion Behaviour of PVC Dry Blends

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Key Words:

- Torque Rheometer
- Mixer Test
- Twin Screw Extruder
- PVC
- Stabiliser

Abstract

This report describes the correlation between measurements done on a laboratory mixer with PVC Dry Blends and their processing behaviour on a counter-rotating twin screw extruder.

Introduction

On July 1st, 2006, the EU Directive 2002/95/EG ("RoHS-Directive, Restriction of Hazardous Substances") was put into force. It restricts producing and trading of products containing i.e. lead, mercury and cadmium.
Because a lot of PVC compounds still contain lead as stabilising media, there is urgency for the PVC industry to replace these stabilisers by less dangerous materials like CaZn stabilisers.

Changing the formulation of a PVC compound by using a new stabiliser, always takes the risk that also the production behaviour will change. The reason behind this is the fact that stabilisers also work as a lubricant. So the change of stabilisers will influence the fusion behaviour of the PVC compound. To make sure that the PVC compound keeps its processing properties it is necessary to adapt the whole compound formulation.

The most common tool to check the fusion behaviour of PVC compounds is the laboratory mixer test.
It is an easy and reliable method to characterize the fusion and degradation behaviour of PVC compounds.

The samples used for this investigation were three PVC Dry Blends with new lead free formulations.

Materials and Methods

Polymer:
Three samples of a PVC Dry Blend with different CaZn-Stabilisers

Test arrangements

Mixer Test:
- Torque-rheometer: Thermo Scientific RheoDrive 4
- Double range torque CAN sensor
- Analysis software Thermo Scientific PolySoft OS
- Mixer Thermo Scientific Rheomix600 OS
- Roller Rotors
- Pneumatic feeding ram

Laboratory Mixer

Extruder Test:
- Laboratory twin screw extruder: Thermo Scientific Rheomex CTW100 OS
- Extruder screws: Standardscrews
- Sheet die 50 x 1.0 mm
- Hopper with vibrator
- Melt-pressure sensors

Laboratory Extruder

Thermo Scientific PolyLab OS Torque-rheometer

Test conditions

Mixer Test:
- Mixer Temperature: 170 °C
- Rotor speed: 30 rpm
- Sample weight: 68 g

Extruder Test:
- Extruder feeding zone: air-cooled
- Temperature profile extruder: 170° / 180° / 190 °C
- Temperature at die: 190 °C
- Speed of extruder: 15 rpm

Test procedure and results

Mixer Test:
A defined amount of a PVC sample is pushed into the running and heated mixer by means of a pneumatic ram.
The drive torque, necessary to run the rotors is measured by a torque measuring cell. The torque is plotted against the measuring time (Fig. 1).

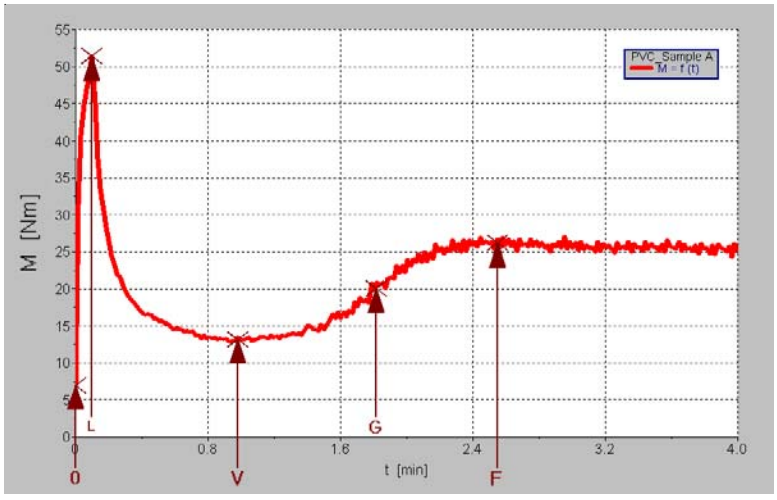

Fig. 1

During the feeding procedure the torque rises to a first maximum (Loading Peak **L**). After the feeding of the sample the torque drops again, because the sample is distributing in the mixer chamber and some additives like waxes are already melting (Valley **V**).
Due to friction and heat the PVC powder starts to agglomerate. This increases the compound viscosity and causes a second rise in torque. The agglomeration process is finished, when the compound formed a homogenous melt. In the torque curve this can be seen as a second maximum, the Fusion Maximum (**F**).

Fig. 2 shows the results of the mixer tests with the three PVC samples in one graph.
Clearly it can be seen that Sample A reaches the fusion maximum much earlier (2.55 min) than Sample B (3.78 min) and Sample C (3.00 min).

Extruder Test:
To correlate this mixer test results with an extrusion process, the three samples were extruded in a counter-rotating twin screw extruder. The melt pressure was measured by a pressure transducer placed halfway down the extruder barrel.

Fig. 3 shows the measured pressure of the three extruder tests in one graph. Sample A shows the highest average pressure (164 bar); Sample B shows the lowest (82 bar); the melt-pressure for Sample C lies in between (128 bar).

This result correlates with the mixer tests. The PVC sample that had the shortest fusion time also showed the highest pressure built up in the extruder.

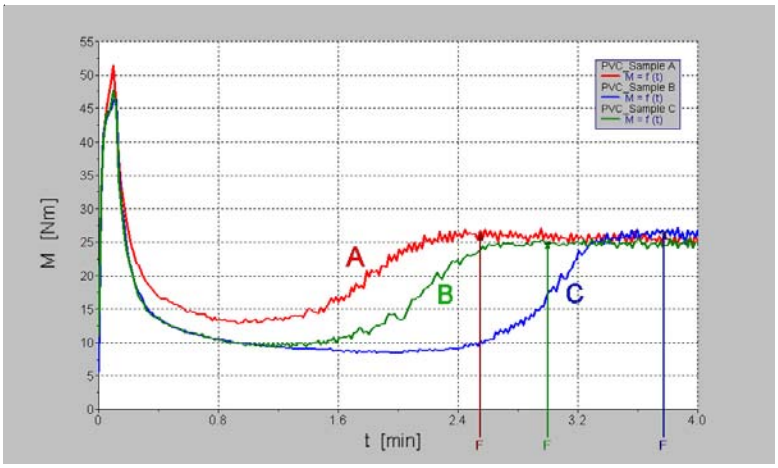

Fig. 2: Mixer tests

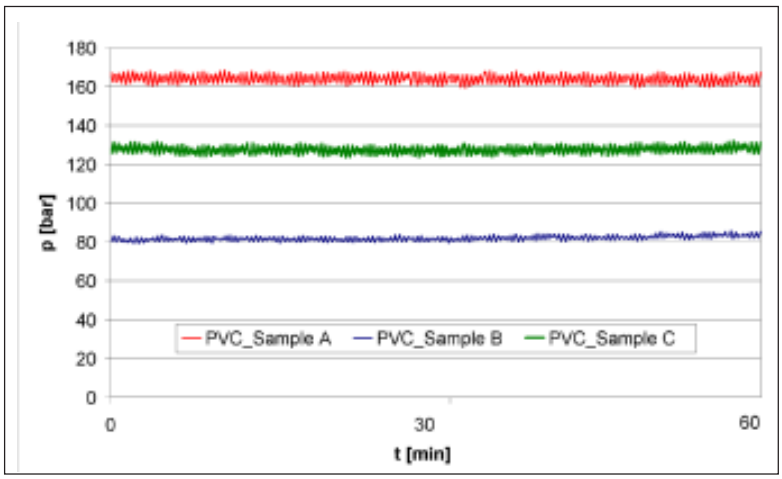

Fig. 3: Extrusion tests

Summary

This correlation shows that the laboratory mixer is a useful and reliable tool to predict differences in the extrusion behaviour of PVC Dry-Blends.

Literature

Directive 2002/95/EC of the European Parliament and of the Council on the Restriction of the use of certain hazardous substances in electrical and electronic equipment.

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