Online Viscometer VIS

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Content

1. Introduction

In order to ensure product quality and operating efficiency when processing sensitive polymers, it is crucial to monitor certain key processing parameters.

For polymers which degrade due to hydrolysis, shear stress, or due to thermal and/or oxidization, it is extremely useful to monitor the polymer viscosity online.

The case examples described here are the processing of PET to sheet for thermoforming. Under temperature and in the presence of moisture, the molecular weight chain will decrease. The influence of moisture on the molecular weight of viscosity on PET (which is measured in IV – the intrinsic viscosity) with difference moisture levels over the same time and at the same temperature is shown in figure 1.

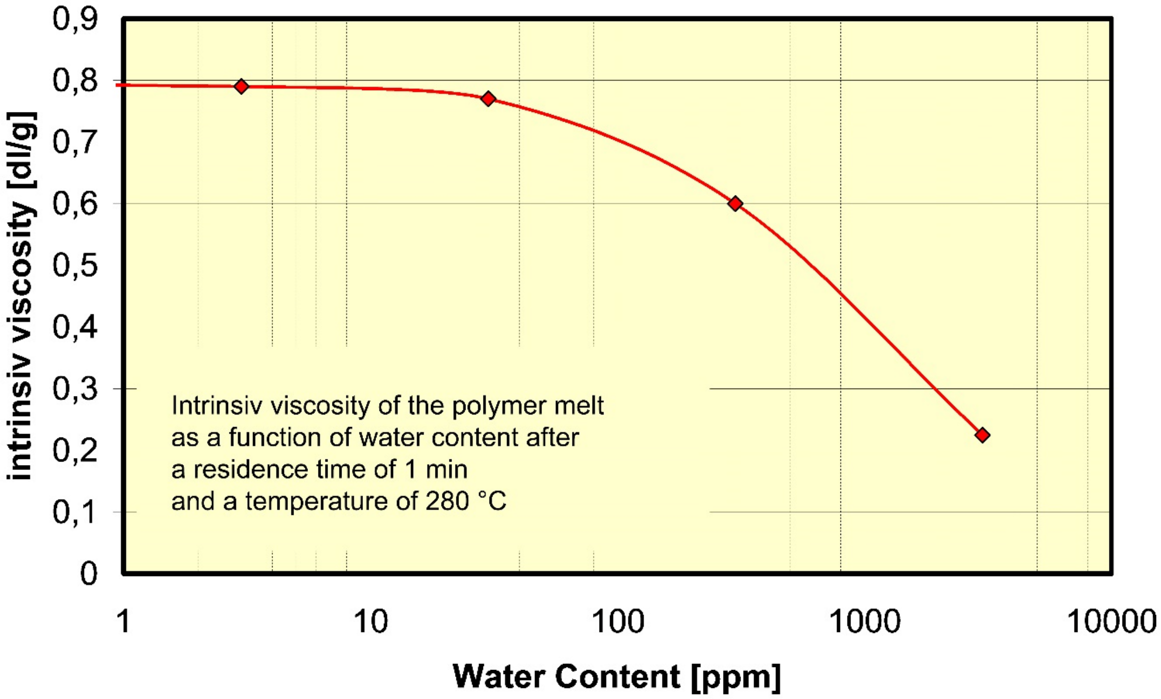

Fig. 1: Polyester degradation by partial hydrolysis - IV of polymer melt as function of water content (at 280°C, residence time 1 min)

The graph makes it clear that when processing PET to sheet for thermoforming, the residual moisture – or drying efficiency (in addition to temperature, residence time, shear stress and pressure) have a significant effect on the properties of the polymer melt.

If the viscosity of the polymer drops, this has a serious, negative effect on the mechanical properties of the final product. The lower molecular weight will lead to a reduced tensile strength and when the sheet is (in a subsequent production process) thermoformed to deep, thin walled containers, the thin wall of the container is prone to splitting. A further problem is maintaining uniform sheet thickness tolerances if the polymer viscosity fluctuates as the material flows differently through the die depending on the viscosity.

One of the main causes for fluctuating residual moisture content is a varying residence time of the material in the drying equipment, the drying temperature, the dew point temperature of the drying gas and the impact of contact with the ambient air. Even if all the above factors are kept stable, the residual moisture content of the input material can vary (for example seasonally) which will result in the melt viscosity and molecular weight of the film.

In order to reduce the impact of viscosity variations, the manufactures of PET sheet for thermoforming typically produce the sheet thicker than necessary, thereby using more material than necessary.

By monitoring the viscosity, it is possible for the producer to take corrective measures. Measurements of the molecular weight or intrinsic viscosity are typically only possible with complicated laboratory equipment and not in real time.

For this reason, a simple and reliable real-time viscosity measurement offers valuable possibilities for material reduction to the manufacturer of PET sheet.

2. The Gneuss Online Viscometer VIS

Gneuss has developed an Online Viscometer which permits continuous monitoring of the melt viscosity and the corresponding processing conditions.

The of the design briefs for this unit was to provide a device which is compact and therefore easy to retrofit without negatively affecting the process (no measurable increase in residence time) simple to use, able to withstand rough production conditions and which provides reliable results (after exact calibration) comparable in their accuracy to laboratory results.

Typically, the Online Viscometer is flanged in between for example a screen changer and melt pump in the extrusion line. In many cases, the modularly designed viscometer is supplied with a flange that is simply fitted into the existing plant (Figure 2). However, it can also be adapted to existing components, so that an extension of the plant is not necessary. If required, the melt channel diameter can also be matched to the customer's existing equipment. The equipment includes a melt (metering) pump with drive motor, reduction gearbox and the necessary melt pressure and temperature sensors together with the visualization and control hard and software.

Fig. 2: Gneuss Online Viscometer VIS

3. Operating Principle

The precision melt (metering) pump diverts a small proportion of the melt flow in bypass via a precision capillary slot.

From the volumetric flow through the capillary, the exact dimension of the capillary and the differential pressure in the capillary it is possible to calculate the shear stress and the dynamic viscosity.

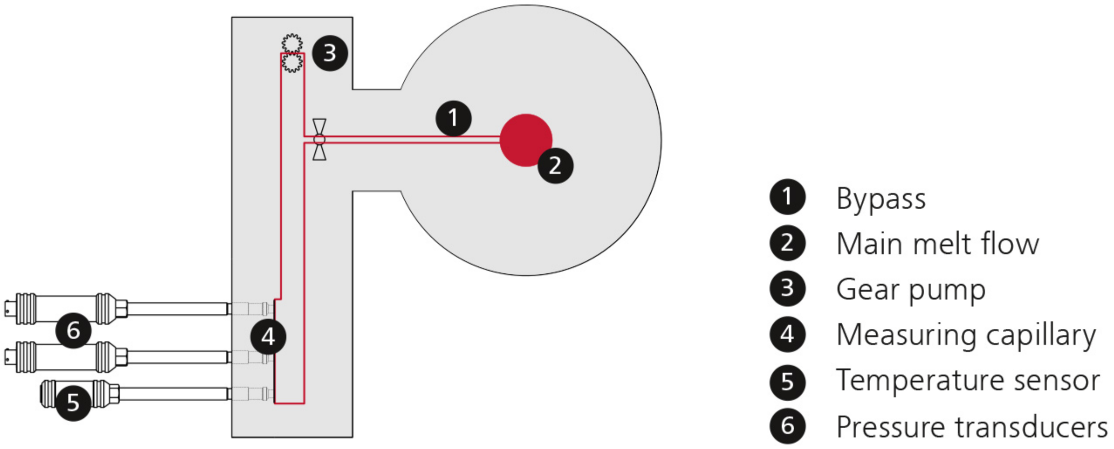

Fig. 3: Online Viscometer VIS mode of operation

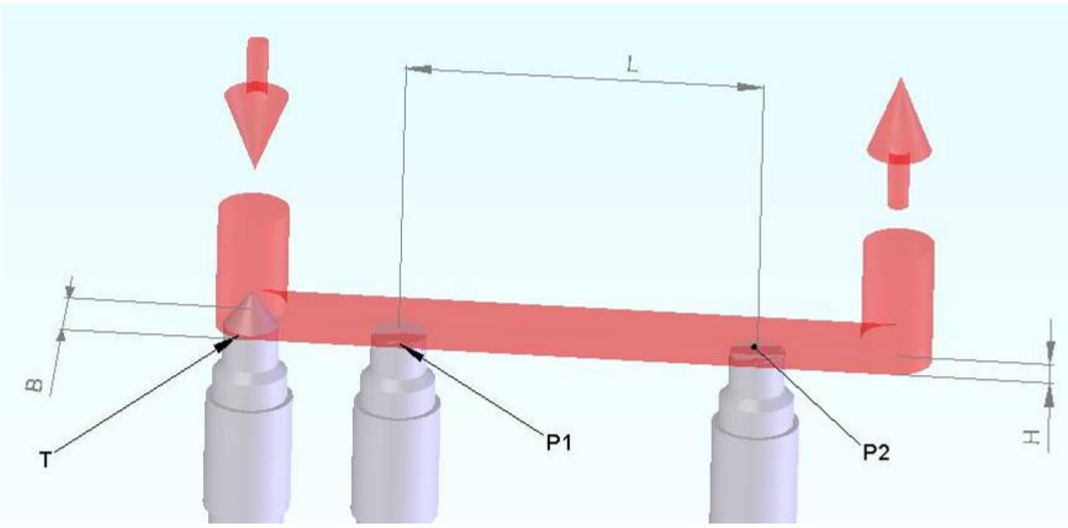

Fig. 4: Definition of Design Parameters

Design Parameters:

H capillary height

L capillary length

B capillary width

V0 flow rate (volume) of the gear pump

Processing Parameters:

N speed of the gear pump

Q (n) volumetric flow through the capillary

Measurements:

P1, P2 Melt pressure in the capillary

T Melt temperature

The Online Viscometer measures the shear stress and the corresponding viscosity. By varying the speed (rpm) of the gear pump, it is possible to set different shear stresses and to measure the corresponding viscosities. With this data and with some correction factors (e.g. Weissenberg / Rabinowitsch, Schümmer, Dodge / Metzner or Reiner / Philipoff) a viscosity curve across a range of shear stresses can be measured and translated into real results.

Features:

The unit is heated electrically or by means of a liquid/vapour heat transfer medium. The user interface is by means of a touch panel display which shows all the running conditions and enables the operator to adjust the parameter settings via a clear and logical menu structure.

With the corresponding capillary slot depth (the capillary can be exchanged during production, viscosities within a range of 1 Pa.s. to 20.000 Pa.s. can be measured. The measurement range is also easily adjusted.

Great care was taken in the design of the unit to avoid dead spots or edges where shear- and temperature sensitive polymers could hang up or the flow could stagnate, the melt channels are manufactured to a high quality in order to ensure smooth flow. One innovative feature is the hinged design of the capillary which is easily removed and easily cleaned (and without stopping production).

4. Case example

4.1 Polyester Bottle Flake Processing with Online Monitoring and Logging of Melt Viscosity

The following is a brief description of the experience of a customer operating the Gneuss Online Viscometer in a line for the production of A-PET sheet for thermoforming.

In this case, the customer runs a large number of different products, comprising of different proportions of bottle flake (reground PET bottles), skeleton waste and virgin material. The more virgin material is used, the higher the viscosity and vice versa.

Due to the ability to monitor the viscosity, the customer was able to introduce countermeasures in order to keep the value within the optimum range. By doing this, it was possible to reduce the quantity of scrap produced by 50 %. At the same time, it was possible to reduce the average film thickness by approximately 10%. The investment in this technology was recovered in only 6 months.

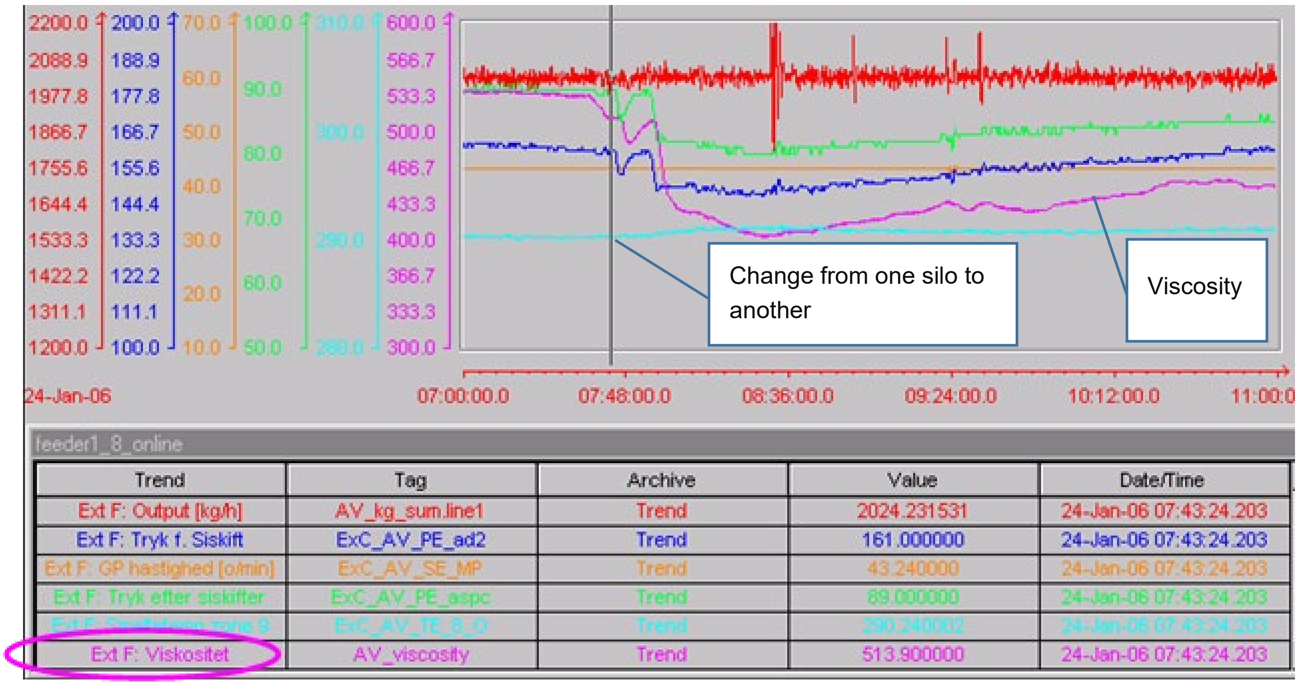

Fig. 6: The viscosity trend shows a material change from one dyer silo to another. The viscosity drops and after a few hours returns to the original level.

4.2 Viscosity Control in Polypropylene Recycling

A recycling company in Northwest Europe buys PP production waste from various applications and reprocess this to pellets for injection moulding flower pots. These recycled pellets must have an MFI value (Melt Flow Index) of approximately 20g (10 min. / 230°C / 2,16 kg). By adding peroxide to the PP, the molecule chain length of the PP is reduced, leading to a lower viscosity (higher MFI). This technique can be used to achieve small viscosity modifications (for example from MFI 4 to MFI 12 but it can also be used to achieve viscosity modifications of several 100. The main advantage of adding peroxide masterbatch is that it enables very reliable and accurate dosing of the active component.

Traditionally, the processor added the peroxide masterbatch at different levels and took sample pellets for MFI testing, increasing or decreasing the percentage of the peroxide masterbatch in order to achieve the required MFI value.

The Online Viscometer firstly provided the possibility of online adjustment of the peroxide, enabling the required MF value to be reached far more quickly and maintained more accurately. Making charges of materials with different MFI values was much easier and major material savings were made during grade changes. Secondly, it was possible to create a control loop between the viscometer and the peroxide masterbatch dosing feeder. Today, it is possible to dial up the required viscosity value in the control system and the dosing feeder is automatically controlled from the reading of the viscometer, the pre-set MFI value is reached quickly and maintained accurately.

5. Summary

- The new Gneuss Online Viscometer is an extremely compact unit and therefore particularly suitable for retrofitting to existing extrusion lines.
- The viscosity measurement is carried out in bypass: no polymer loss.
- The new viscosity meter is advantageous also for the processing of sensitive polymers such as polyester, polycarbonate, polyamide (nylon) etc.
- Material composition, drying efficiency, additive level or reaction progress are easily monitored by following the melt viscosity.

Imprint

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