# Polypropylene Rheology- QC

In this application the effect of degradation on the quality of a polypropylene sample will be shown. The rheological properties of polypropylene which is used e.g. for die casting of injection moulding greatly influences the quality of the finished products. Further, they play a role in the feasibility of the process. Changes in the material often will require changes in the process conditions.

## Samples and Equipment

Two polypropylene samples, one normal and one degraded, have been analysed with a StressTech rheometer at 190 °C. The rheometer was equipped with an elevated temperature cell (ETC) which heats the sample evenly with an accuracy of 0.1 °C.
The tests that have been carried out are a viscometry test, a stress sweep at a constant frequency and an oscillation measurement (frequency sweep).

## Results

Figure 1a and 1b show the results of the oscillation measurement: viscosity, phase angle, storage and loss modulus as a function of the frequency. Both samples show the same type of behaviour, i.e. the viscosity increases with decreasing frequency and seems to approach a finite value, the moduli decrease. Differences can mainly be seen at the lower frequencies.

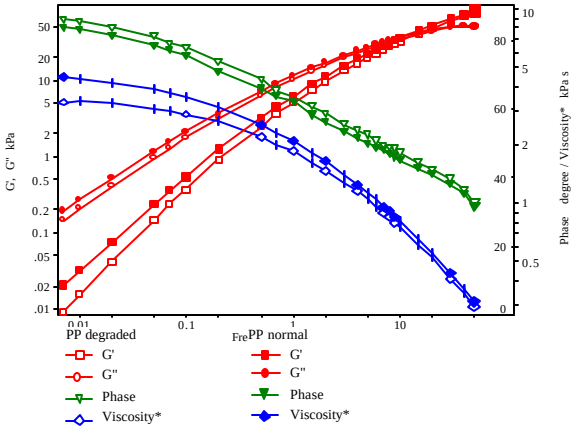


**Fig. 1a** Frequency sweep

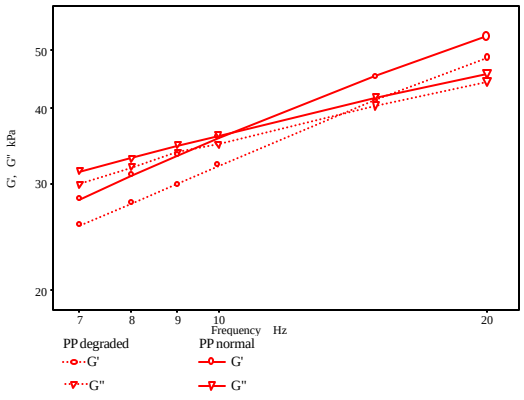


**Fig. 1b** Detail of figure 1a

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At high frequencies both samples are elastic, i.e. the storage modulus G' is higher than the loss modulus G'', the phase angle is below 45°. At 10 Hz respectively 15 Hz there is a crossover as shown in Fig. 1b. At this point the samples become more viscous than elastic.
The difference in the crossover frequency between degraded and normal sample can be attributed to the change in molecular weight. During degradation the molecular weight of the polypropylene is reduced which results in a higher crossover frequency. A decrease in molecular weight can further explain the lower viscosity value of the degraded sample.

Measurements at low frequencies give information about the sample behavior at long time scales. For the degraded polymer there is a change in behavior to be expected at e.g. sagging under gravity. This can cause surface defects in the finished product or influence its stability and thickness.

A test that can directly be connected to the flow of the polymer melt in process is the viscometry test. The results of this test show viscosity and shear stress as a function of the shear rate. Both polypropylene samples have a finite viscosity value at low shear rates, which corresponds to their behavior at low frequencies. Figure 2 shows the results for both degraded and normal sample.

The difference in viscosity at the lowest shear rates is, as said above, attributed to the decrease in molecular weight and will have the described consequences for the process.

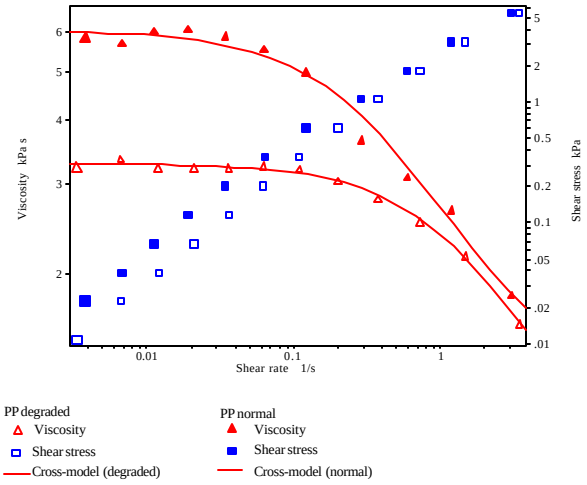


**Fig. 2** Flow and viscosity

At higher shear rate the viscosity decreases which is typical for a polymer where the molecular chains orient themselves in the direction of the flow. The symbols in the diagram give the measurement results, the solid lines show the curve fit of the Cross model which has been made with the RheoExplorer software of ReoLogica Instruments. A model that describes the flow behavior of a material can be used to predict its viscosity or other values, dependent on the model used, at other shear rates than those it has been measured at.

Well-founded knowledge about the flow properties of a material are necessary for the construction of process lines and for the solution of observed problems in the process or the quality of the finished product. This application shows how knowledge about these properties can be gained easily and exactly with the Stresstech.