glass WORLDWIDE

Automatic measurement and evaluation of cord stresses

Henning Katte describes a recently developed automated method for measuring cord stresses in bottles and jars in an objective and reproducible way.

The fracture strength of container glasses is strongly influenced by so-called cord stresses. Strong stresses near the glass surface especially can significantly increase the probability of breakage when the bottle is filled at the bottling factory or handled by the end customer. Continuous and objective control of cord stresses is an essential precondition for ensuring high quality, therefore.

ORIGIN AND SIGNIFICANCE

Ideally, glass is homogenous in composition, ie there are no local variations in the chemical structure. However, due to time and cost constraints in commercial glass production, this cannot be achieved perfectly. The reasons can be manifold: Incompletely melted batch components, insufficient dwell times in the furnace or improper temperature distributions in the forehearth, to name but a few.

Due to fluid dynamics, these compositional differences appear as streaks in glass, called cords, which have a different thermal expansion coefficient to the surrounding glass matrix. This causes strong mechanical stresses. Since the tensile strength of glass is ten times lower than the compressive strength, tension cords near the glass surface especially have a negative influence on the container stability and can lead to costly complaints if the glass breakage happens after leaving the factory.

MEASUREMENT PRINCIPLE

Since the cord streaks are often hardly visible in a normal polariscope used for checking annealing stress, in dark coloured bottles especially, a different method is used to quantitatively measure cord stress. According to ASTM C 978, ring sections are cut from the cylindrical part of the container and analysed with a polarising microscope.

In order to avoid time-consuming polishing of the glass surfaces, the ring is immersed in a liquid that has a similar refractive index to the glass, eliminating light scattering. The polarised light sent through the ring section changes its polarisation state when interacting with stresses in the glass. The resulting optical retardation can be quantified by using a Senarmont or Berek compensator attached to the microscope.

AUTOMATED MEASUREMENT

However, the described method is labour-intensive and time-consuming, since the ring section has to be scanned visually through the microscope to search for the maximum stress value. In addition, the results very much depend on the operator's skills and are therefore subjective. Gage R&R studies have shown that the practically achievable reproducibility is significantly below the desired level.

In order to make the measurement of cord stress more objective and reproducible, the StrainMatic polarimeter system, originally developed by ilis to measure annealing stresses objectively, has been further developed and adapted. The recently announced StrainMatic M4/120 cord tester applies the same physical principles as the manual method but fully automates the measurement of cord stresses in bottles and jars with a diameter of up to 120mm.

After placing the ring section into a petri dish with immersion liquid, the operator only has to start the measurement. After less than one minute, the operator sees a colour-coded image showing the stress distribution for the whole ring section. In addition, the area of maximum tension is identified, highlighted in the image and reported as a numeric value (figure 1). The results obtained can be stored in an integrated database and exported to production line monitoring systems.

SUMMARY

In order to ensure a high glass homogeneity, cord stresses have to be monitored on a routine quality check basis. The currently used manual method is labour-intensive, user-dependent and requires adequately trained personnel. The StrainMatic cord tester automates and accelerates the measurement and ensures documentable and highly reproducible results. ■

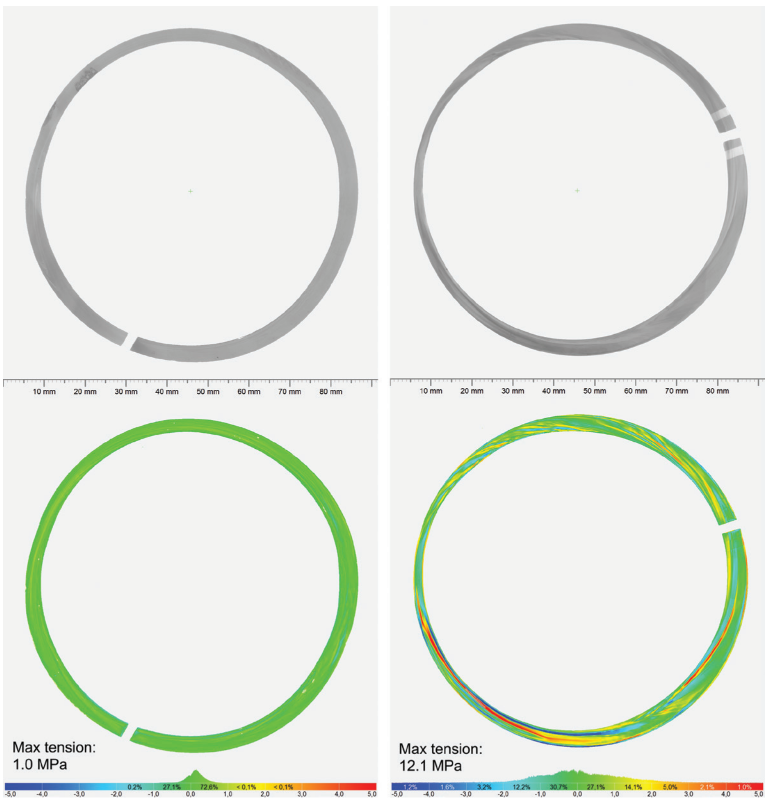

Figure 1: Measurement results of a bottle ring without stress (left) and a sample with significant cord stress (right). Compression is shown in blue and tension in red. Neutral areas appear in green.

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