Strainoptics® **TECHNOTE**

How to Improve Cutting Quality by Monitoring Mid-Plane Tension in a Float Glass Slice

Unlike optical glass subjected to a fine annealing cycle, glass from a float line is not completely stress-free. Residual stresses vary across the ribbon as a result of the temperature distribution in the hot end and the cooling zone near the strain-point temperature. Excessive stresses can cause cutting difficulties and poor production yields.

While average stresses through the glass thickness may be automatically monitored on-line with equipment such as the Strainoptics SCA-1500 stress measurement system, QC for optimum cutting quality can be ensured by a simple procedure using a Strainoptics Model PS-100-MW polarimeter to measure the mid-plane tension in a sample glass slice. Many leading float glass manufacturers are now routinely using this inspection technique in their Quality Control and R&D departments.

The PS-100-MW polarimeter consists of three major components:

a) Plane-polarized illuminator/sample stage
b) Column-mounted microscope with coarse and fine focusing control
c) MWA-100 single-wedge (Babinet) compensator with eyepiece with counter readout

Figure 1. PS-100-MW polarimeter showing MWA-100 compensator and glass slice in proper position for measurement.

Procedure

The procedure described below may be used for float glass or annealed flat glass products.

1. Cut a sample strip to a uniform width, approximately 1 inch (25 mm) by 6 inches (150 mm) in length. Care should be taken to cut the sample cleanly to minimize chipping. Polishing is not necessary, but excessive chipping can make visualization of the magnified image more difficult. Use of an immersion cell fixture and refractive index matching fluid (available from Strainoptics) is recommended, especially for thin glass.

2. Place the slice (or immersion cell) on the sample stage of the PS-100-MW polarimeter. Make sure that the sample is placed directly under the objective lens, with its long axis parallel to the MWA-100 compensator as shown in Figure 1.

3. Focus the microscope on the top edge surface of the glass.

4. Observe the stress pattern through the eyepiece of the MWA-100 compensator. Set the counter to "000" (zero) and observe the black fringe (Figure 2).

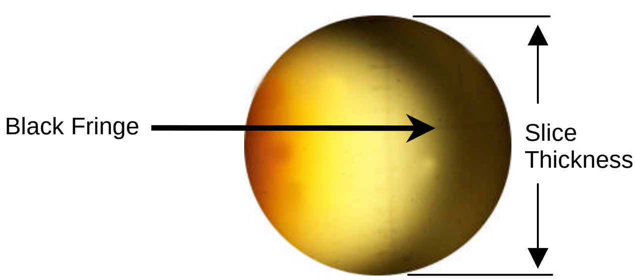

Figure 2

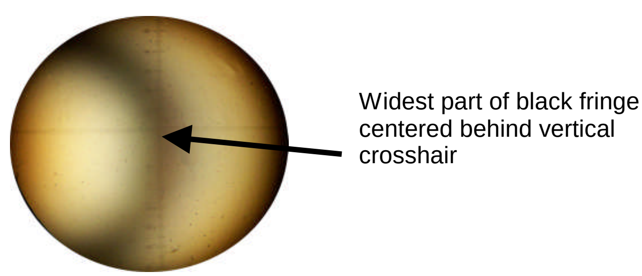

Figure 3

Continued on page 2.

5. To measure center tension, turn the knob of the MWA-100 until the widest part of the black fringe is centered under the vertical crosshair, as shown below in Figure 3. Now read the counter -- this number is *D* counts. Using the MWA-100 counter number *D*, apply these simple equations to calculate the retardation *R* of the sample (in nm) at the mid-plane:

(metric) $R_{nm} = D * \text{compensator constant } ({}^{nm}/_{count})$

(U.S. conventional) $R_{fringes} = D * ({}^{fringes}/_{count})$

The mid-plane tension is: $S_{midplane} = {}^{R}/_{W*C}$ *(MPa)* where *W* = sample width in mm and *C* = Material stress-optical constant

Using the metric system, width is expressed in millimeters (mm), retardation is expressed in nanometers (nm), and stress is measured in megapascals (MPa). For U.S. units, width is in inches (in), retardation in fringes (565 nm = 1 fringe), and stress is measured in pounds per square inch (psi).

Consider the following numerical examples:

The following sample calculations illustrate both metric and U.S. unit measures.

In these examples, the MWA-100 *compensator constant is 5.7 nm/count* (which equals 0.01 fringes/count).

Width of the sample = *W*	Compensator reading = *D*	Retardation = *R*	Stress-Optical Constant (float glass) = *C*	Stress Computation = $S_{midplane}$
25 mm	018	R_{nm} = 18 x 5.7 = 103 nm	C_B = 2.65 Brewster	$\frac{R_{nm}}{W_{mm} * C_B}$ = 1.5 MPa
1 inch	018	$R_{fringes}$ = 18 x 0.01 = 0.18 fringes	$F_{fringes}$ = 1270 psi/fringe	$\frac{R_{fringes} * F_{fringes}}{W_{in}}$ = 228 psi

In these examples, mid-plane tension is measured and laminar stresses are assumed to be in equilibrium. Therefore, the total tensile and compression forces will ideally sum to zero. This implies that the surface compression is approximately 2 times larger than the mid-plane tension. However, surface compression may also be measured using the same equipment and technique described, providing that the sample has been properly prepared. *Note: Surface compression may not be equal on both sides of the glass.*

These technical notes have been developed to assist Strainoptics customers when measuring low-stress or annealed glass products. The staff at Strainoptics or one of our representatives is available for assistance if you have any questions or require additional information.

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