ME 354 MECHANICS OF MATERIALS LABORATORY

MECHANICAL PROPERTIES AND PERFORMANCE OF MATERIALS

Stress Intensity Factors

February 2008 NJS

PURPOSE

To measure the plan strain critical stress intensity factors (K_{Ic}) of polycarbonate and acrylic using the single edge-notch specimen geometry for long and short precrack lengths..

PROCEEDURE

(a) Using a hack-saw, cut a precrack into the gage section of each specimen.

a. Acrylic (*Short Crack*): 3-5 mm
b. Acrylic (*Long Crack*): 7-10 mm
c. Polycarbonate (*Short Crack*): 3-5 mm
d. Polycarbonate (*Long Crack*): 7-10 mm

(b) Measure the gage width *w*, gage thickness *t*, and notch length *a* for both polycarbonate and acrylic specimens and enter the values into Table 1.

Perform the following steps for the acrylic specimen with the Instron in displacement control:

(c) Zero the load cell by initiating the "calibrate" routine.

(d) Check to make sure that both grips are open and that the acrylic specimen can slide freely between the grips. Use the actuator controls to position the grips so that the specimen will be fully clamped at both ends.

(e) Install the specimen: tighten the upper grip first, then tighten the lower grip.

(f) Initiate the data acquisition and control program

(g) Run the test until the specimen breaks.

(h) Carefully observe the behavior of the material near the notched region.

(i) Print the force vs. displacement curve. Use a straight edge to find the slope through the linear region of the data. Draw a 5%-offset line to find P_Q (a line with 0.95*slope of linear region).

(j) Calculate K_{Ic} from the measurement data.

(k) Examine the fracture surfaces and note the nature of the crack growth. Describe your observations on the following page.

Repeat steps (d) – (k) for each of the four specimens

Use the data collected to complete the tables on the following page.

DATA REDUCTION

For this geometry, the mode I stress intensity factor is given by

$$K_{Ic} = FS\sqrt{\pi a}$$

where: $$F = 0.265(1-\alpha)^4 + \frac{0.857 - 0.265\alpha}{(1-\alpha)^{3/2}} \qquad S = \frac{P_Q}{wt} \qquad \alpha = \frac{a}{w}$$

The fracture toughness found is valid for this test only if:

$$\frac{P_{Max}}{P_Q} < 1.10 \qquad \text{and} \qquad t, a, (w-a) > 2.5\left(\frac{K_{Ic}}{\sigma_0}\right)^2$$

DATA

Fill in the following table:

	Acrylic (PMMA)		**Polycarbonate (PC)**	
Test:	*Short crack*	*Long Crack*	*Short Crack*	*Long Crack*
Gage Width w (m)				
Gage Thickness t (m)				
Notch Length a (m)				
$\alpha = a / w$				
Shape Factor F				
Force at initial cracking P_Q (N)				
Maximum Force P_{Max} (N)				

RESULTS

Fill in the following table:

	Acrylic (PMMA)		**Polycarbonate (PC)**	
Test:	*Short crack*	*Long Crack*	*Short Crack*	*Long Crack*
Nominal Stress S (MPa)				
Fracture Toughness K_{Ic} (MPa $m^{1/2}$)				
Yield strength σ_0 (TABLE 4.3) (MPa)				
$2.5 (K_{Ic} / \sigma_0)^2$				
P_{Max} / P_Q				
Test Valid? (yes/no)				
Handbook K_{Ic} (TABLE 8.2) (MPa $m^{1/2}$)				

DISCUSSION (*Sect. 8.7-8.8 in Dowling may help*)

1. Describe the behavior of acrylic and polycarbonate during testing?

2. Describe the failure surfaces of the acrylic and polycarbonate specimens:

3. Recall the stress-strain response of acrylic and polycarbonate measured during a previous lab. Based on the single-edge notch tests conducted today, discuss whether cracks (or crack-like notches) important concerns to the design engineer using these materials:

4. Compare the test-measured of K_{Ic} and the handbook values (TABLE 8.2) for acrylic and polycarbonate similar? What factors caused the difference?