FRACTURE INITIATION IN PMMA

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Three specimen geometries were used to find the fracture toughness of PMMA at room temperature. Results are seen to correlate well when plotted in a K versus 1/G dG/da plot. Using a curve of $\dot{a} = \alpha K^{\beta}$, the load deflection curve for each test can be derived and the results are shown to agree reasonably well with the experimental results only when 1/G dG/da fall below a given limit; for higher values, initiation occurs for values as low as 0.65 MPa√m and a good fit can only be obtained by using different propagation laws.

EXPERIMENTAL

Three specimen geometries with the same relevant dimensions of 80x40x6 of a commercial grade of PMMA were tested under constant displacement rates. The geometries were the 3PB and SENT with pin loading or flat grips; the displacement rates used were in the range of 1 mm/min to 100 mm/min. For these geometries, the fracture toughness can be computed by $K = Y \sigma \sqrt{a}$; the value of σ being obtqined from the load deflection diagram when the behaviour is no longer linear or when the load is at maximum; the crack length is measured on the fracture surface and a initial and a final length can sometimes be identified; Y is a geometric factor.

For the three geometries used in this investigation it can be shown that:

$$C = \frac{\Delta}{P} = \frac{2}{BE} \left(C_o + (1-\nu^2) \int \frac{a}{W} Y^2 \, d\left(\frac{a}{W}\right) \right) \qquad (1)$$

$$K = \frac{E}{2\sqrt{W}} \; \frac{Y \sqrt{(a/W)}}{C} \; \Delta \qquad (2)$$

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$$\frac{1}{G}\frac{d\ G}{d(a/W)} = \left[\frac{Y^2\ (a/W)}{C^2}\right]^{-1} \frac{d}{d(a/W)} \left[\frac{Y^2\ (a/W)}{C^2}\right] \quad (3)$$

In these formulas C_o is a constant with theoretical values of 8 and 1 for the 3PB and SENT geometries respectively.

Figure 1 shows equation (3), and in figure 3 we present the experimental results together with the relevant limits for 1/G dG/da. The different regions for initiation and instability are identified which contain results obtained in more than one geometry. The fracture results show a good agreement with the values reported by Marshal and al. (1) and by Atkins and al. (2).

MODELLING CRACK PROPAGATION

Marshal and al. (1) and Beaumont and Young (3) using TC and DT specimens derived crack propagation curves for PMMA of the form:

$$\mathring{a} = \alpha\ K^{\beta} \quad (4)$$

and this expression together with (1) and (2) was used to generate the load deflection curves.

For the 3PB geometry the results are very close to the experimental results as shown in figure 2. For the SENT specimens the agreement is in general very poor suggesting higher crack velocities. On the other hand the initiation values for the SENT geometries are not compatible with equation (4), sugesting that high 1/G dG/da values promote an intensive damage in the craze and lower initiation values.

REFERENCES

(1) Marshall, G.P., Coutts, L.H., Williams, J.G., J. Mat. Sc. 9, 1974, 1409 - 1419

(2) Atkins, A.G., Lee, C.S., Caddell, R.M., J. Mat. Sc. 10, 1975, 1381 - 1393

(3) Beaumont, P.W., Young, R.J., J. Mat. Sc. 10, 1975, 1334 - 1342

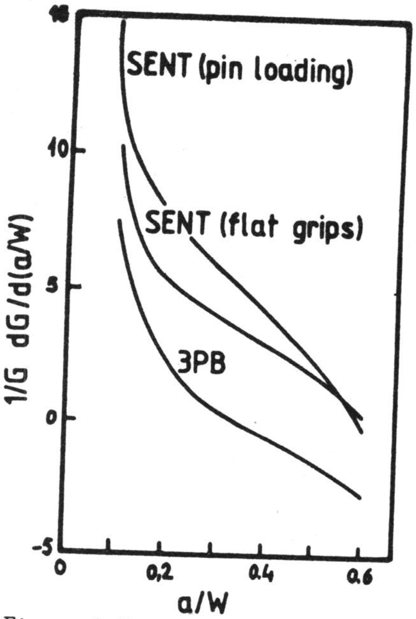

Figure 1 Equation (3) for three geometries.

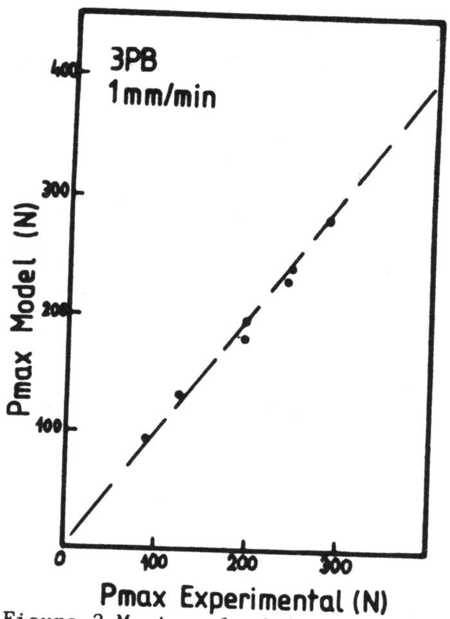

Figure 2 Maximum load for the 3PB geometry.

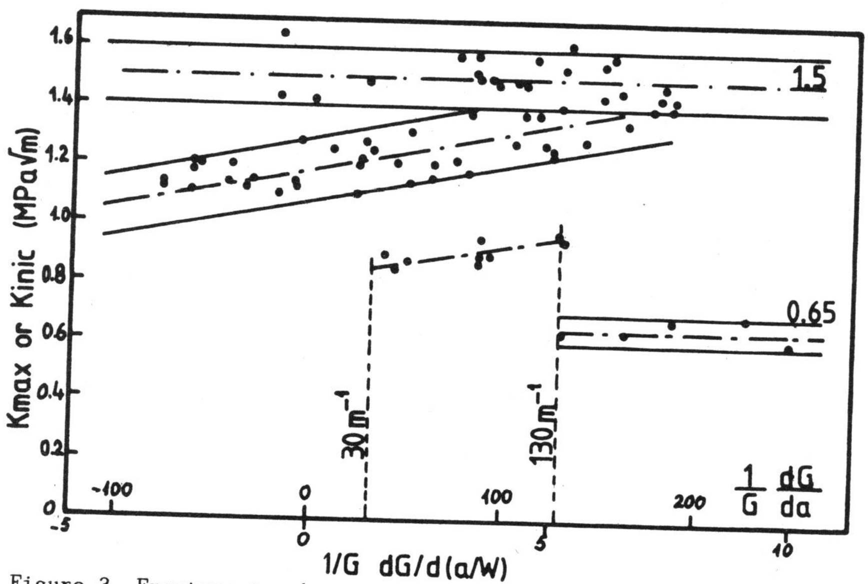

Figure 3 Fracture toughness as a function of specimen geometric stability.