Three-Dimensional Analysis of Crack in Centrally Perforated Photoelastic Cylinders under Internal Pressure

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14. ABSTRACT
The objectives of this study were to (1) Investigate the Effect of Crack Geometry and Location on the Crack Growth Behavior in Centrally Perforated Cylinders under Internal Pressure. (2) Determine the Safety Factor for a Two-Dimensional Analysis of a Deep Part-Through crack.

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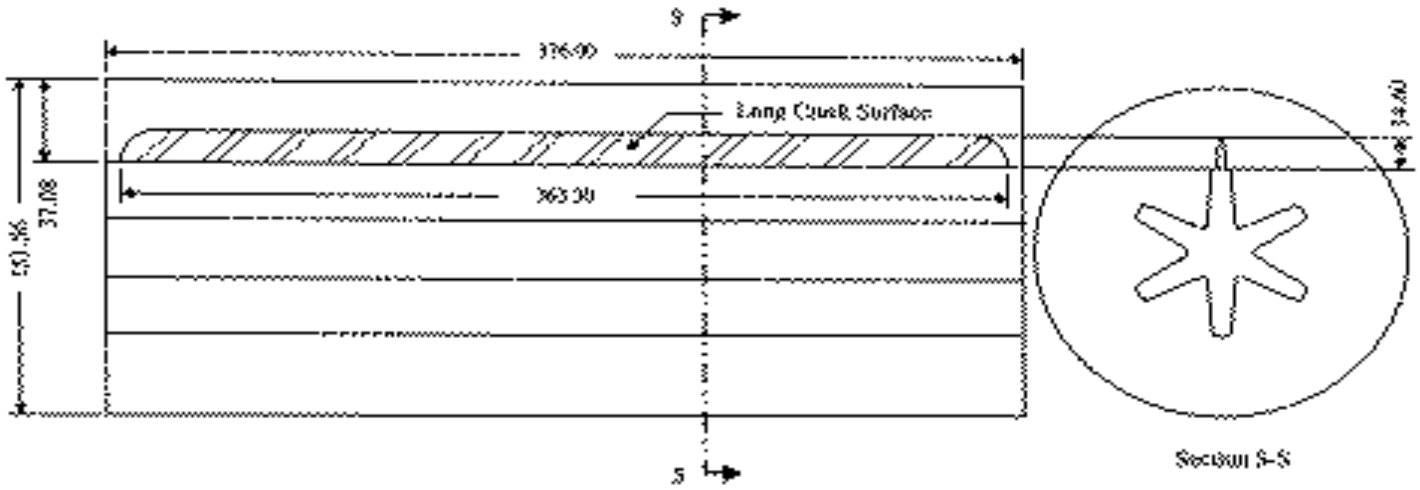
Objectives

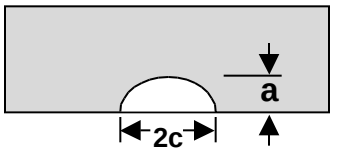
- **Investigate the Effect of Crack Geometry and Location on the Crack Growth Behavior in Centrally Perforated Cylinders under Internal Pressure.**

- **Determine the Safety Factor for a Two-Dimensional Analysis of a Deep Part-Through crack.**

Specimen Geometries

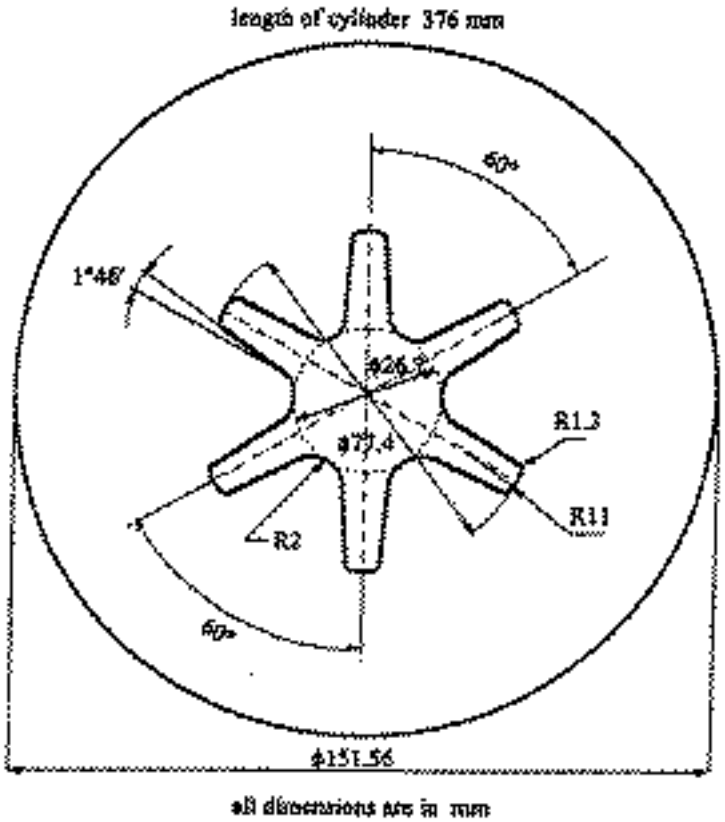


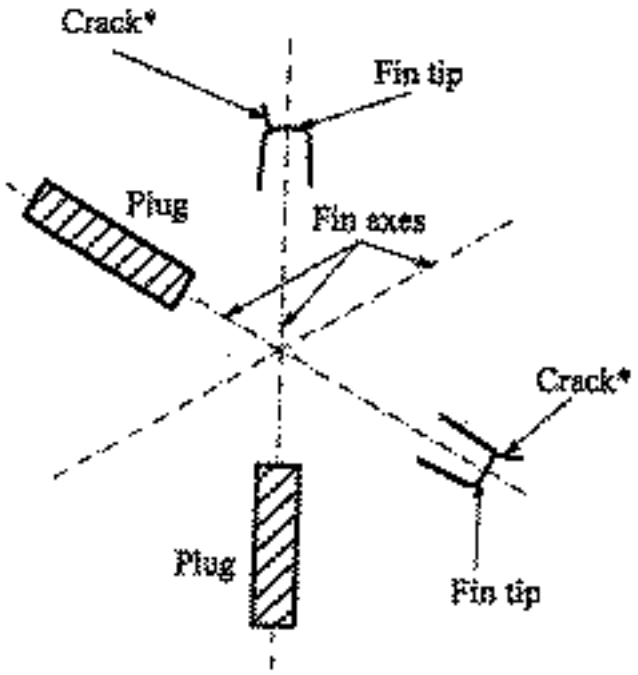
All dimensions in mm



Part-Through Crack

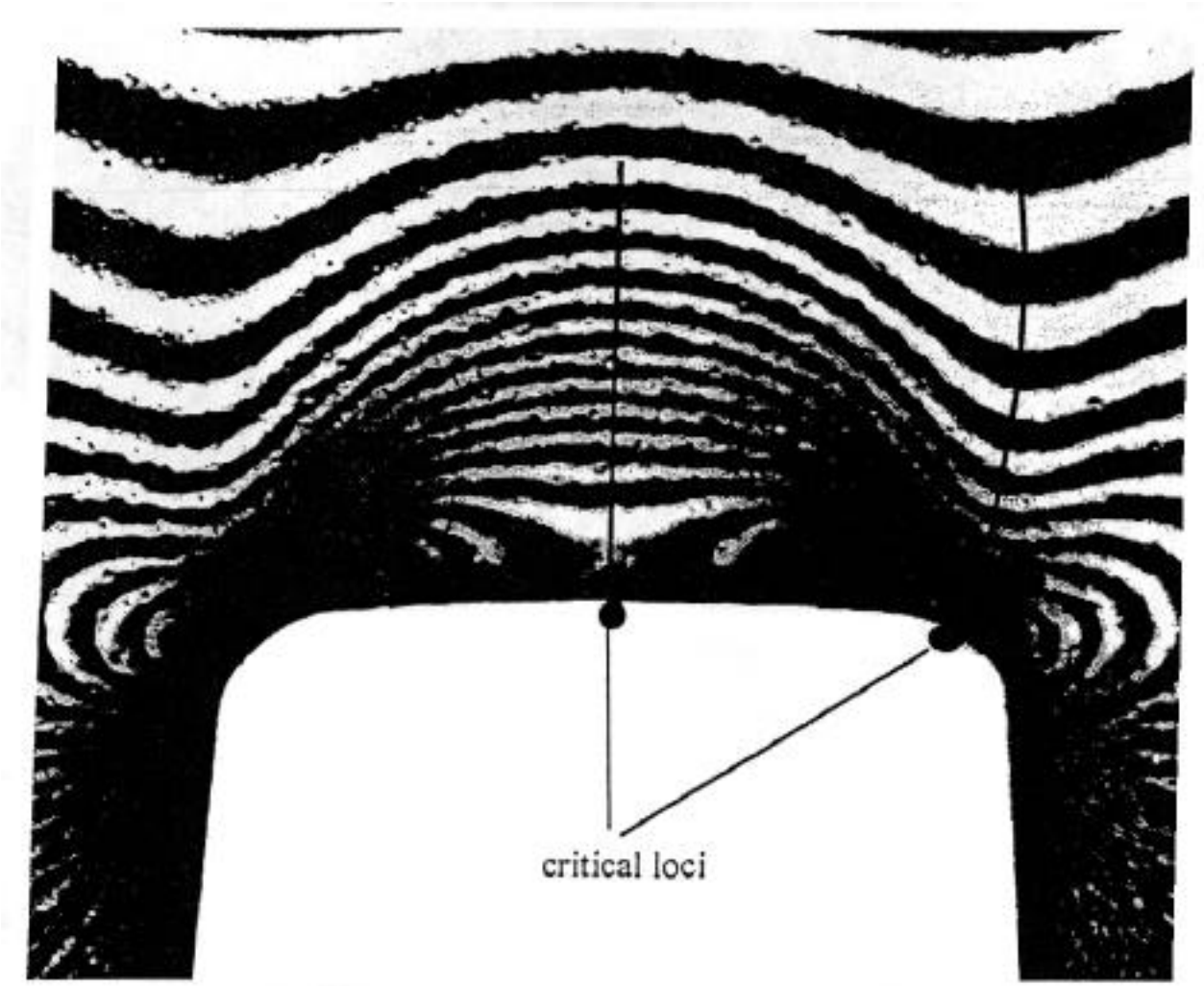
Specimen Dimensions and Crack Locations



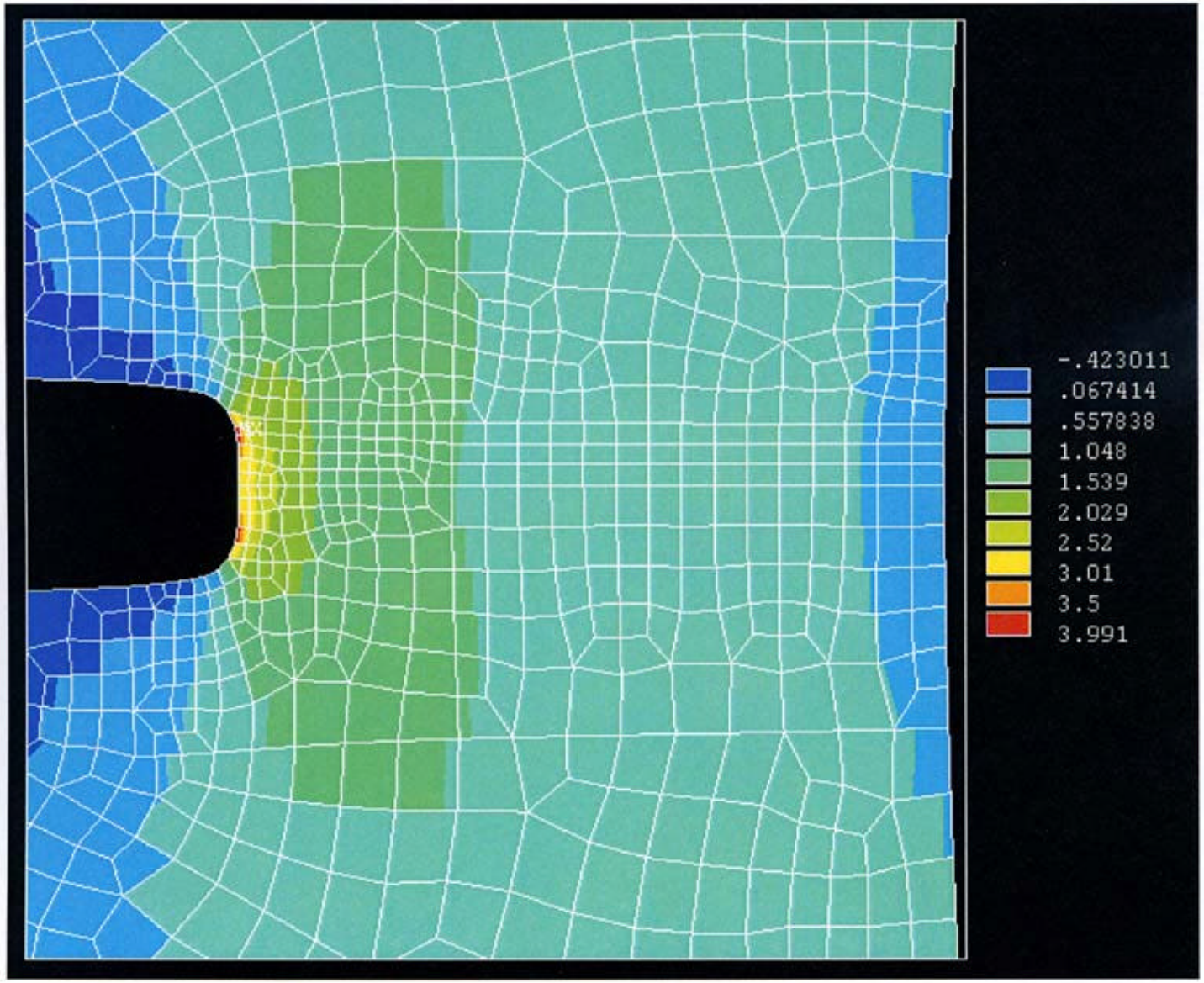


* Path of crack to maximum depth

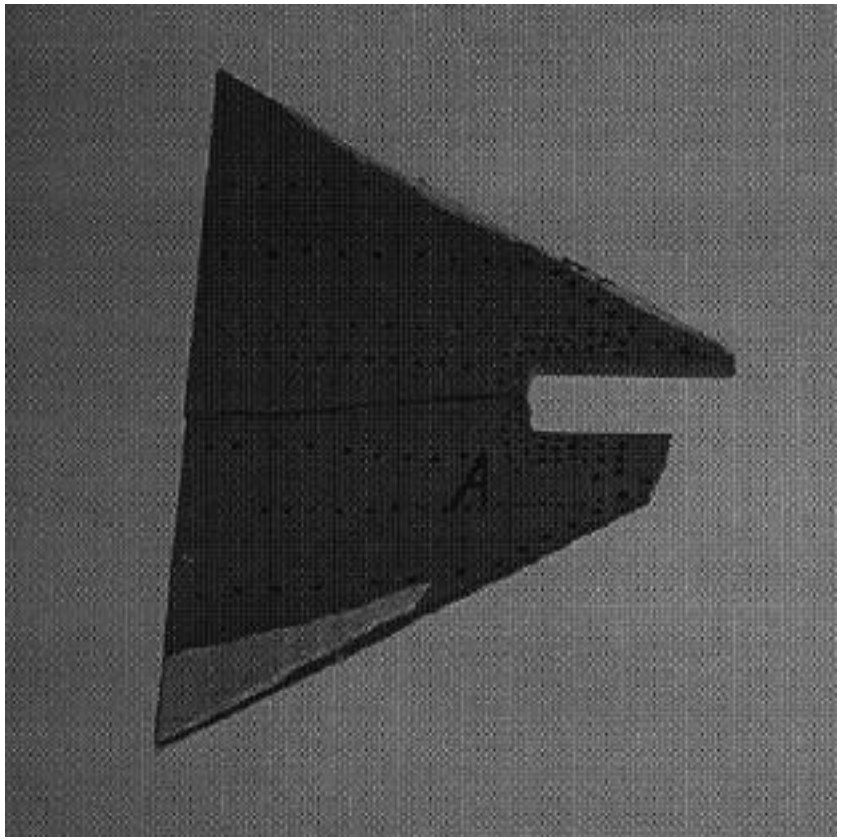
Fringe Patterns Near Critical Loci at Fin Tip



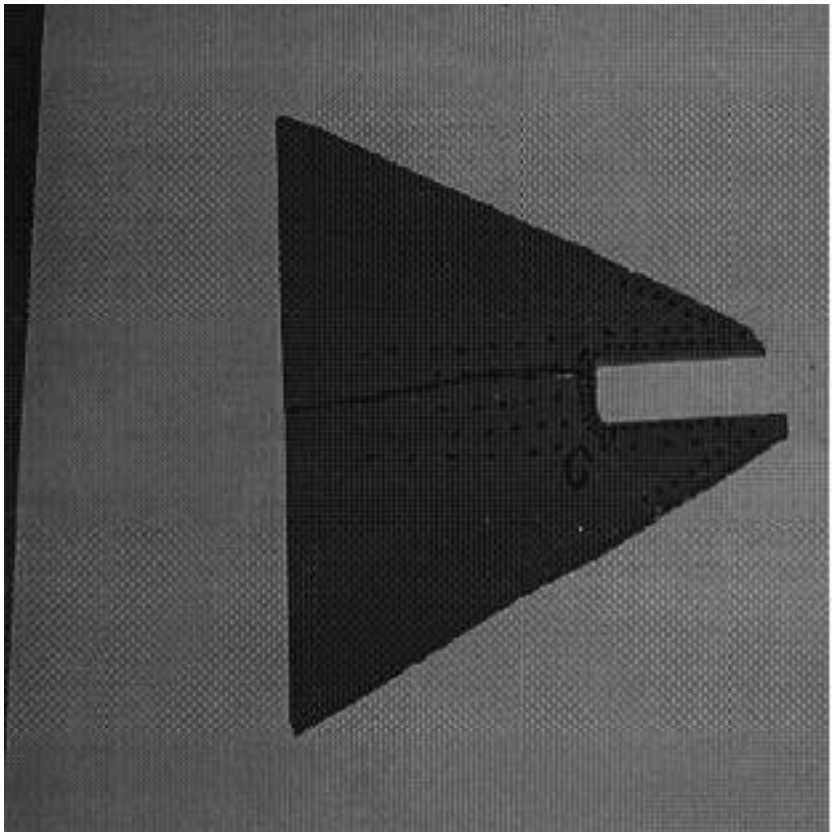
Contour Plot of Stress σ_{yy} (No Crack)



Two-Dimensional Crack Growth Tests

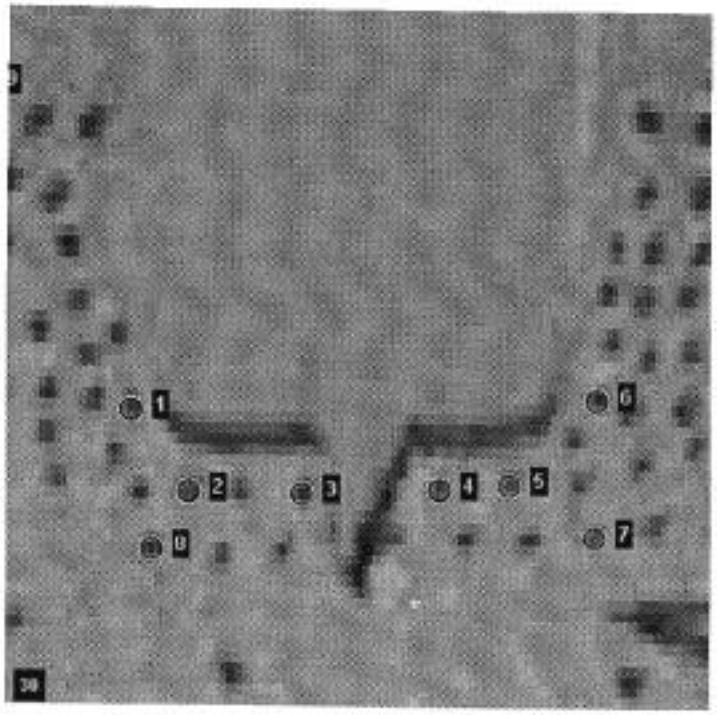


A



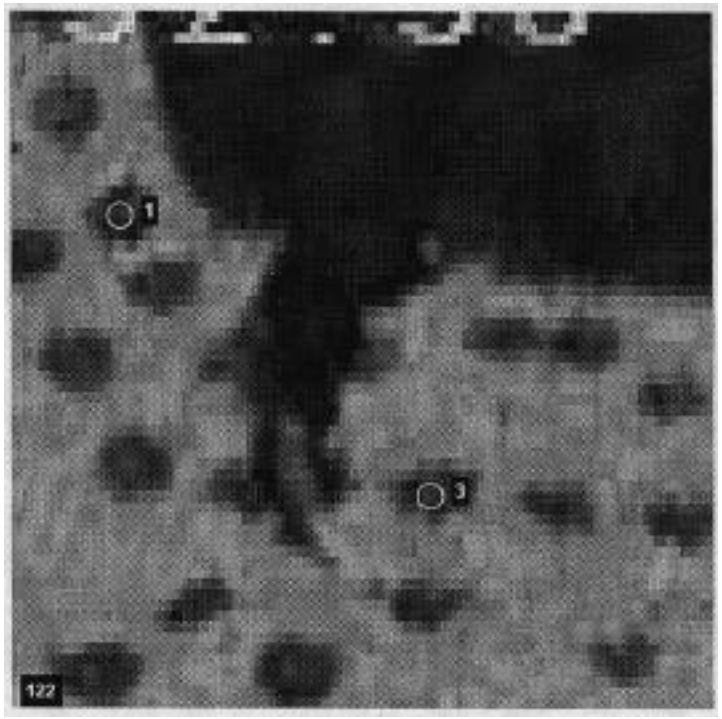
B

Two-Dimensional Crack Growth Tests



A

Crack initiated at the center of the fin

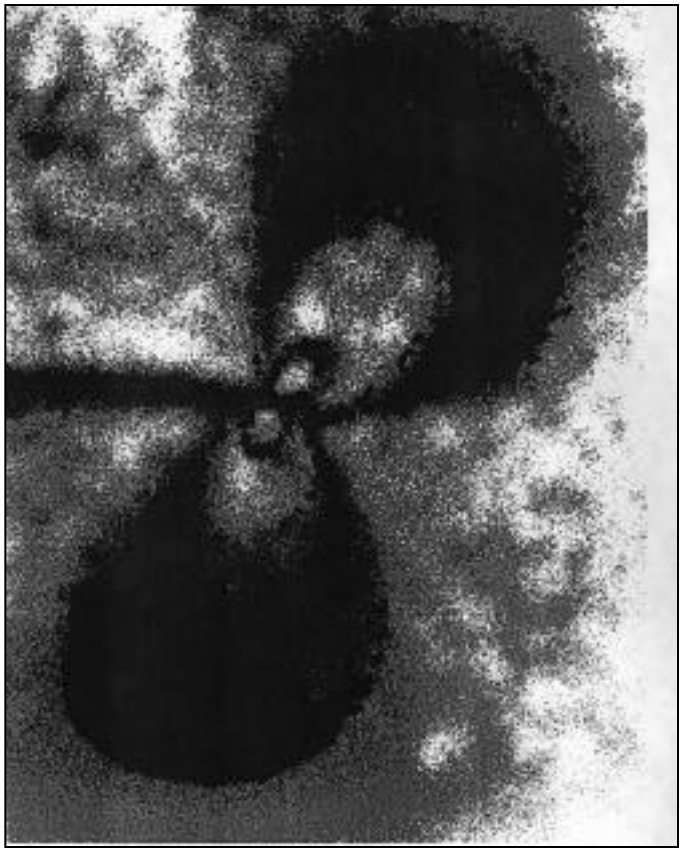


B

Crack initiated at the corner of the fin

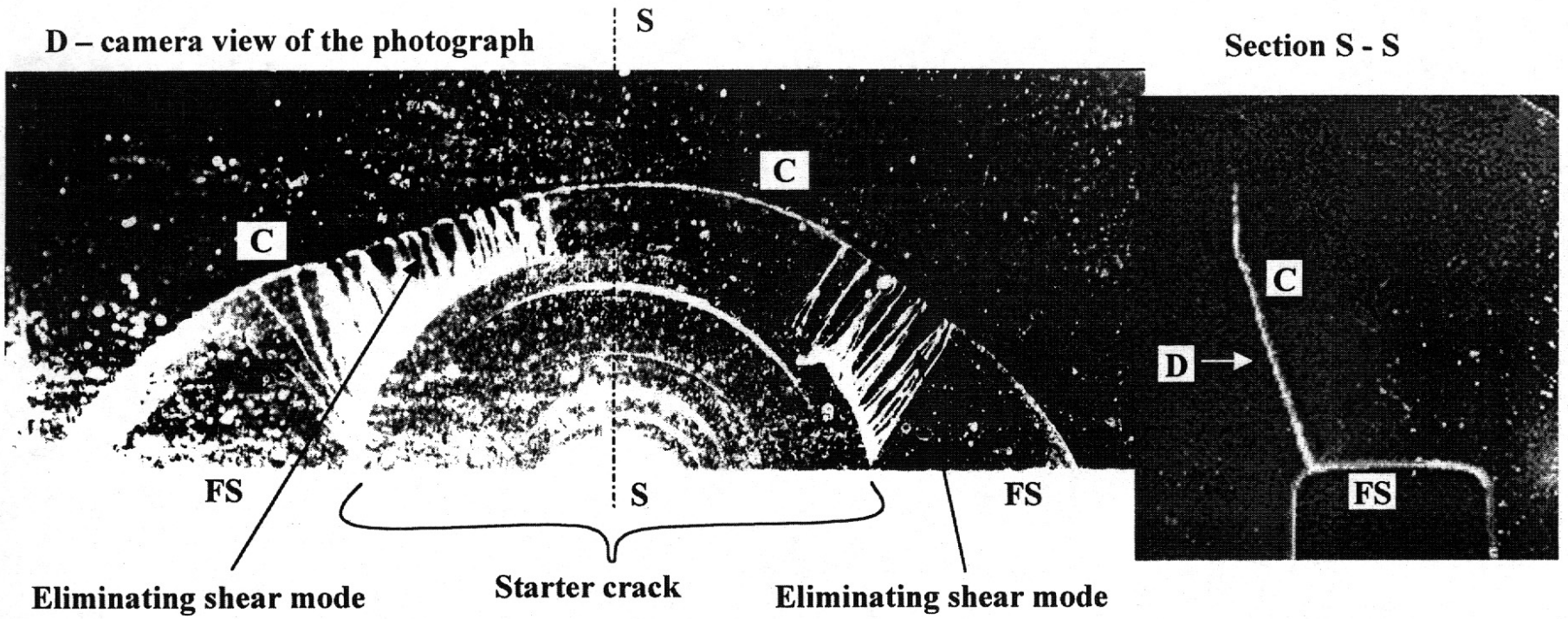
Photoelastic Fringe Patterns

Crack Turning Completed



Crack Turning Incomplete

Typical Off-Axis Inclined Crack Which is Perpendicular to the Fin Surface

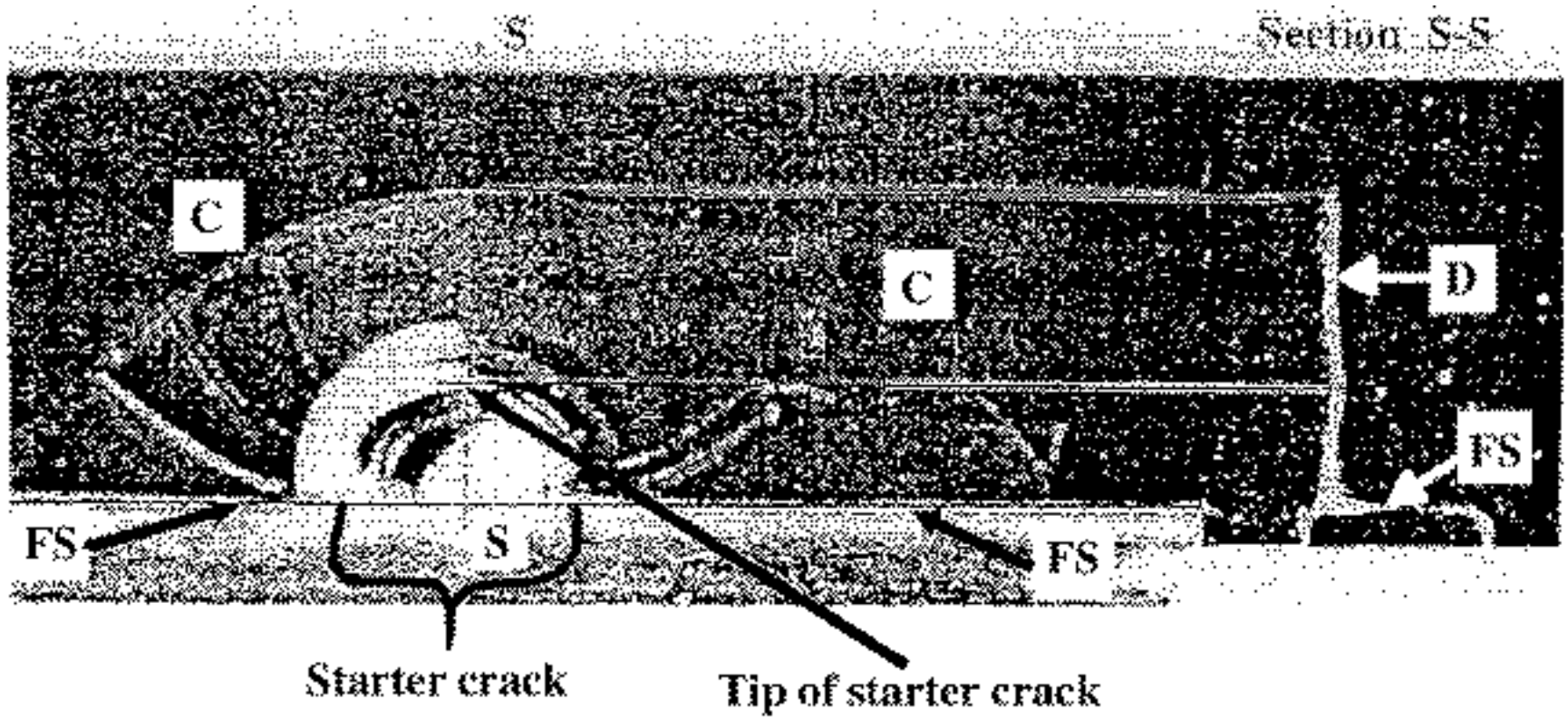


FS – fin surface

C – crack front

magnification factor 3.68

Typical Off-Axis Straight Crack Which is Parallel to the Fin Axis



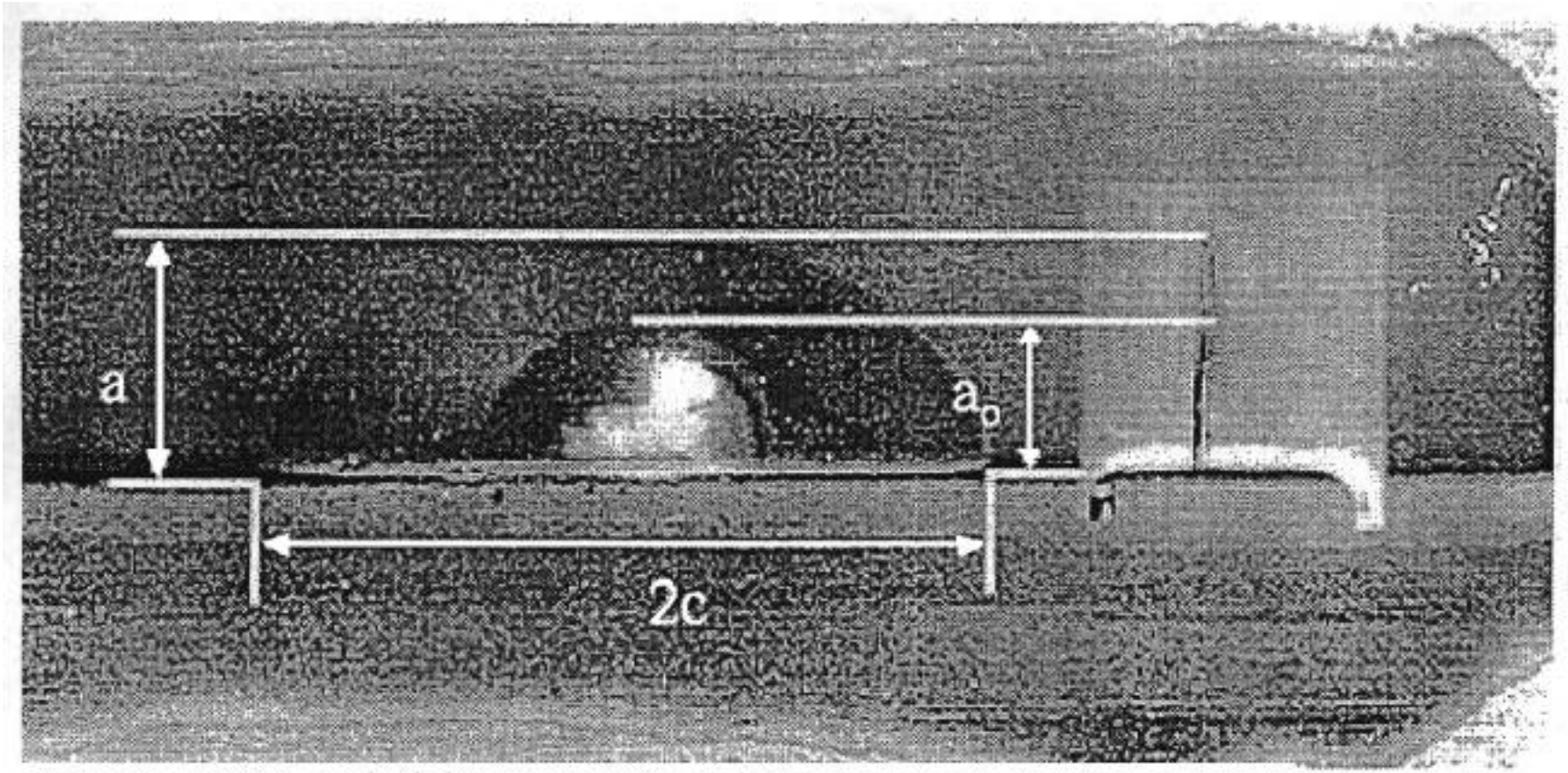
Fin surface

C - crack front

D - camera view of the photograph

Magnification factor: 1.73

Typical Symmetric Crack Which is Near the Fin Axis

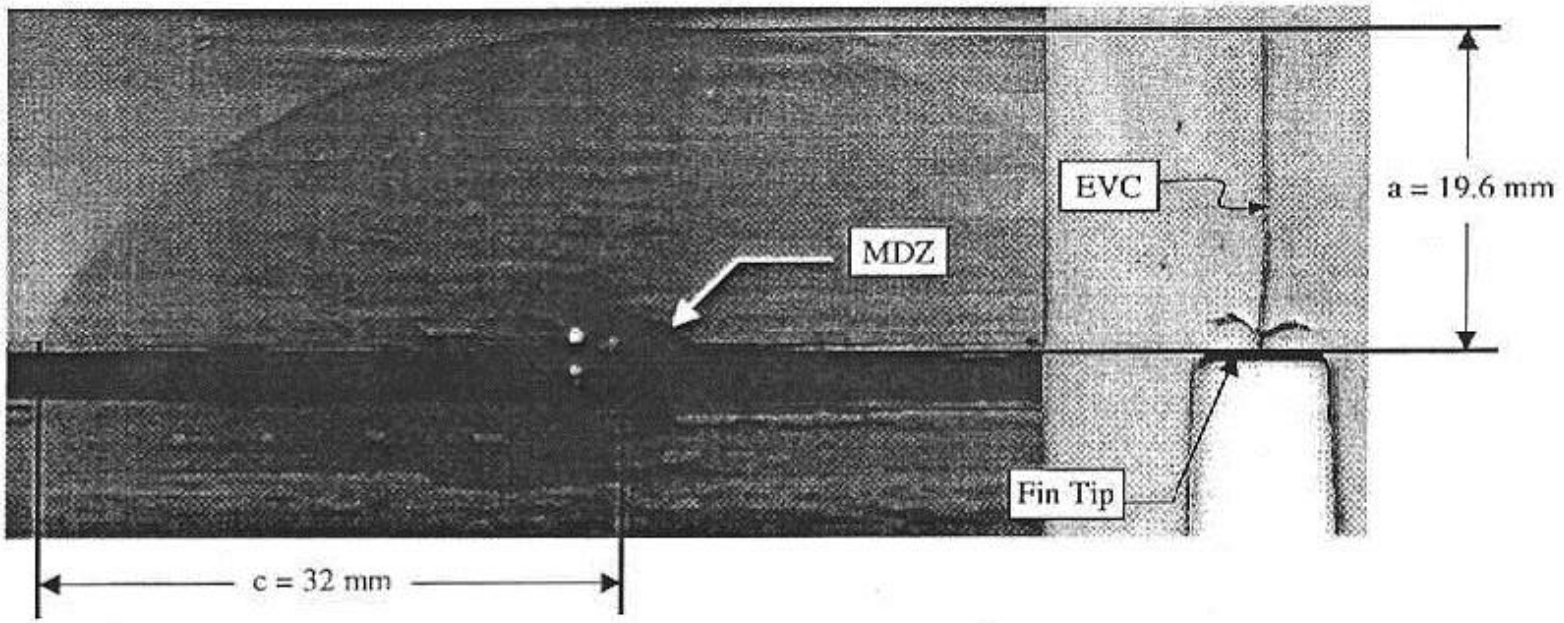


a_o - initial crack

a - final crack

M.F 2.52

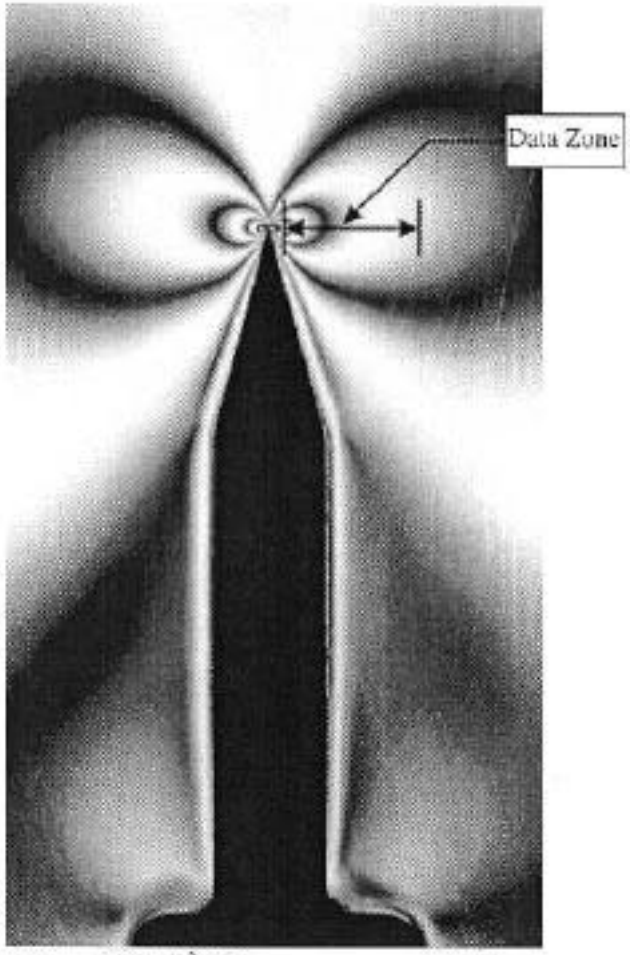
Top and Edge Views of Crack



MDZ – Material Damage Zone
EVC – Edge View of Crack

Fringe Patterns near the Tip of a Symmetric Crack

Center Slice (t = 4.29 mm)



P_{cr}: 2.3×10^{-2} MPa

c_f: 175.30 mm

a_f: 19.6 mm

Data zone: $(r_{ave})_2 - (r_{ave})_1 = 4.2635 - 0.4564 = 3.807$ mm

Summary of Mode I Stress Intensity Factor K and Normalized Mode I Stress Intensity Factor F

	a	c	a/c	a/t	Psf	K	F
Test 3A	15.38	30.74	0.50	0.41	.033	0.31	1.67
Test 5B	14.60	181.65	0.04	0.41	.041	0.74	2.49

Conclusions

- When the crack is perpendicular to the fine surface, a significant three-dimensional effect occurs during crack turning.
- When the crack is either parallel to or in the fin axis, there is no crack turning observed and the crack grows under normal mode only.
- During crack turning crack grows under normal and shear modes.
- For a same a/t ratio the Mode I stress intensity factor for the long crack is much higher than that of the part-through crack.
- The two-dimensional analysis of the deep part-through crack yields a safety factor of 1.49.
- The practice of using two-dimensional analysis to determine the criticality of a deep part-through crack is conservative.