Analysis of Fracture Speed Under Changing Temperatures

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Background
The objective of this research project was to experiment and analyze how the speed of a fracture in a glassy polymer changes as the temperature approaches the glass transition. The expectation was as the temperature of the PMMA plate approaches the glass transition temperature, then the crack speed will decrease. This hypothesis was based upon the relationship between energy dissipation and the size of the zone of plastic deformation around the crack. In addition, this hypothesis utilized that as the material becomes less brittle at higher temperatures, the plastic work zone will increase in size.

Experimental Design
The PMMA Plate was designed using SolidWorks (6.35 x 6.35 x 0.635 cm) with an initial fracture (1.6 cm). This part was then analyzed in ANSYS Mechanical. Within ANSYS, a fine, cylindrical mesh was created around the fracture tip and the SMART Crack Growth feature was utilized for fracture properties. A displacement (0.02 cm) was applied on the edge of the plate, while the other was held fixed. A constant temperature gradient was applied on the larger faces of the plate. The simulation produced results on displacement of the plate, fracture speed, and temperature variance effects.

Analysis of Results
The ANSYS Simulation displayed the following fracture speed results for the given temperature gradient application:
- T = 20 °C, v = 3.7643 cm/s
- T = 60 °C, v = 3.6550 cm/s
- T = 80 °C, v = 3.6857 cm/s
- T = 100 °C, v = 3.6073 cm/s

These results confirm the initial hypothesis as true. As the temperature increases on the plate, the fracture speed decreases. The results from these simulations are in accordance with other literature and poly(methyl methacrylate) experiment values.