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Investigation into the Mechanical Characteristics of a Conventional Arc-shaped PVC Sample

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ABSTRACT

Our work consists of conducting a numerical modeling study on a slender PVC arc-shaped specimen with an internal notch (defect) within the arc, subjected to uniaxial loading at different ratios (a/w). The numerical results obtained allowed us to analyze the influence of this ratio (a/w) on the plastic deformations that occur at the notch. To carry out this work, we relied on the ASTM E399-90 (1997) standard to obtain a standardized specimen and to determine stress concentrations at crack points.Through the obtained results, we observed that plastic deformation confined at the crack tip propagates along the ligament as the ratio (a/w) increases. Additionally, we noticed that the ratio a/w=0.55 yields insignificant results, suggesting that this ratio may represent a critical value for defects in polymer conduits.

Keywords : plastic deformation ; Polyvinyl Chloride , arc-shaped specimens, ratios (a/w)

1. Introduction

Rupture tests are widely used to evaluate polymers transformed into pipelines. These tests often utilize specimens cut from small-diameter pipes, which are necessarily arc-shaped. Because the orientation and thermal history can vary between extruded pipes and injection-molded plates, this additional difference in geometry must be properly accounted for; otherwise, it may mask any effects on material properties.This study focuses on the modeling and analysis of the mechanical behavior of a standardized arc-shaped specimen made of PVC (Polyvinyl Chloride). The use of arc-shaped specimens is common in assessing the mechanical properties of polymers, especially those employed in pipeline applications.The study employs numerical simulations to analyze an arc-shaped PVC specimen under uniaxial loading as a damage model. The arc-shaped specimens were notched at various ratios (a/w) to collect a. Modeling database on the evolution of the crack with uniaxial loading. The results obtained exhibit a highly ductile behavior characterized by the presence of an extended plastic deformation phase.

2. Experimental

The arc-shaped PVC specimen: In the field of mechanical characterization of materials and analysis of cracks in pipelines, researchers have recommended several types of specimens, including tensile arc-shaped specimens, three-point bending specimens, and disk-shaped specimens, among others. The arc-shaped specimen chosen for our study model is designed according to the ASTM E399-90 standard from 1997. It features a notch of length 'a'.Material: Polyvinyl chloride (PVC) is a thermoplastic widely used in engineering applications such as pipelines and pressure vessels.Modelisation : In the uniaxial loading modeling of the arc-shaped specimen, we proposed three ratios of a/w (0.47, 0.50, and 0.55). Mesh correspondence on the arc-shaped specimen was examined through mesh control to find the optimal balance between increment time and the number of elements.

3. Results and discussion

Based on the obtained results, it is evident that manipulating the aspect ratio (a/w) of the standardized arc-shaped PVC specimen has a significant impact on its mechanical behavior. As the aspect ratio increases, there is a noticeable increase in plastic deformation. This suggests that specimens with higher aspect ratios

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are more prone to experiencing plastic deformation under applied stress conditions.Furthermore, the increase in aspect ratio correlates with a reduction in the stress intensity factor at the crack tip. This reduction indicates a decrease in the severity of stress concentration at the notch tip as the aspect ratio increases. However, it's important to note that this reduction in stress intensity factor is accompanied by an increase in the notch opening.

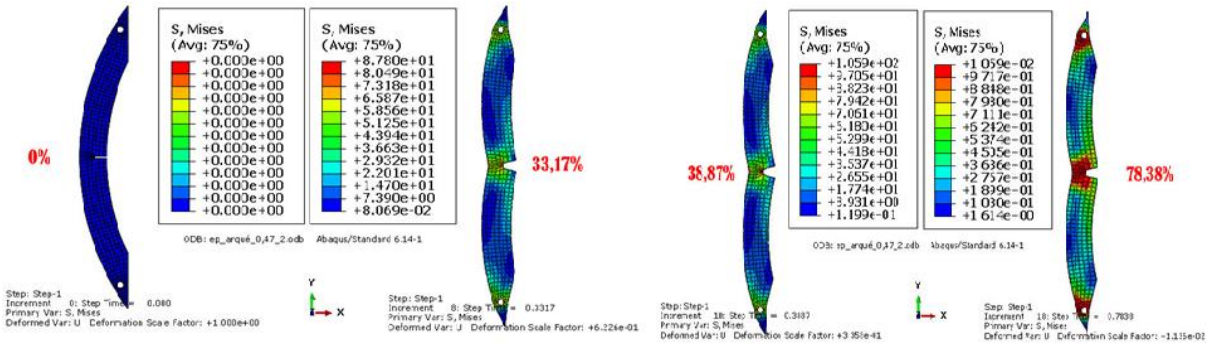

Figure 1: The evolution of the von Mises stress as a function of loading time at a/w=0.47.

4. Conclusion

In conclusion, the findings highlight the complex interplay between aspect ratio, plastic deformation, stress intensity factor, and notch opening in arc-shaped PVC specimens. Increasing the aspect ratio leads to elevated plastic deformation while simultaneously affecting the stress distribution around the crack tip. These insights are valuable for understanding and predicting the mechanical behavior of PVC materials under varying geometric configurations, contributing to the advancement of material science and engineering applications

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