# NUMERICAL SIMULATION OF U-NOTCHED HIGH DENSITY POLYETHYLENE

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**Abstract** - This article aims to make a numerical simulation of the high density polyethylene polymer " HDPE " with three opening lengths of the U notch. The simulated tensile tests are done using simulation software based on the finite element method, the properties insert in the software are taken from the experimental results of same material and same conditions. The results obtained show the increase in embrittlement of the behavior of HDPE during the increase in the notch opening.

**Keywords** - HDPE, Simulation, U Notch, Behavior.

## I. INTRODUCTION

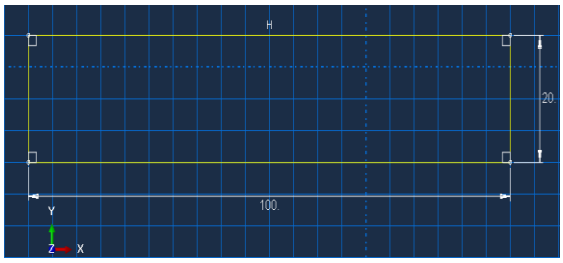
High density polyethylene is a semi-crystalline thermoplastic polymer, it has a molecular structure where the monomers are linked by attractive intermolecular forces to each other, unlike metals HDPE does not contain crystallographic planes or grain boundaries (Constantine, 2015), HDPE has high toughness, good corrosion resistance and high degree of reliability under normal use conditions (K. HACHOUR, 2016), it is considered as a model material for the study of mechanical behavior (ARIEBY, 2007). HDPE is widely used in industrial packaging (Zhengpan Qi, (2018)), HDPE production increased from 11.9 million to 43.3 million in 2007 (Tamboli, 2003). Given these wide applications of HDPE we used it in our study. The main goal of this work is to show the change in the behavior of HDPE in the presence of defects, the simulation results show that the behavior transforming from ductile to brittle and embrittlement increases with the increase in the opening of the notch under tensile tests.

## II. THE WORK METHODOLOGY

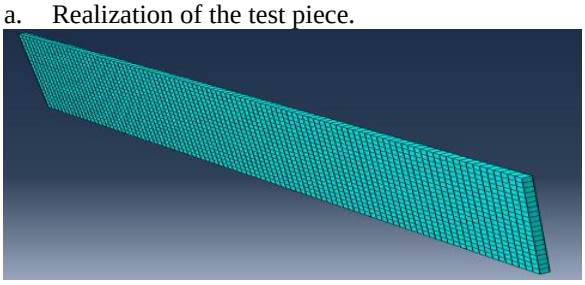
- The material used is HDPE with a density of 0.995g / cm3 and Young's modulus equal to 1153Mpa.
- Tests performed at room temperature and constant charging speed.
- The sets of tests consisted of 4 types of test pieces.

a. A blank test tube for the characterization of the material of dimension (100 * 1.10 * 20).
b. 3 specimens of the same dimensions (100 * 1.10 * 20) notched in U with three different openings 5, 15 and 20mm.
c. The notch depth is the same.

- The following figures represent the realization and the mesh used in the simulation.

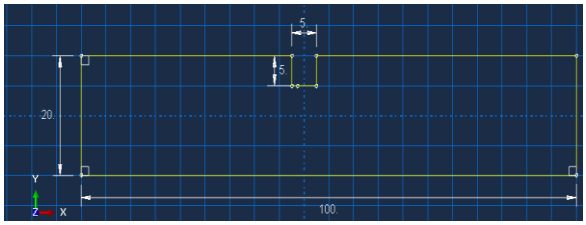



a. Realization of the test piece.

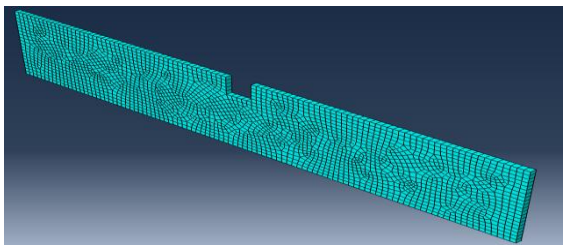


b. Mesh of the blank specimen.

**Fig. 1(ab). The simulation steps of the characterization test specimen.**

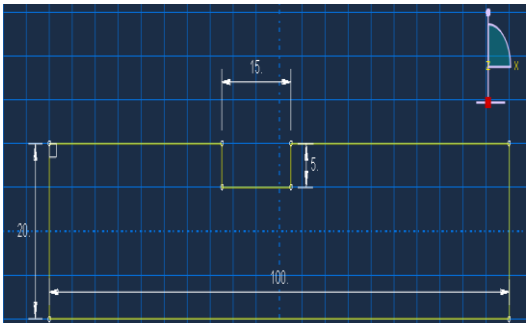



a. Realization of the notched U-shaped specimen of 5mm opening.

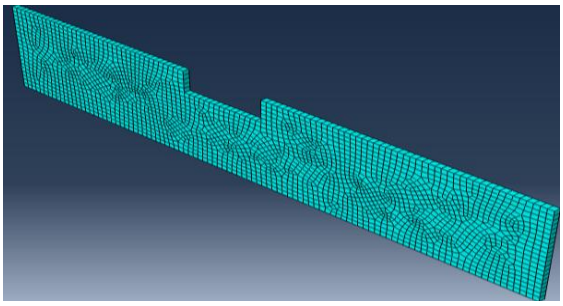


b. Mesh used.

**Fig. 2(ab).The simulation steps of the test specimen with 5mm opening.**

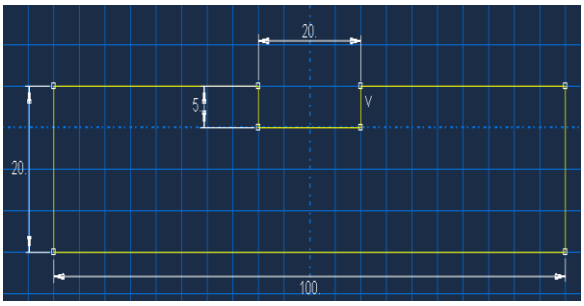



a. Production of the notched U-shaped specimen with an opening of 15 mm.

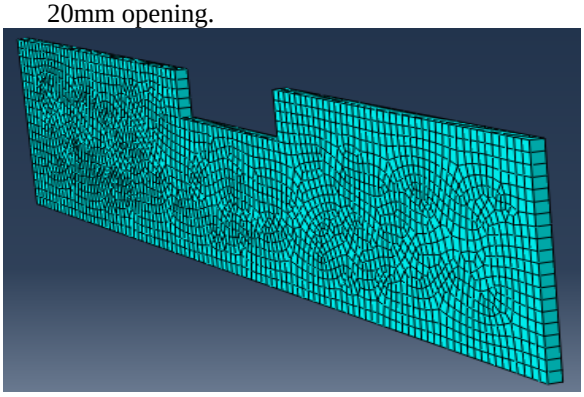


b. Mesh applied.

**Fig. 3(ab). The notch opening specimen simulation steps.**




a. Realization of the notched U-shaped specimen of 20mm opening.



a. Mesh step of the test specimen.

**Fig. 4(ab). Stages of simulation of the tensile test of the 20mm notch opening specimen.**

## III. RESULTS

The simulation results of the tensile tests are transformed in terms of stress-strain curves.

- FIG. 5 represents the curve of HDPE in the virgin state.

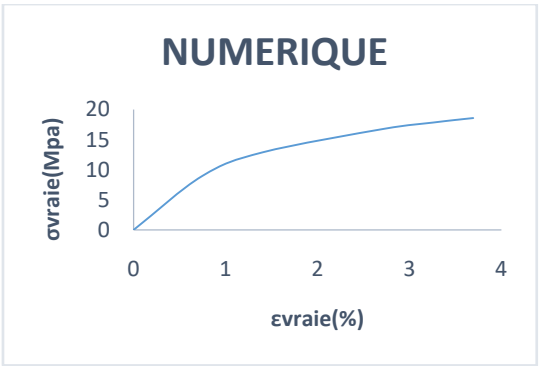



**Fig. 5. True stress-true strain curve of virgin HDPE.**

- The behavior of HDPE without any defect (virgin) divided into three zones. The zone where the behavior is viscoelastic from the start up to 13Mpa, then we have the necking zone where the plastic zone up to 16.8 Mpa, the last zone is the hardening zone. The general behavior of HDPE is ductile.
- The following figures (Fig.6-Fig.7-Fig.8) represent the true stress-true strain curves of U-notch HDPE at 5, 15 and 20mm opening length.

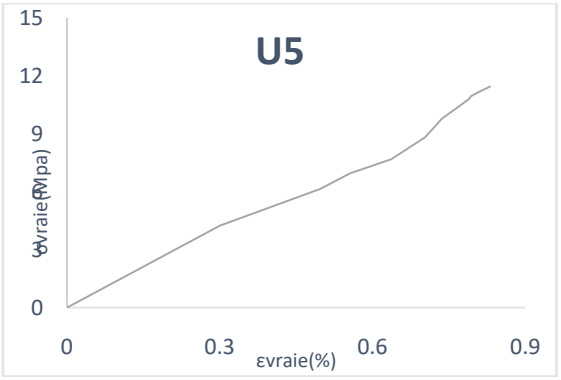



**Fig. 6.HDPE curve in the presence of the U defect of 5mm opening.**

- At the beginning the behavior is elastic, afterwards one notices a plastic instability which defines by the increase and the decrease of the stress in this zone, afterwards the material weakens.

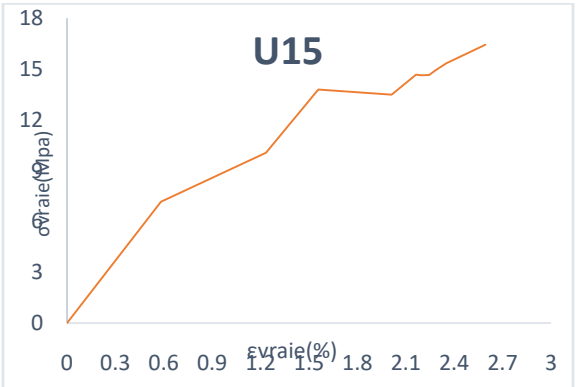



**Fig. 7. Notched 15mm aperture true stress-true strain curve of HDPE.**

- HDPE behaves as an elastic material between 0 and 10Mpa, the next area is plastic, after the behavior becomes brittle.

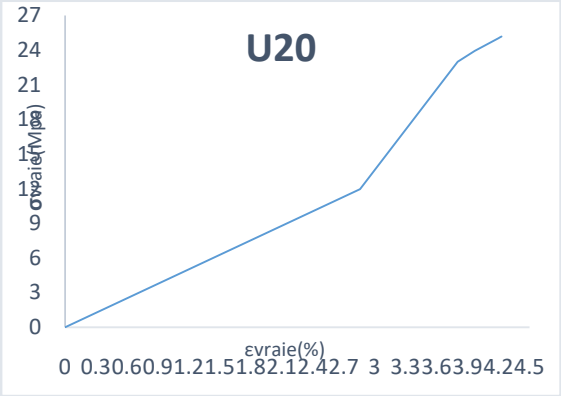



**Fig. 8.HDPE curve with 20mm opening U notch.**

- For the last opening studied, we see that HDPE weakens after the elastic zone.

- FIG. 9 is the comparison of the results of the tensile tests obtained.

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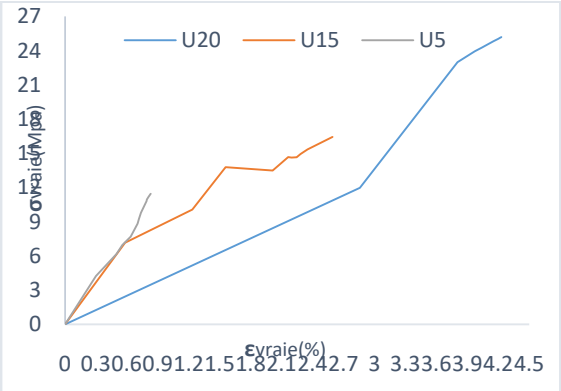



**Fig. 9.Comparison of HDPE results at different U-notch openings.**

- The behavior of HDPE for the three openings at the beginning is elastic, for 5 and 15mm we find a plastic zone which results in the increase and decrease of the stress in this zone, but on the contrary for 20mm of opening the material becomes perfectly brittle.

## IV. CONCLUSION

This work highlights the role of notches in the change of behavior of HDPE, for this reason we simulated tensile tests of HDPE with U-type notch at three aperture lengths and in the virgin state, the results show that HDPE in general has a ductile behavior in the virgin state, for the notches there is a plastic part but the material in the end weakens. We can summarize all that the notch and its geometry changes the behavior of HDPE from ductile to brittle.

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