# Fracture mechanics and damage modeling of injection molded high density polyethylene

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*Fractures are often considered fatal, making an application useless. However, for the opening device of a package, fracture is a necessity to reach the product inside. Predicting and determining this fracture is an important part of the development process. In this thesis the fracture mechanical behavior of an injection molded plastic material is investigated and simulated.*

The opening device on a package is most often made of injection molded plastic material. The plastic material studied in this thesis is high density polyethylene (HDPE). The fracture mechanical behavior of a cracked sample was studied by the use of Digital Image Correlation (DIC), which is a method that allows for the deformation over the whole surface of a sample to be quantified during a deformation test. The same test was simulated in a software for finite element analysis. The physical test and the DIC-analysis were compared to the simulation. It was seen that the simulation captured the physical behavior and the deformation fields well. Thus, showing that it is possible to simulate the fracture mechanical behavior of an injection molded plastic material. By being able to simulate the fracture mechanical behavior, opening devices of packages can be improved and predicted, making it possible to improve the development process, leading to new designs with better mechanical properties and less material use.

The manufacturing process of injection molding creates a material that has mechanical properties vary depending on the position and in which direction a force is applied. It was seen that the material orientation plays an important part in determining the fracture mechanical behavior of an injection molded sample. Depending on the orientation of an initial crack, the fracture mechanical behavior can be very brittle, leaving a sharp fracture surface, or very ductile and being able to stretch quite far before fracture occurs. Furthermore, it was seen by the use of X-ray scattering techniques (SAXS and WAXS) that the degree of material orientation in an injection molded sample is increased when the sample has been loaded in tension. This means that the mechanical properties in the different directions will differ more after loading than before.

Moreover, there are layers created through the thickness of the sample during injection molding. These layers have varying mechanical properties and degrees of material orientation. It was seen by studying a fractured sample in a Scanning Electron Microscope (SEM) that the top layer delaminates from the rest and fractures independently during deformation. It was also seen that small cracks, other than the initial crack, were formed, where a fiber-like structure could be identified. This is presented in Figure 1. Thus, the fracture mechanical behavior of an injection molded plastic material is dependent on several factors, where the microstructure affects the macroscopic behavior.

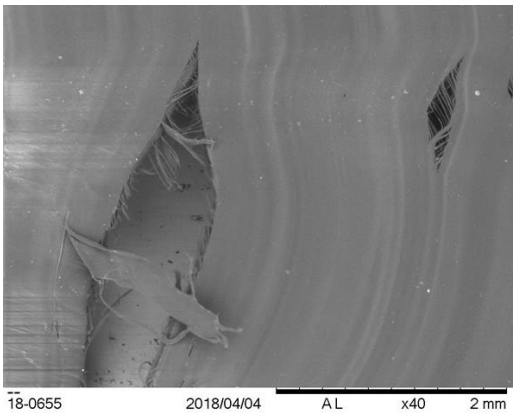


*Figure 1: SEM-image of a fractured sample, showing delamination and fiber-like structure in cracks.*