Case Study: Twin wall sheet testing

INFO Sheet C7.4

Description:	*Material testing - indentation test of twin wall sheets*
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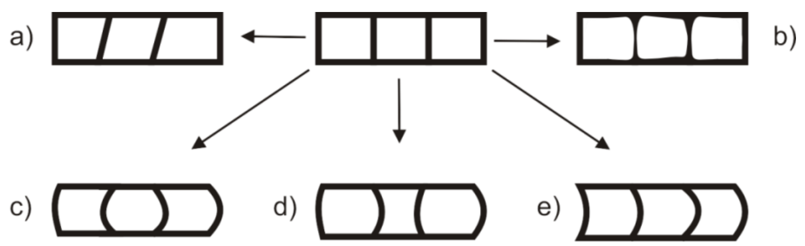
Introduction

When using polymeric materials for solar thermal flat plate collectors, one distinct difference in physical properties compels us to reinvent the absorber design. Due to the low thermal conductivity of polymeric materials, the absorber, in order to prevent local overheating and to increase the collectors' efficiency, needs water contact throughout the whole surface. In general only few absorber designs fulfill this requirement, e.g. thin plastic film absorbers, tube absorbers or twin wall sheets. The latter two are in the focus of recent development due to mechanical stability and economic efficiency. In order to investigate changes in the mechanical properties of the used materials as closely to the product as possible suitable mechanical testing methods need to be applied. For pipes, methods to test different mechanical loads already exist, but for twin wall sheets none of these can be applied.

Twin wall sheets

Produced by melt extrusion, twin wall sheet can be produced with a constant cross-section but variable length. With a little effort, this allows for the production of absorbers with variable dimensions. With these scaling effects the production cost can be reduced effectively. During production the molted polymer is pushed through a dye with the negative profile of the intended cross-section. This original geometry of the twin wall sheets can be distort during the production by fluctuations in temperature, cooling behavior and other factors. The occuring deformations are illustrated in *Figure. 1* and may even occur in combination. These deformations make twin wall sheets, from an analytical point of view, a very inhomogenous speciemen. Therefore it is important to either test many speciemen or to developl new methods that are not influenced by these inhomogenities.



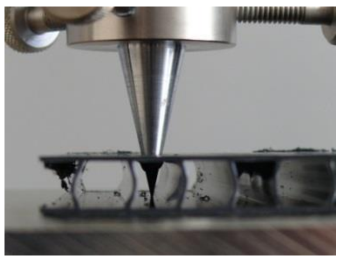


Figure. 1: Left: Geometry variation of an ideal twin wall sheet structure.
Right: Indentation test with sharp indenter.

Two different approaches

For the indentation test a specimen is placed on the table of the testing equipment (standard material testing machine) and an indenter of specific shape is pressed with constant speed into the specimen while the necessary force is recorded. The resulting force-depth-diagram provides information about basic material properties. These properties are expected to change during the ageing of the material and therefore this method is a good qualification for the degradation of the mechanical properties of a material. If changes are little and the inhomogeneity is high, many samples need to be analyzed. In order to reduce effort, a blunt indenter can be used and the testing of the sheets can be analyzed regarding pass or fail criteria.

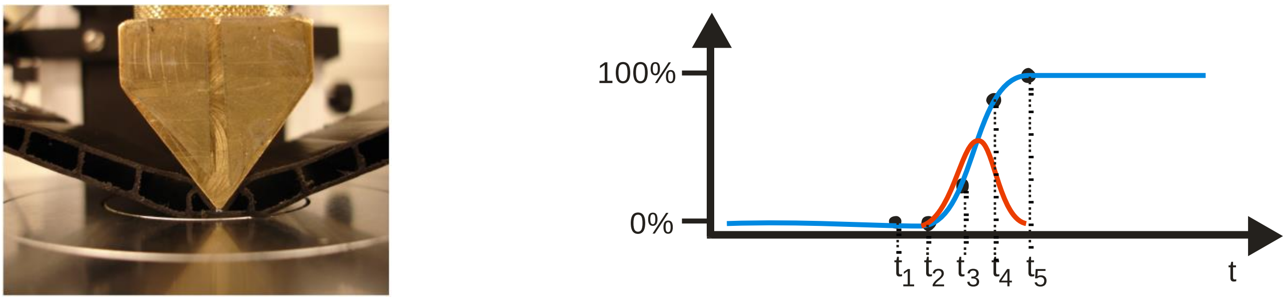


Figure 2. Left: Indentation test with blunt, prismatic indenter.
Right: Schematic of data analysis: At five time (t1-t5) intervals of accelerated ageing samples certain amount of specimen were failing the pass criteria. Based on the distribution function (blue) a probability distribution (red) can be estimated. The interval t5 marks the failure of all specimen.

However, for accelerated ageing tests with unidirectional load exposure, like UV irradiation, this method is not suitable as several geometry related effects interact and make it difficult to identify changes in the force-depth-diagrams related to individual degradation effects. For this purpose the indentation test was modified by using a sharp indenter (*Figure. 1*) piercing through one of the external walls. This way the overall geometry is not affected by the indentation procedure and information about one structural element of the sheet is acquired. In the context of accelerated ageing through UV exposure, by analyzing both sides of the twin wall sheets, it can be differentiated between UV induced and temperature related changes in the mechanical properties of the extruded sheets. Combining these two methods will allow for the improvement of this product specific mechanical testing method which can be used as a standard tool for material testing and quality analyses.

References

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