What keeps your packages together?

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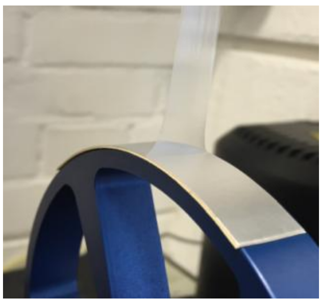
Have you ever taken a closer look at the packages in your home? They consist of several layers of different materials, among them layers of polymer. They all contribute to protect the product. For a packaging company it is very important to ensure that the layers in the package are held tightly together, in order to withstand the stresses associated with transportation, storage and consumer use.

So what is it that makes these layers stick together? The phenomenon is called *adhesion* and describes how strong two surfaces are joined. Measuring adhesion is a tricky task. It is difficult to measure without affecting the result. Imagine that you are measuring the temperature of your steaming hot coffee with an ice cold thermometer. The coffee will then be cooled by the thermometer and by that, the measured temperature will be affected. Though, it is possible to come close to measuring adhesion by separating two surfaces. The measured value is called *adhesive fracture energy*.

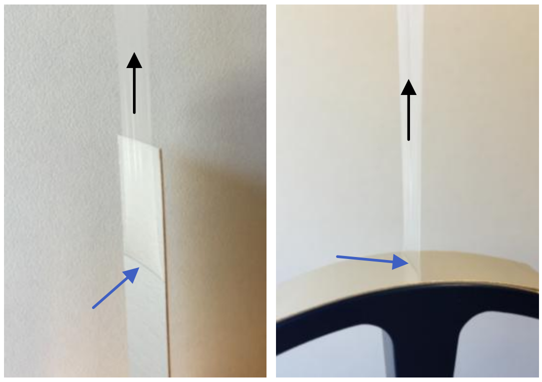
Adhesive fracture energy is often measured by performing peel tests. A peel test is done by letting a machine measure the force needed to pull off one polymer layer. One of the most common ways to peel off the layer is in 90° in relation to the rest of the material. This can be seen in the picture below. The layer that detaches is called peel arm. If the peel arm is very thin it will deform, which requires energy. The measured force from the peel test will therefore contain both the adhesive fracture energy and the deformation of the peel arm.



Packaging material during a 90° test

To extract the adhesive fracture energy from the force, a method called ICPeel can be used. The method calculates how much energy was lost to deform the peel arm. It proved to be difficult to calculate the energy lost in the bend that arises when peeling in an angle.

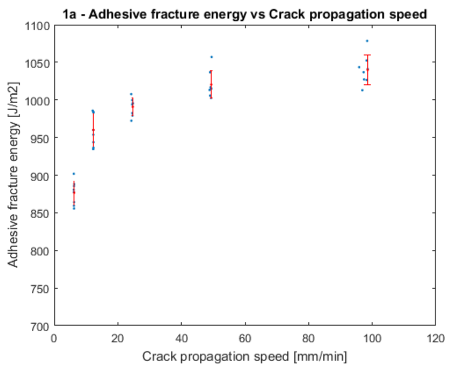
Another way to separate the layers, without bending the peel arm, was developed. In this method the peel arm is pulled along the sample with a peel angle of 0°. The difference between peeling in 90° and 0° can be seen in the following pictures.



To the left a 0° test, to the right a 90° test. Peeled in direction marked by black arrow. The blue arrow marks the crack.

Along with that the layer detaches, a crack is formed between the peel arm and the rest of the material. The crack propagates along the material. The *crack propagation speed* depends on how fast the machine is pulling the peel arm.

The adhesive fracture energy was measured, calculated and plotted using a number of different crack propagation speeds.



Adhesive fracture energy vs. crack propagation speed

As seen in the figure above, the adhesive fracture energy increases when the crack propagation speed is increased. Adhesion is very complex and arises from a number of different mechanisms. A possible explanation for why the adhesive fracture energy increases with increasing speed could be that some of these mechanisms behave differently at high and low speeds.

This can be compared to ripping off a band aid; you can either do it fast and very painful or slowly and less painful. How fast you do it will affect the result. Thus there is not an absolute value of adhesive fracture energy, but it changes by the way you are measuring it.