A numerical-experimental approach to characterize delamination in polymer coated steel

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Introduction

Polymer coated metal sheet is developed by Corus to reduce production costs of e.g. aerosol and food cans. During forming processes the coating may delaminate, leading to the loss of protective and attractive properties.

Figure 1 *Examples of applications for polymer coated metals.*

Objective

Analyze, predict and control the occurrence of coating delamination during industrial forming processes.

Methods

A combined numerical-experimental approach is followed where experiments are used to provide input and verification for an interfacial constitutive model. Interface elements are developed and placed between the polymer layer and the metal substrate to enable the simulation of delamination.

Experiments

Delamination experiments are performed inside a Scanning Electron Microscope (SEM) and the formation of fibrils is observed at the delamination front (see figure 2).

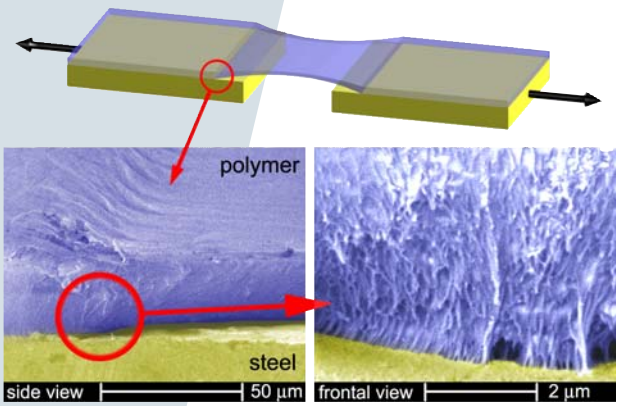

Figure 2 *Peel-off specimen with delamination and micrographs of a delamination experiment with fibrils.*

Modelling

A 3D interface element is developed that relates the stress $\vec{T}$ with the opening displacement $\vec{\Delta}$. During the breaking of the interface an energy ϕ is dissipated (see figure 3).

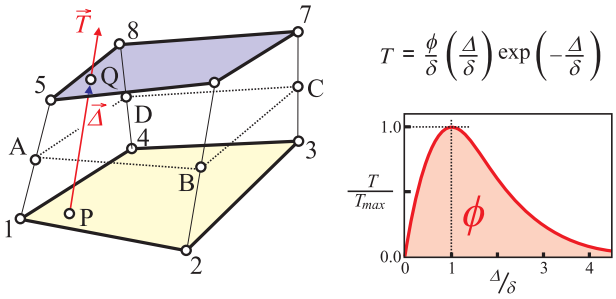

Figure 3 *The interface element and its constitutive behavior, where δ represents a characteristic length.*

The peel-off experiments are simulated with a 3D FEM model, of which a part is shown in figure 4.

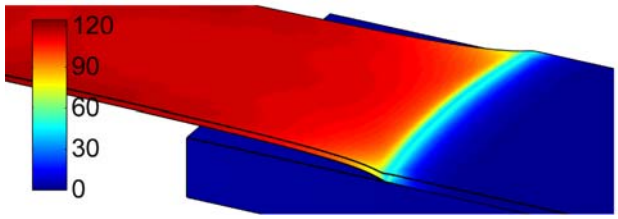

Figure 4 *Deformed shape of the 3D peel-off model. The colors indicate the Von Mises stress [MPa].*

The interface parameters ϕ and δ are determined by fitting the simulation results on the experimental force-displacement curves, as shown in figure 5.

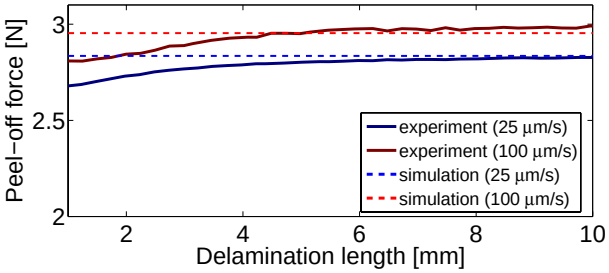

Figure 5 *The force-displacement curves of the peel-off tests at two different speeds.*

Conclusion & future work

Delamination is predicted on the basis of proper interface characterization by a combined numerical-experimental approach. The interface model will be extended by incorporating the influence of substrate roughening on a decrease in the adhesion energy.

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