

## Deformation of polymer-metal laminates

***Citation for published version (APA):***

Rastogi, R., Vellinga, W. P., & Meijer, H. E. H. (2001). *Deformation of polymer-metal laminates*. Poster session presented at Mate Poster Award 2001 : 6th Annual Poster Contest.

***Document status and date:***

Published: 01/01/2001

***Document Version:***

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

***Please check the document version of this publication:***

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

***General rights***

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

***Take down policy***

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

# Deformation of polymer-metal laminates

R. Rastogi, W.P. Vellinga, H. E. H. Meijer

Eindhoven University of technology, Department of Mechanical Engineering

## Introduction

In polymer-metal laminates the moduli and the plastic deformation behaviour of both materials determine the overall behaviour of the laminate upon loading. The mechanism by which the interface deforms is an interplay between the interaction potential and bulk properties of the individual materials.

## Experimental approach

By altering the bulk properties of any one of the two materials and observing the changes and influence on the interface we can get a step closer in to understanding the role of the interface during laminate forming. Hence the polymer was annealed at various temperatures and the changes observed on

- the mechanical behaviour of the bulk polymer.
- crystallinity of the polymer.
- adhesion and deformation mechanism of the polymer on the laminate.

## Methods and Observations

### A: Mechanical behaviour of bulk polymer

PET was injection moulded and annealed at various temperatures as shown in Fig1, followed by compression and tensile loading.

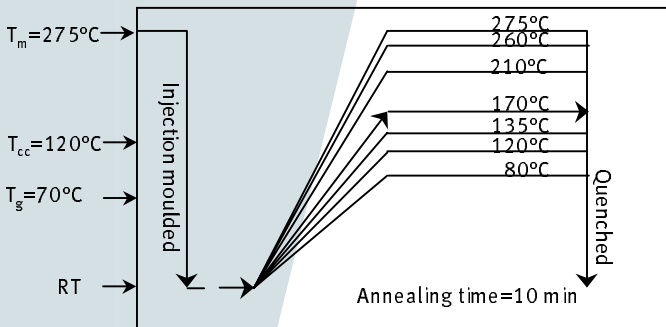


Figure 1: Pet was annealed at various temperatures between  $T_g$  and  $T_m$ .

### B: Relative crystallinity of the polymer

The annealed bulk PET samples were studied using FT Infra-Red spectroscopy. The absorption band at  $1409\text{cm}^{-1}$  can be taken as a reference to normalize all spectra using  $1343\text{cm}^{-1}$  absorption band to determine the relative crystallinity of the samples.

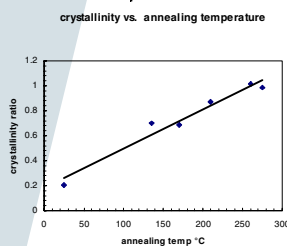


Figure 2: Increase in the relative crystallinity with increasing annealing temperature.

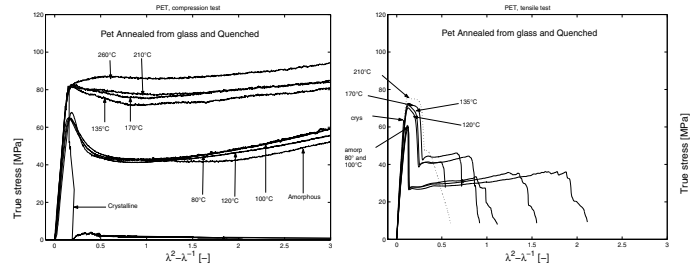


Figure 3: Annealing above  $T_{cc}$ , PET gradually loses strain softening behaviour, with increase in strain hardening and jump in yield stress.

### C: Adhesion and deformation of polymer on the laminates

PET coated Electrochemically coated steel laminates were prepared by block coating polymer solution on the steel substrate and cutting into micro tensile bars. PET-steel laminates were again annealed and quenched. These annealed laminates were then loaded in tension using the Deben Micro-Tensile tester and observed *in-situ* with the optical microscope under cross polarized light.

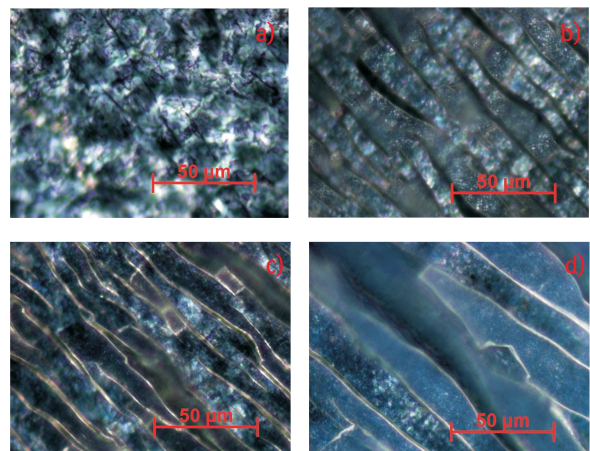


Figure 4: Strained PET-steel laminates observed under cross-polarized light show the formation of shear bands and cracks in the polymer for a) amorphous PET laminate. The laminates annealed above b)  $120^\circ\text{C}$ , c)  $210^\circ\text{C}$  and d) slowly crystallized, do not show shear bands, but brittle failure and delamination.

## Conclusions

- Mechanical behaviour of PET can be influenced by annealing it above its cold crystallization temperature ( $T_{cc}=120^\circ\text{C}$ ).
- Although annealing improved the mechanical properties of the bulk polymer, it lead to weakening in polymer-metal bonding.
- Higher annealing temperatures lead to poorer bonding.
- Bonding layer directly in contact with the metal should be amorphous as crystalline coating delaminates from metal on loading.