Deformation of polymer-metal laminates

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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.

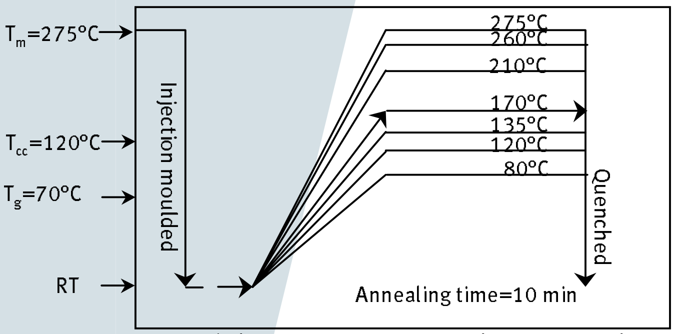

Figure 1: Pet was annealed at various temperatures between T_g and T_m.

B: Relative crystallinity of the polymer

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

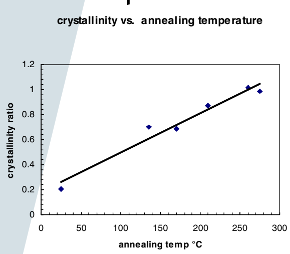

Figure 2: Increase in the relative crystallinity with increasing annealing temperature.

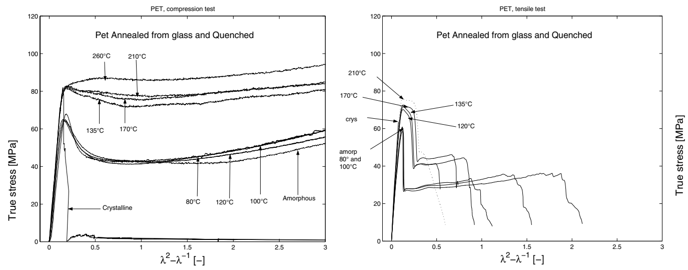

Figure 3: Annealing above T_{cc}, PET gradually looses strain softening behaviour, with increase in strain hardening and jump in yield stress.

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.

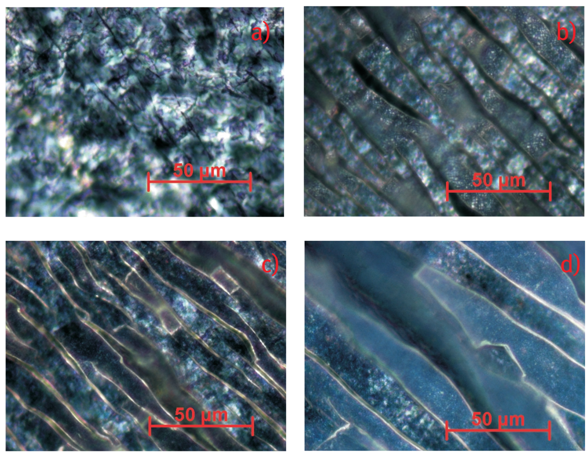

Figure 4: Strained PET-steel laminates observed under cross-polarized light show the formation of shear bands and cracks in the polymer for a) amorphous PET laminate. The laminates annealed above b)120°C, c) 210°C and d) slowly crystallized, do not show shear bands, but brittle failure and delamination.

Conclusions

- Mechanical behaviour of PET can be influenced by annealing it above its cold crystallization temperature (T_{cc}=120°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.