

# Warping of rubber pressed composite panels

S. Wijskamp, E.A.D. Lamers, R. Akkerman



University of Twente  
Twente Institute of Mechanics  
P.O. Box 217, 7500 AE Enschede, The Netherlands  
phone +31-(0)53-4892426, e-mail s.wijskamp@ctw.utwente.nl

## Introduction

The rubber pressing process is applied to produce thermoplastic composite parts. The preconsolidated laminate is reheated to its melting temperature in an infrared oven, then quickly transported to the press where it rapidly cools under high pressure between the steel and rubber tool.

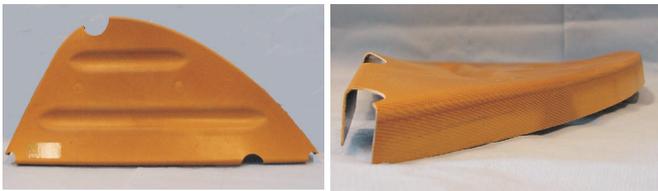


Figure 1 Warping of a woven fabric glass fibre reinforced thermoplastic composite stiffener

A problem that occurs is that intended flat parts become curved after release. Normally, this so-called *warping* is assumed to be caused mainly by the non-symmetrical cooling and resulting gradient in morphology and shrinkage during pressing. Here, it is believed that the non-symmetrical mechanical loading contributes considerably to the product distortions.

## Objectives

The objective is to predict the warping of composite panels in order to optimise the pressing process and the shape of the tool such that trial-and-error costs are reduced.

## Methodology

Before, a one-dimensional coupled thermo-mechanical analysis including the shrinkage stresses due to non-symmetrical cooling was proposed. Now, the temperature profile during forming has been monitored by inserting thermocouples in rectangular flat panels. The temperature of the steel tool was varied. A test series was performed with a thin PTFE foil on the steel tool to analyse the influence on the cooling profile. The resulting curvature of the panels after rubber pressing has been measured with a coordinate measuring device.

## Results

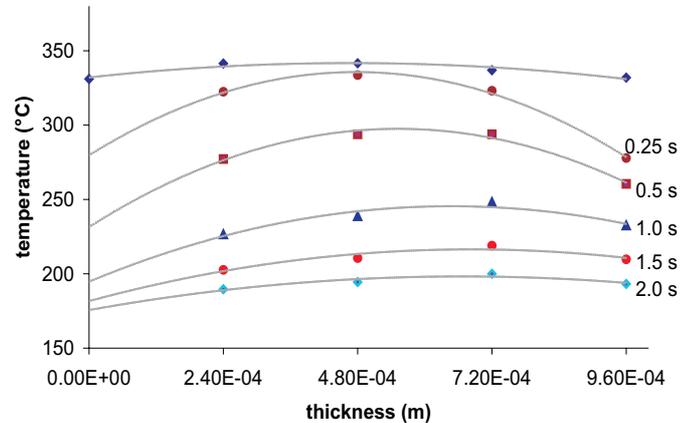


Figure 2 Measured temperature profile through the thickness of a composite panel; the thermocouple on the steel side failed

For higher temperatures of the steel tool, the cooling was measured to be increasingly symmetrical. The heat transfer of the panels pressed on the PTFE coated tool was as good as identical on both sides. However, considerable warping occurred.

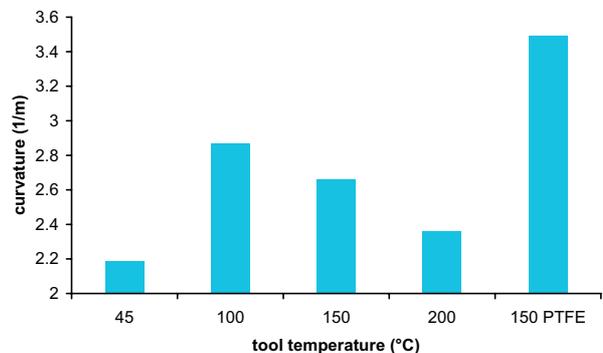


Figure 3 Measured curvature of rubber pressed panels for various processing conditions

## Discussion

The non-symmetrical cooling is not the sole cause for the warping of rubber pressed thermoplastic composites. The different boundary conditions on the steel and rubber tool side seem to induce a large part of the distortions. Currently, Finite Elements analysis is applied to include the effects of mechanical contact, visco-elastic material behaviour and assumed non-uniform loading due to edge effects.