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MOLECULAR ORIENTATION, RESIDUAL STRESSES AND ANISOTROPY OF POLYCARBONATE INJECTION MOULDED DISCS

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Introduction

Injection moulded discs were used to study the relation between moulding conditions and flexure properties of plates. In previous works using polypropylene, it was stated that the skin-core thickness relation is a morphological parameter that enables the prediction of its flexural properties[1]. In the case of amorphous material it was thought that the molecular orientation can influence that parameter.

The molecular orientation induced by the thermo-mechanical history of the material was assessed by birefringence measurements. The birefringence was measured by means of polarised light microscopy along and across the flow direction. Accepting a few simplifications it is possible to estimate the elastic properties of the discs[2].

The elastic properties can be used in a FEM package (ALGOR™), which enables the simulation of the three point support and centre applied load plate flexure test.

The measurements were made with the wedge method. The method was presented as being able to measure the birefringence caused by molecular orientation and insensitive to the internal stresses present in the specimen[3]. In order to verify that sentence, some specimens were subjected to annealing[4].

Mouldings

The material used was a general purpose polycarbonate grade from GE, Lexan 141 R. The moulding programme and the codes used are summarised in tables 1 and 2.

Table 1

T. Mould = 80 °C				
		Flow rate (cm^3/s)		
		10	20	40
T. Melt (°C)	280	A	B	C
	300	F	G	H
	310	J	K	L

Table 2

Flow rate = 20 cm^3/s				
		T. Mould (°C)		
		80	100	120
T. Melt (°C)	280	D	E	-
	300	-	I	-
	310	-	M	N

Birefringence measurements

Four specimens are cut in each disc, two along and two across the flow direction (see figure 1). The triangles must have 30°/60°/90° angles.

The specimens were polished in the two longer edges in order to remove any marks from the cut stage. The specimens are mounted in a bath of paraffin (refractive index 1.48 close to the one of PC, 1.58), as in figure 2.

The light was monochromatic with wavelength of 550 nm. An image analyser Quantimet 500 from Leica, was used to acquire the fringe patterns and to measure the birefringence. The birefringence was calculated from the distance between two consecutive fringes.

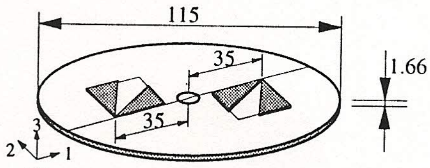

Figure 1 - Specimens cut from each centre-gated disc

Annealing

4 specimens were subjected to annealing during 4 hours at 120°C, followed by 1°C/min cooling.

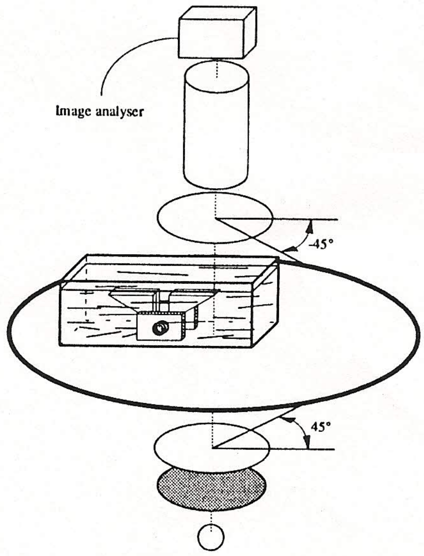

Figure 2 - Birefringence measurements

Results and discussion

The results show that there is a relation between injection moulding parameters and the through thickness birefringence. Increasing the flow rate, the melt-temperature and the mould-temperature results in lower birefringence in both radial and tangential directions (some data are plotted in figures 3-4).

Annealing shows that the internal stresses, locally up to 15 MPa near the wall in the radial direction, also contribute to the birefringence.

Modelling the flexural behaviour with an anisotropic three layer symmetric model (skin/core/skin = 1/6/1 thickness ratios) suggests an average difference of 8% between theory and experiments. Using more layers would improve accuracy. Assuming the material is isotropic gives poor agreement between theory and experimental results.

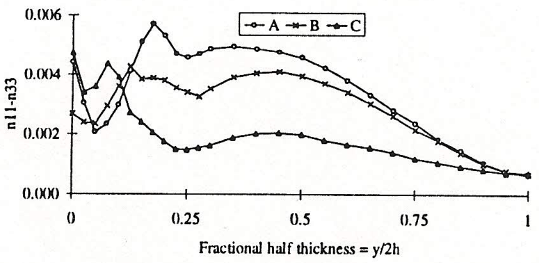

Figure 3 - Radial birefringence

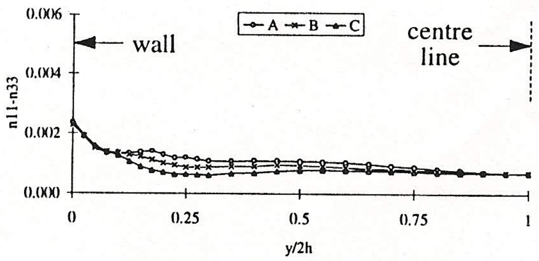

Figure 4 - Tangential birefringence

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