# MOULDING DEFECTS IN CONTINUOUS FIBRE AND RANDOMLY-ORIENTED STRAND CARBON/PEEK COMPOSITES

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**Keywords**: *thermoplastic composites, discontinuous fibres, randomly-oriented strands, compression moulding, voids, manufacturing defects.*

**Introduction**

Randomly-Oriented Strand (ROS) composites are a bulk moulding compound type of material made of strands of unidirectional prepreg tape [1]. Offering great formability compared to continuous fibre composites and higher fibre volume fraction that short-fibre reinforced injection moulded thermoplastics, ROS composites can be employed to manufacture intricate compression moulded components having features such as thickness changes, tight radii, reinforcing ribs, mould-in holes, etc [2,3]. Similarly to short-fibre reinforced injection moulding processes, ROS composites are processed at high pressures. This favors the filling of the mould cavity at the melt temperature, and also helps to compensate for the thermal and crystallization shrinkage of the material during cooling. The latter is important in order to prevent localized loss of pressure, which could lead to void formation. This phenomenon, combined with the high fibre volume fraction of ROS (reduced flow) and unilateral compaction behaviour of compression moulding, make it challenging to manufacture defect-free complex shaped part.
This paper presents an investigation of the effect of the loss of pressure during cooling and void formation on the mechanical properties of continuous fibre (CF) and randomly-oriented strand carbon/PEEK composites. Manufacturing defects were induced on flat panels by opening the mould, i.e. releasing the pressure, at different temperatures in the cooling stage of the moulding process. The different conditions were compared by measuring their short-beam strength according to the ASTM D2344 standard.

**Material and panel manufacturing**

The material of this study was a unidirectional AS4/PEEK tape ($V_f = 59\%$). Two material configurations were tested: CF 24-layer cross-play laminates and ROS. For the latter, the tape was chopped into 25 mm × 6.4 mm strands. 100 mm × 100 mm × 3.3 mm panels were manufactured using an instrumented hot press. In the case of ROS, the material was manually placed inside the mould cavity to achieve a random distribution. All panels were processed at 380 °C, under a pressure of 10 bar. After a 15 min temperature hold, the setup was cooled at a rate of 10 °C/min, and the pressure was increased to 70 bar. Once the temperature reached the targeted demoulding temperature, the mould was slightly opened at a rate of 0.05 mm/s, releasing the applied moulding pressure. The setup was then brought to room temperature at the same cooling rate, followed by the plate ejection. Three pulling temperatures were tested: 300, 310 and 320 °C. These temperatures correspond to the range of crystallization temperature of PEEK [5], where the combined thermal and shrinkage rate is the highest during the cooling stage. A baseline panel moulded without releasing the pressure was also moulded for each material configuration.

**Results**

The short-beam test results are shown in Fig. 1. 16 samples from each panel were tested. For both material configurations, the average short-beam strength of the part demoulded at 300 °C was very similar to the one measured at room temperature, indicating that the degree of crystallinity at that temperature was high enough for the part to be demoulded without defects. At 310 °C and above, a surface defect was observed on the surfaces of the panels, where resin had been pulled off by the mould platens [2, 4]. At 310 °C, the strength was 4.5% and 13.0% lower than that of the baseline for the CF and ROS materials, respectively. At 320 °C, it was 12.5% and 17.7% lower. These results suggest that surface and/or internal defects were formed at those temperatures, leading to a drop in the short-beam strength.

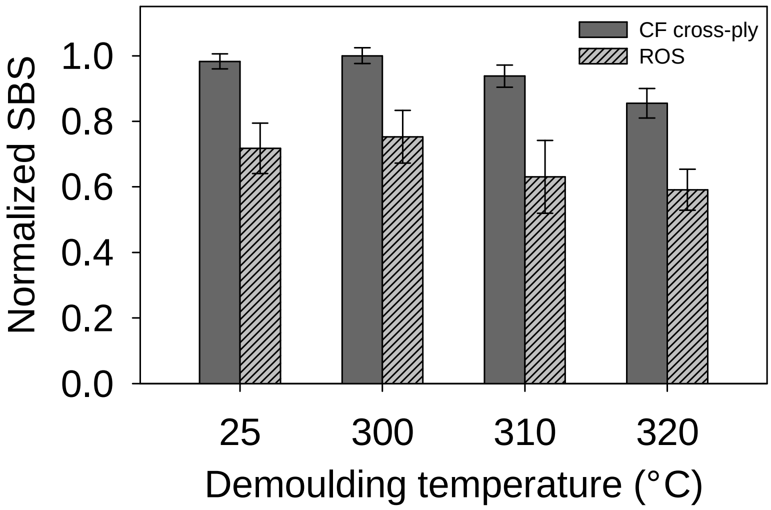


**Figure 1:** *Normalized short-beam strength as a function of the demoulding temperature. The error bars show ± one standard deviation.*

**Future work**

In future work, a detailed analysis will be performed to quantify the size and location of the voids throughout the thickness of each laminate. The induced defects will then be compared to those found on real moulded parts. Finally, the effect on tensile, compressive and flexural properties will be evaluated.

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