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The effect of processing parameters on the interlaminar properties of autoclave cured glass-fibre/epoxy composites

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Introduction

- Nowadays, polymer composites are becoming more and more common, in areas with the highest quality requirements, components made of prepreg are frequently used.
- Highly reproducible, high-performance composites can be produced from prepregs, but this requires a tightly controlled processing environment.
- The process parameters may have a significant influence on the structure and properties of the manufactured composite.
- First, in our research the use and temperature of an isothermal dwell included before reaching the curing temperature were investigated by monitoring the viscosity of the resin during different thermal cycles.
- Furthermore, effects of the following parameters have been determined in the case of autoclave production of glass fibre/epoxy composite plates:
  - Heating rate,
  - The amount of pressure applied to the composite during the cycle and
  - The use of a temperature plateau.

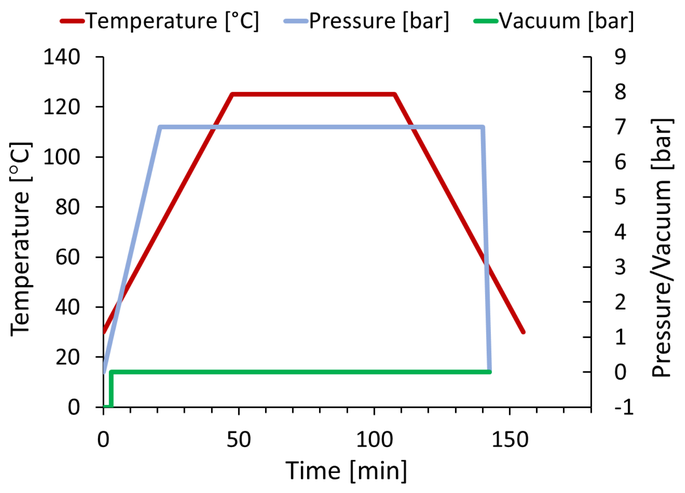
Materials and sample production

- Hexcel's UD S-glass/913 epoxy prepreg was used for composite manufacturing
- The samples for viscosity measurements were layered from 913 epoxy resin film

Composite plates with 3 mm thickness were cured in Olmar ATC 1100/2000 autoclave using four different cure cycles.

1st cycle followed the general recommended parameters:
- 2°C/min heating rate
- 125°C cure temperature
- 60 min cure time
- 7 bar pressure

Differences in further cycles:
- 2nd: 1 bar pressure
- 3rd: 0,5°C/min heating rate
- 4th: 25 min long dwell at 90°C

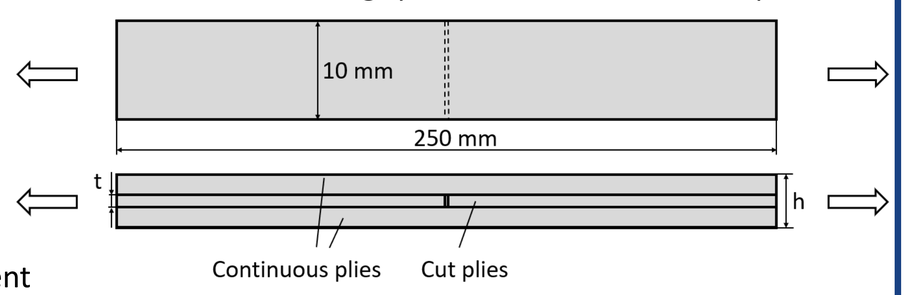


Test methods

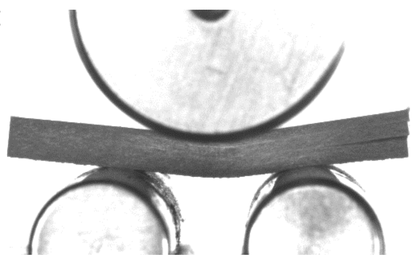
Viscosity measurement by oscillatory rheometry

Further test methods:
- Determination of fibre content by thermogravimetry
- Measurement of density (ASTM D792)
- Calculation of porosity (ASTM D2374)

Fracture toughness (GII,C) evaluation with quasi-static tensile tests using specimens with cut central plies

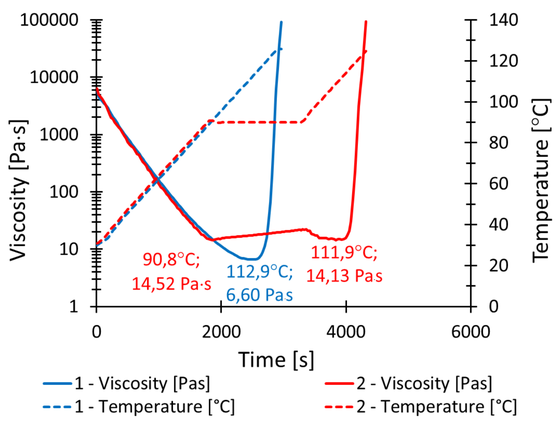


Short-beam shear test (ISO 14130)

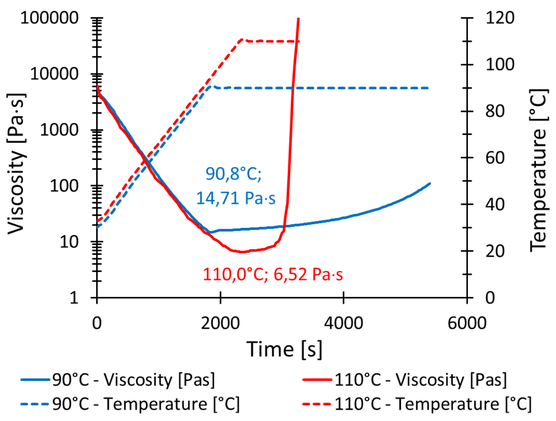


Results

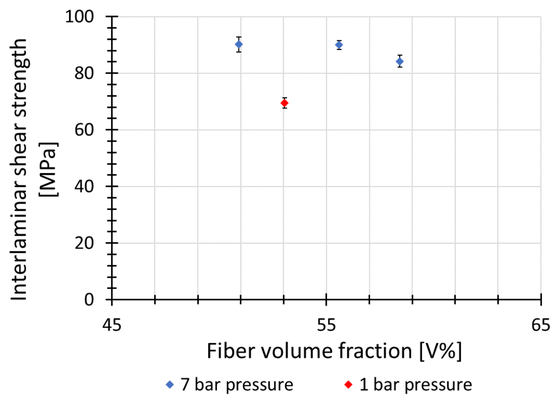
Viscosity measurements 1) without dwell, 2) with dwell (25 min/90°C)



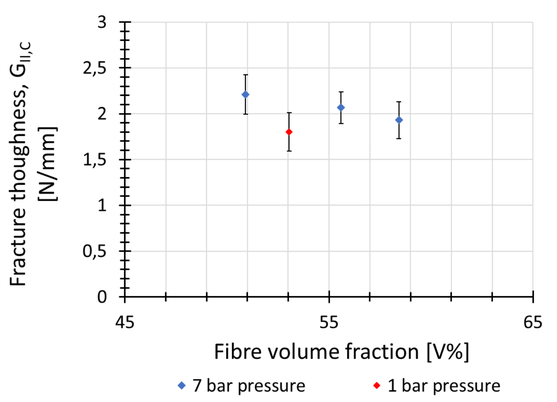
Viscosity measurements with two possible dwell temperatures



Fibre volume fraction-interlaminar shear strength diagram of the different plates



Fibre volume fraction-mode II fracture toughness diagram of the different plates



Conclusion

In our research, we investigated the effects of process parameters on the properties of autoclave cured glass fibre-epoxy composite plates:
- Oscillatory rheometry revealed that the application of the dwell included in the thermal cycle limits the viscosity drop, which might result in a smaller extent of resin leakage. The application of a dwell with a higher temperature may cause the opposite effect and help to maintain low viscosity values longer than in the case of a thermal cycle without dwell.
- The results of thermogravimetry showed that the general cycle caused the largest extent of resin leakage, which resulted in the highest fiber volume fraction. The reduction of pressure or heating rate and the application of the dwell causes smaller resin leakage, thus lower fiber volume fraction.
- Density measurements showed that higher pressures applied during the cure cycle reduce porosity.
- The short-beam shear tests and the tensile test with cut ply specimens revealed that a higher applied pressure or higher resin content results in higher values of interlaminar shear strength and mode II fracture toughness.

Acknowledgements

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