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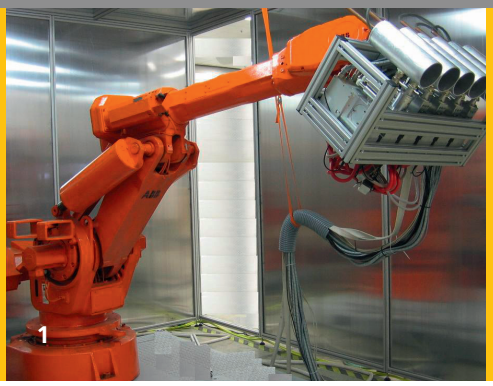

1 *Microwave sources mounted on robot.*

CODE – CURING POLYESTER RESINS ON DEMAND

Vacuum-assisted infusion lamination with microwaves

Large composite components or products such as boats, wind blades or pipes are manufactured using resin infusion technology. These components must be cured under very strict processing conditions because of the need for reproducible polymerization of the resin. The resin is therefore formulated manually in batches. The manufacturer must make a compromise between the impregnation properties of the resin (dependent on the viscosity) and the curing time of the final part.

Unsaturated polyesters are formed by thermoset reactions between a difunctional acid or anhydride (e.g. maleic, fumaric, phtalic, isophthalic, terphthalic) and a difunctional alcohol (e.g. ethylene glycol, diethylene glycol, polypropylene glycol). For the formation of the 3D-network (polymerization), a monomer (e.g. styrene) must react with the unsaturations in the polyester. Commercial polyester systems have a styrene content of about 30 to 50 wt.-%. Heat or radiation triggers the crosslinking reaction. Catalysts (e.g. methyl ethyl ketone, peroxide) are used. Accelerators (promoters) speed up the reaction and inhibitors extend shelf life.

The new curing technology is best suited for large area parts like boat hulls, wind turbine blades, large cabinets etc.

The benefits of the new process are:

- Fundamental change to resin infusion process by separating the filling and the curing process.
- Reduction of curing time from days to minutes.
- Reduction of styrene emission and manual work.
- Increase of the degree of polymerization to nearly 100 % with microwave curing.

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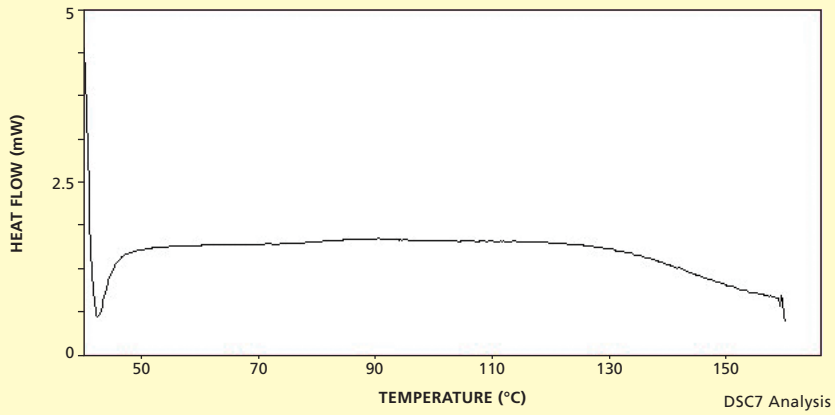

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Process and results

A multi-functional polyester resin was developed that was suitable for resin infusion and microwave curing. It had a low viscosity for optimal filling of the mold without curing. After the filling process was completed a microwave system was applied to start the curing of the resin: as the curing was an exothermic reaction, no further microwave input was then required. A microwave system was developed which, in connection with a temperature control system, ensured a homogenous heating and therefore curing of the resin (2). The microwave system was developed with the help of simulations of the microwave field and resultant heating. The degree of polymerization of the resin was increased using microwaves. Figure 3 shows the DSC graph. The curve is smooth and the polymerization degree was 100 %. Because of the very high degree of polymerization the styrene emission, in particular during demolding, was decreased by over 90 %.

Conclusion

In the project a scaleable microwave system was developed for the homogenous heating and therefore curing of large area parts. Only the combination of the newly developed resin and the microwave system with a temperature control ensured the homogenous processing of the part.

Partners

This project has received funding from the European Community´s Sixth Framework Program (FP6-NMP3-CT-2005) under grant agreement number 516957. It was carried out by 4 companies and 2 research institutes from 3 European countries.

2 *DSC graph of the modified polyester resin cured using microwaves.*