DEVELOPMENT OF TECHNIQUES FOR POLYMERIC DIAPHRAGM FORMING OF CONTINUOUS FIBRE REINFORCED THERMOPLASTICS.

Fact Sheet

Project Information

Grant agreement ID: BREU0135

Start date
1 July 1990

End date
30 June 1994

Funded under
FP2-BRITE/EURAM 1

Overall budget
€ 0

EU contribution
€ 0

Coordinated by
Dornier Luftfahrt GmbH
Germany

Objective

The major objectives which represent significant advances on current practices are, the development of (a) high temperature (300A$ĆAC) resistant material forms which are tailored for the process; (b) high temperature (300A$ĆAC) resistant films capable of an increase in area of 100%; (c) an overall process cycle of 20 min; (d) tools with heating and cooling rates of 20A$ĆAC/min together with a coefficient of thermal expansion of 5x10-6/K.

Preliminary work on polymeric diaphragm forming of continuous fibre reinforced thermoplastics has proved that this process has great potential for the fabrication of complex curvature components from this new generation of high performance composite materials. The equipment which has been used in the recent work has
included hot autoclaves, cold autoclaves, pressclaves and modified vacuum forming machines but there is no clear indication as to which is the most suitable for any particular product. As this technique is very new it requires substantial development to bring it to the stage where it will become both technically and commercially viable. The major objectives which represent significant advances on current practices are, the development of high temperature (300 C) resistant material forms which are tailored for the process, high temperature (300 C) resistant films capable of an increase in area of 100%, an overall process cycle of 20 minutes and tools with heating and cooling rates of 20 C per minute together with a coefficient of thermal expansion of 5E-6 K^{-1}.

The selection and design of the aircraft component was completed. The design and the construction of a consolidation measurement apparatus were completed. The design of the rig for the measurement of the shear deformation behaviour was completed. The software for the thermal analysis was selected and used to carry out preliminary modelling. The tools for the different forming routes were designed and manufactured. Preliminary forming trials have been carried out. The material development is under ongoing improvement. A 1-dimensional transient conduction model and a 2-dimensional radiation model has been developed to optimize the heating process.

Thermoplastic composites offer some advantages against thermoset. They need only short production times as they require no curing reaction. The polymeric diaphragm technique is one production technique where the thermoplastic composite is fixed between 2 diaphragms under vacuum, heated to processing temperature and shaped over a mould by air pressure. This technique is especially suitable for complex parts with high draping rates.

The processing development includes: double and single diaphragm techniques in the cold autoclave with additional heating elements; development of a new machine to optimize the production time and to study the process possibilities under automation aspects for fast production cycles; single diaphragm technique for bonding of flat plates together with stiffening elements (L-stiffeners, etc). A waterjet cutting system has been installed for trimming the produced parts. The complete production line is based on an automation concept to show that composites can be produced in an automatic way comparable to metallic materials.

In parallel to the development of the diaphragm machine, a tooling concept has been developed. In order to form high quality parts in short cycle times, the tool has to be heated as fast as possible to the processing temperature at the surface where it comes in contact with the material to be formed. Internal heating of the mould with thermo oil or electrical cartridges has been found too slow and too expensive. It was decided to develop and build thin tools, externally heated on both sides with infrared heaters. A tooling material had to be selected with low thermal mass for high heating rates. On flat plates and small experimental tools the heating and cooling rate was
determined experimentally. The first forming experiments with this tooling concept were performed in the autoclave, leading to low heating and cooling rates. The spoiler was formed perfectly even with variation in thickness and doublers in the area where the ribs will be riveted. A 1-dimensional transient conduction model and a 2-dimensional radiation model has been developed to optimize the heating process. Preliminary work on polymeric diaphragm forming of continuous fibre reinforced thermoplastics has proved that this process has great potential for the fabrication of complex curvature components from this new generation of high performance composite materials. The equipment which has been used in the recent work has included hot autoclaves, cold autoclaves, pressclaves and modified vacuum forming machines but to date there is no clear indication as to which is the most suitable for any particular product. As this technique is very new it requires substantial development to bring it to the stage where it will become both technically and commercially viable.

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