The facility for automated composite manufacturing provides NLR the capability required for developing fabrication methods and structural concepts in composite for aircraft and other lightweight structures.

The facility has a total floor area of 1000 m² and includes:

- Pilot Plant for pick and place technology, hot drape forming, braiding and Resin Transfer Moulding
- Automated Fibre Placement of thermoset and thermoplastic materials and dry fibres
- Press forming of thermoset and thermoplastic materials
- Thermal analysis of composite materials
- Laminating and curing composites using autoclave processing
PILOT PLANT FOR AUTOMATED COMPOSITE MANUFACTURING

Preform cell
This cell comprises of:
• Zünd cutting machine
• Kuka robot with end effectors for pick and place, preform trimming and tool handling
• Global vacuum press with infra-red heating
• Assembly Guidance laser vision system

Braiding
The Eurocarbon overbraiding machine consists of two concentri- cally mounted braiding rings with 144 and 288 carriers. The two braiding rings can be used to manufacture products with a broad range of cross sections from below ø 50 mm to over ø 600 mm depending on tow size, fibre angle and cover factor. The machine can also be used to manufacture tri-axial braids.

Resin Transfer Moulding
The RTM station consists of a dedicated Isojet injection system for one component resin systems with water heaters for resin tank, injection hoses and product moulds. The closing of the moulds is controlled by a 150 ton press with moveable cross head.

As quality of composite components is heavily influenced by its manufacturing process, the development of automation in composites needs special attention. NLR identifies, develops and tests specific composite processes which are suitable for automation. Not stopping at software simulations, NLR goes to the next level in the development of automated processes. This facility is available for research projects into the possibilities of automation in composites up to high technology readiness levels.
Automated fibre placement machine
A Coriolis fibre placement machine is used to develop structural components in thermoset and thermoplastic composites as well dry fibre preforms. The robot based Coriolis machine is capable of making components with a maximum diameter of 3.0 m and a length of 6.5 m in the horizontal spindle configuration and is capable of making components with a maximum diameter if 4.0 m and a length of 2.0 m in the vertical spindle configuration. For processing thermoplastics and dry fibre a 6 kW laser heating is used. For processing thermoset materials an infrared heater is used.

Heated press
With the Wickert WKP 1000 S press forming of thermoset and thermoplastic materials can be carried out. The press can also be used in support of Resin Transfer Moulding (RTM) processes. The main characteristics of the press are:
- Product space: 600 × 600 × 600 mm
- Both position and pressure controlled
- Pressing force between 20 and 1000 kN
- Temperature up to 400 °C
- Accurate displacement: ±0.03 mm

Autoclave
An autoclave is available equipped with automated data logging of temperatures, pressures and vacuum.

- Working volume: 5.5 m³
- Heat output: 70 kW
- Temperature (max): 400 °C
- Pressure: 20 / -1 bar
- Medium: Air or nitrogen

Vacuum Infusion
A dedicated Isojet machine is available for vacuum infusion. Like the RTM machine it is designed for processing one component resins. The maximum resin capacity is 30 litres. The machine is equipped with an electrical heating system both for the resin tank and the tooling.
EQUIPMENT FOR ANALYSIS AND CHARACTERIZATION

**Rheometer**
With the Anton Paar rheometer MCR302, viscosity measurements can be carried out in the temperature range of -40 °C to 620 °C. In the oscillation mode with plate-plate ∅40 mm, viscosities between 40 kPa.s and 1 mPa.s can be measured. The maximum heating rate is 60 °C/min.

**Differential Scanning Calorimeter (DSC)**
The DSC Q2000 with autosampler from TA Instruments is used to study curing, ageing, melting, crystallisation and specific heat (Cp) of thermosets and thermoplastics at temperatures between -90 °C and +550 °C with heating rates up to 200 °C/min and cooling rates up to 100 °C/min. Modulated DSC (MDSC) is possible. Typical sample size is 15 mg. The sensitivity is 0.2 mW.

**Thermogravimetric Analysis (TGA)**
Moisture-, volatile- and resin content are measured with the Pyris 6 TGA from Perkin-Elmer at temperatures from 5 °C up to 1000 °C on test specimens up to 1500 mg. Maximum heating rate is 50 °C.

**Supporting software**
In support of the composite manufacturing activities, several software applications are available:
- CATIA V5
- CATFiber
- Fibersim
- RTM-Worx
- MSC Nastran / Patran
- Abaqus

**Non Destructive Inspection (NDI)**
A C-scan facility is available for Non-Destructive Inspection.
- Scan window of 4.0 x 2.5 x 2.5 m
- Immersion and squirter inspection mode
- Turn table for circular components (max. diameter 1.9 m)
- Scanning pulse echo and through transmission mode simultaneously
- Linear Scanning Array available
- Complex scan geometries generated from CATIA

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