Composite Material Development and Applications

What is Composite?

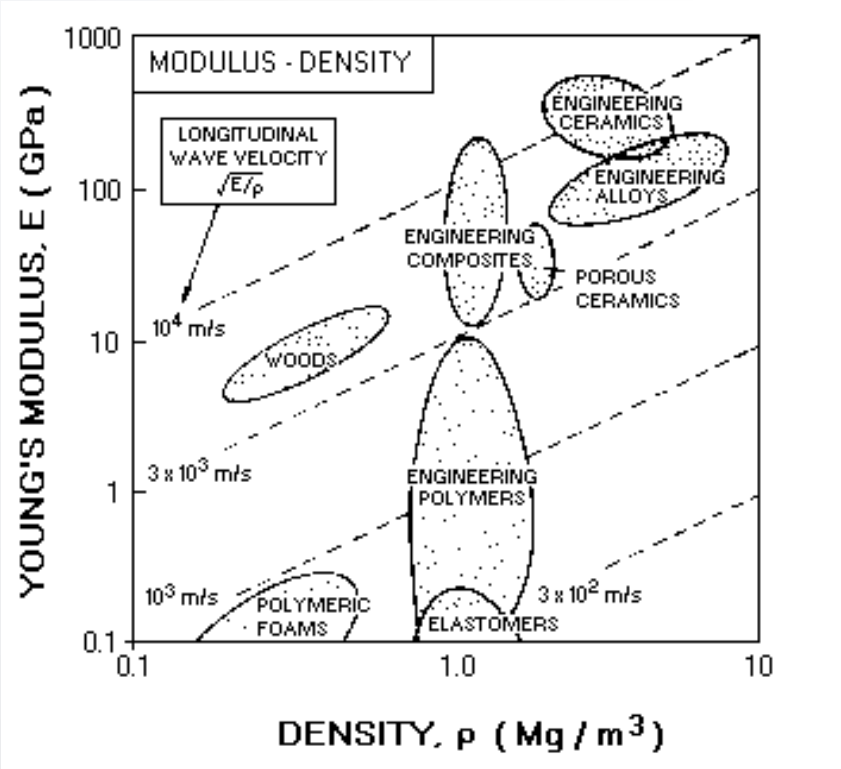
- engineering materials formed by combining two or more materials
- the constituents have significant differences in physical or chemical properties
- the constituents have to be present in sufficient amount
- one material, the matrix, surrounds the other, the reinforcement, by holding them in a fixed position
- stronger, lighter, or less expensive when compared to traditional materials

Applications

- Aviation Industry
  - Aircraft component for A350, B787, etc.
- Automotive Industry
  - Interior and exterior car body component, etc.
- Medical & Healthcare
  - Prosthesis, etc.
- Sporting Goods
  - Bike, paddle, etc.

General Advantages of Composites

- High strength to weight ratio 4 – 10 times better than Steel (e.g. carbon composite)
- Good fatigue properties
- Composites do not corrode
- Variety of manufacturing methods to suit each application (cost/performance)
- Composites are good at absorbing energy



Source: Ashby, MF (1989) On the engineering properties of materials. Acta Metall., 37, 1273

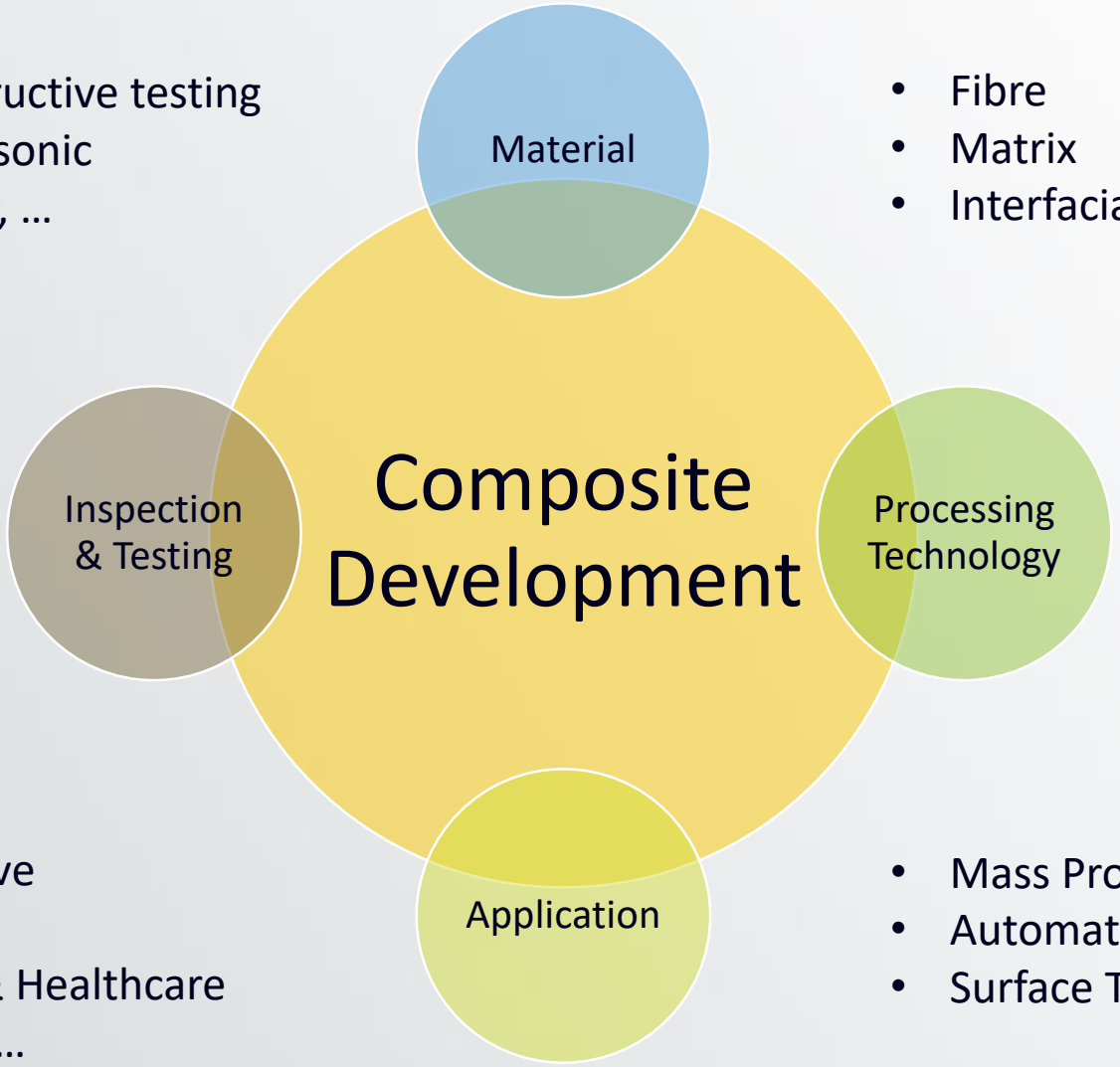
General Disadvantages of Composites

- Raw materials can be expensive
- Difficult to recycle
- Labour intensive
- Hidden damage that is difficult to detect

Composite Development

- Non-destructive testing
  - ultrasonic
  - X-ray, …

- Fibre
- Matrix
- Interfacial Adhesion



- Automotive
- Aviation
- Medical & Healthcare
- Sporting, …

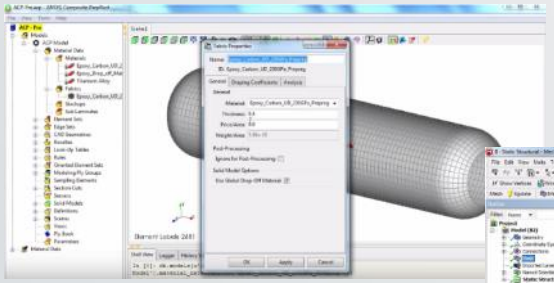
- Mass Production
- Automation
- Surface Treatment

PROCESSING TECHNOLOGY

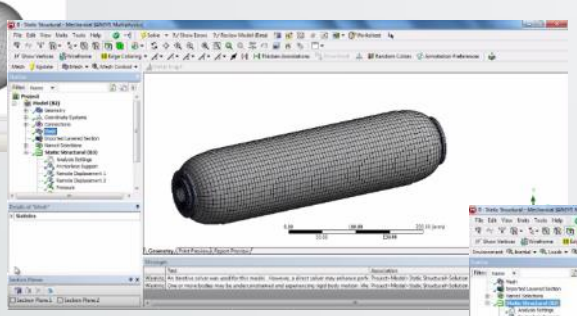
Technology Development

Carbon Composites Part Design

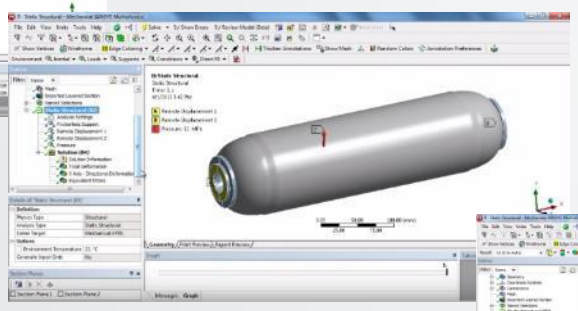
- Design using Computer-Aided Engineering (CAE) tools - ANSYS



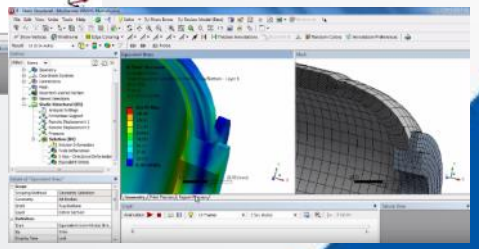
Defining material properties



Generating mesh



Defining boundary condition



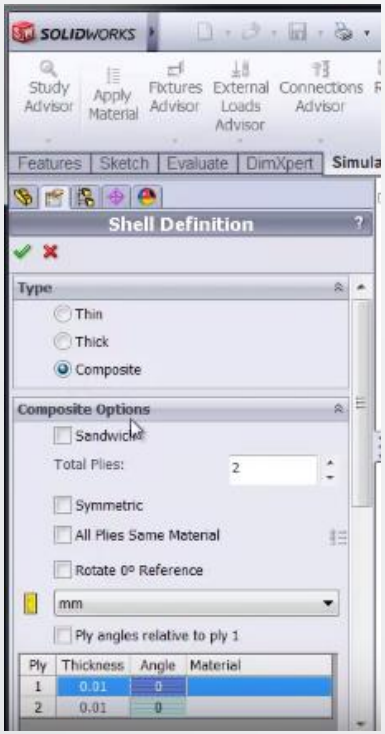
Viewing result

Source: www.ansys.com

Technology Development

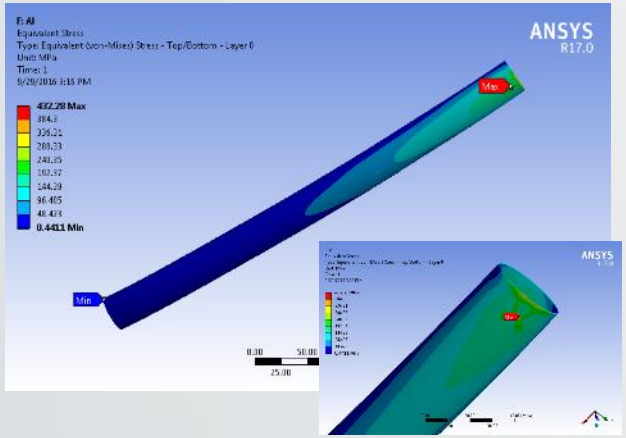
Carbon Composites Part Design

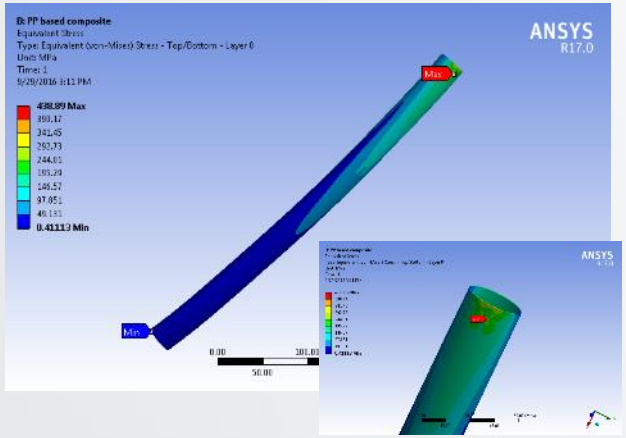
- Design using Computer-Aided Engineering (CAE) tools - SolidWorks

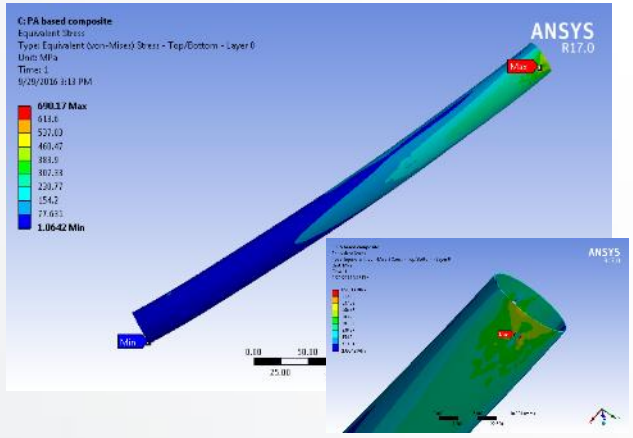


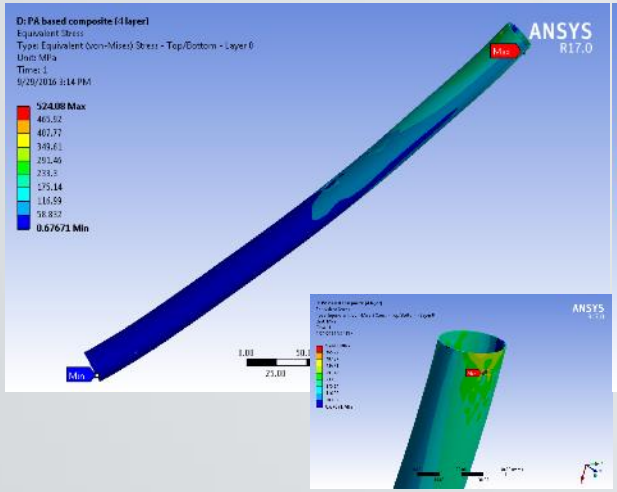
Technology Development

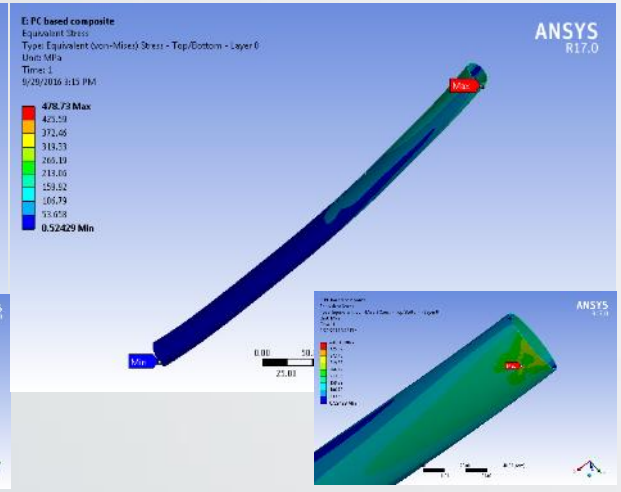
Carbon Composites Part Design









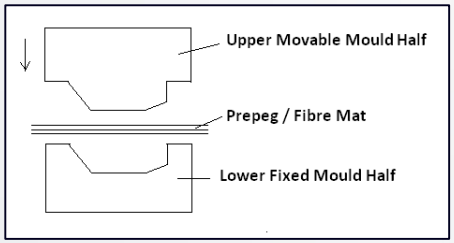


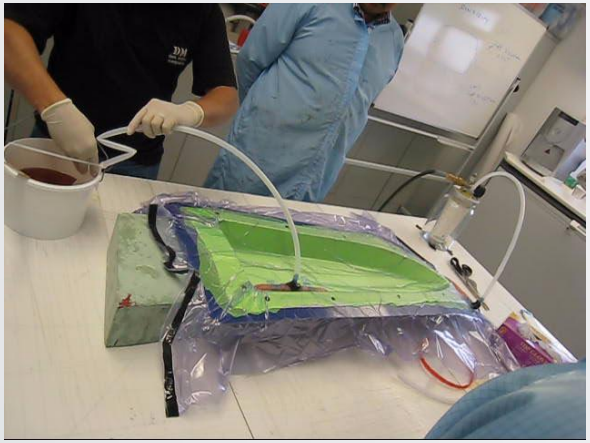
Materials	Maximum Stress (MPa)
Al Alloy	432.28
PP based composite	438.89
PA based composite	690.17
PA based composite (4 CF layers)	524.08
PC- based composite	478.73

Technology Development

Carbon Composites Part Manufacturing

- Hand/Wet Lay-Up
- Hot Press Moulding
- Resin Infusion
- Resin Transfer Moulding
- Autoclave Vacuum Bagging





Technology Development

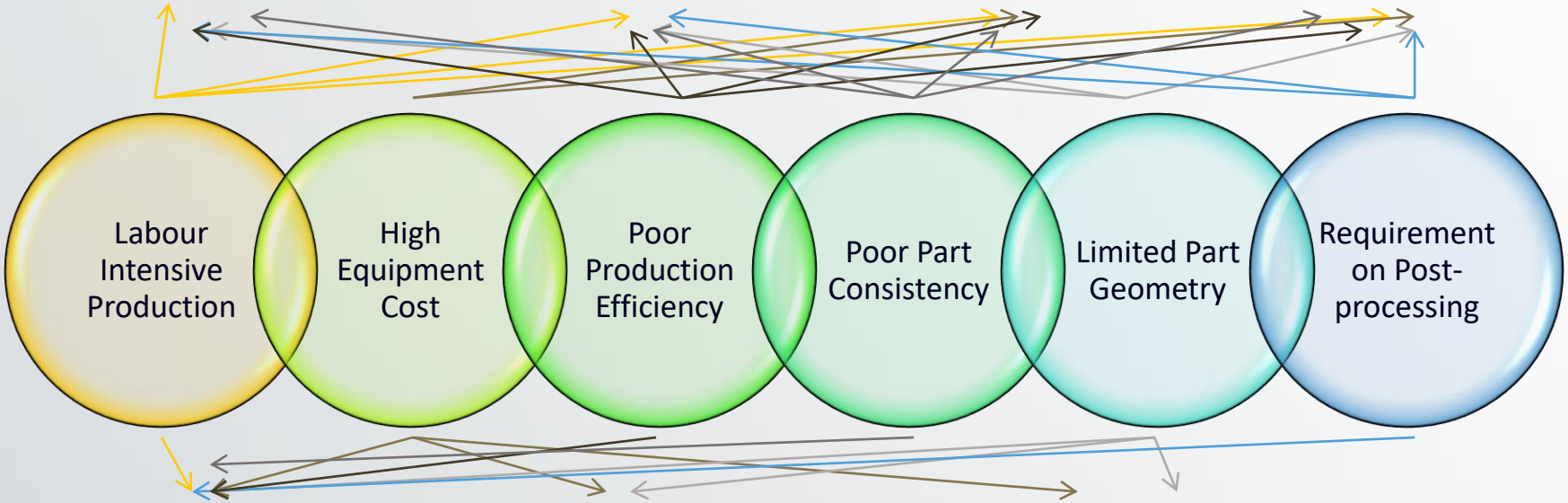
Existing Processing Methods for Polymer Matrix Composite Parts

Hand Lay-up

Resin Infusion

Resin Transfer Moulding

Autoclave Vacuum Bagging



Out-of-Autoclave Process

Filament Winding

Pultrusion

Technology Development

Development of a one-step manufacturing process of 2-material (TP/composite) parts

Technology

- Integration of resin transfer moulding / hot press moulding for composites and overmoulding for thermoplastics

Challenge

- Difference in thermal requirement of thermoset composites and thermoplastics adds to the difficulties in combining the two processes in one single step
- Mould design (thermal isolation)
- Process control

Benefit

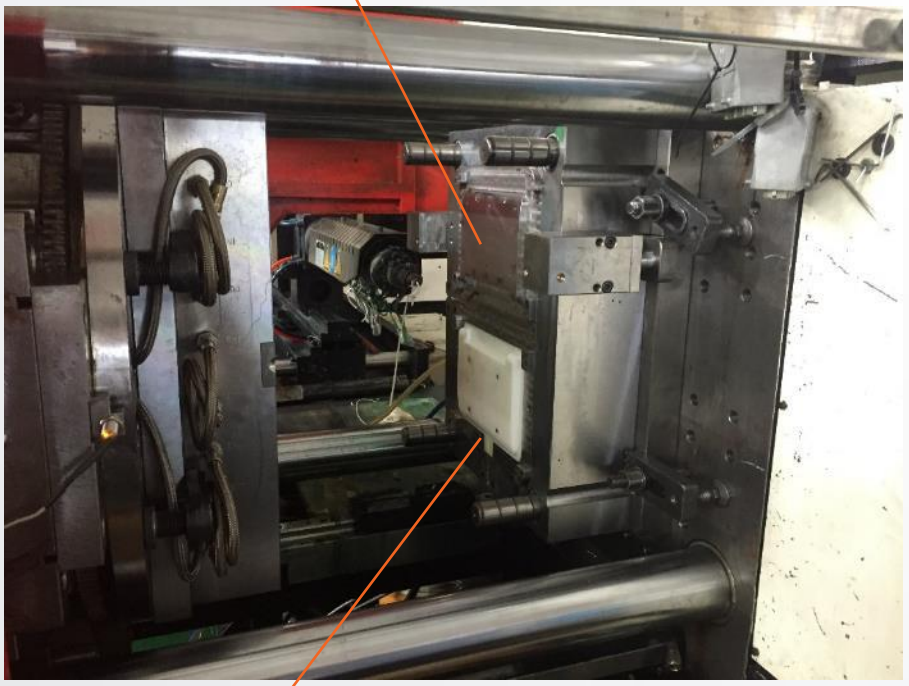
- Improved production efficiency by combining two separate process into one
- Increase design flexibility by combining different materials

Potential Application

- Casing for 3C components, such as smart phones or tablets
- Housing of electrical appliances

Mould

Thermoplastic Injection Moulding



Resin Transfer Moulding

- Mould Materials: Metal and PC/Teflon coated for demoulding of cured epoxy

Process

1: Placing of carbon fibre fabric for RTM
2: Mould close for RTM of epoxy resin

3: Rotation of Epoxy-Carbon fibre composite to accept subsequent injection moulding

3: Injection moulding of thermoplastic parts onto Epoxy-Carbon fibre composite part

Technology Development

Development of an automatic lay-up system for high-strength composite parts for vacuum bagging process

Technology

- Automatic fabric laying system to replace traditional hand lay-up process

Challenge

- Composite pre-pegs and other vacuum bagging materials that are soft and flexible adds difficulties to the pick up process
- Layers of pre-peg have to placed neatly on the mould surface to prevent wrinkles

Benefit

- Enhance production efficiency
- Improve product quality and consistency
- Reduce labour force

Potential Application

- High strength and defect-free composite parts
  - ➢ aviation structural part
  - ➢ autopoarts

Technology Development

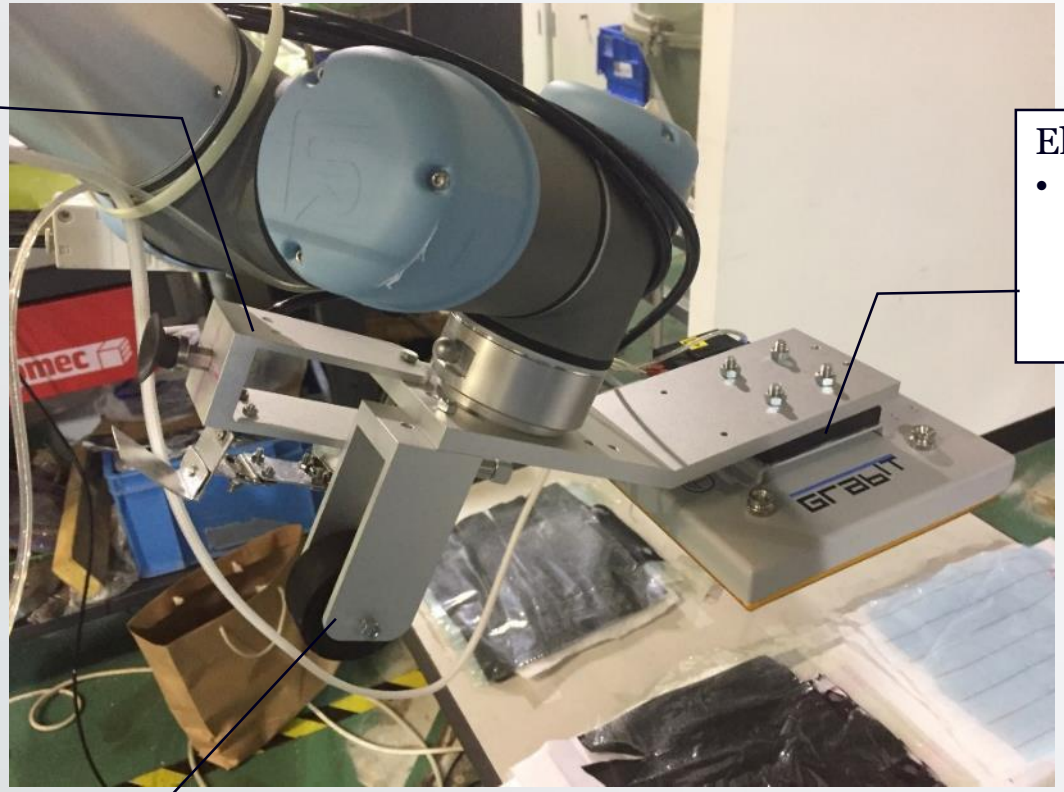
Manual handling process:

1. Placing of composite ply onto tool
2. Tacking of composite plies onto tool surface and between plies
3: Removal of backing sheet
4: Placing of bagging materials (peel ply, release film, breather, etc.)
5: Sealing of vacuum bag
6: Autoclaving

Technology Development

Tools and 6-axis robot:

Backing sheet removal device
- Consists of vacuum suction cups and crimping mechanism



Electrostatic Gripper
- Pick and place of composite ply and bagging materials

Roller
- Materials: Silicone Rubber
- Smoothing composite ply on mould

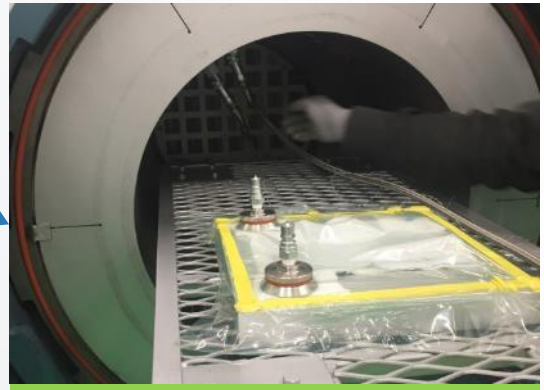
Technology Development

Layup of single ply composite and bagging materials

Technology Development

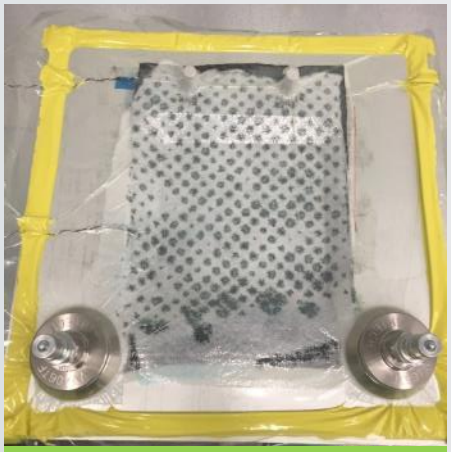
Placement of ply and bagging materials

Placement of vacuum bag and sealing



Connection of vacuum hose and thermocouple

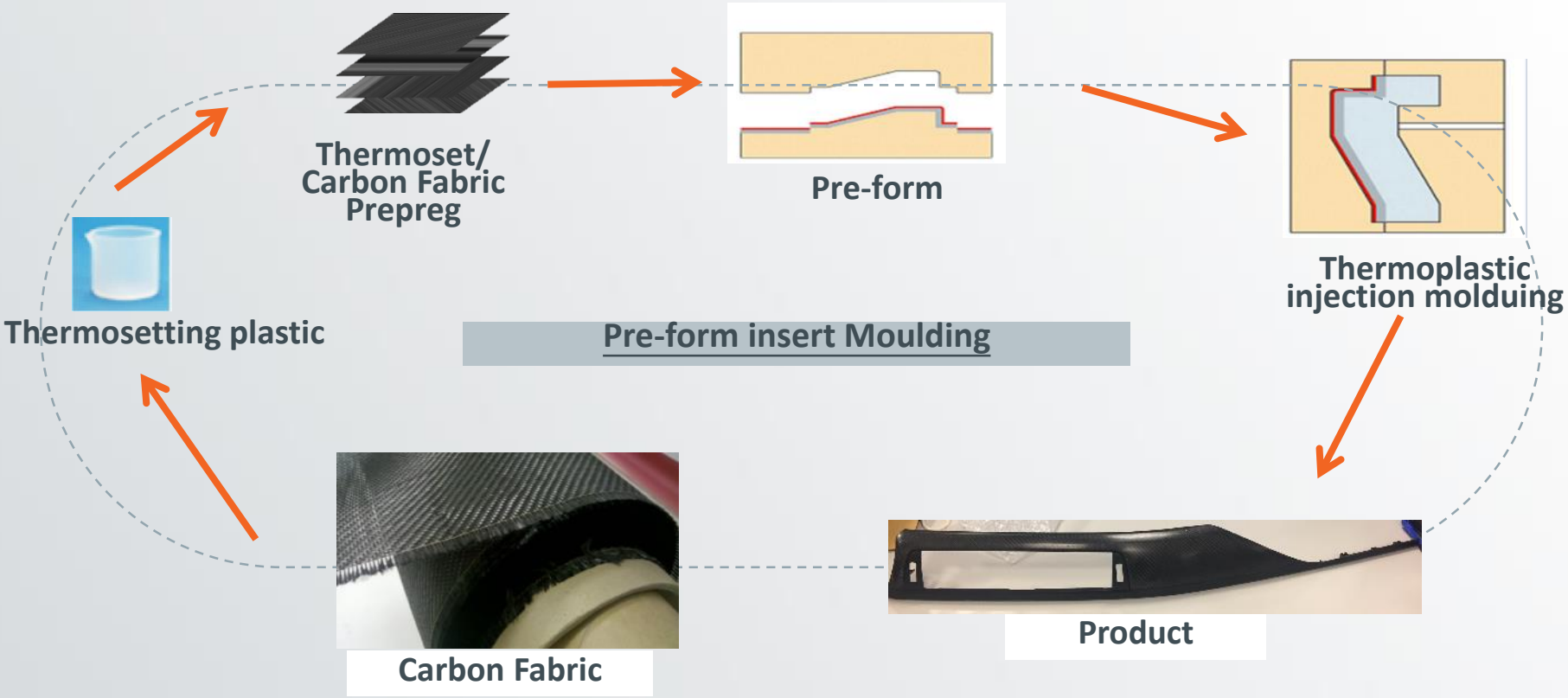
Vacuum applies and curing under pressure and elevated temp



Cured part

Technology Development

Development of Pre-form Insert Moulding



Technology Development

Pre-forming of TS-CF prerpeg

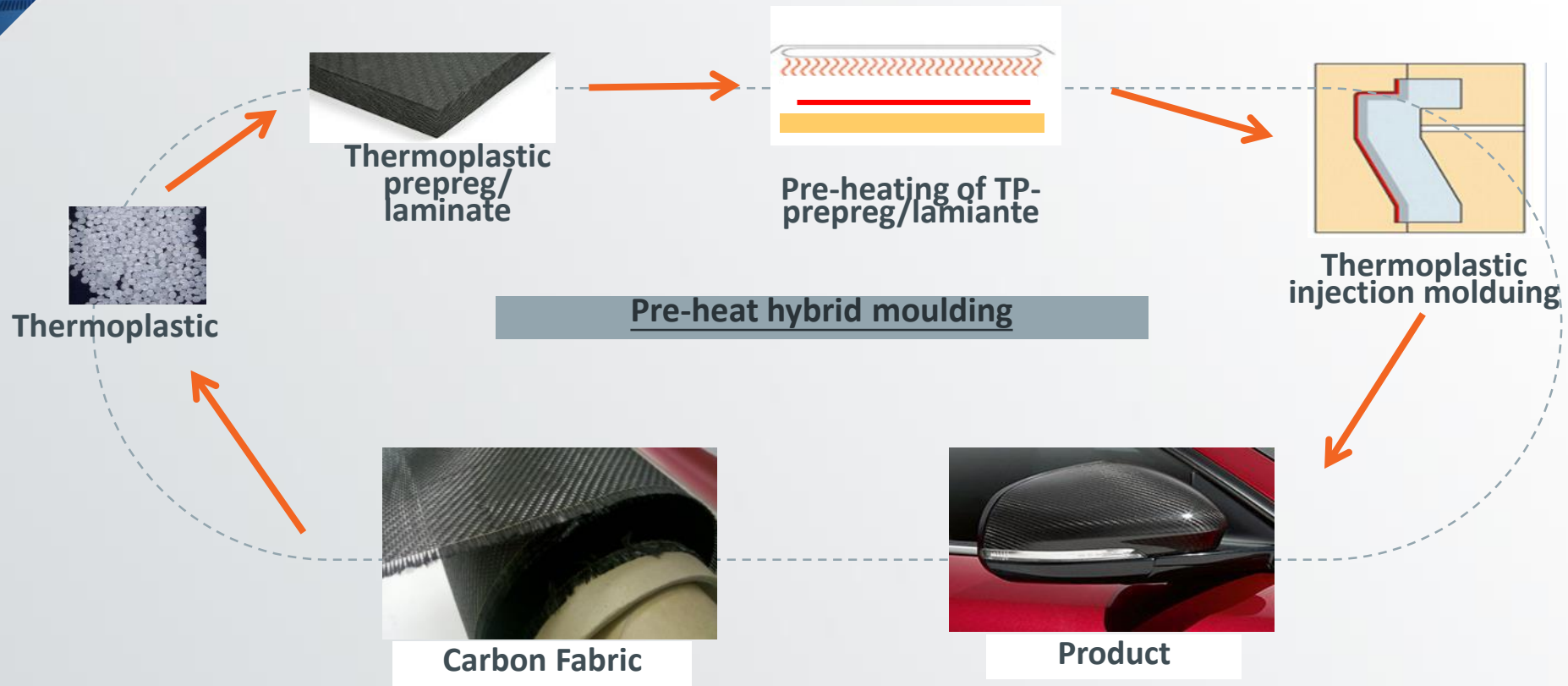
Injection moulding of TS-CF Preform

Technology Development

Injection moulded features for assembly

Technology Development

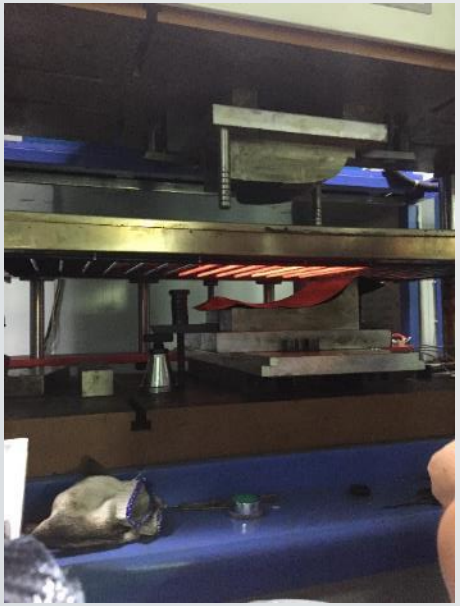
Development of Pre-heat Hybrid Moulding

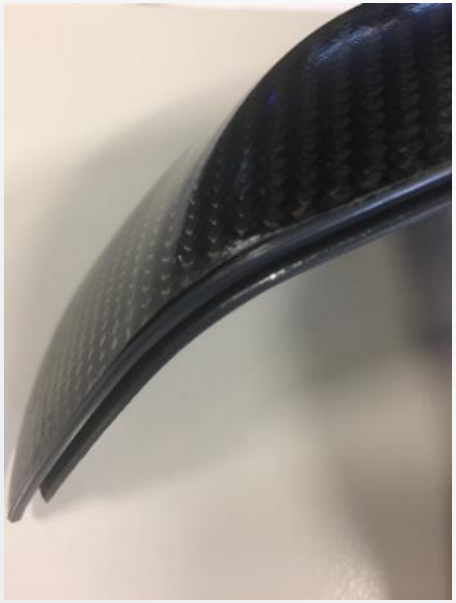


Technology Development

Pre-heating of pre-cut composite → Injection moulding of the pre-heated composite

-Temperature: 120°C-150°C
-Time: 60s-90s





Technology Development

THANK YOU!