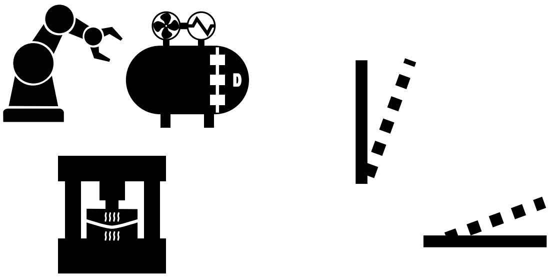
A278

Effect of equipment in a RSDM system
Systems knowledge article



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Introduction[edit | edit source]

The residual stress and dimensional change of a part is closely linked to the thermal history and consolidation the part experiences during manufacturing. Equipment used for thermal transformation, such as ovens, autoclaves and hot presses, prescribe the cure cycles on the part and have direct influence on the part thermal history. Equipment that applies pressure determines the level of part consolidation. This page explains how equipment can indirectly influence the residual stress level within a part.

Prerequisites[edit | edit source]

Recommended documents to review before, or in parallel, with this document:

- Heat transfer
- Thermal management
- System interactions
- Autoclave
- Oven

- Tooling and consumables (system class)
- Effect of tooling in a thermal management system
- Effect of tooling in a RSDM system
- Effect of equipment in a thermal management system

Overview[edit | edit source]

Equipment can indirectly affect the part residual stress level via thermal uniformity and consolidation.

Thermal uniformity[edit | edit source]

During the thermal transformation stage of a part, the system typically involves the part, the tool, and the equipment such as ovens, autoclaves and hot presses. It is the equipment that applies the thermal boundary conditions to the part-tool combination. In the case of a room temperature cure, the equipment is simply the environment (i.e. the room). The equipment prescribes the thermal boundary conditions, which, in combination with the constituent materials, part shape, and tooling, results in the thermal response of the part. This thermal response may very likely not be uniform during different stages of the curing process, which is one the main sources of residual stress within the part. Please refer to pages in prerequisites regarding the interaction between material, shape, tool and equipment in a thermal management system.

Example 1: a part-tool assembly is placed in a convection oven that has strong airflow above the tool and weak airflow below. The difference in airflow is due to the oven design (having the fan on the top). The top layers of the part heat up more quickly than the bottom layers. The temperature gradient causes the top layers to cure before the bottom layers and create residual stresses.

Example 2: a preform/charge is placed in a tool to be cured in a hot press. The tool serves as the medium of heat exchange between equipment and part via conduction. Due to this nature, the layers of the part adjacent to the tool heat up quickly and remain at a uniform temperature. The center of the part takes longer to heat up because the charge has low thermal conductivity. The temperature gradient will cause a degree of cure gradient which ultimately leads to residual stresses within the part.

Consolidation[edit | edit source]

Equipment such as vacuum pumps, autoclaves and hot presses are commnly used to provide consolidation to composite parts during processing. A more consolidated part typically has higher fiber volume fraction and less porosity. As mentioned in the RSDM homepage, resin cure shrinkage and thermal contraction are two of the major drivers for residual stress and part deformation. So a part that is less consolidated with higher resin content may be more prone to residual stresses and deformation.

Related pages

Page type	Links
Introduction to Composites Articles	
Foundational Knowledge Articles	
Foundational Knowledge Method Documents	

Foundational Knowledge Worked Examples	
Systems Knowledge Articles	• Effect of equipment in a RSDM system - A278 • Effect of shape in a RSDM system - A276
Systems Knowledge Method Documents	
Systems Knowledge Worked Examples	
Systems Catalogue Articles	
Systems Catalogue Objects – Material	
Systems Catalogue Objects – Shape	
Systems Catalogue Objects – Tooling and consumables	
Systems Catalogue Objects – Equipment	
Practice Documents	• Ensuring quality during production of variable thickness parts - P127 • Maintaining part quality when changing curing equipment - P122 • Transitioning tooling styles between different thermal transformation equipment - P139 • Troubleshooting a cure cycle for improved production rates - P132 • Troubleshooting quality issues during cure for different equipment types - P141
Case Studies	
Perspectives Articles	• Composites Process Simulation: A Review of the State of the Art for Product Development - A283

About

Help

The individual materials that combine to form the composite material. The constituent materials are separate and distinct on a macroscopic level.

A central processing theme in the manufacturing cycle. This theme is concerned with managing the thermal response of materials during storage and handling or parts/tools when they are subsequently heated.

‘Preform’ is the term for the fibre reinforcement. This is the stage between the raw material form after it is processed into an architecture (fabric, mat, etc.) and becoming a composite.

Engineered materials (designed to have specific properties) made from two or more constituent materials with different physical or chemical properties. The constituents remain separate and distinct on a macroscopic level within the finished structure.

Volume fraction of either matrix or fibres with respect to total composite volume (matrix + fibre).

For polymer matrix composites (PMCs), resin refers to the matrix; the continuous material phase that binds the reinforcement together, maintains shape, and transfers load. Resins are divided into two main groups: thermosets and thermoplastics.