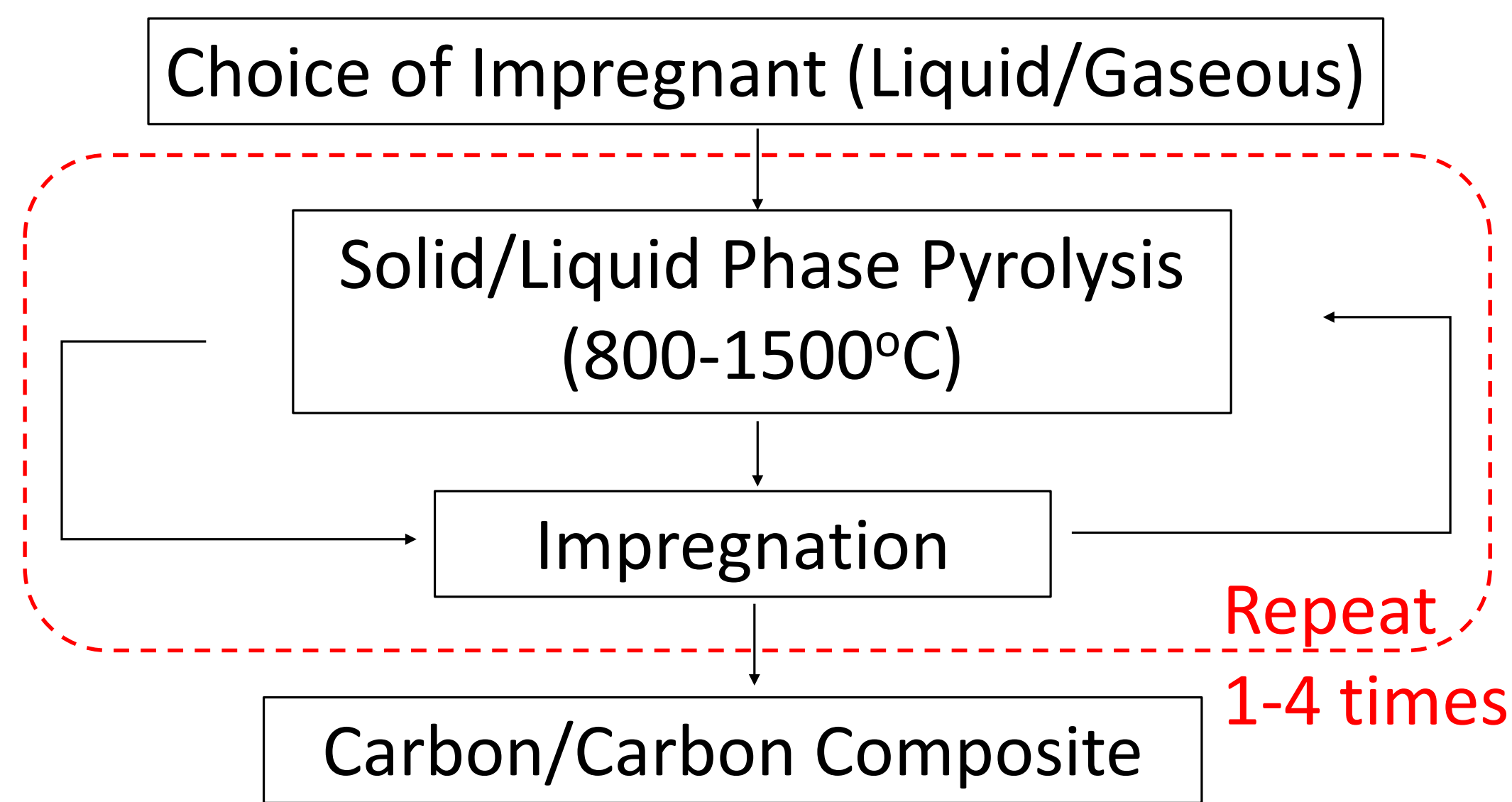


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Introduction

Steps for the manufacturing of C/C composites



Densification process: repetition of the impregnation/carbonization processes for the manufacturing of Carbon/Carbon (C/C) composites.

Optimization of the densification process

- Identification of optimal pyrolysis cycle.
- Identification of optimal re-infiltration parameters.

Overview of the Research

Characterization of the permeability to gas of C/C composites

- Pulse-Decay Test
- Numerical Simulations

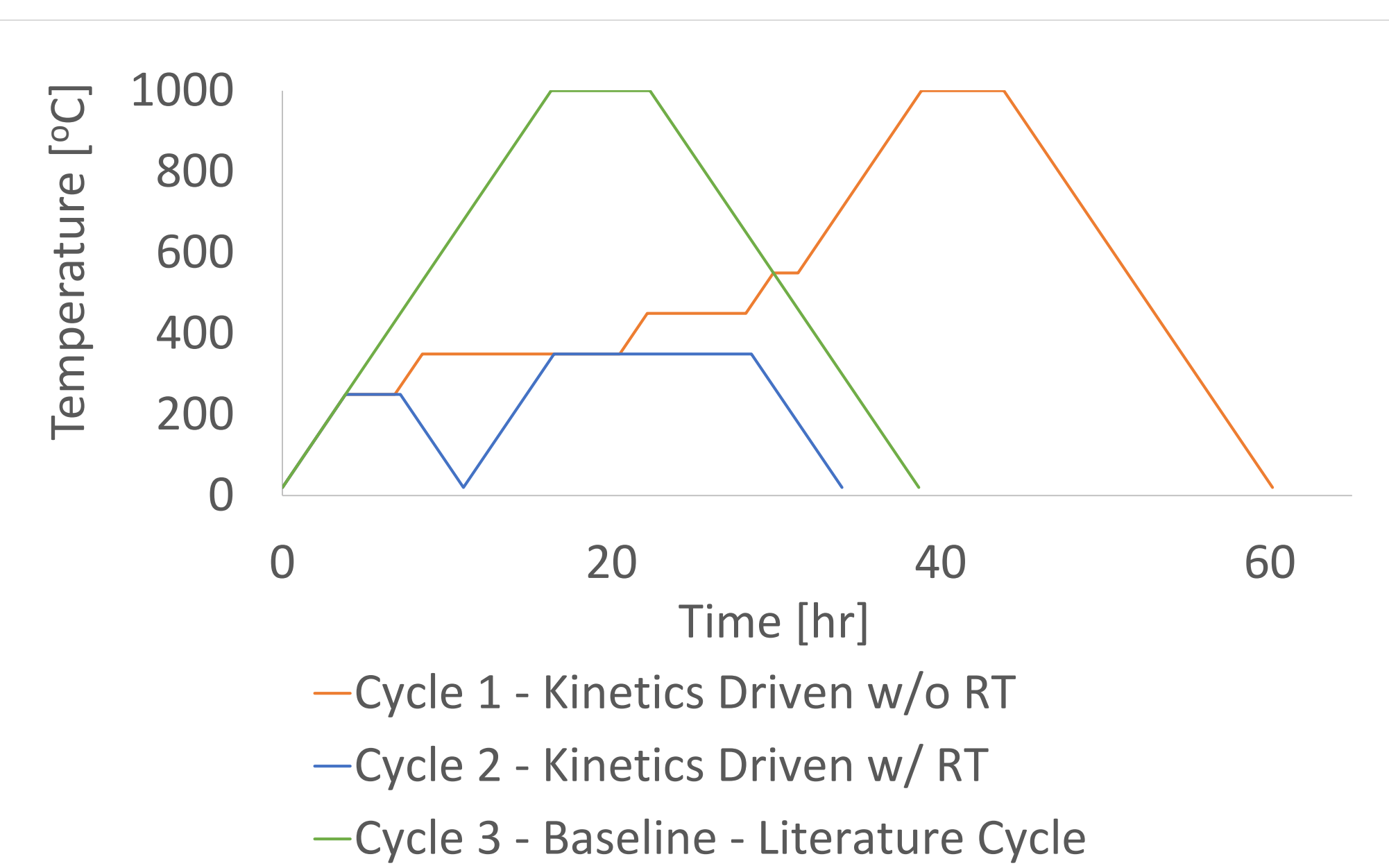
Characterization of the microstructure of C/C composites

- X-Ray Computed Tomography (CT)

Materials and Pyrolysis Cycle Materials

- 5-ply laminates T800 fibers (2x2 twill weave) and MT35700 benzoxazine resin.
- Three samples tested with three different pyrolysis cycles.

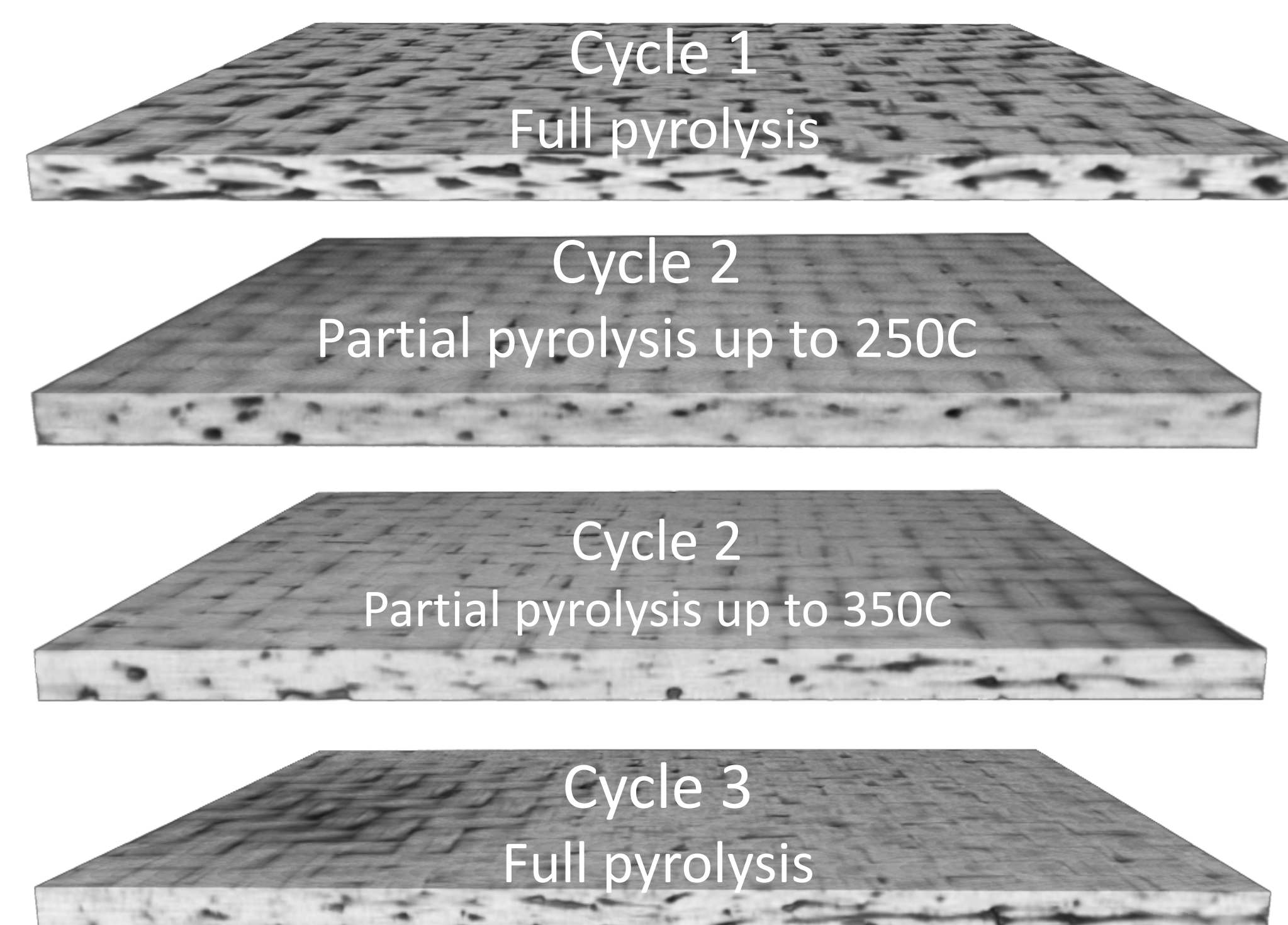
Pyrolysis Cycles



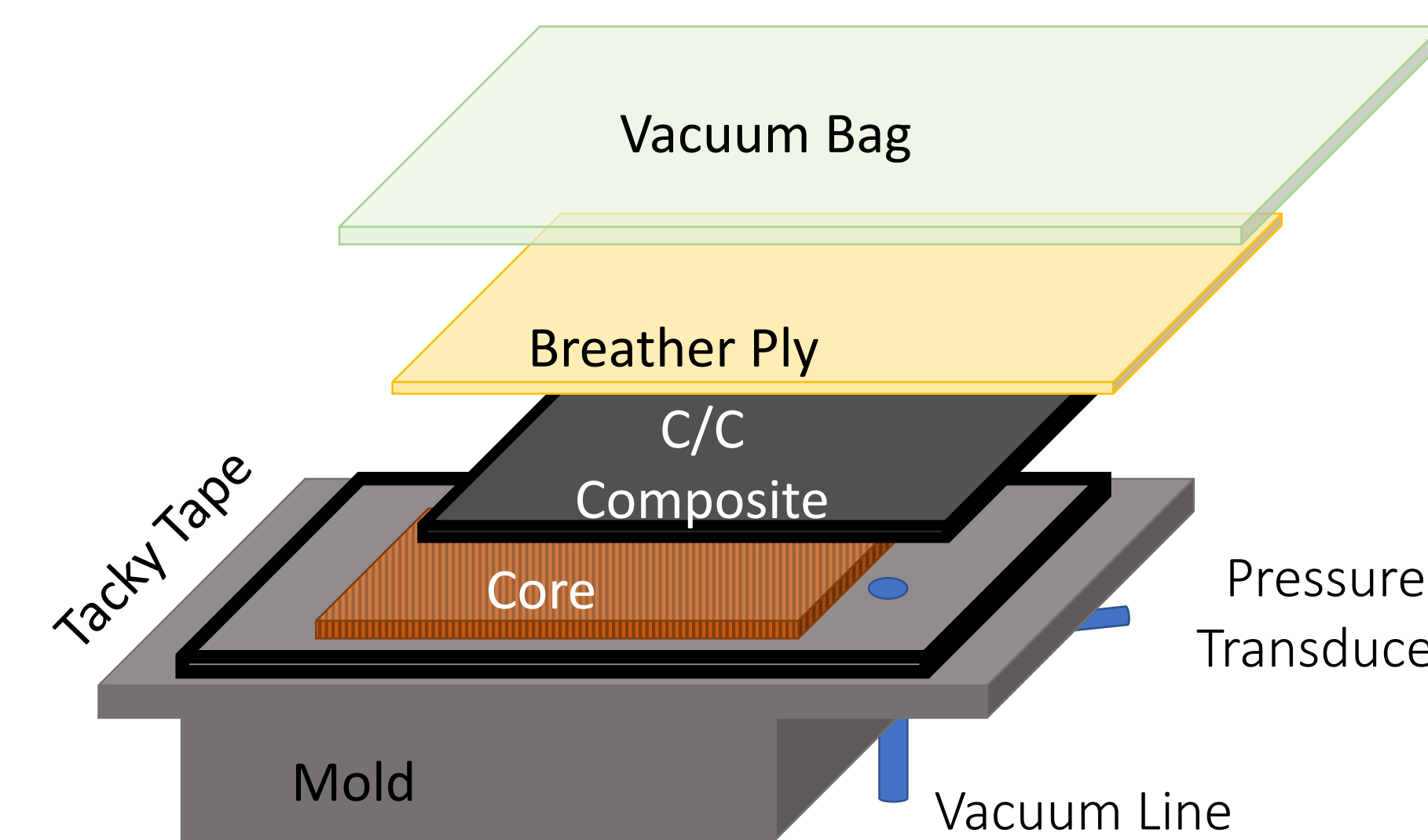
Microstructure Characterization

- X-ray CT to analyze the microstructure of C/C panels.
- Otsu segmentation to evaluate the porosity content after each pyrolysis step.

CT-scans of C/C panels

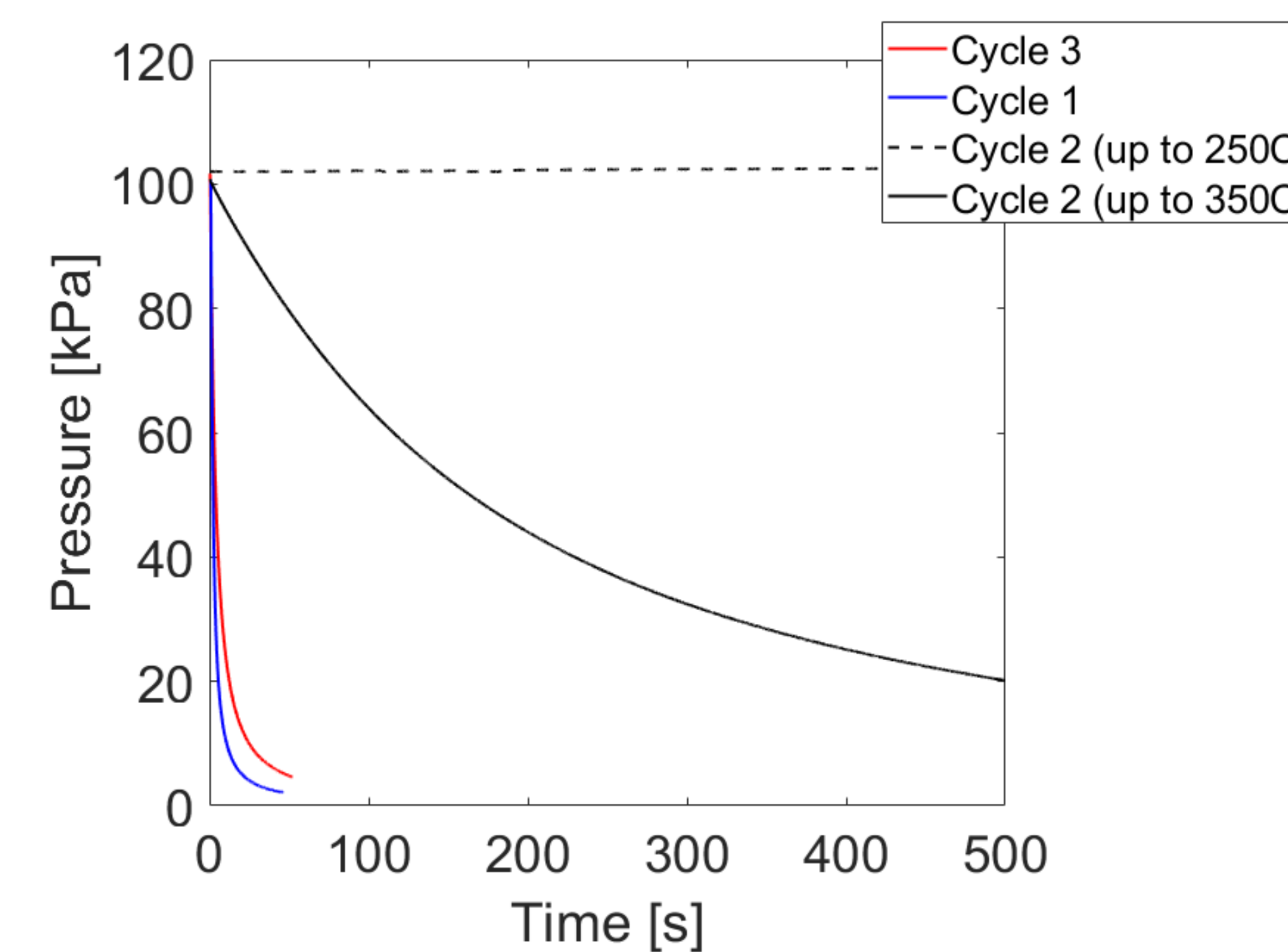


Permeability Characterization Pulse-Decay Experiment Set-Up



- C/C composite is sealed on top of the core → air flows through the thickness.
- Assembly is set under vacuum and air pressure decay in the core is recorded.

Gas Pressure Decay Curves



Numerical Model for the Permeability

- Optimizations to fit a numerical curve generated with 1D model through the thickness are used to evaluate permeability.

$$\frac{\partial P}{\partial t} = \frac{K_i}{\phi \mu} \frac{\partial}{\partial x} \left((P + b) \frac{\partial P}{\partial x} \right) \quad K_g = K_i \left(1 + \frac{b}{P} \right)$$

K_i : intrinsic liquid permeability K_g : gas permeability
 b : Klinkenberg parameter ϕ : porosity μ : viscosity

Correlation of Permeability and Porosity of C/C Composites

	Permeability [m ²] (Pore averaged)	Klinkenberg Parameter [Pa]	Porosity (From CT-scan)
Cycle 1	4.94e-14	2.3e+03	22.36 %
Cycle 2 (Up to 250C)	0	--	3.25 %
Cycle 2 (Up to 350C)	3.48e-16	9.7e+03	10.75 %
Cycle 3	1.81e-14	2.8e+03	19.39 %

- Correlation of the permeability to gas with the connected porosity helps understand how the pyrolysis schedule influences the evolution of the microstructure in C/C composites.
- The correlation helps design optimal pyrolysis schedules and optimal re-infiltration strategies for the fabrication of C/C composites.

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