

Initiation to PAM-RTM Law of Darcy Application: central injection of a square plate

Objective

There two goals of this exercise. It consists first of all in the learning of the software PAMRTM. For this reason, the explanations relating to the software will be detailed and embellished with numerous screenshots.

The second objective concerns the study of the law of Darcy and more specifically the comparison between analytical results given by the law and those obtained from simple simulations. To reach this objective, a simple configuration will be study in this exercise. It will consist of the central filling of a 2D preform. The simple geometry of the piece will make it possible to compare the numerical results with the analytical results deduced from Darcy's law.

Before you start

- Create a local folder on C:\. The software won't work if you try to work on Z:\.
- In your file name: no blank or accentuation
- Get the mesh (Plaque centrale.vdb) from Madoc and copy it in your directory

PAM-RTM Software

Launch Visual-RTM 15.0

Applications (in Lit You Mark Delation STM Co.	Anister Dels Joh Beles Bill	Dearch London-Mt	PQ
B. 2020 L. + A	MAR NUL ABRANCIALARDIA, C. BUG AR RESEARCE.		
He Control of the second of th			



Open the file: Plaque centrale.vdb



To perform the simulation, you need:

- ✓ To define material properties.
- ✓ To associate a material with a geometry.
- ✓ To define the location of your boundary conditions
- ✓ To define the values of the boundary conditions.
- ✓ To define the type of simulation you want to perform.

In this first exercise, the goal is to perform an isothermal injection.

Definition of the material properties

You have to create a new resin and a new reinforcement

0	POLYTECH [°] NANTES
---	---------------------------------

Material Database									?	×
File Database Unit										
All	~	Name	Resin_1							
Search]	Owner Name	vsobotka							
	~	Last Modified By	vsobotka							
	7 A E	Last Modified	2018-10-2	22						
		Description								
Public User Model	+ 💷									
⊡ '⊡ - All Ģ '⊒- Resin		General Thermal Che	emical	+/-	•					
Resin_1		Property		Туре	Value	Va	lue Unit		F(*) Unit	
Fiber		 Density 		Const.		kg.	/m^3	~		
E Reinforcement		 Newtonian Visc 	cosity	Const.	-	N-s	s/m^2	\sim		
Core										

Material Database File Database Unit						?	×
All	Name	Reinforcement1					
Search	Owner Name	vsobotka					
×	Last Modified By	vsobotka					
	Last Modified	2016-11-28					
Dublic Hear Madel	Description						
⊡/⊒+ All È/⊒+ Resin	General Thermal	+/-	•				
Fiber	Property		Туре	Value	Value Ur	nit	F(*) Unit
Reinforcement	 Density 		Const.		kg/m^3	~	
	 Permeability, 1 	st principal axis	Const.	×	m^2	~	
Core	 Permeability, 2 	nd principal axis	Const.	×	m^2	\sim	
Mold	 Permeability, 3 	rd principal axis	Const.	×	m^2	\sim	
	Permeability Angle		Const.	×	rad	\sim	
	Compressibility						
	Fiber Content		F(Shear Angle, Vf)) 📐			
	(

The properties of the material are given below:

Reinforcement

The reinforcement used is a glass fabric whose density is equal to **2560kg.m**⁻³. We consider an isotropic material whose permeability is equal to **K=10**⁻¹⁰**m**².

Resin

The density of the resin equal to **1200 kg.m⁻³**. The viscosity of the resin taken constant and equal to **0.12Pa.s**.



Apply reinforcement to geometry

Open Layer Design Manager



🔳 Layer De	sign Mana	ger											?	×
		LAYER LIS	T (Part/Ply Asso	ciation)							LAMINA	TE LIST		
Layer	Parts ID	Reinforcement	Ply	Thickness (m)	Fiber Content	Angle	Local	•	Part Selection	Laminate	Part ID	Thickness (m)	Offset	
	_								T Add					
									Insert					
									🖳 Сору					
									Symmetry					
									Antisymmetry					
									🗙 Delete					
									1 Move Up					
								*	👵 Move Down					
⊂ Material —														
Database U	ser 🗸	Category Reinfor	✓ Name {*	>Reinforcer 🗸	🕂 🥖 Th	ickness l	Jnit m		Scale Thickr	ness				
Part List —		Mode		 Display 										
2D Parts	🔘 3D	Parts 💿 Layer	O Part	List Hidden L	ayers 🔲 🖶		3D Vie	w			[Reset 🕒 Ap	ply C	lose

You have to select the part ID associated with the reinforcement you have created.

We will choose a thickness of 5mm for the part and the porosity of 40%.

Define of region for boundary conditions

In this part, you need to create 2 regions:

- \checkmark 1 for the injection zone
- ✓ 1 for the vent zone



Define Reg	ion		? ×
⊙+	0 🥖		
Type: Name:	Node Region_1	V Node	⊽ 🛃
	Res	et 🕒 App	oly Close

Select the nodes delimiting the region, then click Apply. Repeat the same operation to create a 2^{nd} region for the vent that is located all around the square.



Boundary conditions

In this 1st simulation, we consider an injection at constant pressure of 1.5bar in the center of the part. The vent is put under vacuum.

Process Condition		?	×	Process Condition	on			?
				C Definition				-
Type: Pressure V				Type:	Vent	~		
Process Name: Pressure_1				Process Name:	Vent_1			
Selection				Selection				
😡 Region 🖳				k∂ Region	Ek 🥖			
Trigger				Trigger				
Database: 🛛 🖌 📔				Database:		🕶 📂 🔛		
Property Type Value Value	Unit F	F(t) Unit		Property	Туре	Value	Value Unit	F(t) U
Pressure Const. 🗸 Pa	~			Vent Pressure	Const. 🗸	• 0	Pa 🗸	· · · ·
Temperature Const. 🗸 300 K	~			State	Const. 🗸	1		
State Const. V 1								
Flowrate Corr								
Tube Length Const. V 0 m	~							
Tube Radius Const. V 0 m	*							
▲				L		•		

Simulation parameters

Click on the following button to define the type of simulation as well as the injected resin.

Simulation Parameters Simulation Parameters Simulation Type Preheating Filling Curing Detect Air Traps Gravity Resin Selection Database : User V[F] Resin_1 V[F]	🚽 🍳 🖗 🏝 🚝 🛎) 🏄 🖳 🜍	1
Simulation Parameters ? Simulation Type Preheating Filling Curing Detect Air Traps Gravity Resin Selection Database : User V[F] Resin_1 V[F] Cutput Frequency Type : Ye fill Frequency : 2.5 V Advanced	Simula	ation Paramet	ers
Simulation Parameters ? Simulation Type Preheating Filling Curing Detect Air Traps Gravity Resin Selection Database : User V[F] Resin_1 V[F] Resin_			
Simulation Parameters ? Simulation Type Preheating Filling Curing Detect Air Traps Gravity Resin Selection Database : User View Injected Resin : (F) Resin_1 View Cutput Frequency Type : % Fill Frequency : 2.5 VAdvanced			
Simulation Type Preheating Curing Curing Detect Air Traps Gravity Resin Selection Database : User Vige: (F) Resin_1 Vige: (F) Resin_1 Vige: Vige: (F) Resin_1 Vige: (F) Resin_	Simulation Parameters	? ×	
 Preheating Filling Heated Filling Curing Detect Air Traps Gravity Resin Selection Database : User ♥ ♠ Injected Resin : (F) Resin_1 ♥ ● Output Frequency Type : 96 Fill ♥ Frequency : 2.5 ♥ Advanced	Simulation Type		
 Filling Heated Filling Curing Detect Air Traps Gravity Resin Selection Database : User V Image: Injected Resin : (F) Resin_1 V Image: Injected Resin : (F) Resin_1 V Image: Pierce Frequency Output Frequency Type : Pierce Pie	O Preheating		
 Heated Filling Curing Detect Air Traps Gravity Resin Selection Database : User ♥ ♠ Injected Resin : (F) Resin_1 ♥ Output Frequency Type : % Fill ♥ Frequency : 2.5 ♦ Advanced 	Filling		
○ Curing □ Detect Air Traps □ Gravity Resin Selection Database : Injected Resin : (F) Resin_1 Output Frequency Type : % Fill Frequency : 2.5 (*) Advanced	O Heated Filling		
Detect Air Traps Gravity Resin Selection Database : User V + Injected Resin : (F) Resin_1 V Output Frequency Type : % Fill V Frequency : 2.5 V Advanced	Curing		
Gravity Resin Selection Database : User ♥ ♥ Injected Resin : ⟨F⟩ Resin_1 ♥ ♥ Output Frequency Type : % Fill ♥ Frequency : 2.5 ♥ Advanced	Detect Air Traps		
Resin Selection Database : User Injected Resin : {F} Resin_1 Output Frequency Type : % Fill Frequency : 2.5 Advanced Reset	Gravity		
Resin Selection Database : Injected Resin : (F) Resin_1 Output Frequency Type : % Fill Frequency : 2.5			
Database : User Injected Resin : (F) Resin_1 Output Frequency Type : % Fill Frequency : 2.5 Advanced	Resin Selection		
Injected Resin : (F) Resin_1 Output Frequency Type : Frequency : 2.5 Advanced Reset	Database : User	✓ +	
Output Frequency Type : % Fill Frequency : 2.5	Injected Resin : {F} Resin		
Output Frequency Type : % Fill Frequency : 2.5 Xect			
Type : % Fill Frequency : 2.5 Advanced	< Output Frequency		
Frequency : 2.5	Type : % Fill	~	
Advanced	Frequency :	2.5	
Advanced			
Bonot Apply Class	Advanced		
Reset Apply Close	Reset 🕒 Apply	Close	



Launch simulation

Click on the following button to open the "start simulation" panel.



Ensure the path used for the solver is well indicated:

C:\Program Files\ESI Group\PAM-COMPOSITES\2019.5\RTMSolver\bin

📧 Start Simulati	on 🔺 ? 🗙
Definition Work Directory: Case Name:	C:\PAMVS Plaquecentrale
Solver Number of Proces	ssors: 1 Max (6) Step: 0 Max. Step (0)
Path: MPI_ROOT:	Group\PAM-COMPOSITES\2019.5\RTMSolver\bin
Compiler Path:	Data Checks
Monitor Log	Write Solver Input 📙 Run Close

Then click Run and Log.

The following windows opens. Explain the meaning of the different information.



Plaque centrale [16.1 KB] - WinTail
mpirun: IBM Platform MPI Community Edition: 09.01.02.01W RTM [11530] Windows 32
(C) Copyright Platform Computing Inc., an IBM Company 1997-2014. US Government Users Restricted Rights: - Use, duplication or disclosure restricted by GSA ADP Schedule Contract with IBM Corp.
Compatible IBM Platform MPI Remote Launch Service version V02.00.00
WARNING: No cached password or password provided. use '-pass' or '-cache' to provide password Intel(R) C++ 64 Compiler XE for applications running on Intel(R) 64, Version 12.1 us
PAM-RIM Version 2016.0, Parallel, Compiled on Jun 7 2016 at 03:43:50 Copyright ESI Group (France) 2004-2016
Executable adapted for MPI-Wrapper MPM!
Running on 16 processors
Calculation is running. It can be aborted by closing this window
<pre>step =2, time=1.102228e-04, DT=1.022280e-05, filled=0, percent= 0.00% step =3, time=1.205976-04, DT=5.936559e-06, filled=3, percent= 0.00% step =4, time=1.205976-04, DT=5.936559e-06, filled=3, percent= 0.01% step =5, time=1.323193e-04, DT=1.022280e-05, filled=3, percent= 0.31% step =6, time=1.595505e-04, DT=1.302459e-05, filled=34, percent= 0.31% step =7, time=1.595505e-04, DT=1.420624e-05, filled=34, percent= 0.34% step =6, time=1.595505e-04, DT=1.420624e-05, filled=34, percent= 0.34% step =6, time=1.97052e-04, DT=2.154844e-05, filled=34, percent= 0.50% step =10, time=2.268113e-04, DT=2.154844e-05, filled=35, percent= 0.67% step =12, time=2.268113e-04, DT=2.996010E-05, filled=65, percent= 0.63% step =13, time=3.377694e-04, DT=4.364972e-05, filled=65, percent= 0.84% step =14, time=3.663378e-04, DT=4.56813e-05, filled=36, percent= 1.24% step =15, time=4.398978e-04, DT=4.356913e-05, filled=16, percent= 1.24% step =17, time=5.651398e-04, DT=4.568128e-05, filled=164, percent= 1.76% step =11, time=4.47688e-04, DT=4.5254512e-05, filled=161, percent= 1.76% step =10, time=6.389188e-04, DT=4.530535e-05, filled=161, percent= 2.08% step =20, time=6.389188e-04, DT=4.530535e-05, filled=161, percent= 2.08% step =20, time=6.389188e-04, DT=4.530535e-05, filled=164, percent= 2.08% step =22, time=6.389188e-04, DT=4.530535e-05, filled=164, percent= 2.08% step =22, time=5.390189e-04, DT=4.53055e-05, filled=164, percent= 2.08% step =22, time=5.390189e-04, DT=4.53055e-05, filled=247, percent= 2.58% step =24, time=1.212000E-03, DT=1.50395E-04, filled=247, percent= 2.58%</pre>
<pre>step =25, time=1.553363e-03, DT=1.839593e-04, filled=262, percent= 3.39% step =26, time=1.742847e-03, DT=1.894844e-04, filled=281, percent= 3.64% step =27, time=1.945439e-03, DT=2.025922e-04, filled=300, percent= 3.88% step =27, time=2.16689a=03, DT=2.114439a=04, filled=34, percent= 4.10%</pre>
step =29, time=2.369759e-03, DT=2.128753e-04, filled=335, percent= 4.34%

Visualization of results

After the end of the simulation, you can check the results.

2 possibilities :

You can either click on "load results"





Or you can:

\rightarrow Open the Viewer

😼 Visual-RTM 12.0.0 - Plaque centrale.vdb





 \rightarrow Load you result file: its extension is .*erfh5*

C	POL	ES	H.			
I Open : E:\P	C_Bureau\Enseig	gnements2018-2019\PA	MRTM\Plaque	Carree	?	× -
Look in:	: PlaqueCarr	ee	-			
Bureau Bureau Ce PC Te Documents	Nom	← entrale.erfh5		Modifié le 17/10/2018 11:07	Type Fichier	ERFH5
Réseau	<					>
Documen	File <u>n</u> ame: Files of <u>typ</u> e:	SYSWORLD POST files	(*fdb;*.fdb.dy	v;*.fdb.erfh5;*.€	Ope Cano	n :el
	Open <u>A</u> s :	Auto		~		//

\rightarrow Then click on the *contour* button and visualize the different fields.

🙀 Visual-Viewer 12.0.0 - Pla	queCarree	
Applications File Edit	<u>V</u> iew <u>I</u>	
📔 🚰 🔡 🗘 👆 📭 Standard	•	
Contour Results	∄ -	
Contour		×
Tree: Entity Y Filter	Variab	oles 💌
B NODE		-
EILLING TIME	NORM	× 5
		24
PRESSURE		ŝ
VISCOSITY		5
		_
Thickness		zî
PERMEABILITY1	NORM	✓ ≦
PERMEABILITY2	NORM	✓ 5 ²
PERMEABILITY3	NORM	× 2 +
4		>
Contour On/Off		
None Banded Smeare Iso Surfaces And Lines Vectors/Tensors	d 🔘 Elemen	t
Options		
Display Advanced Animation		
Show: Spectrum		
Min/Max ID		
Value Of Selected Enti	ty	
Range: On Visible	✓ 🕞 Part	
Scale : Linear 🗸		
Min/Max: 💿 Current State 🔘 Ov	er All States	
Filter: Ranking		
Auto Display	Apply	Close



Post-processing files

In your work directory open with Excel (or any spreadsheet software) the two files:

*filename_*BC1.out and *filename_*BC1.out

These files gather information on the boundary conditions of your simulation.

Work to do

- 1. Perform injection at constant pressure and observe the filling fronts, the pressure field, the total filling time, for opened and closed vents for the isotropic reinforcement.
- 2. Use the information in the "Boundary Conditions" files
 - For the injection simulation on isotropic reinforcement at constant pressure and open vents, plot on Excel for the injection zone and for the vents:
 - The change in pressure, the change in flow, the change in net volume.
 - o Do the same with the vents closed.
 - o Conclusion.
 - Carry out the same simulation with a constant flow rate (1L/min) at the injection zone and plot the same graphs.
- 3. Position 3 sensors.



In the case of constant pressure injection, plot the evolution of the pressure as a function of time for the 3 sensors then:

- Determine the passage time of the front on each sensor.
- Compare this time with the theoretical value given by Darcy's law.
- Repeat the same comparison for a constant start injection.
- 4. Proceed in the same way for an anisotropic reinforcement