Study of couplings in RTM process

Goals of the problem

Non isothermal filling

Crosslinking kinetics

Study of coupled phenomena

Impact of slected models and parameters.

We consider the part shown in the figure below. This thick part possesses a metallic insert. This allows integrating functions in the final composite part. The injection is performed by the left edge whereas the vent is positioned at the right side. The heating is ensured par the top and left edges of the part. As we do not model the mold, we apply temperature directly on these 2 edges. Crosslinking will be taken into account through a kinetic model, as well as the dependency of the viscosity with temperature and conversion degree.

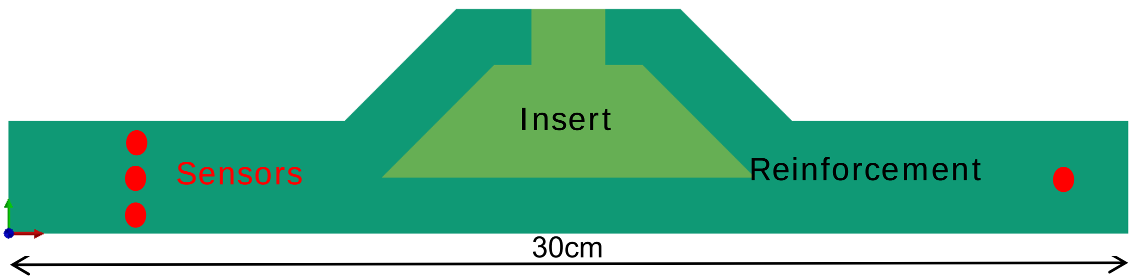

Figure : Drawing of the part

During the simulations, we consider a « heating filling with kinetics ». We take then into account the couplings between the flow of resin, the heat transfer and the crosslinking kinetics.

4 sensors are located inside the preform as show in the figure.

Several simulations must be performed :

→ The 1st ones take into account the filing phase.

→ The second ones, only the crosslinking.

The mesh to import with PAM-RTM is *curing_insert_1.unv*

Properties of materials

Propertiy of reinforcement

Density : ρ = 2560 kg.m^{-3}.

Specific heat : Cp=1000J.kg^{-1}.K^{-1}.

The material is considered as orthotropic :

Thermal conductivity : λ_1=1W.m^{-1}.K^{-1} et λ_2=0.5W.m^{-1}.K^{-1}

Permeabilities : $K_1=10^{-10}$ m² et $K_2=10^{-11}$ m²

We consider a fiber content of 60%.

Initial temperature for the preform is 50°C.

Properties of the resin

Density : ρ = 1100 kg.m^{-3}.

Specific heat : Cp=2300J.kg^{-1}.K^{-1}.

Thermal conductivity : λ=0.22W.m^{-1}.K^{-1}.

Viscosity : $\mu = \mu_0 exp\left(\frac{A}{T}\right) exp(K.\alpha)$ with $\mu_0 = 0.12 Pa.s$, A=300K and K=0.5.

Crosslinking kinetics : $\frac{\partial\alpha}{\partial t} = A_1 \exp\left(-\frac{E_1}{T}\right)\alpha^m(1-\alpha)^n$ with $A_1 = 9.17.10^6 s, E_1 = 7289K, m = 0.85\ and\ n = 1.15$, Crosslinking enthalpy ΔH=320J.g^{-1}.

Properties of the insert

The insert is made of aluminum

Density : $\rho = 2700 kg.m^{-3}$,

Specific heat : $Cp = 900 J.kg^{-1}.K^{-1}$,

Thermal conductivity : $\lambda = 110 W.m^{-1}.K^{-1}$

It is modeled as a core material in PamRTM.

Simulations

<u>1st part :</u>

In this part, we consider the non-isothermal filling of the preform by the resin. We assume the mold in contact with the part is isothermal at a temperature of 100°C. The resin is injected at a constant pressure of 1bar, at a temperature of 20°C.

Run the simulation that takes into account all the couplings.

Comment the results by analyzing the whole set of variables (temperature, cure…). Propose the appropriate modification to solve the issues.

2nd part :

In this part, we only consider the crosslinking of the resin coupled with heat transfer. There is no flow anymore. The preform is assumed to be fully saturated by the resin.

Compare and comment the results (temperature, conversion degree, conversion rate) for the following configurations :

Case n°	**Bottom temperature (°C)**	**Top temperature (°C)**	**Initial temperature (°C)**
1	50	50	20
2	50	20	20
3	20	20	20