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Extended physics modelling of the resin flow during vacuum infusion processes

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Production of composite infusion parts

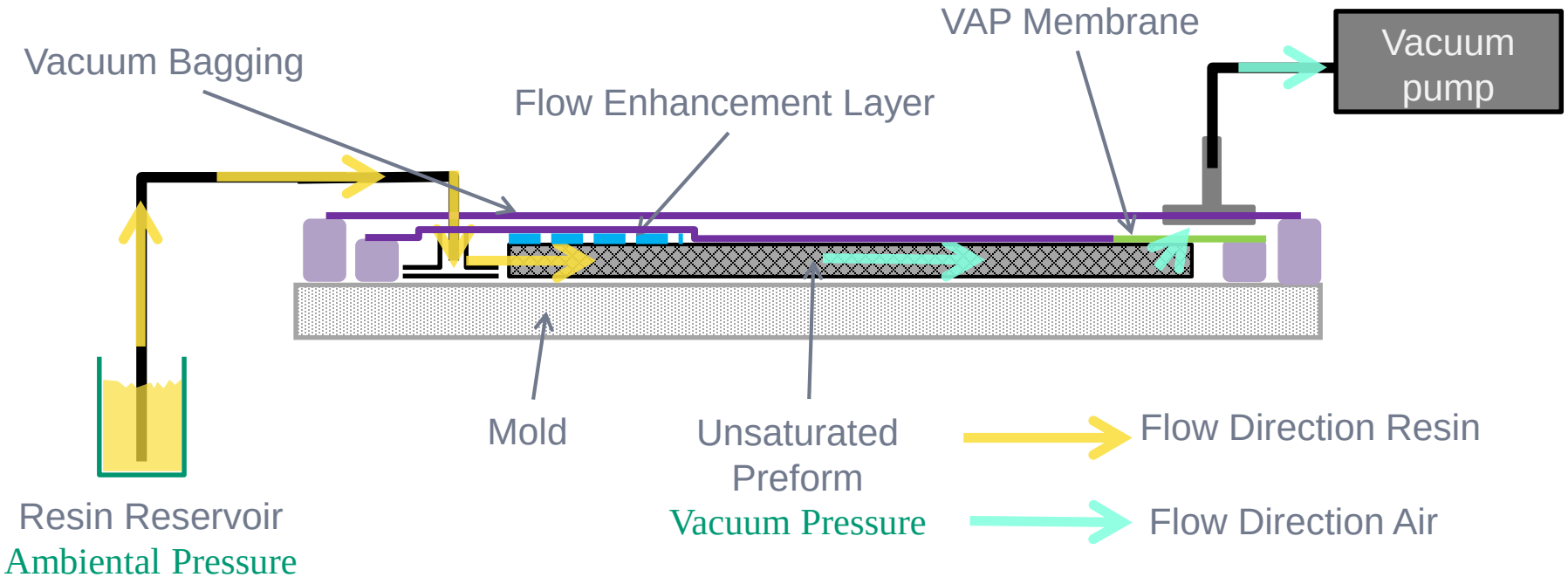
- Production of large structural lightweight composite parts
- Applications: naval, aviation and wind energy industry

Large scale infusion part A400M cargo door

Source: https://www.compositesworld.com/articles/inside-manufacturing-a400m-cargo-door-out-of-the-autoclave

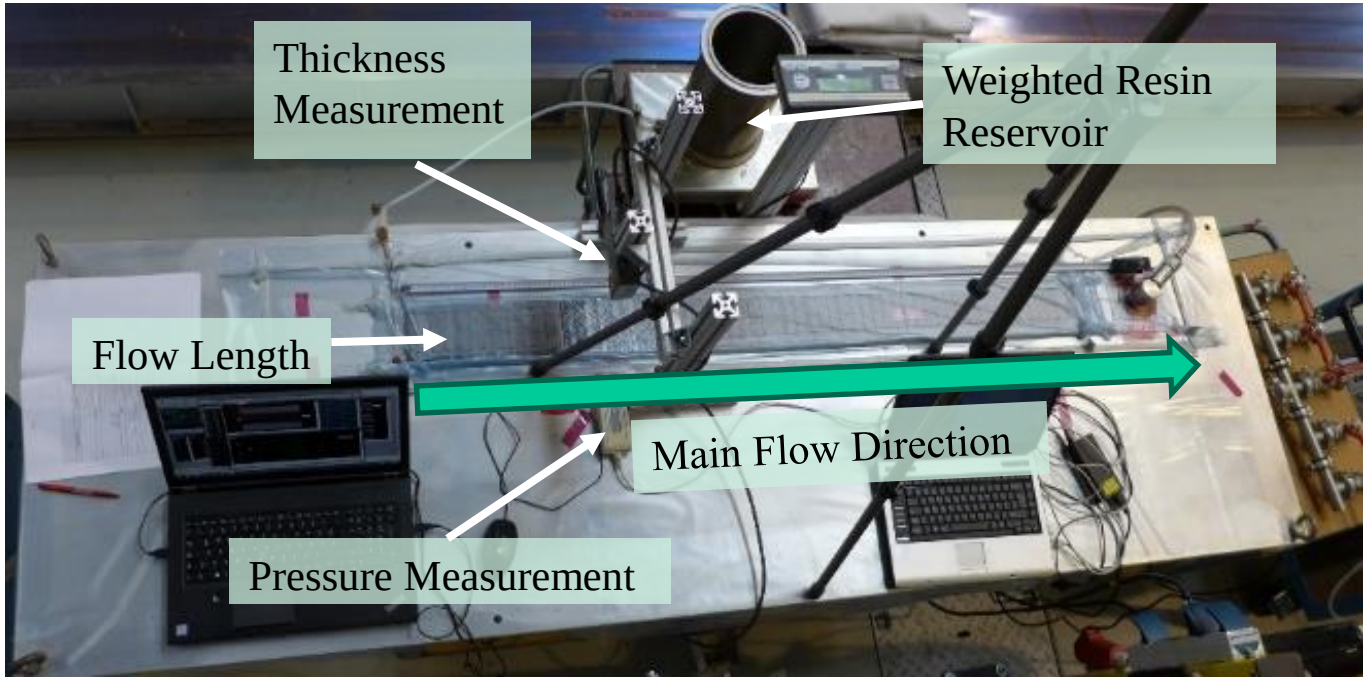
VAP – Vacuum Assisted Process

- Preforming of dry fibre material and saturation with liquid resin
- Resin infusion driven by difference between ambient pressure at resin reservoir and vacuum pressure in preform
- Suction from air at point of last filling



Experimental setup

- Three experiments performed for comparison with simulation
- Linear infusion of preform
- Detection of achievable flow length
- Measurement of pressure, volume flow, part thickness as well as flow front velocity and inclination



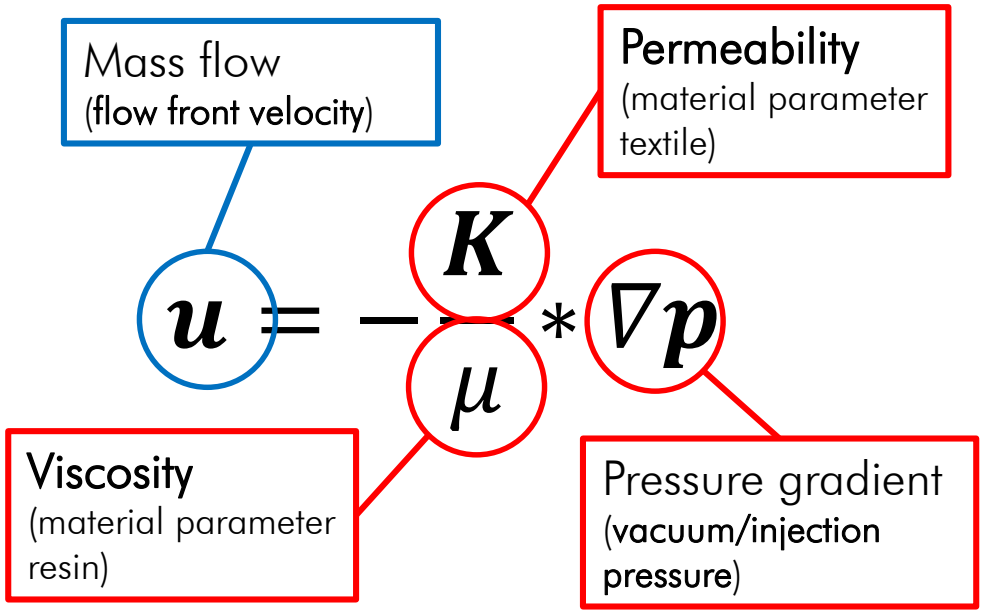
Modulation in COMSOL

- Calculation of process time
- Flow front management and avoidance of air enclosures
- Implementing of cure kinetics, capillary effects

- Calculation of pressure and velocity field using Darcy´s law node for porous media
- Flow front tracking with Level Set node
- Use of storage model, compressibility of fluid dependent on flow front

Calculation of resin flow with Darcy law

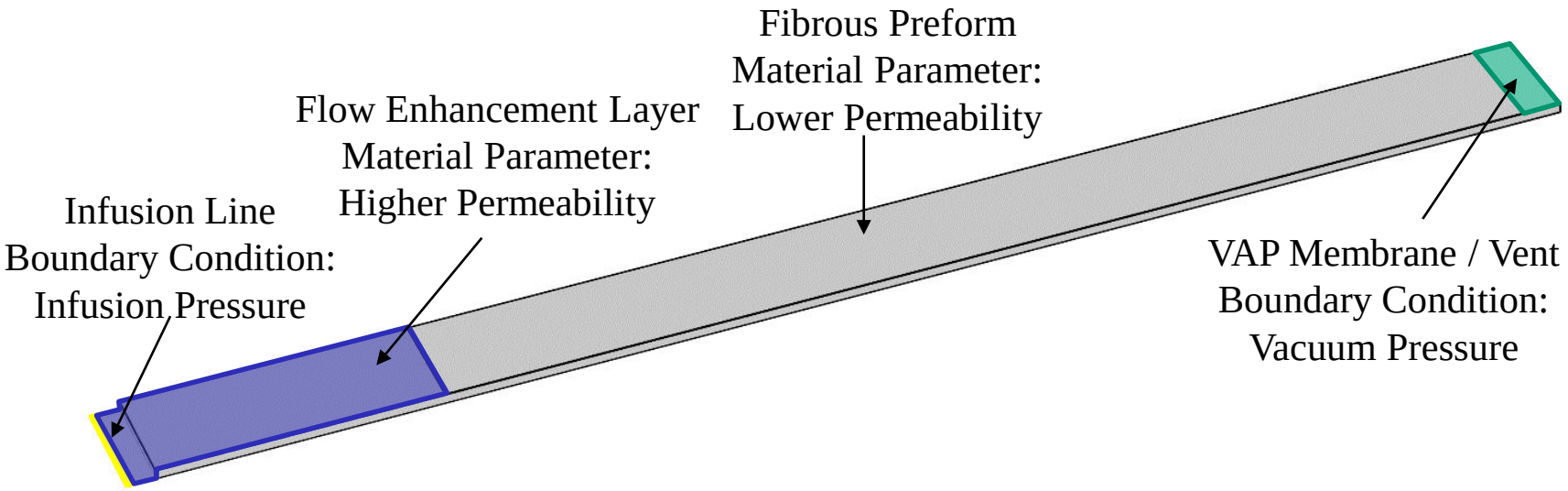
- Darcy`s law used for calculation of flow in porouse media
- Combination with mass conversation
- Flow front tracking with level set function



$$\nabla u = 0$$

Building of model

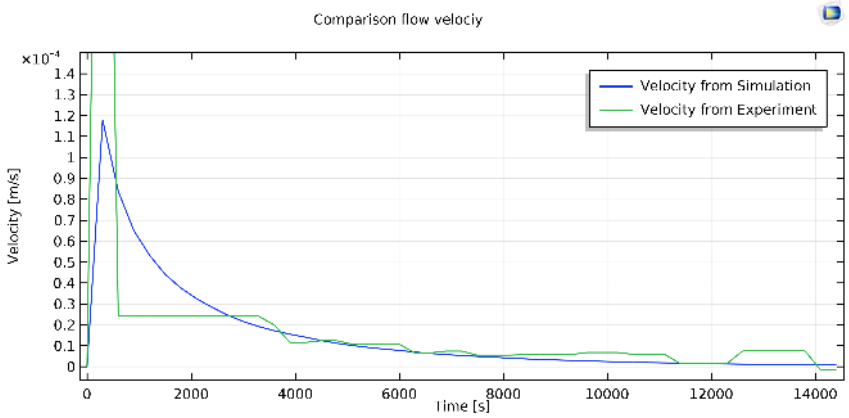
- Model is implemented as 3D geometry for addition of boundary effects later on
- For inlet and outlet surface boundary conditions are set
- Simplified VAP Membrane, semipermeable property not considered
- Different material parameters define distribution enhancement layer and fibrous preform



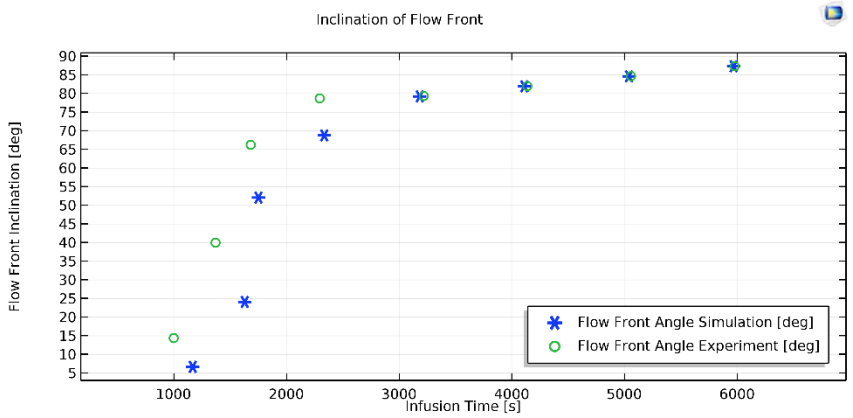
Movement of Flow Front

Flow Front

Pressure Field



Flow front movement



Inclination of flow front

Conclusion

- Influences of thickness variations could be implemented for a simulation near to the process
- Through coupling of thickness variation and filling process and by integration of a pressure field depending on saturation of preform the flow at a vacuum infusion could be calculated precisely
- Stability of levels set function not satisfactory for large changes of geometry and material properties. Adjustable stability criteria (cross wind diffusion/ streamlines) or higher formulation of level set method important
- Dependence of geometry and mesh does not allow the simulation of large and complex geometries

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Thank you for your attention!