LHP: Loop Heat Pipes

ADVANCED MODELLING & SIMULATION – AMS –

WWW.POYRY.COM/AMS; WWW.TRANSAT-CFD.COM; AMS@POYRY.COM

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Loop Heat Pipes

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Motivation and Background

— Background

- Interest in simulation of flow in LHP with a view to,
  - Analyze effect of geometry modification, filling quantity, etc.
  - Predict temperature, pressure, phase volume fraction, heat transport limits etc. to guide design

— Objectives

- Demonstrate capability of TransAT to simulate flow and heat/mass transfer in LHP
- Discuss current status and improvements if necessary

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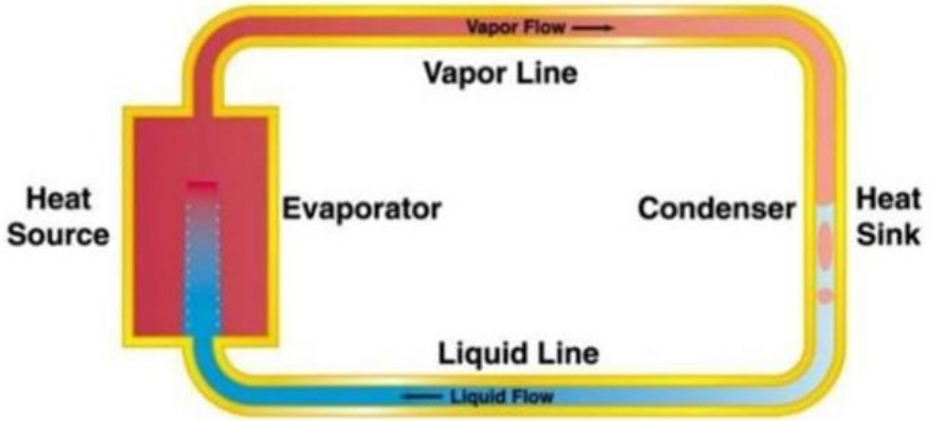
Experiment

—EXP LHP

- Ethane as medium
- Copper tube with filling 15.061 g
- Gas pipe: 800 mm
- Liquid pipe: 605 mm
- Condenser coil: 538 mm
- Pipeline: o.d. 6 mm, thickness 1.5 mm



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LHP simulation (water as a medium)

— Model

- Compressible 2-phase flow with phase change
- Evaporator not modelled → Left wall direct heat flux imposed
- Condenser coil not modelled → Right wall is set with subcooling
- Dispersed phase-change model with specified bubble/drop radius
- Peng-Robinson EoS for 2 phases
- Antoine Eq. for saturation curve

— Conditions

- 2D domain with mass filling of ~3 g
- Initialized as 10% liquid with initial pressure of 1 atm and temperature of 100°C
- Length: 610 mm
- Height: 410 mm
- Pipecross-section: 6mm x 2.4mm
- Left heat input: 1 W
- 10°C subcooling at Condenser wall

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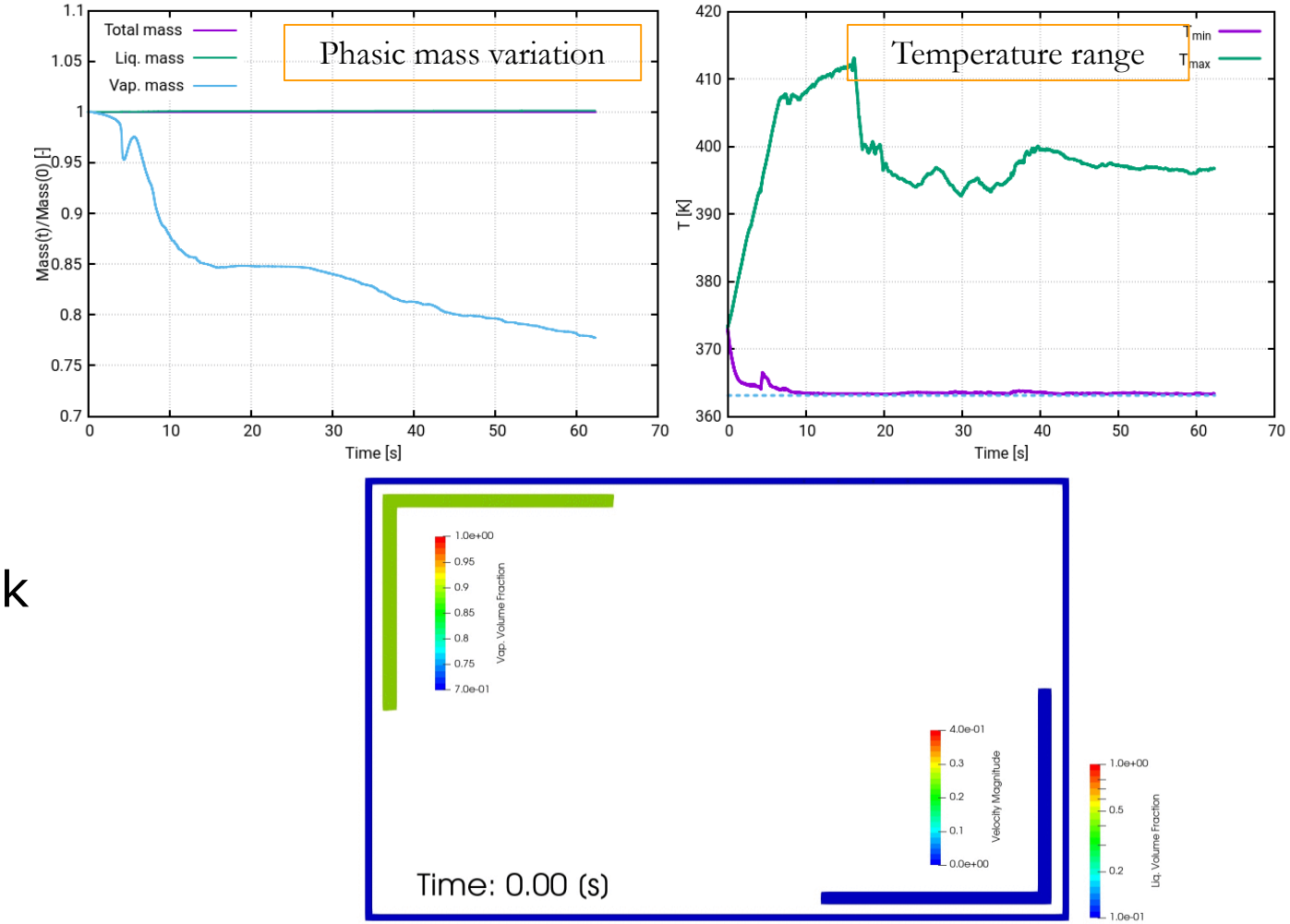
LHP simulation

- Temperature range has equilibrated
- Pressure and average quality are still evolving
- Clockwise flow has been established by introducing momentum sources to mimic the capillary suction of the wick in the evaporator section.
- Vapour condenses on the right pipe segment and flows towards the evaporator segment.



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LHP simulation (Ethane as a medium)

— Model

- Compressible 2-phase flow with phase change
- Evaporator not modelled → Left wall direct heat flux imposed
- Condenser coil not modelled → Right wall is set with subcooling
- Dispersed phase-change model with specified bubble/drop radius
- Peng-Robinson EoS for 2 phases
- Antoine Eq. for saturation curve.

— Conditions

- Square channel (2.8 mm) with mass filling of ~ 8 g
  - Initialized as 80% liquid with initial pressure of 0.43 bar and temperature of 170 K
- Length: 600 mm
- Height: 400 mm
- 10°C subcooling at Condenser wall
- Left heat input: 2 W
- Heat flux can be increased to 20 W in steps

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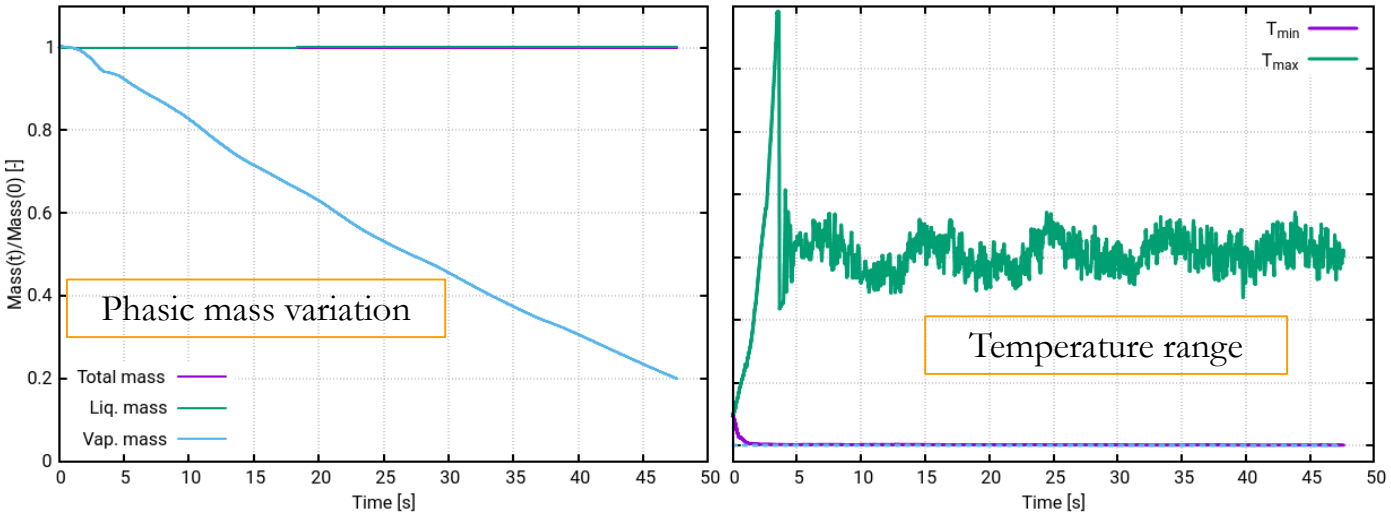
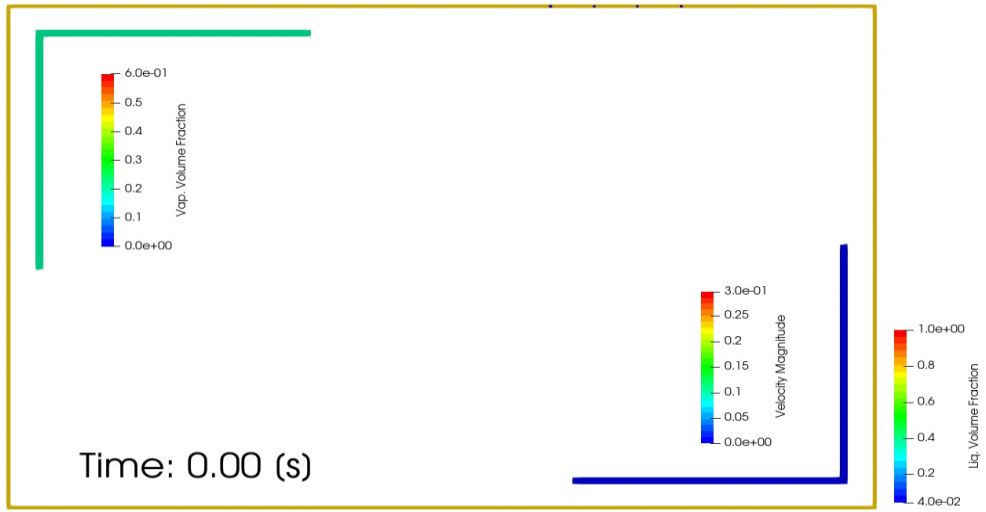
LHP simulation

- Temperature range has equilibrated
- Pressure and average quality are still evolving
- In the demonstration cases, evaporation and condensation is achieved using wall boundary conditions.
- Modeling of the Evaporator and condenser is required and can be achieved using UDFs.





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— www.poyry.com/ams; ams@poyry.com

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