One-Dimensional Transient Cold Filling Simulation of a Molten Salt Central Receiver Pipe

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Molten Salt as a Heat Transfer Fluid

- Efficiency with central receivers
- High freezing temperatures
- Preheating costs
- Cold filling
Cold Filling

Cold filling is the filling of a receiver panel which is initially at a temperature below the molten salt freezing temperature.
Previous Work

- Numerical model used to simulate cold filling a vertical pipe with a ternary salt
- Filling Modes
Previous Work

- Delameter & Bergan (1986)
  - Numerical model used to simulate cold filling a vertical pipe with Solar Salt
  - Found the critical inlet velocities and temperatures for various initial tube temperatures

- Pacheco et al. (1995)

- Pacheco & Dunkin (1996)

- Lu et al. (2010)

- Lu et al. (2013)

- Liao et al. (2014)

- Liao et al. (2015)

- Xu et al. (2016)
Modelling Framework and Methodology

- Numerical model used to simulate cold filling a vertical pipe with Solar Salt
- MATLAB
- One-Dimensional
Numerical and Mathematical Modelling

• Property functions
• Coupled pressure and velocity
• Track three temperatures
  1) Molten salt
  2) Frozen salt
  3) Receiver tube
Validation

1) Liao et al. (2015)
2) Xu et al. (2016)
Validation

Inputs:
• Tms_inlet = 575 K
• Lr = 3.5 m
• Ts_initial = 345 K
• t_max = 5 s
Validation

Simulation Results

Validation Data (Xu et al)
Preliminary Results

Inputs:
- $T_{ms \_inlet} = 546 \, K$
- $L_r = 3.5 \, m$
- $T_{s \_initial} = 295 \, K$
- $t_{\_max} = 5 \, s$
- $v_{\_inlet} = 2 \, m/s$
Preliminary Results

Axis Molten Salt Velocity vs Time (x=2m)
Preliminary Results

Molten Salt Temperature vs Distance

- $T_{\text{liquid}}$
- $T_{\text{solid}}$

Distance (m) 0 0.5 1 1.5 2 2.5 3 3.5

MS Temperature (K) 490 500 510 520 530 540 550

$t = 0.25s$
$t = 1.00s$
$t = 1.75s$
$t = 2.35s$
$t = 5.00s$
Preliminary Results

MS Temperature vs Time at different distances

- $x = 0\text{m}$
- $x = 1\text{m}$
- $x = 2\text{m}$
- $x = 3\text{m}$
- $x = 3.5\text{m}$

$T_{\text{liquid}}$

$T_{\text{solid}}$
Conclusion

• The cold filling solution
• Promising research
• Working model
• Future work
THANK YOU!

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