Technical University of Denmark

DETAILED MODELLING OF CHARGING BEHAVIOUR OF SMART SOLAR TANKS

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DETAILED MODELLING OF CHARGING BEHAVIOUR OF SMART SOLAR TANKS

DTU

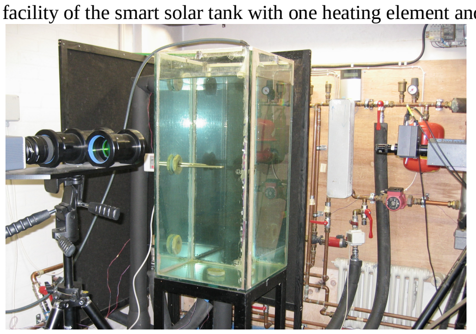
DTU Civil Engineering
Department of Civil Engineering

- **Aim**: to validate detailed models for calculation of temperature distribution and thermal stratification in smart solar tanks for solar combisystems during charging
- **Method**: Computational Fluid Dynamics (CFD) modelling, temperature and Particle Image Velocimetry (PIV) measurements.
- **Why smart solar tank**?

Smart solar tank charged with a variable auxiliary volume ⇨ Lower heat loss and higher system thermal performance

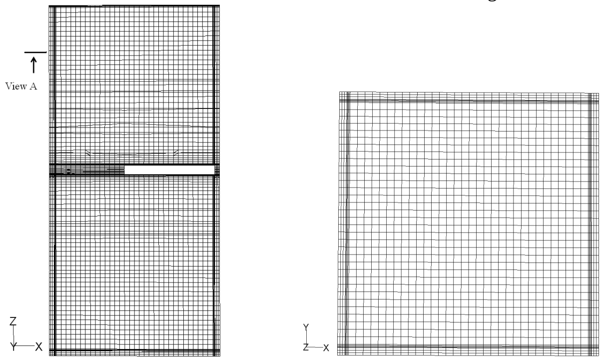
- The solar tank can be charged either by an electric heating element situated in the tank or by an electric heating element in a side-arm mounted on the side of the tank.

The PIV test facility of the smart solar tank with one heating element and a side-arm.



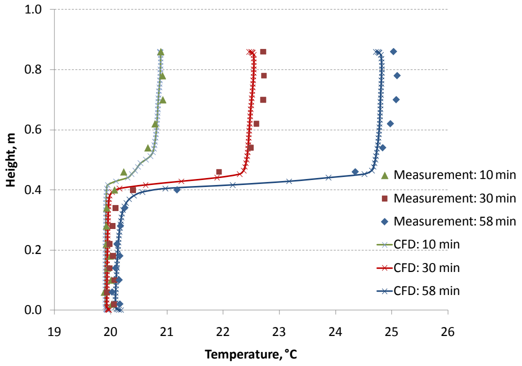
Tank with an internal electric heating element

The CFD model of the tank with an internal electric heating element



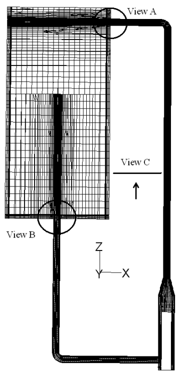
(a). Vertical middle plane of the model (b). Cross section of the model (View A)

Thermal stratification in the tank with an internal heating element

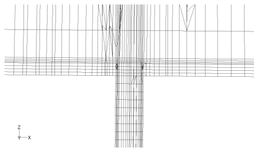


Tank with electric heating element built in a side-arm

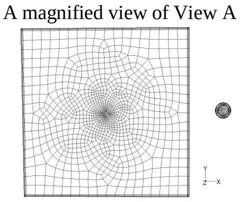
The CFD model of the tank with electric heating element built in a side-arm



(a) Middle plane of the model

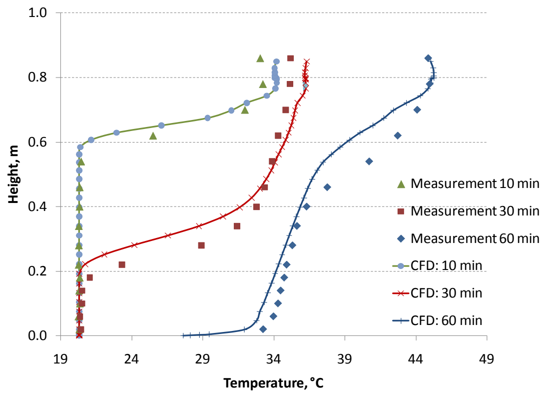


(b) A magnified view of View A & B

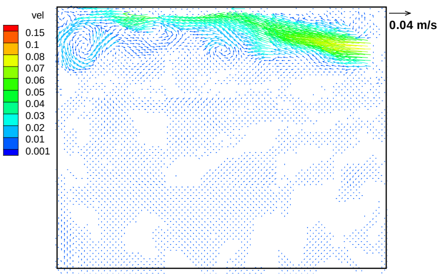


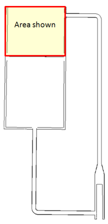
View C
(c) Cross section of the model

Thermal stratification in the tank with a side-arm

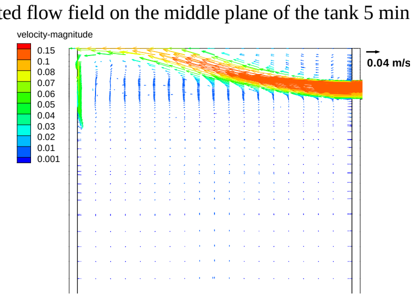


PIV measured flow field on the middle plane of the tank 5 min after the start





CFD predicted flow field on the middle plane of the tank 5 min after the start



Conclusions:

- A mesh interval size of 0.03 m and 0.006 m is sufficient for CFD modeling of charging behavior of the tank and the side-arm, respectively. The most appropriate time step size is 3 s.
- The CFD model predicts well thermal stratifications in the tank, but gives underestimated temperatures due to incorrect heat loss of the tank which should be further investigated.
- The CFD model predicts successfully the flow pattern in the tank, although the velocity magnitude of the flow is higher than the PIV measurements.

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