Next-Generation Heat Recovery

"Non-condensable gas in two-phase dynamic simulation"

Introduction

Renewable sources like wind and solar are quickly becoming more abundant in electric power production. 2015 has been a milestone in the global transitions to renewables, more renewable capacity has been installed than non-renewable capacity. These renewable sources are however inherently fluctuating, increasing the demand for flexibility in the remainder of the network. For NEM, this implies that our next-generation heat recovery steam generators (HRSG's) need to compensate by starting and stopping faster and faster.

HRSG's are an essential part of many power plants. A HRSG converts exhaust heat from a gas-turbine to steam, which is then used for electricity production. With a HRSG power plants can increase their overall efficiency from 40% to 60%. In order to design the next-generation fast starting HRSG's we are investing in dynamic modeling.

We are offering an opportunity to work with our R&D department on our newest multi-phase dynamical models.

R&D Department

The company NEM consists of 600 people of which 15 form the **R&D department**. To design next-gen HRSG's we are active in the fields: performance calculations, dynamic simulations, CFD flow studies, FEM stress analysis, lifetime assessment and techno-economic studies.

Current dynamical model

Effort in dynamic modelling has led to simulation code that allows 1 two-phase fluid (e.g. water). A 1D model is chosen because HRSG's consist of long, small diameter tubes. Tube flow can be described well by the axial component only. The physical model is described by: mass-balances, momentum-balances and energy-balances. These balances are 1^{st} order discretized in time and space. An implicit form of the numerical model is solved using Newton-Raphson iteration. Fluid state is described by pressure and specific energy and it is assumed that liquid- and gas-phase move at equal velocity, this is called a HEM[1].

[1] Homogeneous Equilibrium Model

The limitation of the current model is that we cannot simulate a number of critical use-cases of our product. When our product is started after a longer period of standstill, air may be present in the system along with water. Having air in the system during startup significantly changes the dynamics of the system; air exists instead of boiling or condensing water. Air cannot be modeled with the current system. Including air in the simulation will allow us to cover these critical use-cases and give us much better confidence in our designs.

Assignment

Goal:

- Investigate and implement the physics of a non-condensable gas (air) within our current model.
    - *Adding the physics of non-condensable gas (air) introduces inequality constraints that represent appearing and disappearing gas.*

Tasks:

- Study literature
    - On physical models with non-condensable gas.
    - On numerical handling of these models.
- Formulate selection criteria for model variants in cooperation with NEM.
- Implement most suited model variants.

Benifits:

- This assignment will allow you to tackle a challenging problem in multi-phase flow.
    - The modelling of multi-phase flow is by far not fully developed and the necessary physics and mathematics are of much wider use than steam generators.
- Your focus can be largely on mathematical models, programming effort will be limited as the model is only 1 dimensional.
- You will receive an appropriate financial compensation.

Contact

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