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SHORT ABSTRACT

Abstract title: Development and validation of a CFD model for evaporation and heat transfer in humid air flows inside Wet Cooling Towers

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Abstract text *(maximum 350 words.)*

Under the pressure of climate change and the need for low-carbon energy production, nuclear energy currently places itself as a pertinent candidate to fulfill this goal.
To ensure a proper cooling of the reactor, nuclear power plants often use Wet Cooling Towers (WCT) which role is to reduce the water temperature exiting the cooling system by spraying it in a cold air flow driven by natural convection. The air temperature and humidity rise inside the tower due to evaporation and heat transfer before being released in the atmosphere under the form of a humid air plume.
Two issues have to be carefully considered when operating the WCT. First is the risk of “recirculation”, i.e. a portion of the exiting hot air re-entering the inlet of the WCT due to atmospheric conditions. Second is the quantification of the amount of water lost through evaporation in air, thus having to be re-pumped from an external natural source.
To correctly represent those complex phenomena, one has first to achieve an accurate modeling of the physics at stake within the WCT. Moreover, since those are intrinsically multidimensional flows, Computational Fluid Dynamics (CFD) provides a suitable framework to tackle such questions.
Using the open source CFD solver code_saturne, we developed a dedicated modeling for WCT that accounts for evaporation and heat transfer between air and liquid water to predict the thermodynamic state of the humid air exiting the WCT. Liquid water quantities are transported as active scalars in the 3D domain and can to represent both the fill pack zone and the water rain zone.
Then, we perform a validation of this model using data from the MISTRAL experiment, located at Bugey french nuclear power plant. MISTRAL is a 18m height facility used to quantify the thermal performance of WCT design. Experiments on MISTRAL provide us with air and water temperature measurements along with air velocities and evaporation rates, which allows a detailed validation of the proposed modeling.

Obtained results are correctly matching the experiments and represent a first significant step towards further work to study the humid air plume dispersion under various climate conditions.

Motivation*

The goal of this presentation is to show the capability of open-source CFD approaches to properly represent the physics behind humid air flows including interactions with liquid water through evaporation and heat transfer. Those phenomena are ubiquitous in the environment and our further ambition is to merge this approach with atmosphere thermodynamics to obtain an harmonized modelling between the physics inside and outside the cooling towers to simultaneously simulate the formation and the dispersion of WCT humid air plume.et