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Numerical Analysis of Two-Phase Flow in DSG Solar Receivers Using an Euler-Euler Modelling Technique

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1. Introduction

This research focuses on examining Direct Steam Generation (DSG) receivers, highlighting their benefits such as enhanced plant efficiency, reduced heat exchanger numbers, and the elimination of a Heat Transfer Fluid (HTF). DSG technology, utilized in facilities like the commercial plant at eLLO in southern France, shows potential. Accurate prediction of steam quantity is vital for evaluating plant efficiency and receiver durability. This study employs Conjugate Heat Transfer Computational Fluid Dynamics (CFD) simulations to analyze internal flow and temperature distribution in both horizontal and slightly inclined DSG receivers.

2. Methodology

The analysis is centered around the eLLO plant in France, which employs Fresnel technology with a nominal capacity of 9 MWe. Utilized software includes NEPTUNE_CFD and SYRTHES, previously applied in two-phase analyses [1]. An Euler-Euler approach was utilized to model each phase separately [2], with phase coupling through interface transfer models considering momentum exchange and heat and mass transfer.

Simulations were conducted under nominal plant conditions, with water at 70 bar and mass flows ranging from 300 to 600 kg/(sm²). Both uniform and non-uniform heat fluxes were considered, with the latter obtained through ray tracing simulations [3]. Various tilt angles were simulated to evaluate their impact on flow regimes and temperature distribution. The eLLO plant's receivers, located on a hill, have inclinations ranging from -5° to +5°. Transient state simulations were performed due to oscillations between liquid and vapor phases.

3. Results

The results primarily focus on tube wall temperature, vapor fractions, velocities, and outlet vapor quality. Figure 1 illustrates steam quality relative to distance from the inlet for different tilt angles, indicating higher void fraction at the outlet for negative angles. This is attributed to

vapor movement towards the inlet, notwithstanding increased receiver temperatures inducing thermal fatigue. Subsequent discussions will explore receiver temperature distribution and vapor production to enhance power plant operations.

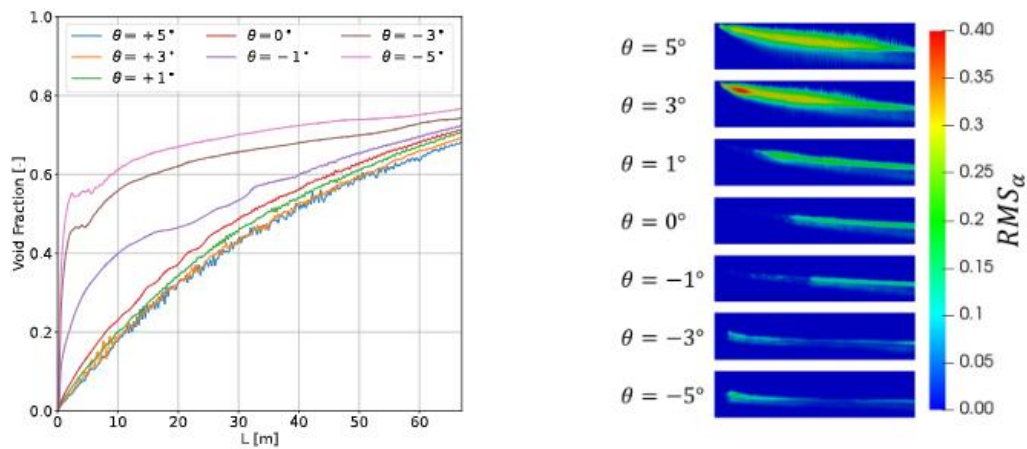


Fig.1: Average void fraction and RMS for different tilt angles

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