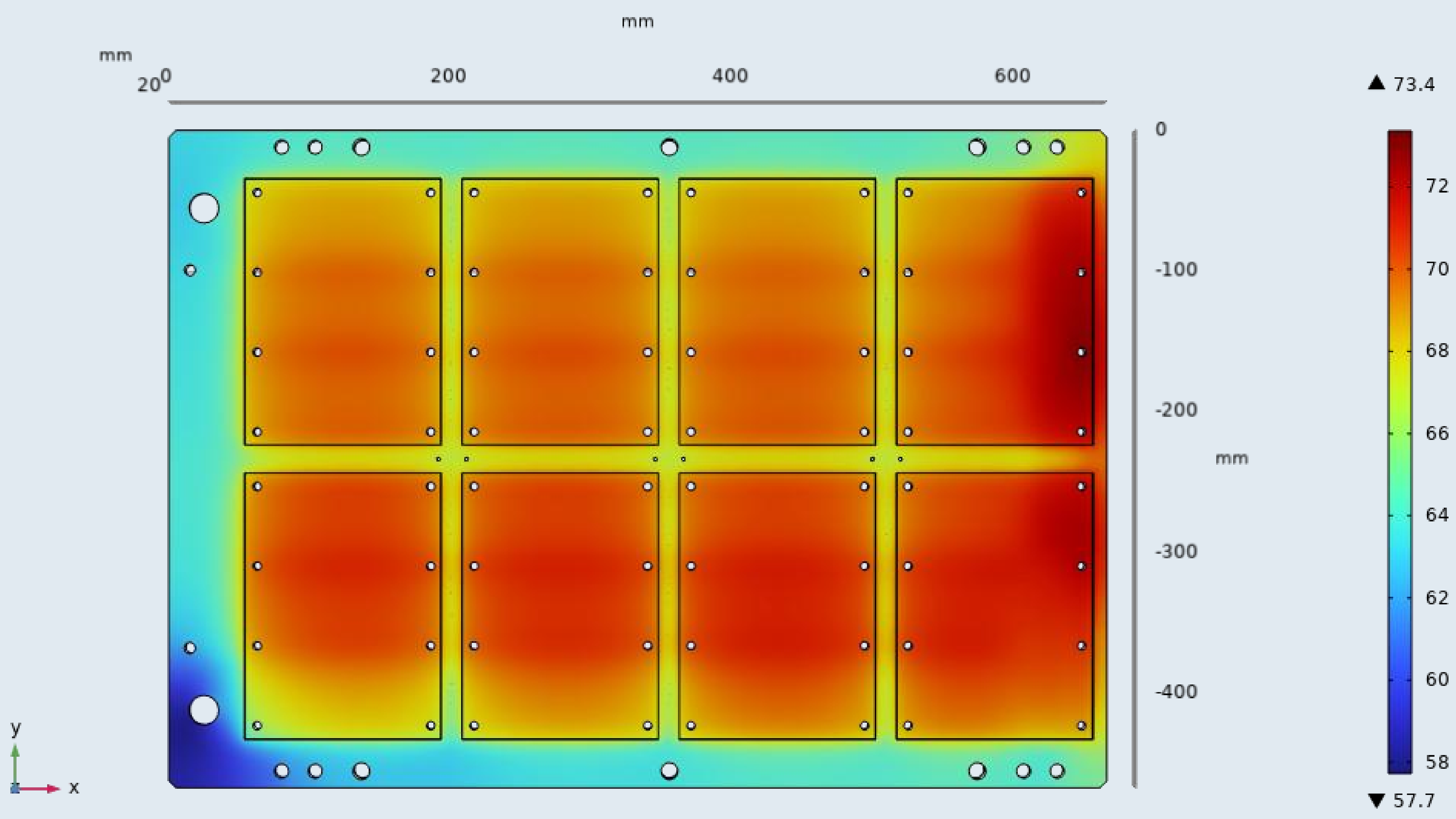

Modeling of Two-phase Cooled IGBT Module for Rail Transit Applications

Accelerate assessment of two-phase cooling solution with the combined use of COMSOL Multiphysics® and Engineering Equation Solver.

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Introduction & Goals

IGBT (Insulated-gate bipolar transistor) is one of the most crucial components that provide driving power for the high-speed trains. It requires a new approach to cope with stringent requirements of maximum temperature and thermal uniformity[1]. Pumped two-phase cooling for improving thermal management of IGBT in rail transportation has been investigated both experimentally and numerically. The experiments of two-phase cold plate is firstly conducted and then a practical, fast and accurate approach to predicting the performance of two-phase cold plate is demonstrated.

The goal of this research is to provide an efficient tool to help engineers accelerate assessment of two-phase cooling solution, facilitating non-expert engineers to easily characterize the thermal performance of IGBT module operating at various conditions.

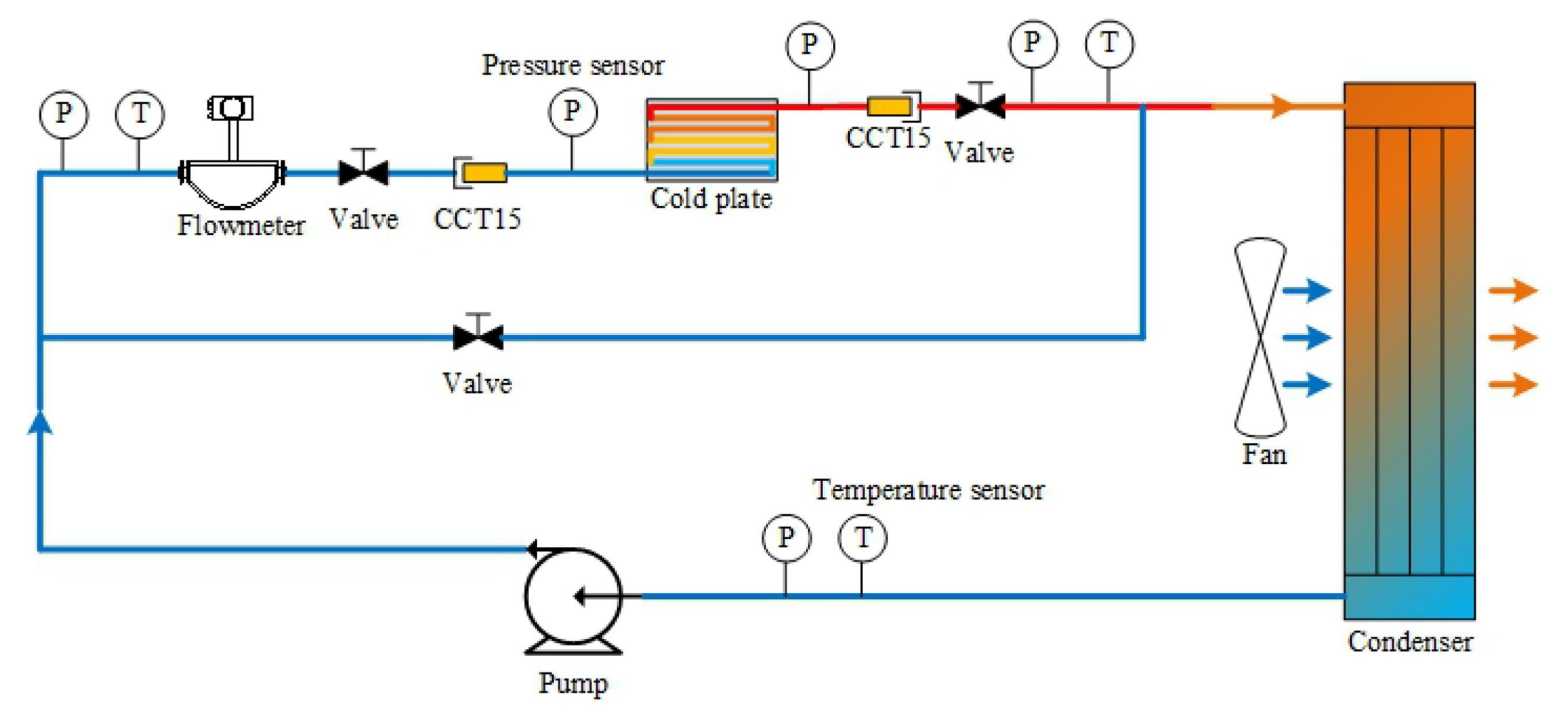

FIGURE 1. The test set-up of two-phase cooled cold plate

Methodology

The experimental study on pumped two-phase cold plate of IGBT used in HXD1C locomotives was conducted at a mass flow rate of 0.14 kg/s and a heat load of 2640 W to 13200 W, with R245fa as the working fluid. Based on the experimental conditions, local heat transfer coefficient and fluid temperature have been derived from EES (Engineering Equation Solver) analysis.

The Heat Transfer Module of COMSOL® is used to model the 3-D steady thermal conduction problem, while the EES software is invoked to define the convective heat flux boundary. By the combination of 3D and 1D simulation tools, i.e., COMSOL® and EES, the calculation efficiency of temperature field has been dramatically increased.

Results

The comparison between experimental data and COMSOL simulation has been depicted point by point. The maximum absolute temperature deviations for the heat load of 100% and 20% are 2.1 K and 1.2 K, respectively; meanwhile, the MAE (Mean Absolute Error) are respectively 0.84 K and 0.60 K.

It proves that the EES-COMSOL calculation procedure[2] is a practical, fast and accurate approach to predicting the performance of two-phase cold plate.

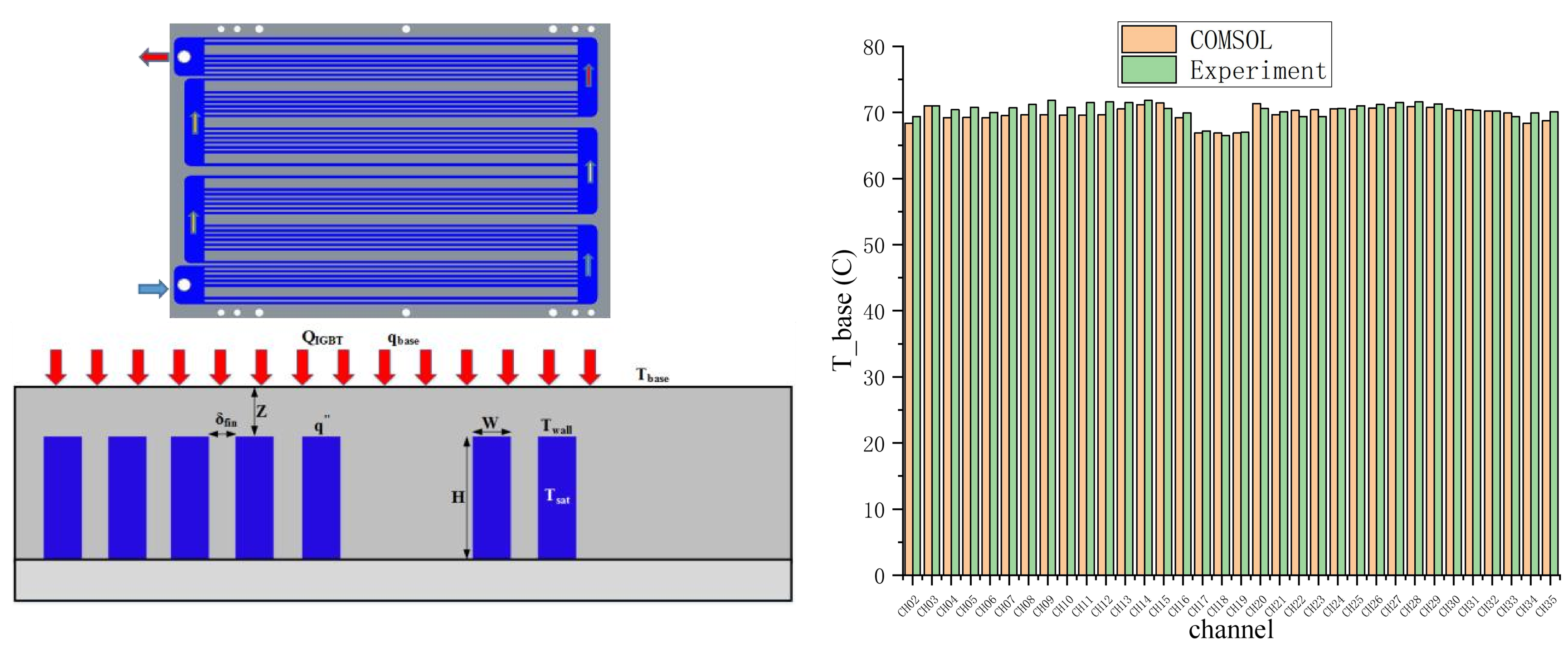

FIGURE 2. The cold plate channel layout and corresponding temperature distribution from experiments and simulations.

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