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Use of STAR-CCM+ for Heat Exchanger Product Development

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The presentation will demonstrate the use of STAR-CCM+ to help develop a new type Charge Air Cooler (CAC) for heavy duty off-highway applications. A fin-tube type cross flow CAC requires very small mesh size in CFD model to capture its fin geometric characteristics and resolve the thermal boundary layer. Hundreds of millions of cells may be generated in the CFD model for a Conjugated Heat Transfer (CHT) study of the whole CAC unit, which will then require huge computing resources and make the CFD study very inefficient. The single and dual stream heat exchanger models in STAR-CCM+ require the input of test data and therefore cannot be used for new product development.

The following procedure has been developed to predict the CAC thermal performance including heat rejection rate and pressure drop on charge air and cooling air sides:

1. Use of STAR-CCM+ to perform two separate CHT studies on the CAC inner and external fins to find the correlations of Nusselt number and Darcy friction factor with flow Reynolds number;
2. Use of an in-house program developed by C++ to build a virtual CAC product with the real dimensions and working conditions and predict the overall heat rejection rate, pressure drop on the cooling air side and the charge air pressure drop over the CAC core;
3. Based on the charge air pressure drop over the CAC core and the overall heat rejection rate obtained at Step 2, the whole CAC unit including tanks and core is modelled by the single stream heat exchanger model in STAR-CCM+ to predict charge air total pressure drop.

The developed methodology was validated against test results of two CAC units and has been successfully used to help design of CAC tanks to meet the customer specification on the charge air total pressure drop.

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