Flowmaster
Fluid thinking for systems engineers

Case Study

Automotive

Cummins

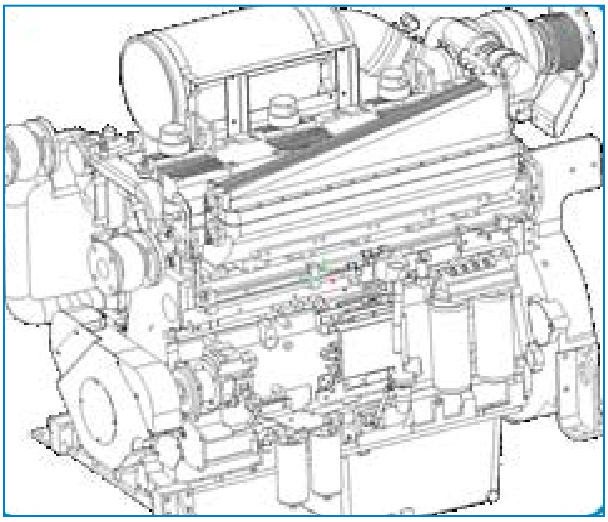
Designing industrial diesel engine cooling systems with Flowmaster

With an extensive engine product line, Cummins Engine Inc. supplies engines to manufacturers stretching across: on- and off- highway vehicles, light duty automotive OEMs, power generation, and marine industry. A global presence in the diesel power industry, Cummins not only designs and manufactures diesel engines, but is also involved with the distribution, and servicing of diesel related technologies. With engines being used across varied industries, Cummins must design their systems to meet many different conditions.

Starting with their engine business, Flowmaster was first introduced in 2002 as a replacement to Cummins' long standing internal code, Flow Circuit Simulation (FCS). FCS was a FORTRAN based code with no graphical user interface (GUI). With the assistance of support engineers at Flowmaster UK, the cooling system for the QSK60 engine was modeled as a benchmark system. The Flowmaster model of the QSK60 cooling system had a strong correlation with the test data provided and also a strong correlation with the internal code, FCS.

As a result of the accurate modeling of the QSK60 engine, a decision was made to standardize Flowmaster as the 1-D fluid system analysis tool. Since the success of the QSK60 engine modeling at Cummins in Daventry, England,

Flowmaster is being successfully used to model lubrication and cooling systems at the Cummins headquarters in Columbus, Indiana, and also at Cummins Research and Technology Institute in Pune, India.



QSK19 Engine

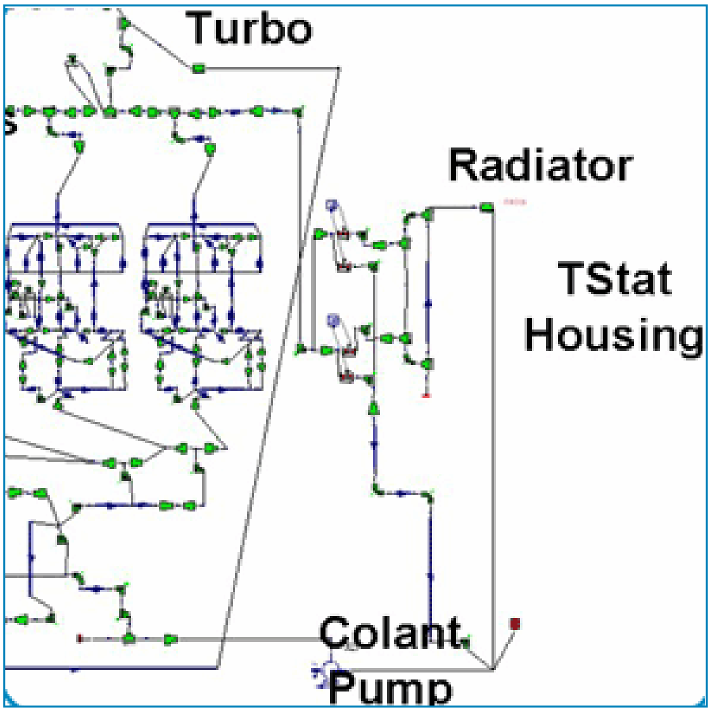
Initial Flowmaster modeling was used to determine flow rates and pressure drops. Recently, engineers at Cummins have begun to take advantage of the thermal capabilities of Flowmaster. One of the first to model a cooling system utilizing the heat transfer capabilities, Mike Auferdermauer, an engineer in the Marine division at Cummins, presented his work at the internal Flowmaster User group meeting at Cummins in early May.

Mike's challenge was to take an existing engine, model QSK19, and develop a new cooling system for a marine application. The major elements from the base engine that would be kept were: the water pump, oil cooler, engine block, and heads. The main areas that needed to be addressed were to assist in the design of a new thermostat housing, determine proper hose sizes and lengths, and also design a secondary cooling device.

Before designing the new cooling system, it was imperative to have a certain comfort level in the accuracy of the results generated by Flowmaster. This comfort level was attained by making use of a Flowmaster flow balanced model of the QSK19 gas engine, adding in thermal components, and validating against test cell results. (The QSK19 gas engine base model was flow balanced, or validated against test flow data and adjusted to match the test results.) The simulation results were within 5% of testing. Now having a high confidence level of Flowmaster as an accurate simulation tool, Mike proceeded to use Flowmaster to design the new cooling system.

Starting with the validated QSK19 cooling system thermal model, the new single loop cooling system would be designed. The existing thermostat housing, secondary cooling device, and hoses were replaced, and the data of the remaining components stayed intact. This includes the pressure drop data across the engine block and heads, oil cooler data, and also the pump curves. Thermal performance data came from a few sources. The heat exchanger suppliers assisted Mike with flow versus pressure drop curves and heat rejection data points. Also, past performance data coupled with CFD results from suppliers were utilized to estimate heat loads.

The newly designed thermostat housing was built in Flowmaster and for verification purposes compared with CFD results. With thermal components in place, simulations were performed. There were two objectives to simulating this cooling system. First was to balance the flows across the model by optimizing the size secondary cooling device and bypass loop of the thermostat. The other objective was heat balancing. The three heat conditions simulated were taken directly from the conditions conducted in a test cell. By using these three tests, all possible scenarios will be captured.



Part of Flowmaster network

Worst case scenario examines the worst possible set of conditions an engine can be put under. This is a standard used to test extreme conditions. Rated conditions come directly from customers specifications. Finally, varied flows examines how the system performs at low – high flow, this provides a matrix of system flow rates.

Currently, the Flowmaster model has been validated against CFD results. This was done for design verification purposes. The accuracy between the two simulation tools was 0.9%. In process, the hardware designed in Flowmaster is being tested on the engine for flow and heat balance. A good correlation is anticipated between the test cell and the Flowmaster simulation. Beyond this, the Flowmaster model of the redesigned QSK19 will be used to replace real time testing for transient and partial load analyses.

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