HART SCIENTIFIC
A Fluke Company

Application Note

Engine Cooling System Design Testing

Engine Manufacturing Industry

Engine manufacturers make different kinds of internal and external combustion engines, such as spark-ignition, diesel, gas turbine, and steam engines. These engines are used in a variety of applications such as transportation, factory automation, and electricity production.

Background

All heat engines operate in a cycle of repeated sequences. The cycle includes heating a working fluid or compressing a gas fuel mixture, performing mechanical work, and finally rejecting unused or waste heat. At the beginning of each cycle, energy is added by heating the fluid or igniting the compressed fuel. Mechanical work is performed by allowing the super-heated fluid or high pressure gas to expand, driving turbines or pistons. The remaining lower-pressure gases still contain unused energy in the form of heat. This heat is known as "rejected heat" and must be removed. At this point, the entire process starts over again.

Heat engines can't convert all input energy to useful mechanical energy in the same cycle. Some amount of energy is always lost in the form of heat. The purpose of the engine's cooling system is to remove excess heat and keep the engine operating at its most efficient temperature while allowing it to reach the correct operating temperature shortly after start up. Ideally, the cooling system will keep the engine running at its most efficient temperature regardless of operating conditions.

Temperature Measurement Critical to Engine Manufacturing

Part of the test work done at companies like General Motors, Cummins, and Caterpillar is determining the cooling capacity required for proper engine operation. For any given engine these companies must determine cooling capacity, horsepower rating, and specific application (highway, marine, construction etc.). This process requires a flow meter to measure the coolant flow rate, and it requires two PRTs or RTDs to measure coolant temperature at entrance and exit points in the engine. Flow mixers are used just upstream of the PRTs to prevent temperature measurement errors due to temperature stratification in the coolant.

To make a measurement, the test cell operator sets the desired speed and load and waits for the engine to stabilize. Data is taken at 10Hz over a sampling period of several minutes to get an average flow rate and deltaT. The specific heat is calculated from accepted curves and, along with the flow rate and deltaT, is plugged into the following equation to calculate the amount of waste power that must be removed from the engine:

$$\mathbf{HT = MF \times SH \times DT}$$

Where:

HT = Heat transfer (kw)   SH = Specified Heat: $\frac{kj}{kg - {}^{\circ}C}$

MF = Mass flow: $\frac{kg}{min}$ DT = Delta Temp: $\frac{{}^{\circ}C}{60}$

Temperature accuracy is critical for the correct design of an efficient cooling system.

Customer Profile

Hart has sold to both Caterpillar and Cummins for this application. Caterpillar designs and builds medium and high speed engines for trucks, ships, and construction and mining machines. Cummins designs and builds engines for busses, trucks, trains, and other kinds of vehicles and machines.

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Hart Equipment Supplied to Caterpillar and Cummins

- 1529-R Chub E-4 thermometer readouts
- 1560 *Black Stack* thermometer readouts with 2562 PRT scanner modules
- 5612 probes

Other Applicable Hart Products Not Supplied to Customers

- 9935-S Log*Ware* II software (for unattended data-logging)
- 1590 or 1575 Super-Thermometer readout with the 2590 or 2575 scanner module

Potential Customers

Any manufacturer or designer of heat engines.