Design and Development of Automotive Engine Cooling Systems

Available on-site at your location, call us for pricing information.

GOAL OF COURSE: Provide the basic fundamentals for a systematic approach in the design and development of automotive, highway truck, agricultural, military, construction equipment vehicle cooling systems that meet all customer expectations.

OBJECTIVE: The objective of the two day intensive seminar is to study the different components of the Automotive Cooling System and to demonstrate how they may be combined to produce an effective, high quality system at low cost. Emphasis is placed on safety, quality, timing and cost. The effect of the engine cooling system on engine design and durability is also discussed. The importance of communication and interaction with different engineering groups and disciplines, including manufacturing, are stressed to minimize warranty and to enable meeting all engine cooling functional objectives and costs within the packaging constraints under the hood.

AUDIENCE: Although the seminar is directed to engine cooling designers, technicians and engineers, its purpose is to also inform and familiarize engine cooling basic and advanced concepts to those disciplines that interface with engine cooling design and development. These would include program management, CFD, engine-transmission-drive line design, aero and thermodynamics, engine control systems, fuel economy, emissions, manufacturing, field testing and analysis and scientific laboratories.

PHILOSOPHY OF DESIGN. The customer's confidence in the overall vehicle performance as well as the cooling system is the basis of design. The cost of the engine cooling components and their functionality as a system to meet all engine cooling and relative vehicle objectives are also a part of the design basis.

DESIGN PROCEDURE: The seminar is divided into four sections, Hardware, Fundamentals, Design and Development.

The students are first introduced to the various components, their function and their location in the engine cooling system. Fundamental heat transfer equations and concepts are then presented. A model is specified based on the vehicle operating characteristics. The radiator, fan and oil cooler are sized and selected to meet required fluid stream temperature and flow objectives. The AC condenser and charge air cooler are added to the model and the radiator and fan are resized and selected to meet the added heat load of these components.

The coolant pump, de-aeration system, thermostat, pressure cap, plumbing, drive train, drag coefficients and rolling resistance, trailer frontal area, vehicle and trailer weights and grade are incorporated as part of the model and the affect of these components and variables on the engine cooling system are evaluated.

The front end system resistance and fan curves are used to determine air flow. The engine coolant system resistance curves and pump throttling curves are used to determinve coolant flow.

The advantages and disadvantages of different radiator types and air moving devices are evaluated and a selection is made based on optimum performance and minimum cost within given packaging constraints. The selected radiator is characterized for effectiveness and for overall, outside and inside heat transfer coefficients.

Supplier fan curves and heat transfer device performance curves are corrected to represent their actual performance in the vehicle.

DEVELOPMENT PROCEDURE: The students are introduced to different development tests required to finalize the engine cooling design. The importance of first doing an analytical analysis of the expected results and then confirming the results in an environmental chamber, wind tunnel or in the field is emphasized. The comparison of actual performance to ideal performance is studied.

The test and development procedures discussed include:

a. air flow non-uniformity correction.

b. determination of the front end mass air flow.

c. characterize the coolant pump in the vehicle.

d. determine de-aeration ability.

e. determine front end system resistance to air flow.

f. determine coolant flow system resistance.

g. determine vehicle wheel HP and tractive effort curves.

h. the use of a towing dynamometer.

i. determine engine heat rejection to the coolant at peak power.

j. use of the climatic chamber and wind tunnel.

k. field tests.

ASSOCIATED AREAS: OEM and Supplier relations and responsibilities on how to most effectively accomplish the goals of designing and developing an engine cooling system within cost and timing constraints is presented. Warranty and cost reduction issues are discussed.

INSTRUCTOR'S EVALUATION: An evaluation of the seminar is provided as part of a Summary Report submitted to the seminar requester.

INSTRUCTOR: Alexander Kargilis, P.E. has over 40 years experience in the design and development of automotive, truck, military and off highway vehicle HVAC and Engine Cooling components and systems.

He has written HVAC and engine cooling design and development texts, test procedures and standards used throughout the USA and world.

He works with automotive OEM and suppliers in the optimum sizing and application of all the units that comprise these systems both as individual components and as viable operating systems in an automotive city, highway, off-highway and military vehicle environment.

He is an engine cooling and HVAC consultant throughout the USA, Canada and Europe. His course alumni include all the major automotive and off highway vehicle manufacturers and suppliers, i.e., General Motors, Ford, Daimler-Chrysler, John Deere, Toyota, Volvo, J I Case, Visteon, Delphi, Denso, Sanden, Calsonic, Siemens, Behr, Modine, Caterpillar, TRW, Tesma, Halas, Goodyear, Peterbilt, Honda, Fiat,Cummins, Dana, Nissan, Bosch, US Army Command, Kenworth, Long, Freightliner, Harley-Davidson and many others.

He received his engineering degree from Wayne State University, has several patents on heat transfer devices used in the automotive industry, is on the adjunct faculty of the Lawrence Technological University in Southfield, Michigan and is a registered professional engineer.

His expertise in the design, development and manufacture of automotive engine cooling and HVAC components and systems has been proven and fine-tuned over many years in the laboratory, manufacturing plant, on the test track and millions of miles in the field.

Engine Cooling Syllabus, Day one, AM

Initial Technical Survey; Introduction; History; Hardware; Design procedure outline; Design fundamentals; Basic thermodynamic equations; Engine heat rejection; Tandem vs series orientation; Begin cooling design road map; Coolant pump and coolant system resistance curves; Spark strategy; Engine power and torque; Transmission heat rejection; Air and coolant temperatures; Vehicle driving condition; Radiator frontal area; Air-to-boil concept; Radiator selection; Tube length correction; Effectiveness; LMTD; NTU; Overall heat transfer coefficient; Coolant flow and radiator degradation; Coolant pump flow and head.

Engine Cooling Syllabus, Day one, PM

Continue road map; Cooling fan; Viscous drive; Slip curves; Fan curves; Front end system resistance curves; Heat load contribution with added AC condenser; Charge air cooler; Vehicle operating characteristics; WOT wheel horsepower; Rolling resistance; Aerodynamic force coefficient; Tractive effort; Vehicle operating points- vehicle alone and with trailer, level highway and grade; Off highway; Problem Set 1.

Engine Cooling Syllabus, Day two, AM

Radiator performance; Frontal area; aspect ratio; Seals; Down flow; Crossflow; Tandem; Heat transfer surfaces; Radiator design variables; radiator comparative performance at equivalent air side pressure drop; Number of tube side passes; Type of construction; Materials; Fan and shroud; Radial-axial-mixed flow fans; Fan drives- electric motor, engine and hydraulic driven; Fan installation- blower & draw through; Hybrid, Fan design parameters; Fan noise; Fan diameter; Number of blades; Fan out of shroud dimension (FOOS); Fan tip to shroud clearance; Fan pulley ratio; Viscous drive cut-in temperature; Types of fan shrouds; Selection procedure; Coolant pump cavitation; Suction pressure; Air in coolant; Deaeration; Erosion corrosion; Coolant boiling points; Deaeration schematics; Oil coolers and oil cooler schematics; Converter RPM and slip; Coolants; Plumbing, Control devices; Thermostat, Pressure caps-vented, constant pressure, open; Hot pressurized bottle; Hoses; Hose routing; Hose clamps; Deaeration and coolant recovery; Bleeds; Inlet and outlet thermostats; Front end and underhood air exhaust; Bernoulli's equation; Pressure coefficient; Front end air flow characterization; Viscous drives; Hysterisis; Fluid viscosity; selection of cut-in temperature; Electric motors fan drives; Hydraulic fan drives; Fan and fan drive applications; Durability; Field vibration signature.

Engine Cooling Syllabus, Day two, PM

Warranty; OEM and Supplier roles and responsibilities; Functional objectives; development; Laboratory and field evaluation of vehicle cooling systems; Lab equipment; Cooling system characterization; Service fill; Coolant flow recovery; Coolant level sensitivity; In-vehicle pump curve; Vehicle front end system resistance and front end air flow; Static pressure profile; Mass air flow across the front end; Heat balance and air flow; Non-uniformity correction; WOT wheel horsepower; Vehicle tractive effort curves; Cooling system confirmation; Towing dynamometer; Field trips; radiator seals; Fuel cell primer; Problem set 2.