Intelligent cooling for passenger cars

Oil, air, fuel and coolant systems are all coming under extreme scrutiny from vehicle system designers and developers to make vehicles more efficient and to meet the increasing demands of emissions limits.

The solution is to control these systems by using more electronics, which are more dynamic and intelligent than unregulated mechanical devices.

A cooling system must be capable of keeping the engine temperature within safe limits under the most arduous of conditions, such as ascending a long steep gradient at full throttle and operating in high ambient temperatures. However, most of the time this only represents a very small proportion of a vehicle's operating environment. An engine's cooling system will overcool during these time unless there is a method of reducing its effectiveness: this device is commonly known as a thermostat. It opens and closes at set temperatures, and regulates the flow of coolant to the radiator.

Evolution of the cooling system

With the implementation of smaller, more efficient and powerful engines, the vehicle manufacturers' aim is to enhance and make better use of existing technology. In search of efficiency, they have reduced friction, lowered reciprocating masses and used the management of heat production and heat loss in design plans when producing a downsized engine.

Refining a vehicle's cooling system has added additional temperature sensors to monitor different parts of the system for more accurate cooling regulation. Vehicle manufacturers are also using electric or electromechanical water pumps that can be controlled subject to temperature and engine load demands.

Since the downsizing of the internal combustion engine, it has become more commonplace to use turbo chargers and intercoolers. Cooled exhaust gas regulation is also used to boost power and reduce emissions.

An evolution of the cooling system has seen the use of an additional electric water pump, which uses a brushless motor with the impeller to form part of the rotor that drives the coolant. (Fig. 1)

They are used to protect the turbocharger from excessive heat under high load conditions, after stopping the engine. This prevents the oil accumulated on the turbo impeller shaft from carbonizing, and can prevent vapour locks forming in the turbo coolant circuit.

The use of the pump in this case is controlled by a relay and the pump is switched on and off subject to demand. The pump is activated by the engine control unit after switching the ignition off for a set time. During this period of activation, the pump drives the coolant from the radiator to the turbocharger. (Fig 2)

As the use of this additional pump developed for turbo cooling, the use of air-to-liquid intercoolers was seen. An air-to-liquid intercooler in the intake manifold is used to cool the charged air. This allows the size of the charge air system from the turbocharger to the inlet valves to be reduced.

To cool the charged air, the coolant circulation pump is operated according to load. The system has an additional radiator and pumps coolant to the intercooler and to the turbocharger. The temperature difference between the air after the intercooler and the outside temperature is around 20 °C to 25 °C with high load requirements giving the combustion chamber a more dense volume of air.

Pulse width modulation

Further development of this system would give greater control of the additional coolant pump, with the use of pulse width modulation (PWM) to control the pump.

The electronically regulated coolant pumps are equipped with their own control electronics, which use the PWM signal from the engine control unit to calculate the rotational speed for the pump and actuate the electric motor. At the same time, the power consumed by the electric motor is monitored by the control electronics.

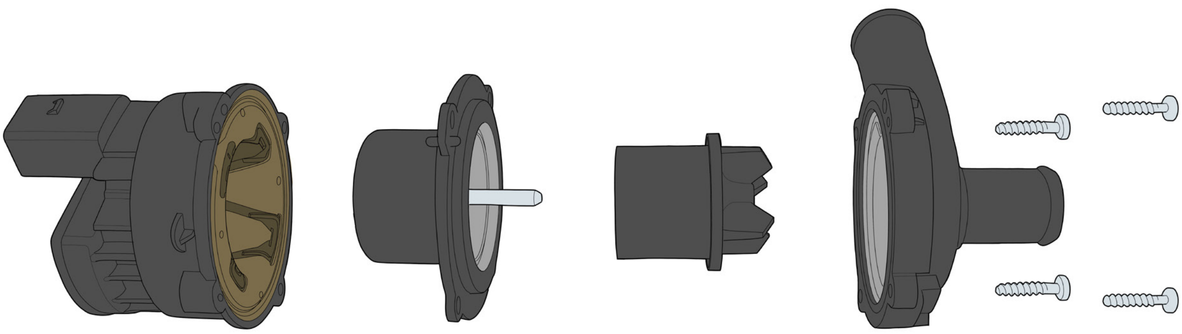

Fig. 1

As an example, the pump is operated subject to load and can be activated under the following conditions:

- Every time the engine is started for a short period of time.
- Constant above charge air temperature of 50 °C in the intake manifold.
- A temperature difference of less than 12 °C in the charge air before and after the intercooler.
- When the engine is running, every 2 minutes, for 10 seconds to avoid heat accumulation, especially in the turbo, depending on the individual engine map.
- 0-8 minutes after the engine has been turned off to avoid overheating with formation of steam bubbles in the turbo.

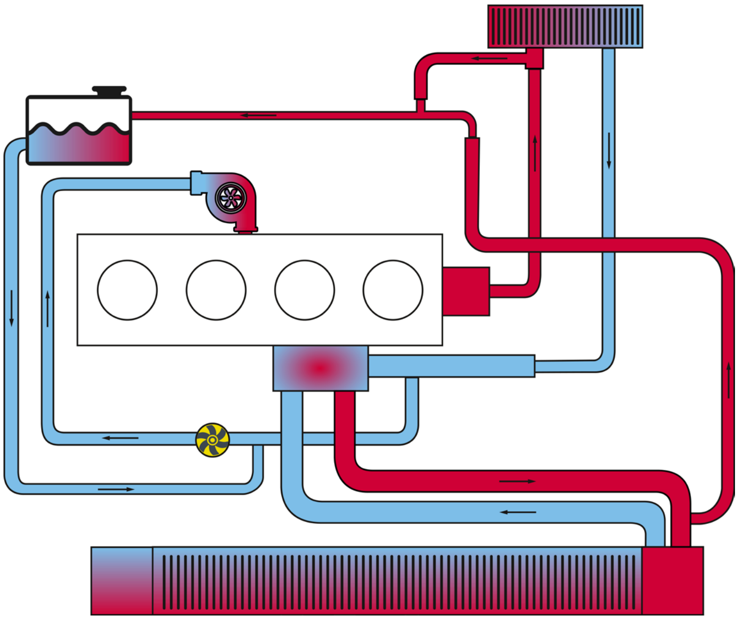

Fig. 2

The control electronics report feedback from the pump to the engine control unit by connecting the PWM signal from the engine control unit to earth at uniform intervals. This is to report if the pump is ready for operation and gives self-diagnosis if the pump is blocked or running dry, as well as electrical faults.

The engine ECU would then log fault codes bringing the engine management lamp on, alerting the driver of a fault which would then need to be diagnosed.

When refilling a cooling system equipped with any variant of electrical coolant pump, follow manufacturer's instructions for bleeding the air from the cooling system.

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