

Electronically controlled cooling

Reason for the development

Perfect engine function also influences the engine's performance. In the case of thermostat-controlled cooling, coolant temperatures vary from 95℃ to 110℃ in the part-load range and from 85℃ to 95℃ in the full-load range. Higher temperatures in the part-load range result in a more favourable performance level, which also has a favourable influence on consumption and pollutants in the exhaust gas. Lower temperatures in the full-load range increase performance. The air suctioned in is heated up less, leading to an increase in performance.
The development of an electronically controlled cooling system aims to regulate the engine's operating temperature to a reference value depending on the load state. The system is regulated to an optimum operating temperature according to characteristic diagrams that are stored in the engine control unit by the electrically heated thermostat and the cooling fan stages. This allows the cooling to be adapted over the whole engine performance and load range.

The advantages of adapting the coolant temperature to the current engine operating state are:

- Reduction of consumption in the part-load range
- Reduction of CO and HC emissions

Changes compared with the conventional cooling circuit

- Integration in the coolant circuit through minimum design-related changes - coolant distributor body and thermostat are in one structural unit (e.g. VW)
- The coolant regulator (thermostat) on the engine block is no longer required

- The engine control unit contains the characteristic diagrams of the electronically controlled cooling system in addition

Set-up of the coolant distributor body

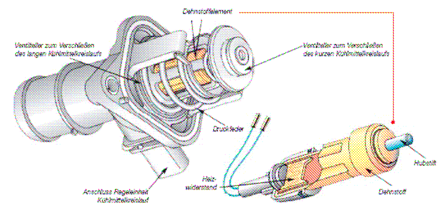
The coolant distributor body is mounted directly on the cylinder head in place of the connector muff.
It should be considered on two levels.
The individual components are supplied with coolant from the top level.
The feed to the coolant pump is an exception to this.
The coolant return from the individual components is connected on the lower level.
A vertical channel connects the top and bottom levels.
stehender Kanal verbindet die obere mit der unteren
The thermostat opens/closes the vertical channel with its small valve disc.
The coolant distributor body is practically the coolant distributor station to the large or small circuit.

Function of the coolant control unit

The functional components

- Expansion element thermostat (with wax element)
- Resistance heating in the wax element
- Compression springs for the mechanical sealing of the
- coolant channels
- 1 large and 1 small valve disc

The function



The expansion element thermostat in the coolant distributor body is continually surrounded by coolant. The wax element controls unheated as before, but is designed for a different temperature. The coolant temperature makes the wax melt and expand. This expansion has the effect of lifting a lifter pin. This usually happens (without voltage applied) according to the new temperature profile of 110℃ coolant temperature at the engine output. There is a heating resistor embedded in the wax element. When voltage is applied to this, it also heats the wax element and the lift, i.e. the displacement, not only depends on the coolant temperature but also according to the characteristic diagram stored in the engine control unit.

Long and short coolant circuit

As with previous circuits, there are two circuits that are being controlled in this case. The short circuit, for engine cold-start and part-load, is used to heat the engine quickly. The electronically controlled engine cooling has not yet taken effect. The thermostat in the coolant distributor body has blocked the return flow from the radiator and released the short path to the coolant pump. The radiator is not integrated in the coolant circuit.

The long coolant circuit is either opened by the thermostat in the coolant regulator after a temperature of about 110℃ has been reached or by the characteristic diagram depending on the load. The radiator is now integrated in the coolant circuit. Electric fans are switched on if necessary to support cooling by wind blast or in idling.

Coolant temperature sensor

The temperature sensors work as NTC sensors. The coolant temperature reference values are stored in the engine control unit as characteristic diagrams. The actual coolant temperature values are taken at two different spots in the coolant circuit and sent to the control unit as voltage signals.
Coolant actual value 1 - directly at the coolant output on the engine in the coolant distributor.
Coolant actual value 2 - on the radiator before the coolant leaves the radiator.
Signal use: The comparison between the reference temperatures stored in the characteristic diagrams with actual temperature 1 results in the duty cycle for the current feed to the heating resistor in the thermostat. The comparison between the coolant actual values 1 and 2 forms the basis for triggering the electric cooling fan.

Diagram-based control of the thermostat

There is a heating resistor embedded in the wax element of the expansion element thermostat. This heats the wax additionally, the wax expands, generating the lift “x” of the lifter pin according to the characteristic diagram.
The mechanical adjustment of the thermostat results from lift “x”. The heating is triggered by the engine control unit according to the characteristic diagram through a PWM signal (pulse-width modulated).
There are different heat-up periods depending on the pulse width and the time.
Rule:

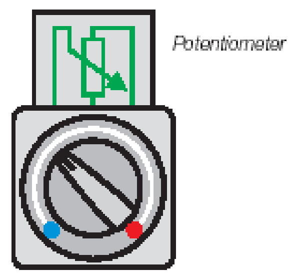
- PWM low (without voltage) = high coolant temperature
- PWM high (with voltage) = low coolant temperature

Characteristic diagram reference values

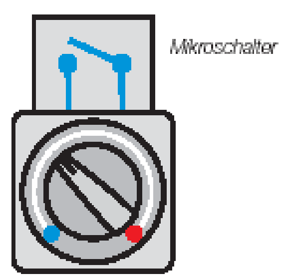
Triggering of the thermostat for diagram-controlled engine cooling (large or small cooling circuit) is controlled through characteristic diagrams. The respective temperature reference values are stored there.
The load (air mass) and speed result in the coolant temperature to be set.

Temperature reference values that depend on the speed and the intake air temperature are stored in a second characteristic diagram. This results in the coolant temperature to be set. The lower value from the comparison of characteristic diagrams 1 and 2 is used as the reference value, and the thermostat is set accordingly. The thermostat is only activated when a temperature threshold is exceeded and the coolant
temperature is closely below the reference value.

Regulating the coolant temperature when heating is required (VW here as an example)



With a driving style between part-load and full-load, the coolant temperature fluctuates between 110℃ and 85 ℃. A temperature difference of 25℃ would be noticeable and unpleasant inside the vehicle if the heating was switched on. The driver would have to readjust the heating continually.
With the aid of the potentiometer, the electronics recognises the driver's heating requirements and regulates the coolant temperature accordingly,
e.g. from rotary knob setting 70% = 95℃



A micro-switch on the rotary knob for temperature selection opens as soon as the 'heater off' position is left. This triggers a pneumatic two-way valve
which in turn activates the coolant switch-off valve for the heater heat exchanger through vacuum.

Electronic control

The engine control unit has been extended by the connections for the sensors and actuators of the electronically controlled cooling system:

- Current feed to the thermostat (output)
- Radiator return temperature (input)
- Radiator fan control (2 x output)
- Potentiometer on the heater regulator (input)

Calculation of the functions for characteristic diagram temperature is carried out once an hour. System regulation is initiated as a result of the function calculations:

- Activation (current feed) of the heater resistor in the thermostat for diagram-controlled engine cooling to open the long coolant circuit (regulation of coolant temperature).
- Triggering of the cooling fan to support fast reduction in coolant temperature.

Effect of functional failure

Coolant temperature sensor

If the sensor (engine output) for the coolant temperature fails, a specified replacement value of 95℃ is used to co ntinue coolant temperature regulation and fan level 1 is activated permanently.
If the sensor (radiator output) for the coolant temperature fails, regulation remains active and fan level 1 is activated permanently. If the temperature drops below a certain level, fan level 2 is activated. If both sensors fail, maximum voltage is applied to the heater resistor and fan level 2 is activated permanently.

An entry is made in the fault memory.