General information

Cooling the engine with water

– What's the reason for cooling?

Let's look at the history.

The temperatures produced during fuel combustion (up to 2000°C) are harmful to the engine.

The engine is therefore cooled down to "operating temperature".

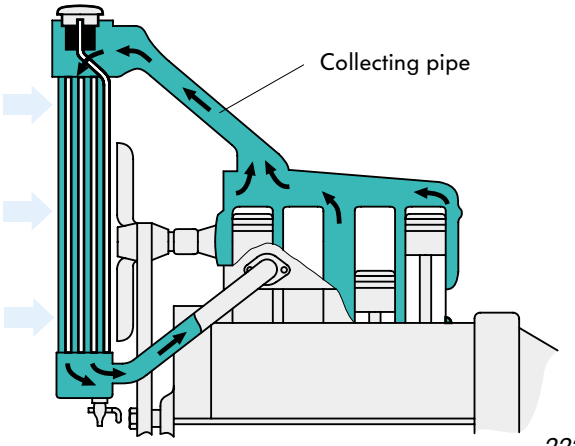
The first water-based method used was the thermo-syphon cooling process. The heated - and therefore lighter - water rises up a collecting pipe and into the upper part of the radiator. The water is then cooled by the headwind streaming around the radiator. This causes the water to drop down and flow back into the engine. Flow in this circuit runs as long as the engine is running. The cooling process was fan-assisted. Temperature control was still not possible. The water circulation rate was later increased by means of a water pump.

Weak-points:
- Long warm-up period
- Low engine temperature during the cold season

A coolant control, or thermostat, later came into use as engine technology advanced.
The temperature of the water circulating through the radiator is controlled depending on the coolant temperature.

This process was described in 1922 as follows:
These devices serve to raise engine temperature quickly and prevent it from cooling.

This "thermostat-controlled" cooling system had the following functions:
- short warm-up period
- maintenance of a constant operating temperature.



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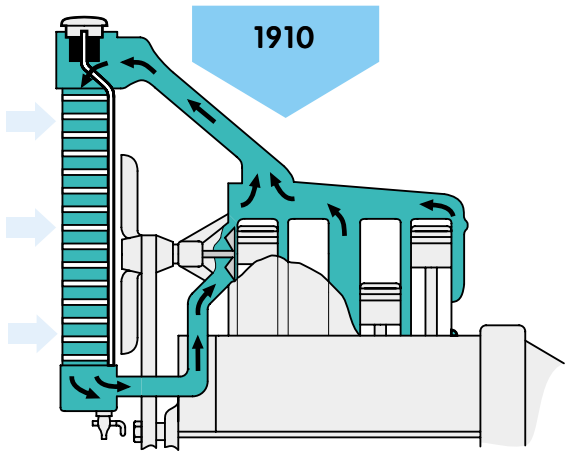
The thermo-syphon cooling system — an automatic circulatory cooling system



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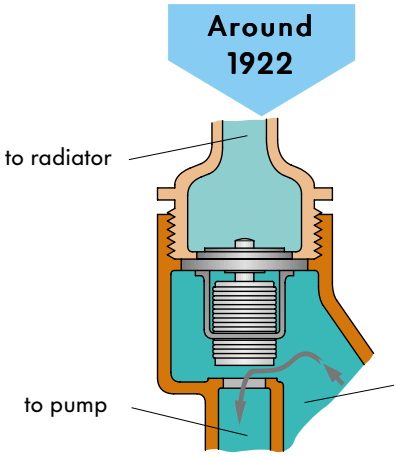
The water circulation rate is increased by a water pump



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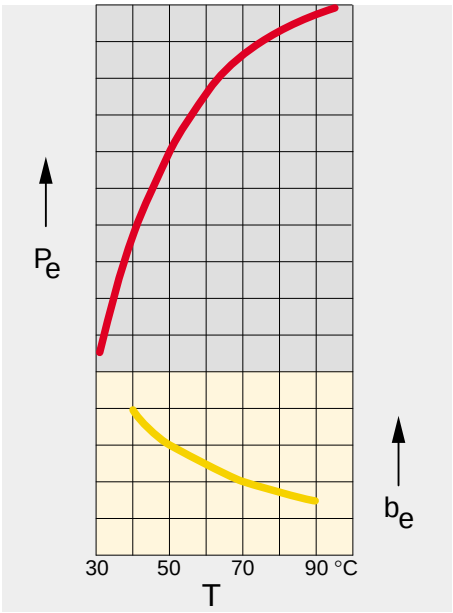
Coolant control (corrugated hose thermostat) gives more rapid heating during the warm-up period

The thermostat, therefore, was a major improvement and made possible the so-called “bypass water line“. As long as the engine has not reached the desired operating temperature, the water does not flow through the radiator rather it flows back into the engine along a short path. This control concept is still used today in all systems.

The chart on the right shows the effect of engine temperature on power output and fuel consumption.

However, the correct engine operating temperature is nowadays important not only for power output and consumption; it is also essential for low pollutant emissions.



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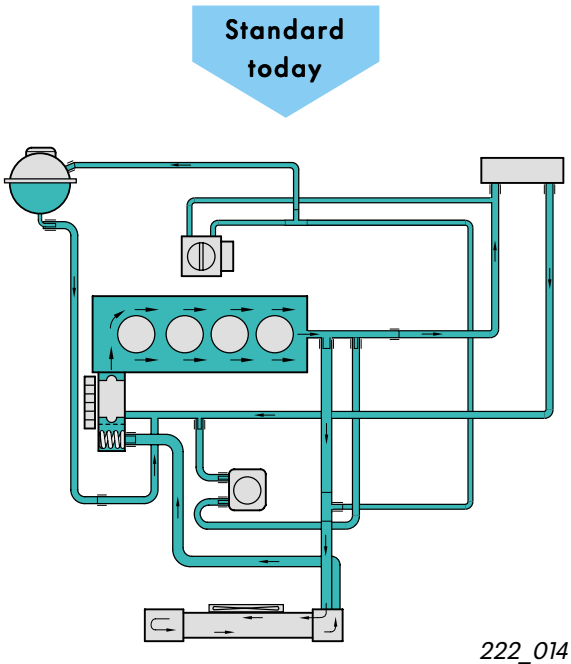
P_e = power output
b_e = fuel consumption
T = engine temperature

Engine cooling is based on the principle that pressurised water starts to boil at temperatures between 115°C to 130°C and not at 100°C.

The cooling circuit is subject to a pressure of 1.0 - 1.5 bar. This is known as a “closed-circuit cooling system“.
For this purpose, the system has an expansion tank which is only half full.

The corrugated hose thermostat has been replaced by an elastic thermostat (waxstat).

The cooling medium is not only water but a mixture of water and coolant additive. This mixture offers frost protection, has a higher boiling point and protects light-alloy parts of the engine against corrosion.



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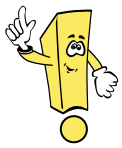
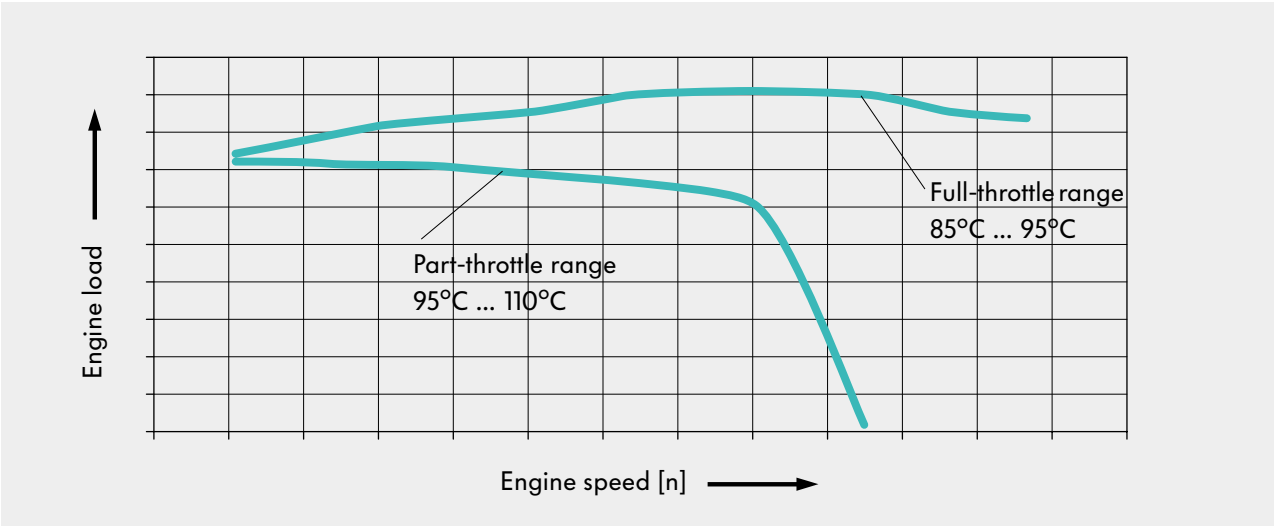
Closed-circuit cooling system
with elastic thermostat and expansion tank filled with coolant

The coolant temperature level





Coolant temperature level as a function of engine load with mapped cooling

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Engine load and cooling should always be regarded in context.

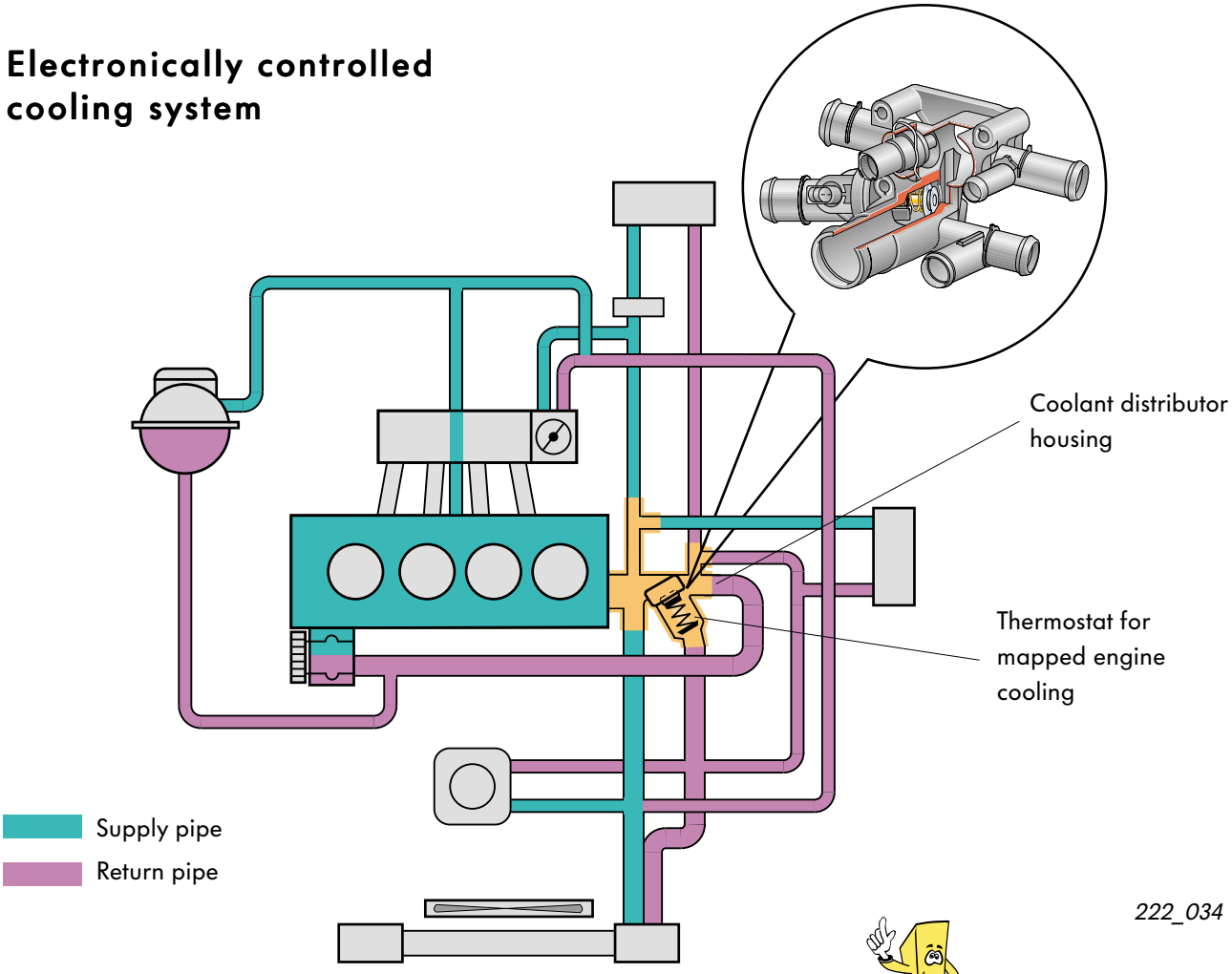
Engine performance is dependent on proper engine cooling.

In the thermostat-controlled cooling system, the coolant temperatures range from 95°C to 110°C in the part-throttle range and from 85°C to 95°C in the full-throttle range.

- Higher temperatures in the part-throttle range improve performance, which in turn reduces consumption and pollutants in the exhaust gas.

- Lower temperatures in the full-throttle range increase power output.
  The induced air is heated to a lesser degree, boosting performance.

Electronically controlled cooling system

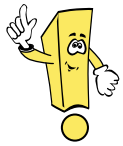


Electronically controlled cooling circuit – (schematic diagram)

The aim of developing an electronically mapped cooling system was to set the operating temperature of the engine to a specified value depending on the load state.

An optimal operating temperature is set according to maps stored in the engine control unit via the thermostat to be heated electrically and the radiator fan settings.

Cooling can thus be adapted to the engine's overall performance and load state.



Advantages

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

- Lower consumption in the part-throttle range
- Reduced raw CO and HC emissions

Changes to the conventional cooling circuit:

- Integration in the cooling circuit through minimal design modifications.
- The coolant distributor housing and thermostat are combined to form a single unit.
- There is no longer any need for a coolant thermostat on the engine block.
- The engine control unit also contains the maps of the electronically mapped cooling system.