Digest of engine cooling issues

In engineering terms it is generally accepted/good practice that engine water/coolant temperature should run as near as possible to 212F/100C (water boiling point) because a well-warmed engine improves combustion and raises oil temperature (which reduces oil degradation/sludge formation/caramelling – seen inside the camshaft/rocker cover) thus alleviating oil lubrication restrictions and lessening mechanical wear.
Following this logic it is advisable to fit a coolant thermostat – the simplest being an in-line thermostat inside the top hose.

Originally most Triple-M cars were fitted with a thermo-siphoning cooling system i.e. with neither a water pump nor a thermostat – doubtless for cost, and in the mid 30s, thermostats were neither well-developed nor readily available.
Thermo-siphoning offered a simple system but with many compromises – slower warm up, generally lower running temperatures except in high load, hot weather, or low speed stationary traffic jam situations. The 'sizing' of the thermo-siphoning cooling system and radiator was almost certainly designed by development trial-and-error to meet the worst case engine heat output/road speed/gear conditions in UK ambient temperatures.
The net result being that at most 'normal' (UK) driving and northern European conditions the engine temperature would be less than optimal.

Modern traffic conditions, in comparison with those in the 1930's, mean much more low speed and idle operation in urban areas (traffic jams, queues at traffic lights, etc).

Coolant flow rate and temperature.
Thermo-siphoning coolant circulation (flow rate) depends only on the temperature differences between that inside the engine (predominantly that in the cylinder head) and the radiator and consequently this flow rate is slow.

The fitment of water pumps to the higher-powered (supercharged) vehicle variants increased the water flow velocity through the engine and radiator to improve cooling.

The physics of heat exchange is primarily influenced by temperature difference between the hot fluid (engine water/coolant) and the cold fluid (air through the radiator), HENCE BOTH increasing the water/coolant temperature with a thermostat AND a pump to increase water/coolant velocity aid heat transfer to the coolant inside the cylinder head and heat rejection performance from the radiator.

Radiator airflow
Low speed/city traffic/idling conditions mean minimal airflow through the radiator, hence the need for forced convection with the aid of a fan.

Cleanliness
Good water-side heat transfer requires clean/no rust/no sludge deposits both inside the engine and inside the radiator – plain water coolant cannot recommended as this leads to much corrosion/rust/sludge.
Similarly the air passageways through the radiator should be kept clean – no flies/road debris/oil/etc.

In summary improve:
1. Conditions inside the coolant passageways in both the engine and radiator should be improved by raising the temperature with a thermostat and water velocity/flow rate with a pump.
2. Radiator airflow – for low road speeds/idle, add a fan.
3. Cleanliness – i.e. good quality coolant anti-corrosion inhibition/antifreeze.

Check the operation of your temperature gauge. The kettle test is easy enough if you can find a kettle to keep the boil out near the car or just pop down to the chemist and get a thermometer

Another possible cause of overheating maybe a lean mixture. You can put the car on rolling-road dynamometer (dyno) or maybe get a Colourtune to diagnose that.

Exhaust temperature is best indicator of that. Again grab your infrared temperature gun and check the exhaust temp where it comes out of the head.
Alternatively you can usually tell if something is not right here, just by feel, assuming you know what it was like when mixture was OK. If the car is running lean the exhaust will get hot very quickly from start up.

Practical experience

From my days when I was responsible for cooling system design and development (amongst a number of other engineering features over the years), some vehicles had thermostats which included a 'plate/disc' which moved as thermostat opened; this plate/disc progressively closed the inlet to the by-pass. Some modern vehicles use a more sophisticated electrically controlled thermostat.
However the majority of mass-produced cars tend to use a 'simple' thermostat which just opens to the radiator, leaving the by-pass open.

Provided the cross-section area of the by-pass is not too large, the coolant flow pressure drop through the radiator is generally much less than that through the by-pass, hence most of the flow goes through the radiator, particularly when the thermostat is fully open as in high ambient temperatures at low speeds/traffic jam situations.

Radiator heat dissipation/rejection (as with all heat exchangers), is a function of the temperature difference between the hot fluid (in this case coolant/water) and the cold fluid (in-coming air), so as the coolant temperature in Triple-M unpressurised cooling systems approach boiling point c.100C the heat dissipation/rejection increases.
In the extreme, some loss of radiator coolant flow down an open by-pass will have a small adverse effect on cooling performance. However I suggest that such a loss would be more than compensated for when a water pump and electric fan are fitted (recommended).

Cleanliness of the entire cooling system (i.e. in the cylinder block, head, and radiator) is very important **and there should be no sludge in any part of the cooling system**, such as I found when stripping my radiator, block, and cylinder head where a previous owner had been running on plain water.
There were a significant amount of brown corrosion deposits e.g. the water galleries in the cylinder block in particular were more than an inch deep behind the jacket side plates; similar can be found in the radiator and cylinder head.
Nothing came out when opening the drain taps on the block and radiator!

To keep the coolant passageways clean (after removing all evidence of the corrosion sludge), it is essential to have plenty of anti-corrosion additives in the coolant.
I prefer to use a 50/50 water/good quality ethylene glycol anti-freeze solution, though others claim success with a summer coolant/water wetting solution (or some such thing).

Anti-freeze is really a misnomer, as for the majority of time freeze protection is not required but corrosion protection is required 100% of time.

Note that in a weak anti-freeze solution the anti-corrosion additives become depleted/’used-up’ which leads to corrosion and eventual sludge formation, I’ve seen this happen in 100,000 mile endurance test car!

The effect of corrosion/sludge, apart from impeding coolant flow, is to reduce:

- The water-side heat transfer extraction from the hot metal in the engine and
- The heat rejection to the metal tubes/passages inside the radiator

which exacerbate cooling problems.

The essential thing is that when checking the coolant there should a clear, clean, usually coloured fluid with no rusty brown evidence.

There’s lots more I could add, but I guess I’ll save that to bore you with later.

Bruce Sutherland.