Module 7: Cooling System Components

Basic Cooling System Components

READY FOR REVIEW

- Radiator location
  - Convenient position under the hood of the vehicle
  - Actual location under the hood depends on:
    - Engine configuration
    - Available space
    - Shape or line of the hood
- Radiator components
  - Top and bottom tanks
  - Core
- Radiator core
  - Allows coolant to pass through it
  - Either vertical down or horizontal cross flow direction
  - Serves as a good conductor of heat away from the engine
- Header tank (reservoir)
  - Can be mounted separately from the radiator
  - Has a supply of coolant
  - Located higher than the top of the radiator
  - Usually made of hardened plastic
  - Allows a visual check of fluid level through the plastic
- Radiator cap
  - Fitted on some tanks
  - Used to increase the coolant's boiling point
  - Can be located directly on top of the radiator or on the header (surge) tank
- Thermostat
  - Located under the thermostat housing
  - The engine running at an operating temperature allows the circulation of coolant to flow from the engine to the radiator.
  - A cold engine is closed to allow the engine to warm up more rapidly.
- Thermostat housing
  - Normally located on the outlet side of the coolant flow from the engine
  - The majority used today are made from aluminum alloy.
  - Will corrode away instead of the engine or cylinder head
  - Known as the sacrificial component
- Water pump
  - Normally bolted to the front of the engine block
  - The bottom radiator hose comes from the radiator.
    - Connected to the water pump inlet
    - Driven by the engine via a fan or drive belt
- Water pump and coolant
  - Coolant leaves the outlet of the radiator where much of the heat is removed.
  - Water pump impellers force the coolant through water jackets.
- Cooling fan location
  - Either on the water pump shaft or attached directly to the engine crankshaft
  - In most cases, there requires some engine power to drive the fan.
- Cooling fan blades
  - Made of steel or plastic
  - Draw cooling air through the radiator core
  - Lowers the temperature of the coolant
- Radiator hoses
  - Most vehicles have two radiator hoses:
    - The top hose is attached to the thermostat housing and allows heated coolant to enter the top or inlet side of the radiator.
    - The bottom (lower) hose is connected between the outlet of the radiator and the inlet of the water pump.
- Radiator hose and by-pass hose clamps
  - Radiator hoses and by-pass hoses are held in position by clamps.
  - Attached to the engine block or radiator assembly
  - Types are:
    - Spring clamps
    - Wire wound clamps
    - Worm drive clamps
- Heater hoses
  - Normally preshaped for a particular make and model of vehicle

- The construction is same as a radiator hose with reinforcing material embedded.

- Coolant flow
  - Hot coolant comes in through the hose attached to the thermostat circuit.
  - Sheds some heat into the vehicle
  - Cools down
  - Returns to the engine via the water pump inlet

Radiators

READY FOR REVIEW

- Why many radiators are mounted at the front of the vehicle:
  - In the path of the greatest airflow
  - Air carries the heat away.
  - Liquid cools before returning to absorb more heat from the engine.
- Space considerations and header tank
  - Where the radiator is mounted depends on space and how the engine is mounted.
  - Header tank
    - Can be mounted away from the radiator
    - Provides a coolant supply stored above the engine
    - Made of sheet metal or hardened plastic
- Materials used for the tank and core
  - The radiator has two tanks and a core.
  - Materials used:
    - Must be good heat conductors like brass or copper
    - Brass and copper are often used for tanks.
    - Combined with copper core
  - Modern vehicles
    - Often use plastic tanks
    - Combined with aluminum core
    - Saves weight
    - Still provides good heat transfer
- Radiator core tubing
  - A number of tubes in the core carry coolant between the two tanks.
  - Tube patterns
    - Vertical down-flow
    - Horizontal cross-flow
    - The cross-flow radiator is easier to fit under the steeply-sloped hood.
- Core fins
  - Small, thin, cooling fins are in the core.
  - In contact with tubes
  - The shape of the fins increases the surface area exposed to the air.
- Removal of coolant heat
  - Where heat removal from coolant takes place
    - Coolant touches the tube walls.
    - The tubes touch the fins.
  - How heat is removed
    - First, by conduction
    - Then, by radiation and convection at the surface of the fins
    - Air rushing by carries heat away.
- Coolant flow to the engine
  - Liquid emerges cooler at the bottom of the radiator.
  - Travels through the lower radiator hose to the water pump inlet
  - Flows through the engine again

Common Types of Radiators

READY FOR REVIEW

- Down-flow radiator
- Cross-flow radiator
- Low-flow coolant (double bypass) radiator

Coolant Hoses

READY FOR REVIEW

- Function of coolant hoses
  - Coolant hoses transfer coolant throughout the cooling system.
  - Heater coolant hoses carry coolant to the heating system usually located inside the vehicle cabin.
- Mounting and flexible hoses
  - Most engines are mounted on flexible mountings.
  - Reduces noise and vibration
  - The radiator is mounted to the vehicle body, so flexible hoses are needed.
- Diameter of the hoses
  - Vary in diameter depending on the volume of coolant passing through
  - Heater hoses carry a smaller volume.
- Composition
  - Most are made of rubber.
  - Subject to pressure, so reinforced with a layer of fabric
- Shape
  - Molded to a special shape to suit the model and make of the vehicle
  - Some heater coolant hoses have special shapes.
- Hot coolant and high pressures
  - All hoses are subject to hot coolant and high under-hood temperatures.
  - Can deteriorate and fail

Water Pumps

READY FOR REVIEW

- Location and layout of water pumps
  - Usually located in front of the cylinder block
  - Belt-driven from the pulley on the front of the crankshaft
  - Connected by a hose to the bottom of the radiator where cooler liquid emerges
- How it works
  - The water pump has fan-like blades on the rotor or impeller.
  - Coolant enters the center of the pump.
  - The rotor spins.
  - Centrifugal force moves the liquid outward.
  - Coolant is driven through the outlet into cooling passages called water jackets.
- Water jackets are passages in the engine block and cylinder head that surround cylinders, valves, and ports.
- Water jackets can direct coolant to hot spots to stop local overheating.
  Example: exhaust ports in the cylinder head

Centrifugal Force

READY FOR REVIEW

- Centrifugal force is the force that pulls outward on a rotating body.
- Centrifugal force applied to a vehicle
  - A vehicle turning a curve is a rotating body.
  - Subject to centrifugal force that resists turning
  - Tries to keep the vehicle moving in a straight line
  - Also, centrifugal force causes the out-of-balance wheel to vibrate.
- Centrifugal force and the water pump
  - Can be a useful force
  - When coolant enters, the center of the water pump and rotor spins.
  - Centrifugal force moves the liquid outward.

Types of Drives for Water Pumps

READY FOR REVIEW

- Water pumps have two types of drives.
  - The belt drive is usually mounted at the front of the engine.
  - The gear drive is driven off the gear train and it may face the front or the rear of the engine.

Types of Drive Belts

READY FOR REVIEW

- V-belt
  - V-shaped
  - The load is applied to both angled smooth surfaces.
  - Typically used in:
    - Combination
    - Matched sets
    - Pairs
    - Commonly available as 3/8 in. (9.5 mm) to 1/2 in. (12.7 mm) wide
- Poly V (serpentine)
  - A flat belt with different surfaces on each side
  - The side with the serpentine-ridged surface receives the load.
  - The smooth-surface side receives no load.
  - One belt is typically used to drive most or all the accessories.
  - Commonly available as 1 in. (25.4 mm) to 1 1/2 in. (38.1 mm) wide

Cooling System Thermostat

READY FOR REVIEW

- Thermostat function and location
  - The thermostat helps the engine to warm up.
  - Found in different positions on different engines
- Valve operation
  - The thermostat is a valve.
  - Operates according to the coolant temperature
  - When the coolant is cold, a spring holds the valve closed.
- The cold engine starts.
  - Coolant circulates within the engine block and cylinder head.
  - Circulates through the coolant bypass to the water pump inlet
  - Cannot get to the radiator
- The engine warms up.
  - Coolant in the engine gets hotter and hotter.
- The valve starts to open.
  - Wax-like substance in the thermometer
  - Expands as the engine nears an operating temperature
  - Starts to open the valve
  - Coolant starts to flow to the radiator.
- Trapped air is released.
  - Thermostats have a small hole or valve.
  - Lets out air trapped in the engine block
- Heated coolant is pumped.
  - Heated coolant is pumped from an outlet in the cylinder head.
  - Goes into upper radiator hose, then to radiator.

Cooling Fans

READY FOR REVIEW

- Extra airflow
  - With the vehicle moving at high speed, the coolant is cooled by airflow through the radiator.
  - At low speed or with the engine idling, the fan provides the extra airflow.
- Electric fans
  - The fans are driven different ways.
  - More and more modern vehicles use electric fans.
  - Air-conditioned vehicles often have extra fans.
  - Electric fan mounting
    - Behind the radiator
    - In front
    - Both
    - Arrangement is difficult with a belt-driven fan.
    - Some fans are driven from the crankshaft.
- Longitudinally-mounted engine
  - The fan is usually mounted on the water pump shaft.
  - The drive belt turns the water pump and fan.
  - Some use a hydraulic link from the power steering system.
- Fan blades
  - Rigid or flexible
  - Rigid blades are often noisy and use more energy.
  - Noise is reduced by using irregular spacing of the fan blades.
- Shroud
  - Some vehicles use shroud.
  - Directs all air moved by the fan through the radiator core
- Waste of energy and fuel
  - At high speeds, there is plenty of air flowing through the radiator.
  - A fan always working at full speed wastes energy.
  - Since the engine drives the fan, it also wastes fuel.
  - Need a way to control the fan

- Heat-sensitive switch
  - In contact with the coolant
  - Works like a thermostat
  - Turns the fan on and off according to the coolant temperature
- Viscous hub
  - Another way to alter the speed of the fan uses a viscous hub.
  - The fan slips when it is cold.
  - As the engine heats up, it grips more and more.

Temperature Indicators

READY FOR REVIEW

- Overheating
  - Can seriously damage the engine
  - Useful to have as a warning of trouble
- Temperature indicator
  - The device is sensitive to the engine temperature.
  - Sends readings to the temperature gauge or warning lamp
  - An accurate reading depends on the sensor always being immersed in liquid.
  - When measuring the coolant levels, it warns if the level is too low.

Radiator Pressure Cap

READY FOR REVIEW

- Problem with boiling coolant
  - Boiling coolant is as serious for the engine as having it freeze.
  - Boiling coolant in the water jacket becomes vapor.
  - There is no liquid left in contact with the cylinder walls or head.
  - Heat transfer by conduction stops.
  - Heat builds up.
  - Can cause serious damage
- Damage prevention
  - A radiator-pressure cap is one way to prevent boiling coolant.
  - Uses pressure to change the temperature at which water boils
- Rising coolant temperature
  - Coolant expands.
  - Pressure in the radiator rises.
  - Lifts the boiling point of water
- Rising engine temperature
  - Coolant expands further.
  - Pressure builds against a spring-loaded valve in the radiator cap.
  - At a preset pressure, the valve opens.
- In a recovery system, hot coolant flows out into the overflow container.
- As the engine cools, the coolant contracts and pressure in the radiator drops.
- Vacuum vent valve
  - Atmospheric pressure in the overflow container opens a second valve (vacuum vent valve).
  - Overflow coolant flows back into the radiator.
- Stopping low pressure
  - The system stops low pressure from developing in the radiator.
  - Stops atmospheric pressure from collapsing the radiator hoses

Four Purposes of a Radiator Cap

READY FOR REVIEW

- Seals the radiator
  - Prevents the entry of air, which causes corrosion
  - Prolongs the useful life of antifreeze and cooling system additives
- Allows the cooling system to operate under positive pressure
  - Raises the effective boiling point of coolant
  - Minimizes coolant loss
  - Minimizes cavitation erosion
- Maintains system pressure at a preset level with the use of a pressure relief valve
  - Prevents damage to the radiator core and hoses
  - Maintains a consistent boiling point for coolant
- Allows overflow coolant to reenter the radiator during cool-down with the use of a vacuum valve
  - Maintains the correct coolant level in the radiator
  - Eliminates air pockets

Typical Radiator Cap Operation

READY FOR REVIEW

- Cooling system at atmospheric pressure
  - The vacuum valve is closed.
  - The pressure relief valve is closed.
- Cooling system operating at high load/high heat
  - The vacuum valve is closed.
  - The pressure relief valve opens when the system pressure exceeds the cap rating.
  - Coolant is released into the expansion tank.
- System cool-down
  - The vacuum valve opens allowing coolant to return from the expansion tank.
  - The pressure relief valve is closed.

Recovery System

READY FOR REVIEW

- The recovery system maintains coolant in the system at all times.
- The engine temperature rises and pressure builds.
  - As the engine temperature rises, the coolant expands.
  - Pressure builds against the valve in the radiator cap.
- The valve opens and coolant flows to the overflow container.
  - At a preset pressure, the valve opens.
  - Hot coolant flows out into the overflow container.
- As the engine cools, the coolant contracts, and the pressure in the radiator drops.
- Overflow coolant flows back to the radiator.
  - Atmospheric pressure in the overflow container opens the second valve.
  - Overflow coolant flows back into the radiator.
- Acts to prevent corrosion
  - No coolant is lost.
  - Excess air is kept out of the system.
  - Air and water contains oxygen.
  - Oxygen reacts with metals to form corrosion.
  - The system acts to prevent corrosion.

Thermo-Switch

READY FOR REVIEW

- Preset temperature levels
  - The thermo-switch opens and closes according to preset temperature levels.
  - Some thermo-switches are mechanical and others are electrical.
- Designs
  - May switch off when the temperature rises above a certain level
  - May switch on when the temperature reaches a certain level
- Bimetallic strip principle for heat switches
  - Two different metals or alloys are attached back to back.
  - As they are heated and cooled, they expand and contract differently.
- Effect of heating
  - Different metals and alloys are joined and heated.
  - The faster expansion of one forces the whole strip into a curved shape.
- Completing a circuit
  - The strip changes shape.
  - Can be designed to complete a circuit
  - The resulting electrical signal can do a range of tasks or it might have a mechanical effect such as opening a passageway.
- Effect of cooling
  - Cooling produces the opposite effect.
  - Breaks the circuit and closes the passage