JAN 2023 MDE

7. With reference to plate type heat exchangers:

(a) sketch the assembly, labelling the main components and indicating the direction of flow; (5)

(b) state the materials used for the plates and seals; (2)

(c) state the purpose of the plates being corrugated; (2)

(d) state the purpose of *tell tales*. (1)

(a) Assembly and Flow Direction:

A plate heat exchanger (PHE) is a compact and efficient heat exchanger that utilizes thin metal plates for heat transfer between two fluids. Here's a breakdown of its assembly and flow direction:

- **Main Components:**
  - **Frame:** A sturdy frame that houses and clamps the entire assembly.
  - **Movable Tie Rods:** Rods with threaded ends that tighten the frame, compressing the plate pack.
  - **Pressure Plates:** Thick metal plates at each end of the assembly that seal the plate pack and connect to fluid inlet/outlet ports.
  - **Gaskets:** Seals placed around the periphery of each plate to prevent fluid mixing between the channels.
  - **Plate Pack:** The core of the PHE, consisting of numerous thin, corrugated metal plates stacked alternately.
- **Flow Direction:**
  - The two fluids flow through separate channels formed between adjacent plates. The corrugations create a tortuous path for the fluids, ensuring they flow turbulently and maximize heat transfer across the large plate surface area.
  - The flow direction of each fluid can be counter-current (most efficient) or co-current (simpler design for specific applications) depending on the desired temperature profile.

(b) Plate and Seal Materials:

- **Plates:** Typically made of high-grade stainless steel (e.g., AISI 316) for its:
  - **Strength:** To withstand high operating pressures and temperatures.
  - **Corrosion Resistance:** Crucial for handling various fluids and preventing leaks.
  - **Thermal Conductivity:** Efficient heat transfer between the fluids.
- **Seals:**
  - **Elastomeric materials:** Often nitrile rubber (NBR) or ethylene propylene diene monomer (EPDM) for their:
    - **Elasticity:** To create a tight seal around the plate edges.
    - **Chemical Resistance:** Compatible with the fluids being handled.
  - **Selection depends on specific application temperature and fluid types.**

(c) Purpose of Corrugated Plates:

The plates in a PHE are not flat; they are corrugated with a specific pattern. This corrugation serves several purposes:

- **Increased Heat Transfer Surface Area:** The corrugations significantly increase the surface area of the plates compared to flat plates. This allows for more efficient heat transfer between the fluids flowing through the channels.
- **Enhanced Turbulence:** The corrugations promote turbulent flow within the channels. This turbulent flow mixes the fluids more effectively, leading to a more uniform temperature distribution and improved heat transfer efficiency.
- **Structural Strength:** The corrugations add rigidity to the thin plates, allowing them to withstand higher operating pressures without deforming.

(d) Purpose of Tell-Tales:

Tell-tales are small holes or drilled passages strategically placed on the pressure plates or frame of a PHE. They serve two main purposes:

- **Leak Detection:** In case a gasket fails or a leak develops within the plate pack, the tell-tale will allow fluid to escape from the leaking channel. This serves as a visual indication of a potential problem. The leaking fluid can be collected and analyzed to identify the source of the leak.
- **Venting During Assembly and Maintenance:** When filling the PHE with fluid or during maintenance procedures, tell-tales can be used to vent trapped air from the channels. This ensures proper flow and prevents air pockets from hindering heat transfer efficiency.

Oct 2021

October 2021 MDE

6. (a) Describe, with the aid of a sketch, the construction of a plate type heat exchanger. (7)

(b) State THREE advantages of the plate types, compared with the tube type heat exchanger. (3)

(a) Plate Heat Exchanger Construction:

A plate heat exchanger (PHE) offers a compact and efficient design for transferring heat between two fluids. Here's a breakdown of its construction:

Main Components:

- **Frame:** A sturdy housing, typically made of cast iron or stainless steel, that encloses and supports the entire assembly.
- **Pressure Plates:** Thick metal plates positioned at each end of the assembly. These plates seal the plate pack and have connections for fluid inlets and outlets.
- **Tie Rods:** Threaded rods that pass through the frame and tighten with nuts, applying pressure to compress the plate pack.

- **Gaskets:** Seals positioned around the periphery of each plate to prevent leakage between the fluid channels formed between adjacent plates. Gasket material selection depends on the specific fluids being handled.
- **Plate Pack:** The heart of the PHE, consisting of numerous thin, corrugated metal plates stacked alternately. The corrugations create a wavy pattern on the plates.

Flow Path:

- Two separate fluids flow through dedicated channels formed between adjacent corrugated plates. The corrugations create a tortuous path, forcing the fluids into turbulent flow which maximizes heat transfer across the large plate surface area.
- The flow direction of each fluid can be arranged in a counter-current (most efficient) or co-current (simpler design for specific applications) configuration.

(b) Advantages of Plate Heat Exchangers over Shell and Tube Heat Exchangers:

1. **Compact Size and Lighter Weight:** PHEs are significantly smaller and lighter than shell and tube exchangers for achieving the same heat transfer duty. This makes them ideal for applications with space constraints, such as building HVAC systems or marine applications where weight reduction is crucial.
2. **Superior Heat Transfer Efficiency:** The large plate surface area and the turbulent flow within the channels lead to significantly better heat transfer efficiency compared to shell and tube exchangers. This translates to a smaller PHE size required for achieving the desired heat transfer rate, saving space and material.
3. **Lower Pressure Drop:** The design of plate heat exchangers allows for lower pressure drop on both the hot and cold fluid sides compared to shell and tube exchangers. This translates to lower pumping costs and reduced energy consumption for operating the system.
4. **Easier Maintenance:** The plate pack in a PHE is accessible for cleaning or replacement. By loosening the tie rods and separating the pressure plates, the plates can be individually accessed for maintenance. This is simpler compared to shell and tube exchangers, which might require more disassembly effort or even removal of piping connections.
5. **Versatility:** Plate heat exchangers can handle a wider range of fluid viscosities and pressures compared to shell and tube exchangers. This makes them suitable for various applications, including handling viscous fluids or those with high-pressure differentials.

June 2021

June 2021 MDE

6. (a) State FOUR conditions for the fresh water cooling system treatment program to be effective. (4)

(b) State the function of the inhibitor used in fresh water cooling treatment. (3)

(c) Explain the safety considerations needed when handling the inhibitors. (3)

Fresh Water Cooling System Treatment Program Effectiveness:

For a fresh water cooling system treatment program to be truly effective, four key conditions need to be met:

1. **Proper Water Analysis:** The program should begin with a thorough analysis of the makeup water entering the system. This analysis identifies factors like hardness, mineral content, pH level, and potential contaminants. By understanding the water characteristics, a targeted treatment program can be implemented.
2. **Correct Chemical Selection and Dosage:** Based on the water analysis, appropriate treatment chemicals like corrosion inhibitors, biocides, and scale inhibitors should be chosen. The correct dosage of these chemicals is crucial. Insufficient quantities won't be effective, while overdosing can lead to adverse effects or environmental concerns.
3. **Consistent Monitoring and Testing:** Regular monitoring of the cooling water system is essential. This includes checking the concentration of treatment chemicals, pH levels, conductivity, and signs of corrosion or biological growth. Taking water samples periodically for laboratory analysis can provide valuable insights into the system's health.
4. **Maintenance Procedures:** A preventative maintenance program should be established to ensure the continued effectiveness of the treatment program. This includes tasks like cleaning strainers and heat exchangers, inspecting components for signs of wear, and performing periodic system blowdown to remove accumulated sediments.

(b) Function of Inhibitor in Fresh Water Cooling Treatment:

A corrosion inhibitor is a key component of most fresh water cooling system treatment programs. Its primary function is to:

- **Form a Protective Film:** The inhibitor creates a thin protective film on the metal surfaces within the cooling system. This film acts as a barrier between the metal and the corrosive elements present in the water, such as dissolved oxygen or chlorides.
- **Passivation:** Some inhibitors can promote the formation of a passive oxide layer on the metal surface. This passive layer further enhances corrosion resistance.
- **Neutralize Aggressive Ions:** Certain inhibitors can chelate or complex with aggressive ions in the water, reducing their ability to attack the metal surfaces.

(c) Safety Considerations When Handling Inhibitors:

Many cooling system inhibitors can be hazardous if not handled properly. Here are some safety considerations:

- **Personal Protective Equipment (PPE):** Always wear appropriate PPE like gloves, safety glasses, and respirator (if recommended) when handling inhibitors. Refer to the specific product's Material Safety Data Sheet (MSDS) for detailed instructions.
- **Proper Storage:** Store inhibitors in their original containers, in a cool, dry, well-ventilated area away from direct sunlight and heat sources. Keep them out of reach of children and pets.
- **Spill Response:** Have a plan in place for handling accidental spills. Clean up spills promptly using appropriate spill response kits and following the manufacturer's instructions. Dispose of contaminated materials according to local regulations.
- **Training:** Ensure personnel handling inhibitors are adequately trained on their safe handling procedures, emergency response protocols, and the proper disposal methods for spent chemicals or rinse water.

oct 2020

October 2020 MDE

6. (a) Describe, with the aid of a sketch, a keel type cooling water system, labelling the MAIN components. (6)

(b) Explain the purpose of EACH of the following in the cooling system:

(i) header tanks; (3)

(ii) vent lines. (1)

(a) Keel Cooling System: Components

A keel cooling system is a closed-circuit cooling system for marine engines that utilizes seawater for heat transfer. Here are the main components:

- **Heat Exchanger (Keel Cooler):** This is a key component, typically mounted externally on the hull below the waterline. Engine coolant circulates through tubes or channels within the heat exchanger, transferring heat to the surrounding seawater flowing over the outside.
- **Circulation Pump:** An engine-driven or electrically powered pump is responsible for circulating the coolant through the closed loop within the system.
- **Thermostat:** This valve regulates the coolant temperature by controlling the flow of coolant through the heat exchanger. When the coolant reaches a set temperature, the thermostat opens, allowing coolant to flow through the heat exchanger for cooling.
- **Expansion Tank:** This tank accommodates the volume changes of the coolant due to temperature fluctuations. It also serves as a reservoir for any trapped air within the system.
- **Seawater Inlet and Outlet:** These connections allow seawater to enter the system, flow past the heat exchanger, and exit back into the sea after absorbing heat from the coolant.
- **Shut-Off Valves:** Valves positioned at strategic points in the system allow for isolation of sections for maintenance or repairs.
- **Strainers:** These filters placed on the seawater inlet line prevent debris and marine growth from entering the system and potentially clogging the heat exchanger.

(b) Purpose of Specific Components:

(i) Header Tanks:

- **Function:** There might be one or two header tanks depending on the system design. A header tank acts as a reservoir for the coolant and provides space for coolant expansion due to temperature changes. This expansion space prevents excessive pressure buildup within the closed loop.
- **Additional Functions:** The header tank may also incorporate features like:
  - **Overflow Outlet:** This allows excess coolant to escape the system and prevent overfilling in case of a coolant mix error or expansion beyond the tank's capacity.
  - **Fill Point:** This allows for refilling or topping up the coolant level in the system.
  - **Level Indicator:** This helps visually monitor the coolant level within the system.

(ii) Vent Lines:

- **Function:** Vent lines play a crucial role in removing trapped air from the system. Air pockets within the system can impede proper coolant circulation and reduce heat transfer efficiency.
- **Operation:** Vent lines are typically located at high points in the system, such as the top of the header tank or at high points in the piping circuit. These lines allow trapped air to escape the system as the coolant fills the cavities during initial system filling or after topping up the coolant level. They might also be equipped with one-way valves that allow air to escape but prevent seawater ingress.

may 2021

May 2021 MDE

6. With reference to tube type heat exchangers, explain the purpose of EACH of the following:

(a) baffle plates; (2)

(b) sliding tube plate; (2)

(c) tell tale ring; (2)

(d) vent cock; (2)

(e) anodes. (2)

Tube-Type Heat Exchanger Components and Functions:

Tube-type heat exchangers are widely used in various industries for transferring heat between two fluids. Here's an explanation of the purpose of each component you mentioned:

(a) Baffle Plates:

- **Function:** Baffle plates are thin metal plates strategically positioned within the shell side of the heat exchanger. They disrupt the straight-through flow of the shell-side fluid, forcing it to flow across the tubes multiple times. This increases the number of times the shell-side fluid interacts with the tubes, enhancing heat transfer between the fluids.
- **Benefits:** Baffle plates improve the overall heat transfer efficiency of the exchanger. They also help to distribute the shell-side fluid flow more evenly across the tube bundle, preventing stagnant zones and maximizing heat transfer potential.

(b) Sliding Tube Plate:

- **Function:** Not all tube-type heat exchangers have a sliding tube plate. This feature is typically found in specific designs, such as U-tube heat exchangers. A sliding tube plate allows for the controlled movement of the U-tubes at one end.

- **Purpose:** The sliding tube plate enables thermal expansion and contraction of the U-tubes during temperature changes. This prevents excessive stress on the tubes and the tube joints at the fixed end by accommodating the length variations due to temperature fluctuations.

(c) Tell-Tale Ring:

- **Function:** A tell-tale ring is a small groove or machined channel located on the shell side of the heat exchanger, typically near the tube bundle. It might also be a small drilled hole or passage within the shell.
- **Purpose:** The tell-tale ring acts as a leak detection mechanism. In case a tube develops a leak and allows the inner fluid to mix with the shell-side fluid, the tell-tale ring will provide a path for the leaking fluid to escape the tube bundle area. This leakage can then be visually detected, indicating a potential tube leak within the heat exchanger.

(d) Vent Cock:

- **Function:** A vent cock is a small valve located on the shell side of the heat exchanger, typically at a high point.
- **Purpose:** The vent cock serves two main purposes:
    1. **Air Venting:** During the initial system filling or after maintenance procedures, the vent cock allows trapped air within the shell side to be purged. Air pockets can hinder proper circulation and heat transfer efficiency.
    2. **Pressure Relief:** In case of an unexpected pressure buildup within the shell side due to trapped fluids or other reasons, the vent cock can act as a safety relief valve, releasing excess pressure and preventing damage to the heat exchanger.

(e) Anodes:

- **Function:** Anodes, also known as sacrificial anodes, are consumable metal elements installed within the shell of the heat exchanger. They are typically made from a metal that is more susceptible to corrosion than the tube material.
- **Purpose:** Anodes act as a cathodic protection system. By corroding preferentially, they attract the corrosive elements in the shell-side fluid, protecting the tubes from corrosion. As the anode material corrodes and wears away, it needs to be replaced periodically.

may 2021

May 2021 MDE

5. With reference to the main engine cooling water systems:

   (a) explain the purpose of the header tank; (4)

   (b) explain why both heaters and coolers may be fitted; (4)

   (c) state, with reasons, the type of pumps used. (2)

Main Engine Cooling Water System Components:

(a) Purpose of the Header Tank:

The header tank in a main engine cooling water system plays a crucial role in maintaining proper coolant circulation and pressure:

- **Expansion and Contraction:** Coolant expands as its temperature increases and contracts as it cools down. The header tank provides a dedicated space to accommodate these volume changes. This prevents excessive pressure buildup within the closed-loop system during operation.
- **Air Removal:** The header tank is typically located at a high point in the system. This allows trapped air bubbles to accumulate in the tank, where they can be easily purged through a vent line. Air pockets within the system can impede coolant circulation and reduce heat transfer efficiency.
- **Coolant Level Monitoring:** The header tank often has a transparent section or level indicator which allows for visual monitoring of the coolant level within the system. This helps identify potential leaks or the need for topping up the coolant if the level drops below the recommended operating range.
- **Overflow Prevention:** Some designs incorporate an overflow outlet in the header tank. This prevents overfilling the system in case of a coolant mix error or expansion beyond the tank's capacity. The overflow allows excess coolant to escape and avoid system pressurization issues.

(b) Heaters and Coolers in the System:

The presence of both heaters and coolers in a main engine cooling water system caters to maintaining the optimal engine operating temperature across various conditions:

- **Engine Coolers:** The primary function of the cooling system is to regulate engine temperature and prevent overheating. Engine coolers, often referred to as heat exchangers, utilize various methods (seawater, freshwater/seawater mix, or dedicated coolants) to transfer heat away from the engine and maintain a safe operating temperature range.
- **Engine Heaters:** In cold weather conditions, the engine may take longer to reach its optimal operating temperature, which can lead to inefficient combustion and increased wear. Engine heaters, often utilizing jacket water heating or electrical elements, pre-heat the coolant before

starting the engine. This ensures faster engine warmup, improved efficiency, and reduced wear during cold starts.

**(c) Type of Pumps Used and Reasons:

Centrifugal pumps are the most commonly used type of pump in main engine cooling water systems due to several advantages:

- **Positive Displacement:** Centrifugal pumps continuously move a specific volume of coolant through the system, ensuring sufficient circulation for effective heat transfer.
- **Reliability:** They offer a relatively simple and robust design, with fewer moving parts compared to other pump types, leading to reliable operation and less maintenance downtime.
- **Efficiency:** Centrifugal pumps can achieve good flow rates and pressure head characteristics, efficiently circulating the coolant throughout the system.
- **Self-Priming (in some designs):** Some centrifugal pump designs incorporate self-priming capabilities, allowing them to remove trapped air from the line during initial filling or after maintenance procedures. This simplifies system startup and ensures proper coolant circulation from the beginning.

While other pump types like gear pumps might be used in specific applications, centrifugal pumps generally offer the best combination of reliability, efficiency, and self-priming capabilities for main engine cooling water systems.

oct 2021

October 2021 MDE

2. With reference to air coolers, explain the purpose of EACH of the following:

(a) zinc anodes; (3)

(b) vent cocks; (3)

(c) tube fins. (4)

Air Cooler Components and Functions:

Air coolers utilize the principle of evaporative cooling to provide a cool and refreshing airflow. Here's a breakdown of the purpose of each component you mentioned:

(a) Zinc Anodes:

- **Function:** Zinc anodes are sacrificial elements typically installed within the water tank of an air cooler. They are made of zinc, a metal more susceptible to corrosion than the materials used in the water tank.
- **Purpose:** Zinc anodes act as a cathodic protection system. By corroding preferentially, they attract the corrosive elements present in the water, protecting the water tank from corrosion. As the zinc anode corrodes and wears away, it needs to be replaced periodically during maintenance to ensure continued protection for the water tank.

(b) Vent Cocks:

- **Function:** Vent cocks are small valves typically located on the water tank of an air cooler, often at a high point.
- **Purpose:** Vent cocks serve two main purposes:
    1. **Air Venting:** During the initial filling of the water tank or after maintenance procedures, the vent cock allows trapped air within the tank to be purged. Air pockets in the tank can hinder the water circulation within the system and reduce the effectiveness of the evaporative cooling process.
    2. **Overflow Prevention:** In some designs, the vent cock might also act as a simple overflow mechanism. If the water tank is overfilled, excess water can escape through the vent cock, preventing overflow and potential water damage to the surrounding area.

(c) Tube Fins:

- **Function:** Air cooler heat exchangers consist of a series of thin metal tubes through which water circulates. These tubes are not smooth; they have extended surfaces in the form of fins. The fins can be flat, louvered, or have other shapes depending on the design.
- **Purpose:** Tube fins significantly increase the heat transfer surface area between the circulating water and the surrounding air. This allows the water to absorb more heat from the air passing through the fins as it evaporates. The larger the surface area, the more efficient the heat transfer and the cooler the air exiting the air cooler. The specific fin design can also influence airflow characteristics and overall cooling performance.

jan 2019

January 2019 MDE

6. With reference to diesel engine cooling water:

    (a) explain why the water requires treatment; (6)

    (b) describe the type of treatment that should be used. (4)

(a) Why Treatment is Needed:

Diesel engine cooling water requires treatment to address several potential problems that can arise if left untreated. These problems can significantly impact engine performance, reliability, and lifespan:

- **Corrosion:** Untreated water can be corrosive to the metal components within the engine cooling system, such as cylinder liners, water jackets, and the radiator. This corrosion can lead to leaks, blockages within the system, and ultimately, engine damage.
- **Scale Formation:** Minerals dissolved in the water can precipitate out as scale when the water temperature increases. Scale buildup on heat transfer surfaces within the engine and radiator reduces cooling efficiency and can lead to engine overheating.
- **Biological Growth:** Stagnant water in the cooling system can promote the growth of bacteria, algae, and other microorganisms. This biological growth can clog the system, reduce coolant flow, and even lead to biocorrosion of metal components.
- **Cavitation:** Air bubbles can form and collapse within the coolant under certain conditions. This phenomenon, known as cavitation, can erode metal surfaces within the engine and pump, leading to premature component wear and potential failures.

(b) Cooling Water Treatment:

To address these concerns, a multi-pronged approach to cooling water treatment is typically employed:

- **Corrosion Inhibitors:** These chemicals form a protective film on metal surfaces, hindering the interaction between the water and the metal, and slowing down the corrosion process. Specific inhibitors are chosen based on the water chemistry and system materials.
- **Anti-Scalants:** These chemicals act in two ways:
    - Thresholding agents prevent scale formation by keeping the dissolved minerals dispersed in the water, preventing them from coming out of solution and forming deposits.
    - Dispersants keep any formed scale particles suspended in the coolant, preventing them from accumulating on heat transfer surfaces.
- **Biocides:** These chemicals kill or inhibit the growth of bacteria, algae, and other microorganisms within the cooling system, preventing biofouling and its associated problems. The specific biocide chosen depends on the type of microorganisms likely to be present in the water source.
- **Anti-Cavitation Agents:** These additives can help reduce the formation and collapse of air bubbles within the coolant, mitigating cavitation damage to engine components.

The specific treatment chosen will depend on factors like the engine type, operating environment, and the water quality used in the cooling system. Regular monitoring of the coolant and system condition is crucial to ensure the effectiveness of the chosen treatment program.

jan 2019

January 2019 MDE

7. (a) Describe, with the aid of a sketch, a keel type cooling water system, labelling the MAIN components. (6)

(b) Explain the purpose of EACH of the following in the cooling system:

(i) header tanks; (3)

(ii) vent lines. (1)

(a) Keel Cooling System: Main Components

A keel cooling system is a closed-circuit system utilized for cooling marine engines by transferring heat to seawater. Here are the main components:

- **Heat Exchanger (Keel Cooler):** This is the heart of the system, typically mounted externally on the vessel's hull below the waterline. Engine coolant circulates through tubes or channels within the heat exchanger, transferring heat to the surrounding seawater flowing over the outside.
- **Circulation Pump:** An engine-driven or electrically powered pump is responsible for circulating the coolant through the closed loop within the system.

- **Thermostat:** This valve regulates the coolant temperature by controlling the flow of coolant through the heat exchanger. When the coolant reaches a set temperature, the thermostat opens, allowing coolant to flow through the heat exchanger for cooling.
- **Expansion Tank:** This tank accommodates the volume changes of the coolant due to temperature fluctuations. It also serves as a reservoir for any trapped air within the system.
- **Seawater Inlet and Outlet:** These connections allow seawater to enter the system, flow past the heat exchanger, and exit back into the sea after absorbing heat from the coolant.
- **Shut-Off Valves:** Valves positioned at strategic points in the system allow for isolation of sections for maintenance or repairs.
- **Strainers:** These filters placed on the seawater inlet line prevent debris and marine growth from entering the system and potentially clogging the heat exchanger.

(b) Purpose of Specific Components:

(i) Header Tanks:

There might be one or two header tanks depending on the system design. Here's a breakdown of their functions:

- **Coolant Reservoir and Expansion Space:** The header tank acts as a reservoir for the coolant and provides space for coolant expansion due to temperature changes. This expansion space prevents excessive pressure buildup within the closed loop.
- **Additional Functions:** The header tank may also incorporate features like:
    - **Overflow Outlet:** This allows excess coolant to escape the system and prevent overfilling in case of a coolant mix error or expansion beyond the tank's capacity.
    - **Fill Point:** This allows for refilling or topping up the coolant level in the system.
    - **Level Indicator:** This helps visually monitor the coolant level within the system.

(ii) Vent Lines:

Vent lines play a crucial role in removing trapped air from the system. Air pockets within the system can impede proper coolant circulation and reduce heat transfer efficiency.

- **Location:** Vent lines are typically located at high points in the system, such as the top of the header tank or at high points in the piping circuit.
- **Function:** These lines allow trapped air to escape the system as the coolant fills the cavities during initial system filling or after topping up the coolant level. They might also be equipped with one-way valves that allow air to escape but prevent seawater ingress.

may 2018

May 2018 MDE

6. Sketch a typical diesel engine cooling water system, describing the purpose of EACH component. (10)

oct 2019

October 2019 MDE

7. Sketch a typical diesel engine cooling water system, describing the purpose of EACH component. (10)

A typical diesel engine cooling water system utilizes a closed-loop design to regulate engine temperature and prevent overheating. Here's a breakdown of the main components and their functions:

Components:

1. **Engine Block and Cylinder Head:** These are the primary heat sources within the system. Coolant absorbs heat generated by combustion within the engine block and cylinder head.
2. **Water Jacket:** Passages within the engine block and cylinder head that allow coolant to circulate and absorb heat directly from these hot engine components.
3. **Cooling System Pump (Water Pump):** This pump, typically driven by the engine crankshaft via belt, gears, or an electric motor, circulates the coolant throughout the closed loop.
4. **Thermostat:** This temperature-controlled valve regulates coolant flow. When the coolant reaches a set operating temperature, the thermostat opens, allowing coolant to flow through the radiator for cooling. When the coolant temperature drops below the set point, the thermostat closes, restricting flow to the radiator and allowing the engine to reach its optimal operating temperature faster.
5. **Radiator:** This heat exchanger is the primary cooling component. Hot coolant flows through tubes within the radiator, while air flows across the tubes. The large surface area of the radiator fins promotes heat transfer from the coolant to the surrounding air. A fan may be positioned in front of the radiator to draw air through the fins for more effective heat dissipation, especially at low engine speeds.
6. **Bypass Line:** A pipe that allows coolant to circulate around the radiator when the thermostat is closed. This helps the engine reach operating temperature quickly during startup.
7. **Expansion Tank:** This pressurized tank accommodates the volume changes of the coolant due to temperature fluctuations. As the coolant heats up, it expands, and the excess coolant is stored in the tank. When the coolant cools down and contracts, coolant is drawn back from the tank into the system.
8. **Temperature Sensor:** Monitors the coolant temperature and sends a signal to the engine control unit (ECU) or an indicator gauge on the dashboard.
9. **Hoses and Pipes:** Connect the various components within the system and provide a closed-loop path for coolant circulation.

Purpose of Each Component:

- **Engine Block and Cylinder Head:** Transfer heat to the coolant.
- **Water Jacket:** Provides a passage for coolant to circulate around the hottest areas of the engine.
- **Cooling System Pump:** Maintains continuous coolant circulation.
- **Thermostat:** Regulates coolant flow to maintain optimal engine operating temperature.
- **Radiator:** Transfers heat from the coolant to the surrounding air.
- **Bypass Line:** Allows the engine to warm up quickly.

- **Expansion Tank:** Accommodates coolant volume changes due to temperature variations.
- **Temperature Sensor:** Monitors coolant temperature for control and information purposes.
- **Hoses and Pipes:** Connect the components and provide a closed path for coolant flow.

This is a basic layout, and some systems might incorporate additional components like heaters for cold weather operation, pressure relief valves, or low-level coolant sensors to provide warnings or automatic shutdowns in case of coolant system issues.

oct 2018

October 2018 MDE

6. With reference to diesel engine water coolers:

   (a) describe how performance is measured; (5)

   (b) describe the possible causes of the performance falling off. (5)

(a) Measuring Diesel Engine Water Cooler Performance:

The performance of a diesel engine water cooler is evaluated based on its ability to maintain the engine's optimal operating temperature range. Here are some key metrics used for measurement:

- **Coolant Outlet Temperature:** This is the primary indicator of the water cooler's effectiveness. The coolant exiting the water cooler should be within a specific range specified by the engine manufacturer. A lower coolant outlet temperature indicates better heat dissipation by the water cooler.
- **Coolant Flow Rate:** A sufficient flow rate of coolant through the engine and the water cooler is crucial for effective heat transfer. The recommended flow rate is typically specified by the engine manufacturer and can be measured using flow meters installed in the cooling system.
- **Airflow Rate:** The volume of air passing through the radiator core of the water cooler is essential for heat exchange with the surrounding environment. Airflow rate can be measured using anemometers positioned strategically in front of the radiator.
- **Pressure Drop:** The pressure difference between the coolant inlet and outlet of the water cooler indicates the resistance to flow within the system. A high pressure drop can signify blockages, scaling within the water cooler core, or an undersized unit struggling to handle the coolant flow.

(b) Possible Causes of Performance Decline:

Several factors can contribute to a decrease in the performance of a diesel engine water cooler:

- **Fouling and Blockages:** Dust, debris, and other contaminants can accumulate on the radiator fins and within the water passages, reducing airflow and hindering heat dissipation. Leaves, insects, or even mud buildup can significantly impact airflow. Internal blockages within the water cooler core due to scale formation or corrosion deposits can also impede coolant flow.

- **Deteriorating Fan Performance:** If the fan belt becomes loose or worn, or if the fan itself is damaged or malfunctions, the airflow through the radiator will be reduced, affecting the water cooler's ability to reject heat.
- **Coolant Degradation:** Over time, coolant loses its anti-corrosion and anti-freeze properties. Degraded coolant can lead to internal corrosion within the water cooler core, reducing its heat transfer efficiency. Additionally, low coolant levels can compromise the system's ability to absorb and remove heat from the engine.
- **Incorrect Coolant Mix:** Using an improper coolant concentration or a coolant type not suited for the engine and operating conditions can lead to inefficiencies.
- **Thermostat Issues:** A malfunctioning thermostat can cause the engine to run too hot or too cold. If the thermostat is stuck open, the coolant will continuously circulate through the radiator even when cooling is not required, potentially leading to engine under-temperature operation. Conversely, a stuck-closed thermostat will prevent coolant from reaching the radiator for cooling, causing overheating.
- **Water Cooler Age and Wear:** Over time, the water cooler core can become less efficient due to fin degradation, corrosion, or internal leaks. Regular maintenance and cleaning are crucial to extend the lifespan and performance of the water cooler.

By monitoring the key performance metrics and addressing these potential causes, you can ensure that the diesel engine water cooler maintains optimal engine operating temperature and prevents overheating issues.