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1. (a) Explain why the air outlet from the turbocharger should be cooled before entering the diesel engine cylinder. (4)

   (b) Explain why the charge air cooler has fins attached to its tubes. (2)

   (c) State possible reasons why the charge air coolers performance may be reduced. (4)

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2. (a) With reference to the section of timing chain shown in the figure below, identify the component parts A-E. (5)

   (b) Explain the reasons why chains may elongate or slacken in service and the areas that may wear. (5)

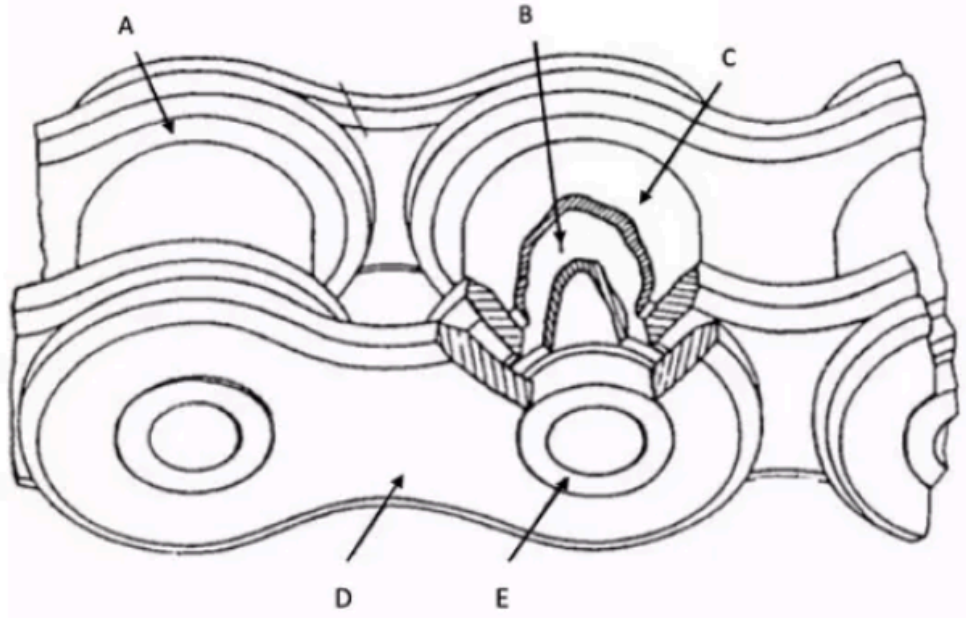

Fig Q2

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3. Describe a procedure for manually testing the set points on diesel generator HT cooling water, high temperature alarm and shut down. (10)

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4. (a) Sketch a scroll type fuel pump, labelling the main components. (6)

(b) Explain how the pump sketched in part (a) may vary the end of delivery. (4)

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5. With reference to diesel engine fuel:

(a) explain the meaning of the term *microbial contamination*; (1)

(b) describe the possible problems the engine may encounter if the fuel received is contaminated with microbes; (4)

(c) explain how *microbial contamination* can be avoided; (3)

(d) explain the actions to be taken if *microbial contamination* is severe. (2)

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6. (a) State FOUR functions of lubricating oil. (4)

(b) Explain EACH of the following terms:

(i) hydrostatic lubrication; (2)

(ii) boundary lubrication. (2)

(c) State ONE advantage and ONE disadvantage of using grease as a lubricant in a plain bearing. (2)

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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)

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8. Describe the possible causes and remedies for EACH of the following diesel engine faults:

(a) low lubricating oil pressure; (3)

(b) overheating; (3)

(c) unstable speed. (4)

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9. With reference to friction clutches, state EACH of the following:

(a) THREE advantages of a wet clutch; (3)

(b) THREE disadvantages of a wet clutch; (3)

(c) ONE advantage of multiple plates; (1)

(d) THREE disadvantages of multiple plates. (3)

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10. With reference to a reduction gearing and pneumatic clutch arrangement of a propulsion system:

(a) state FIVE protection devices fitted; (5)

(b) explain the need for EACH device stated in part (a). (5)

JAN 2023 MDE

1. (a) Explain why the air outlet from the turbocharger should be cooled before entering the diesel engine cylinder. (4)

(b) Explain why the charge air cooler has fins attached to its tubes. (2)

(c) State possible reasons why the charge air coolers performance may be reduced. (4)

Importance and Function of Charge Air Cooling in Diesel Engines:

(a) Cooling Air Before Entering the Cylinder:

Air compressed by the turbocharger heats up significantly due to the compression process. Here's why it's crucial to cool this air before entering the engine cylinder:

- **Denser Air for More Power:** Cooler air is denser, meaning it contains more oxygen molecules per unit volume. This denser air allows for a larger and more efficient fuel burn, resulting in increased engine power output.
- **Reduced Emissions:** High intake temperatures can promote the formation of nitrogen oxides (NOX) in the combustion process. Cooling the air helps to control these emissions and comply with regulations.
- **Improved Efficiency:** Denser air from the intercooler allows for more complete combustion, leading to better fuel efficiency.
- **Reduced Wear and Tear:** Lower intake temperatures reduce thermal stress on engine components like pistons, valves, and cylinder liners, promoting engine longevity.

(b) Fins on Charge Air Cooler Tubes:

Charge air coolers (CACs) typically use a design with fins attached to the tubes for efficient heat transfer:

- **Increased Surface Area:** The fins significantly increase the surface area of the tubes exposed to the cooling air (ambient air or engine coolant). This allows for faster heat transfer from the hot compressed air within the tubes to the cooler air flowing across the fins.
- **Improved Airflow:** The fins are designed to promote efficient airflow over the tubes, maximizing heat transfer effectiveness.

(c) Reduced Charge Air Cooler Performance:

Several factors can lead to a reduction in the effectiveness of a charge air cooler:

- **Blocked Fins:** Dirt, debris, or even insect nests can accumulate on the fins, restricting airflow and hindering heat transfer. Regular cleaning is essential.
- **Internal Fouling:** Over time, the internal passages of the CAC can become clogged with oil deposits or contaminants from the engine. This reduces the flow of compressed air through the cooler.
- **Leaking Coolant (if using Liquid-to-Air CAC):** If the CAC uses liquid coolant for cooling, leaks can reduce the effectiveness of the cooling process.

- **Damaged Fins:** Bent or damaged fins can compromise airflow and heat transfer.

Regular maintenance checks, including cleaning the fins and inspecting for leaks or damage, are crucial for maintaining optimal performance of the charge air cooler.

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2. (a) With reference to the section of timing chain shown in the figure below, identify the component parts A-E. (5)

(b) Explain the reasons why chains may elongate or slacken in service and the areas that may wear. (5)

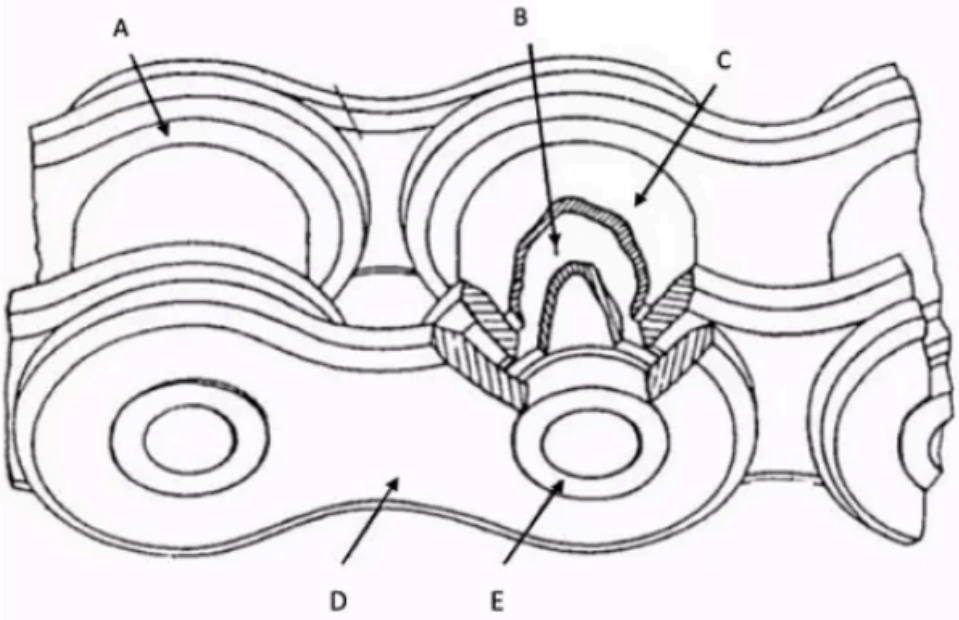

Fig Q2

may 2021However, based on a generic timing chain design, here are the possible components:

- **Link Plate (Chain Body):** The main body of the chain, consisting of alternating flat plates that connect the side plates. (Not labeled in the image)
- **Inner Link Plate:** The inner plate that connects the side plates on the inside of the chain. (Not labeled in the image)
- **Outer Link Plate:** The outer plate that connects the side plates on the outside of the chain. (Not labeled in the image)
- **Side Plate:** The side plates that fit between the link plates and form the chain's sides. They interlock with the sprocket teeth. (Labeled in the image as A and C)
- **Roller:** A cylindrical roller between the side plates that reduces friction as the chain travels over the sprocket teeth. (Labeled in the image as B and D)
- **Bush Pin:** The pin that connects the side plates at each link. (Labeled in the image as E)

It's important to note that the terminology may vary depending on the specific manufacturer or design.

There are several reasons why chains, including timing chains in diesel engines, may elongate or slacken in service:

1. Wear and Stretch:

- **Metal Fatigue:** Over time, the constant cyclical loading and unloading of the chain as it rotates causes metal fatigue. This weakens the metal in the chain links, causing them to elongate slightly.
- **Roller and Bush Pin Wear:** The rollers and bush pins that reduce friction between the chain and sprocket teeth wear down over time. This wear increases the space between links, effectively lengthening the chain.

2. Improper Tension:

- **Incorrect Initial Tension:** If the chain is not tensioned properly during installation, it can be too loose from the start. This allows for additional slack to develop as the chain wears.
- **Tensioner Failure:** The automatic tensioner maintains appropriate chain tension. A malfunctioning tensioner could allow the chain to become too loose.

Areas that may wear:

- **Chain Links:** As mentioned earlier, the link plates themselves experience metal fatigue and can elongate slightly.
- **Rollers and Bush Pins:** These components directly contact the sprocket teeth and are prone to wear. Worn rollers and bush pins increase the space between links, effectively lengthening the chain.
- **Sprocket Teeth:** While less common, the sprocket teeth can also wear down. This wear can cause the chain to ride higher on the teeth, which can contribute to chain slack.
- **Chain Guides:** Worn guides can allow the chain to move excessively, increasing wear on the chain and sprockets.

By understanding these reasons for chain elongation and the areas that wear, mechanics can perform regular inspections to identify potential problems early on. This allows for preventative maintenance such as chain and sprocket replacement before they wear excessively and cause engine performance issues or potential failure.

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3. Describe a procedure for manually testing the set points on diesel generator HT cooling water, high temperature alarm and shut down. (10)

Manually Testing Diesel Generator HT Cooling Water Set Points (Alarm and Shutdown)

Important Notes:

- **Safety First:** Ensure all safety precautions are followed before performing this procedure. Refer to the manufacturer's manual for specific safety instructions related to your generator model.
- **Qualified Personnel:** Ideally, a qualified technician familiar with the generator and its control system should perform this test.
- **Alternatives:** Consult the manufacturer's manual to see if there are alternative methods for testing the set points, such as using diagnostic software or built-in testing functions.

Procedure:

1. **Preparation:**
    - **Generator Off and Secured:** Ensure the generator is completely off and disconnected from any electrical load. Lock out or tag out any switches to prevent accidental startup.
    - **Identify Components:** Locate the HT cooling water temperature sensor, the high-temperature alarm indicator (light or buzzer), and the engine shutdown mechanism (usually a relay or contactor). Refer to the generator manual or electrical schematics for guidance.
    - **Tools:** Gather necessary tools, which might include a reliable thermometer with a range exceeding the expected high-temperature set point, a heat source (optional), safety glasses, gloves, and rags.
2. **Temperature Monitoring:**
    - Start the engine and allow it to run for a short period to reach normal operating temperature. Monitor the coolant temperature using the generator's built-in gauge or your separate thermometer at the designated point (refer to the manual).
3. **Alarm Test:**
    - **Gradual Increase (Preferred Method):** If feasible, gradually increase the coolant temperature using a controlled heat source (e.g., heat lamp) directed towards the cooling system. This allows for observing the alarm activation at the designated set point.
    - **Manual Intervention (Alternative):** If a controlled heat source isn't available, you might carefully simulate a temperature rise by briefly disconnecting the sensor or simulating a high resistance with a resistor (consult a qualified electrician for safe implementation).
    - Monitor the instrument panel or alarm indicator. Once the coolant temperature reaches the alarm set point as specified in the manual, the high-temperature alarm should activate (usually a visual or audible signal).
    - Record the observed temperature at which the alarm activates.
4. **Shutdown Test (Use Caution):**
    - **Important:** Proceed with extreme caution as this test involves stopping the engine. Ensure no critical loads depend on the generator's operation during this test.
    - **Gradual Increase (Preferred Method):** If using a controlled heat source, continue raising the coolant temperature slightly above the alarm set point. Observe if the engine shuts down automatically as programmed.
    - **Manual Intervention (Alternative):** If using manual intervention, keep the sensor disconnected or resistance simulated for a very brief period (seconds) just beyond the alarm set point. The engine control system should trigger a shutdown.
    - Record the observed temperature at which the engine shuts down.
5. **System Reset and Verification:**

- Once the alarm and shutdown functions have been tested, allow the engine to cool down naturally.
- Reconnect the sensor (if disconnected) or restore normal operation if a resistor was used.
- Verify that the engine starts and runs normally after the cooling system temperature has returned to a safe range.

6. **Documentation:**
   - Document the observed alarm and shutdown set points during the test and compare them to the manufacturer's specifications.
   - Document any discrepancies or malfunctions for further investigation or repairs.

Important Reminders:

- Exercise caution during the test, especially during the shutdown simulation.
- Consider alternative testing methods recommended by the manufacturer if available.
- If unsure about any step, consult a qualified technician for safe and proper execution of the procedure.

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4. (a) Sketch a scroll type fuel pump, labelling the main components. (6)

   (b) Explain how the pump sketched in part (a) may vary the end of delivery. (4)

(a) Labeled Sketch:

- **Scroll Housing:** Houses the spiral groove (scroll).
- **Spiral Groove (Scroll):** Helical groove machined inside the housing.
- **Rotor:** Spool-shaped rotor with a tight fit inside the scroll.
- **Eccentric Cam Follower Pin:** Off-center pin on the rotor.
- **Cam Follower Groove:** Groove on the drive sleeve where the pin rides.
- **Drive Sleeve:** Connected to the engine, rotates the rotor.
- **Inlet Port:** Where fuel enters the pump.
- **Outlet Port:** Where fuel exits towards the engine injectors.

(b) Varying End of Delivery

The scroll type fuel pump sketched in part (a) doesn't directly control the "end of delivery" (injection timing) of fuel. Fuel injection timing is typically controlled by a separate mechanism within the engine's fuel injection system.

The scroll pump's function is to **meter the fuel quantity** delivered per engine cycle based on load. Here's how the pump design indirectly affects the end of delivery:

- **High Load:** As explained previously, larger pockets form at high load, delivering more fuel per pump revolution. This **increases the volume of fuel available** for injection during the injection window controlled by the separate injection timing mechanism.

- **Low Load:** Smaller pockets deliver less fuel per revolution, reducing the **amount of fuel available** for injection during the same injection window.

In essence, the scroll pump indirectly influences the end of delivery by providing a **variable fuel quantity** based on load, which can then be injected at the appropriate time determined by the injection timing control system.

JAN 2023 MDE

5. With reference to diesel engine fuel:

(a) explain the meaning of the term *microbial contamination*; (1)

(b) describe the possible problems the engine may encounter if the fuel received is contaminated with microbes; (4)

(c) explain how *microbial contamination* can be avoided; (3)

(d) explain the actions to be taken if *microbial contamination* is severe. (2)

Diesel Engine Fuel and Microbial Contamination:

(a) Microbial Contamination:

Microbial contamination in diesel fuel refers to the presence and growth of microorganisms like bacteria, fungi, and algae within the fuel. These microscopic organisms can thrive in certain conditions and pose problems for the engine and fuel system.

(b) Problems Caused by Microbial Contamination:

Microbial contamination in diesel fuel can lead to several issues for the engine:

- **Blocked Filters:** Microbial colonies and associated biomass can clog fuel filters, restricting fuel flow to the engine and potentially causing power loss or engine stalling.
- **Corrosion:** Certain microbes can produce byproducts like organic acids that contribute to fuel system corrosion, damaging pumps, injectors, and other components.
- **Degraded Fuel Quality:** Microbial activity can break down fuel components, reducing its energy content and hindering combustion efficiency. This can lead to increased fuel consumption and decreased engine power output.
- **Gel Formation:** In cold weather conditions, some microbes can produce gel-like substances that can thicken the fuel, further impeding fuel flow and potentially causing engine startup issues.

(c) Avoiding Microbial Contamination:

Here are some key strategies to prevent microbial contamination in diesel fuel:

- **Minimize Water Ingress:** Water provides a medium for microbial growth. Maintain a water-tight storage system and regularly drain any accumulated water from the fuel tank.
- **Proper Storage Practices:** Store fuel in clean, sealed containers and avoid prolonged storage times, especially in warm and humid conditions.
- **Fuel Filtration:** Utilize appropriate fuel filters that can help trap microbial contaminants before they reach the engine.
- **Biocide Additives:** Consider using biocide fuel additives as a preventative measure. These additives can inhibit the growth of microbes within the fuel.
- **Regular Fuel Testing:** Periodically test fuel samples for signs of microbial contamination.

(d) Actions for Severe Microbial Contamination:

If microbial contamination is identified as severe, here's what to do:

- **Do Not Operate the Engine:** Further running the engine with contaminated fuel can exacerbate problems.
- **Drain and Dispose of Contaminated Fuel:** Safely drain the contaminated fuel from the tank and dispose of it properly according to environmental regulations.
- **Clean the Fuel System:** The fuel tank, lines, and filters need thorough cleaning to remove microbial growth and debris. This might involve using specialized cleaning solutions and procedures.
- **Refill with Clean Fuel:** Only refill the system with fresh, clean fuel after ensuring proper cleaning of the fuel system.
- **Consider System Inspection:** In severe cases, a professional inspection of the fuel system components might be necessary to assess any potential damage caused by the contamination.

By following these preventative measures and taking prompt action when contamination is discovered, you can minimize the risk of engine problems and ensure optimal performance from your diesel engine.

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6. (a) State FOUR functions of lubricating oil. (4)

(b) Explain EACH of the following terms:

(i) hydrostatic lubrication; (2)

(ii) boundary lubrication. (2)

(c) State ONE advantage and ONE disadvantage of using grease as a lubricant in a plain bearing. (2)

Lubricating Oil Functions and Types of Lubrication:

(a) Functions of Lubricating Oil:

Lubricating oil plays a critical role in engine operation by performing several essential functions:

1. **Reduces Friction:** The primary function of lubricating oil is to create a thin film between moving parts, reducing friction and minimizing wear on components. This ensures smooth operation and improves engine efficiency.
2. **Heat Transfer:** Engine operation generates significant heat. Lubricating oil helps transfer heat away from critical components like pistons, rings, and bearings, preventing overheating and potential damage.
3. **Corrosion Protection:** Lubricating oil forms a protective layer on metal surfaces, inhibiting corrosion caused by moisture, combustion byproducts, or acidic contaminants within the engine.
4. **Sealing and Leak Prevention:** In some engines, the lubricating oil film helps to seal clearances between pistons and rings, reducing blow-by of combustion gases and preventing oil leaks.

(b) Types of Lubrication:

(i) Hydrostatic Lubrication:

- **Description:** Hydrostatic lubrication utilizes an external pressure source, such as a pump, to force oil between the bearing surfaces. This pressurized oil film separates the moving parts completely, preventing metal-to-metal contact.
- **Advantages:** This method provides a very effective lubrication regime, offering excellent wear protection and minimal friction. It is well-suited for high load applications.

(ii) Boundary Lubrication:

- **Description:** Boundary lubrication occurs when the lubricating oil film is too thin or the pressure between the bearing surfaces is too high to completely separate them. In this regime, special lubricant additives play a crucial role. These additives form a microscopic protective layer on the metal surfaces, reducing friction and wear even under conditions of partial metal-to-metal contact.
- **Disadvantages:** Boundary lubrication offers less wear protection compared to hydrostatic lubrication and is more susceptible to friction increases under high loads or extreme temperatures.

(c) Grease as a Lubricant in Plain Bearings:

Advantage:

- **Long Service Intervals:** Grease has a thicker consistency than oil and can stay in place for longer periods, requiring less frequent re-lubrication compared to oil in plain bearings. This can be beneficial for applications where access to lubrication points is difficult.

Disadvantage:

- **Heat Dissipation:** Grease generally has a lower heat transfer capacity compared to oil. This can be a disadvantage in high-temperature applications where efficient heat dissipation is crucial for preventing overheating of bearing components.

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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.

3

JAN 2023 MDE

8. Describe the possible causes and remedies for EACH of the following diesel engine faults:

(a) low lubricating oil pressure; (3)

(b) overheating; (3)

(c) unstable speed. (4)

Diesel Engine Faults: Causes and Remedies

Here's a breakdown of possible causes and remedies for the common diesel engine faults you mentioned:

(a) Low Lubricating Oil Pressure:

Causes:

- **Low Oil Level:** Insufficient oil in the crankcase reduces pressure.
- **Worn Oil Pump:** A worn pump may not generate enough pressure.
- **Clogged Oil Filter:** A blocked filter restricts oil flow and reduces pressure.
- **Bearing Wear:** Worn bearings can allow oil to bypass, lowering pressure.
- **Oil Leak:** Leaks from the engine can cause oil loss and pressure drop.

Remedies:

- **Check and Top Up Oil:** Verify oil level and add recommended oil if needed.
- **Inspect and Replace Oil Pump:** If worn, replace the oil pump to restore pressure.
- **Change Oil Filter:** Replace the oil filter with a new one to ensure proper flow.
- **Engine Rebuild/Replacement:** In severe cases, worn bearings may require engine rebuild or replacement.
- **Identify and Fix Oil Leak:** Locate the leak source and repair it to stop oil loss and maintain pressure.

(b) Overheating:

Causes:

- **Low Coolant Level:** Insufficient coolant reduces heat transfer capacity.
- **Faulty Thermostat:** A stuck-closed thermostat prevents coolant from reaching the radiator for proper cooling.
- **Clogged Radiator:** Blockages in the radiator core hinder airflow and coolant circulation.
- **Faulty Fan:** A malfunctioning cooling fan or clutch can reduce airflow over the radiator.
- **Defective Water Pump:** A failing water pump cannot circulate coolant effectively.
- **Excessive Engine Load:** Operating the engine under heavy load for extended periods can lead to overheating.

Remedies:

- **Check and Top Up Coolant:** Verify coolant level and add the recommended coolant if needed.
- **Test and Replace Thermostat:** Check thermostat operation and replace it if stuck closed.
- **Clean or Replace Radiator:** Clear any blockages from the radiator core for optimal airflow.
- **Repair or Replace Cooling Fan/Clutch:** Ensure the fan operates properly and replace if faulty.
- **Inspect and Replace Water Pump:** Check the water pump for leaks or failure and replace if necessary.
- **Reduce Engine Load:** If possible, reduce engine load or operation time under heavy loads to allow for proper cooling.

(c) Unstable Engine Speed:

Causes:

- **Fuel Injection Issues:** Faulty injectors, clogged fuel lines, or a dirty fuel filter can disrupt fuel delivery, causing uneven combustion and unstable engine speed.
- **Air Intake System Problems:** Leaks in the air intake system can introduce unmetered air, affecting the air-fuel mixture and causing unstable engine speed.

- **Governor Malfunction:** A faulty governor, which regulates engine speed, can lead to erratic engine RPM.
- **Turbocharger Problems:** Issues with the turbocharger, such as a sticking wastegate or boost leaks, can affect air intake and lead to unstable speed.
- **Internal Engine Wear:** Worn piston rings, valves, or valve guides can affect compression and contribute to unstable engine speed.

Remedies:

- **Inspect and Service Fuel System:** Check injectors, clean fuel lines, and replace the fuel filter to ensure proper fuel delivery.
- **Identify and Repair Air Intake Leaks:** Locate and seal any leaks in the air intake system to maintain a proper air-fuel mixture.
- **Test and Repair/Replace Governor:** Test the governor operation and consider replacing it if faulty.
- **Diagnose and Fix Turbocharger Issues:** Depending on the problem, repair or replace the turbocharger or its components.
- **Engine Rebuild or Replacement:** In severe cases of internal wear, an engine rebuild or replacement might be necessary.

Remember: These are general causes and remedies. Always consult your engine's specific manual and seek professional help if needed for diagnosis and repairs.

JAN 2023 MDE

9. With reference to friction clutches, state EACH of the following:

(a) THREE advantages of a wet clutch; (3)

(b) THREE disadvantages of a wet clutch; (3)

(c) ONE advantage of multiple plates; (1)

(d) THREE disadvantages of multiple plates. (3)

(a) Advantages of a Wet Clutch (3):

1. **Improved Cooling:** Wet clutches are bathed in engine oil, which helps dissipate heat generated by friction during clutch operation. This is particularly beneficial for high-performance applications or situations involving frequent clutch engagement (e.g., stop-and-go traffic).
2. **Smoother Engagement:** The oil provides a dampening effect, reducing the abruptness of clutch engagement and creating a smoother feeling when starting or shifting gears.
3. **Reduced Wear:** The oil lubricates the clutch plates, minimizing wear and tear on the friction surfaces and extending clutch life.

(b) Disadvantages of a Wet Clutch (3):

1. **Power Loss:** Due to the oil's resistance, there's a slight power loss from the engine to the wheels compared to a dry clutch. This is a trade-off for the benefits mentioned above.

2. **Maintenance:** Wet clutches require periodic oil changes to maintain their lubrication properties and prevent clutch slippage due to contaminated oil.
3. **Messy Service:** Disassembling a wet clutch can be messier because of the engine oil involved compared to a dry clutch.

(c) Advantage of Multiple Plates (1):

1. **Increased Torque Capacity:** By using multiple clutch plates, the total friction surface area is increased. This allows the clutch to handle higher engine torque without slipping, making it suitable for powerful engines.

(d) Disadvantages of Multiple Plates (3):

1. **Increased Weight and Bulk:** More plates add weight and complexity to the clutch assembly compared to a single-plate design.
2. **Gradual Engagement:** With multiple plates, engagement might feel slightly less direct compared to a single-plate clutch due to the need to overcome friction between more surfaces. This can be a subjective feeling, and some riders might prefer a smoother engagement.
3. **Complexity of Adjustment:** Depending on the design, adjusting engagement point or clutch play might involve manipulating multiple components compared to a simpler single-plate setup.

3

JAN 2023 MDE

10. With reference to a reduction gearing and pneumatic clutch arrangement of a propulsion system:

(a) state FIVE protection devices fitted; (5)

(b) explain the need for EACH device stated in part (a). (5)

Protection Devices in a Reduction Gearing and Pneumatic Clutch Propulsion System (a):

Here are five common protection devices found in a reduction gearing and pneumatic clutch arrangement of a propulsion system:

1. **Overload Clutch:** This is a secondary clutch mechanism that automatically disengages when the system experiences excessive torque beyond its normal operating limits. This protects the reduction gears and other drivetrain components from damage due to overload.
2. **Low Oil Pressure Switch:** This switch prevents clutch engagement or disengages the clutch if the lubrication oil pressure falls below a minimum threshold. This safeguards the gears and bearings from wear and tear due to insufficient lubrication.
3. **High Engine Speed Interlock:** This interlock prevents clutch engagement above a certain engine speed (RPM) limit. This protects the clutch components from excessive wear and tear during high-speed engagement.

4. **Air Pressure Warning System:** This system monitors the compressed air supply for the pneumatic clutch and provides an alert if the pressure falls below a safe operating level. This allows the operator to take corrective action before clutch disengagement due to air pressure loss.
5. **Gearbox/Reduction Gearbox Temperature Sensor:** This sensor monitors the temperature of the gearbox or reduction gearbox. If the temperature exceeds a safe limit, an alarm might be triggered, or the system might automatically disengage the clutch to prevent overheating and potential damage.

(b) Explanation for Each Protection Device:

1. **Overload Clutch:** Protects the reduction gears and drivetrain from excessive torque that could cause gear breakage, shaft shearing, or other mechanical failures.
2. **Low Oil Pressure Switch:** Ensures proper lubrication of the gears and bearings to prevent overheating, excessive wear, and potential seizure.
3. **High Engine Speed Interlock:** Prevents clutch engagement at high RPMs where the rapid engagement forces can damage the clutch components and potentially lead to slipping issues.
4. **Air Pressure Warning System:** Allows for early detection of air pressure issues before complete clutch disengagement, preventing sudden loss of propulsion and potential safety hazards.
5. **Gearbox/Reduction Gearbox Temperature Sensor:** Protects the gearbox and reduction gears from overheating, which can lead to gear wear, lubricant breakdown, and potential component failure.

These protection devices work together to ensure safe and reliable operation of the propulsion system by safeguarding against various potential failures.