Nov 2018

1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Nov 2018

2. With reference to a crane operated by a constant pressure hydraulic system incorporating unidirectional, fixed displacement pumps that run continuously, explain EACH of the following:

   (a) the purpose of the accumulator; (2)

   (b) how the hydraulic pressure is regulated; (2)

   (c) how the speed and direction of the hoist motor is varied; (3)

   (d) how the torque available from the hoist motor can be varied. (3)

Nov 2018

3. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:

   (a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)

   (b) sketch a Star connection, showing the relationship between phase and line voltages; (2)

   (c) state the relative speed of both connections; (2)

   (d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

Nov 2018

4. With reference to a solid state (inverter) starter for a 3 phase induction motor:

   (a) explain the starting characteristics of this system; (4)

   (b) list the advantages and disadvantages when compared to conventional starting methods. (6)

Nov 2018

5. (a) Explain EACH of the following refrigeration terms:

   (i) superheated; (2)

   (ii) saturation temperature; (2)

   (iii) sub-cooled. (2)

   (b) Sketch a basic vapour compression refrigeration system, showing the refrigerants condition as explained in part (a). (4)

Nov 2018

6. (a) State THREE types of damper that may be used to control the airflow in an air conditioning system. (3)

   (b) Describe, with the aid of a sketch, an automatic fire damper installed in a vertical air duct or in those that pass through bulkheads designated as fire boundaries. (7)

Nov 2018

7. The lifting arrangement shown in the figure, has two slings, A, with a SWL of 5 tonnes, four slings, B, with a SWL of 2.5 tonnes with a ring and beam each of which have a SWL of 12 tonnes .
Explain the suitability or otherwise of this arrangement for lifting a generator engine, including flywheel, weighing 8.5 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart. (10)

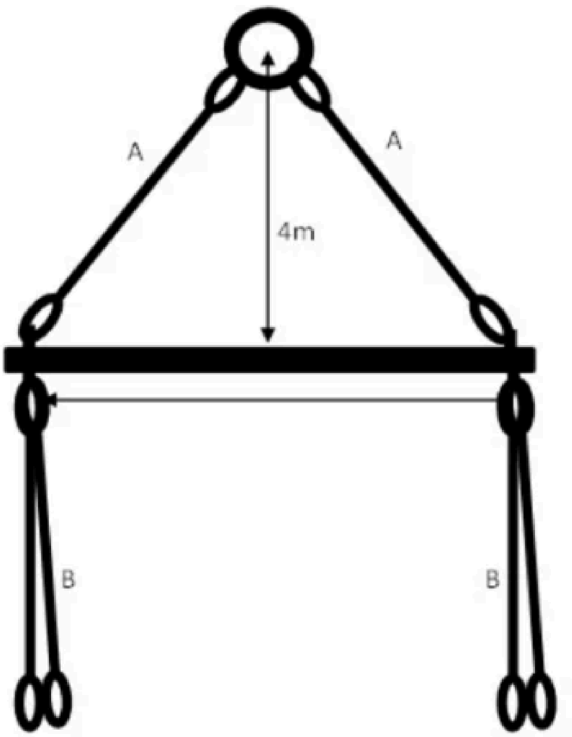

Fig Q7

Nov 2018

8. Describe the procedure that should be followed if an outboard motor has been submerged in sea water. (10)

Nov 2018

9. (a) List THREE defects that may be found during an inspection of a fixed bladed propeller, stating the possible cause of EACH. (6)

(b) State the likely consequences if the defects stated in part (a) are not rectified. (4)

Nov 2018

10. With reference to the application of protective coatings to a vessel's hull:

(a) state the functions that the coating should perform; (3)

(b) state the legislation that applies to certain coatings and what certification is required to comply with it; (2)

(c) outline the process for re-coating the hull of a vessel in drydock. (5)

Nov 2018

1. Describe, with the aid of sketches, how an axial piston pump can vary the volume of liquid it displaces. (10)

Axial piston pumps achieve variable displacement through a clever mechanism involving a swash plate and pistons arranged around it. Here's a breakdown focusing on the key aspects relevant to an engineering exam:

Key Players:

- **Drive Shaft:** Rotates to provide power to the pump.
- **Cylinder Block:** Stationary housing with cylindrical bores where pistons reside.
- **Pistons:** These are axial pistons, meaning their movement is parallel to the drive shaft axis.
- **Swash Plate:** A flat disk positioned at a variable angle relative to the drive shaft axis. Pistons connect to the swash plate via a slipper or yoke, allowing them to tilt.

Varying Displacement with Swash Plate Angle:

1. **Swash Plate Angle:** The angle of the swash plate directly affects the piston stroke length.
2. **Zero Angle:** When the swash plate is perpendicular to the drive shaft (zero angle), the pistons move almost straight up and down with minimal stroke. This results in the **lowest** displacement (volume of liquid moved per rotation).
3. **Increased Angle:** Tilting the swash plate creates an angle between the piston and cylinder block axes. As the angle increases, the piston stroke length grows. This allows for a **larger volume** of fluid to be drawn in and expelled per rotation, leading to higher displacement.

Control Mechanisms (Examples):

- **Hydraulic/Mechanical/Electrical Input:** Depending on the pump design, an external control system adjusts the swash plate angle. This control system can be:
  - **Pressure compensator:** Maintains constant system pressure by adjusting the angle.
  - **Load-sensing control:** Optimizes power delivery by adjusting the angle based on external load.
  - **Joystick control:** Allows for operator control of flow rate by adjusting the angle mechanically or electronically.

Benefits of Variable Displacement:

- **Adjustable Flow Rate:** By controlling the swash plate angle, the pump can deliver a wide range of flow rates to meet the varying demands of the hydraulic system. This improves efficiency and allows for precise control over actuator performance.
- **Energy Saving:** When lower flow rates are required, the pump can adjust its displacement to avoid unnecessary energy consumption.

By understanding the relationship between swash plate angle and piston stroke length, you can grasp how axial piston pumps achieve variable displacement and cater to the dynamic flow requirements in hydraulic systems.

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2. With reference to a crane operated by a constant pressure hydraulic system incorporating unidirectional, fixed displacement pumps that run continuously, explain EACH of the following:

   (a) the purpose of the accumulator; (2)

   (b) how the hydraulic pressure is regulated; (2)

   (c) how the speed and direction of the hoist motor is varied; (3)

   (d) how the torque available from the hoist motor can be varied. (3)

Hydraulic Crane System with Unidirectional Pumps:

Here's an explanation of each aspect of the constant pressure hydraulic system you described, incorporating unidirectional, fixed displacement pumps:

(a) Purpose of the Accumulator:

In a constant pressure system with fixed displacement pumps that run continuously, an accumulator plays a crucial role in:

- **Peak Flow Demands:** The accumulator acts as a reservoir for pressurized hydraulic fluid. During moments when the crane requires a sudden surge of flow for operations like lifting heavy loads or rapid lowering, the accumulator can supplement the pump's output and provide the necessary extra fluid. This helps maintain consistent system pressure and prevents performance dips during peak demands.
- **Smoothing Pressure Fluctuations:** Even with continuous pump operation, there can be minor fluctuations in pressure due to pump inefficiencies or varying flow demands. The accumulator helps absorb these pressure fluctuations, providing a steadier flow of pressurized fluid to the crane's actuators (hoist motor, luffing cylinder, etc.).

(b) How Hydraulic Pressure is Regulated:

A constant pressure system maintains a set pressure level throughout the circuit. Here's how it's achieved:

- **Pressure Relief Valve:** This valve is set to a specific pressure threshold. If the system pressure exceeds this limit due to pump output, the pressure relief valve opens and diverts excess fluid back to the reservoir. This bypass mechanism ensures the pressure doesn't climb above the safe operating limit.
- **Pump Unloading Valve (Optional):** Some systems might incorporate an additional pump unloading valve. This valve can be controlled by the system pressure. When the pressure reaches the desired level, the valve unloads the pump by diverting its output back to the reservoir. This prevents unnecessary energy consumption when the system doesn't require full pump capacity.

(c) How Speed and Direction of the Hoist Motor are Varied:

The speed and direction of the hoist motor (responsible for raising and lowering loads) are typically controlled using a **solenoid-operated directional control valve**. This valve has multiple positions that can be activated by electrical signals from the crane operator's controls. Here's how it works:

- **Center:** Neutral position, fluid flow is blocked within the valve. The hoist motor remains stationary.
- **Port 1:** Directs pressurized fluid to one side of the hoist motor, causing it to rotate in a specific direction (raising the load).
- **Port 2:** Directs pressurized fluid to the opposite side of the hoist motor, causing it to rotate in the opposite direction (lowering the load).
- **Relief:** The valve might have a built-in pressure relief function to bypass excess pressure if needed.

By controlling the direction of fluid flow using the solenoid valve, the operator can change the rotation direction of the hoist motor, achieving raising or lowering of the load. The speed of the motor is primarily controlled by the flow rate of the pressurized fluid. A higher flow rate translates to a faster motor speed (faster lifting or lowering). This flow rate can be indirectly controlled by adjusting the engine speed of the prime mover driving the pump (assuming a variable-speed engine is used).

In some systems, additional components like flow control valves might be introduced to offer more precise control over the flow rate and, consequently, the hoist motor speed.

(d) How Torque Available from the Hoist Motor is Varied:

The torque available from the hoist motor is primarily determined by the system pressure and the displacement of the motor itself. In this constant pressure system:

- **System Pressure:** Since the pressure is maintained at a constant level by the pressure relief valve, it cannot be directly adjusted to vary torque.
- **Hoist Motor Displacement:** The displacement of the hoist motor is a fixed design parameter. A larger displacement motor can inherently generate higher torque compared to a smaller one at the same pressure.

Therefore, in this specific system configuration, the torque available from the hoist motor is limited and cannot be easily varied during operation.

However, some crane designs might incorporate additional features to achieve variable torque, such as:

- **Multiple Speed Motors:** Using a multi-speed hoist motor with different displacement settings allows for selecting a gear that offers the desired torque for the specific load.
- **Variable Displacement Pump (if not a fixed displacement pump):** If the system utilizes a variable displacement pump, the pump output (flow rate and pressure) can be adjusted, indirectly affecting the torque available at the hoist motor.

It's important to note that the specific methods for controlling speed, direction, and torque can vary depending on the crane's design and the manufacturer's chosen control system.

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3. With reference to a 440 Volt, 3-phase motor supplied with six terminal connection in the terminal box:

   (a) sketch a Delta connection, showing the relationship between phase and line voltages; (2)

   (b) sketch a Star connection, showing the relationship between phase and line voltages; (2)

   (c) state the relative speed of both connections; (2)

   (d) sketch and label the terminal link connections so the motor will run in permanent Delta mode. (4)

440V, 3-Phase Motor with Six Terminals: Connection Modes

Here's a breakdown of Delta and Star connections for your 440V, 3-phase motor with six terminals, referencing the relationship between voltages and speed, and explaining how to configure it for permanent Delta mode.

(a) Delta Connection:

- **Description:** In a delta connection, the three motor windings are connected end-to-end, forming a triangular loop. Each winding connects between two line terminals.
- **Voltage Relationship:**
  - Line Voltage (VL): This is the voltage measured between any two of the three lines feeding the motor (VAB, VBC, VCA). In your case, the line voltage is 440V.
  - Phase Voltage (VP): This is the voltage measured across each individual winding (between any line terminal and the connection point of the other two windings). In a delta connection, the phase voltage is equal to the line voltage (Vp = VL = 440V). This is because the line voltage is applied directly across each winding.

(b) Star Connection:

- **Description:** In a star connection, the three motor windings are connected at one end (usually internally within the motor), forming a star shape. The other ends of the windings are connected to the three line terminals. This creates a neutral point at the center of the star.
- **Voltage Relationship:**
  - Line Voltage (VL): Same as delta connection (VL = 440V).
  - Phase Voltage (VP): This is the voltage measured between any line terminal and the neutral point. The phase voltage in a star connection is calculated by dividing the line voltage by the square root of 3 ($V_p = V_L / \sqrt{3}$). For a 440V line voltage, the phase voltage is approximately 254V ($V_p \approx 440V / \sqrt{3}$). This is because the windings are connected in series, and the voltage is divided across them.

(c) Relative Speed:

- **Starting Torque:** Delta connections generally offer a higher starting torque compared to star connections for the same motor. This is because the full line voltage is applied directly across each motor winding phase in delta.
- **Running Speed:** The running speed of the motor remains approximately the same in both delta and star connections, assuming the motor is designed for both configurations. This is because the fundamental synchronous speed of the motor is determined by the number of poles and the line frequency. The connection method primarily affects the starting torque and current.

(d) Permanent Delta Connection:

Since your motor has six terminals (likely three for each winding - U1, U2, V1, V2, W1, W2), configuring it for permanent delta doesn't require any jumpers or links. Here's why:

- In a delta connection, each winding connects between two line terminals.
- With six terminals, you already have three individual connection points for each winding.

Therefore, **leave all six terminals unconnected**. The internal configuration of the motor windings will handle the delta connection without any additional modifications.

Important Note: Always refer to the motor's manufacturer's manual or data plate for specific connection instructions. Modifying motor connections without proper knowledge can damage the motor or pose safety risks. Consult a qualified electrician if you're unsure about the connection process.

Nov 2018

4. With reference to a solid state (inverter) starter for a 3 phase induction motor:

(a) explain the starting characteristics of this system; (4)

(b) list the advantages and disadvantages when compared to conventional starting methods. (6)

Solid-State (Inverter) Starter for a 3-Phase Induction Motor

A solid-state starter, also known as an inverter starter, utilizes power electronics to control the starting and operation of a 3-phase AC induction motor. Here's a breakdown of its starting characteristics, advantages, and disadvantages compared to conventional methods.

(a) Starting Characteristics:

- **Controlled Voltage Ramp:** Unlike a direct-on-line (DOL) start where full voltage is applied to the motor, an inverter starter gradually increases the voltage and frequency applied to the motor during startup. This "soft start" approach offers several benefits:
  - **Reduced Inrush Current:** The gradual voltage ramp limits the initial surge of current drawn by the motor during starting, reducing stress on the electrical system and potential voltage dips.
  - **Limited Torque Control:** In some models, the inverter starter can provide limited control over the starting torque delivered by the motor. This can be beneficial in applications where excessive torque during startup is undesirable.
- **Smooth Acceleration:** The controlled voltage and frequency increase result in a smoother acceleration of the motor, minimizing mechanical stress on the motor and driven equipment.

(b) Advantages compared to Conventional Methods (DOL Start):

- **Reduced Stress on Electrical System:** The lower inrush current during starting with a soft start helps protect electrical components like transformers and cables from wear and tear.
- **Improved Power Quality:** By limiting the inrush current, inverter starters can minimize voltage dips on the power line, improving overall power quality for other equipment connected to the system.
- **Reduced Mechanical Stress:** The smooth acceleration minimizes mechanical stress on the motor's bearings, shaft, and couplings, leading to potentially longer motor life.
- **Limited Torque Control (in some models):** The ability to control starting torque can be beneficial in applications such as conveyors or pumps where high starting torque might cause issues with the driven load.

(c) Disadvantages compared to Conventional Methods (DOL Start):

- **Higher Initial Cost:** Inverter starters typically have a higher initial cost compared to a simple DOL starter due to the more complex power electronics involved.
- **Increased Complexity:** The inverter starter requires additional control circuitry and components, introducing a potential single point of failure compared to a simple contactor-based DOL starter.

- **Potential for Harmonic Distortion:** Depending on the design of the inverter starter, the switching of the power electronics can introduce harmonic distortion into the power supply. This might require additional filtering to meet power quality standards in some cases.

In conclusion, solid-state starters offer significant advantages over conventional DOL starts for 3-phase induction motors. However, their higher cost and increased complexity need to be considered when making a selection for a specific application.

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5. (a) Explain EACH of the following refrigeration terms:

(i) superheated; (2)

(ii) saturation temperature; (2)

(iii) sub-cooled. (2)

(b) Sketch a basic vapour compression refrigeration system, showing the refrigerants condition as explained in part (a). (4)

Refrigeration Terms and Vapour Compression Cycle

(a) Refrigeration Terms:

(i) Superheated:

- **Definition:** In a refrigeration system, a substance is considered superheated when its temperature is **higher than its saturation temperature** at a given pressure. Saturation temperature refers to the temperature at which a substance changes its state (e.g., liquid to vapor) for a specific pressure.
- **Application:** Superheat is typically used in reference to the condition of refrigerant vapor leaving the evaporator coil in a vapor compression refrigeration cycle. The superheated vapor ensures all the liquid refrigerant has evaporated in the evaporator before reaching the compressor, preventing liquid from entering the compressor which can cause damage.

(ii) Saturation Temperature:

- **Definition:** The saturation temperature is the specific temperature at which a substance transitions between its liquid and vapor phases for a given pressure.
- **Application:** In refrigeration, the saturation temperature of the refrigerant is crucial for determining its ability to absorb heat in the evaporator and release heat in the condenser. The refrigerant absorbs heat at its saturation temperature in the evaporator, causing it to evaporate.

(iii) Sub-cooled:

- **Definition:** Sub-cooled refers to a liquid state where the temperature of the liquid is **lower than its saturation temperature** at the current pressure.
- **Application:** Sub-cooling is less common in typical vapor compression refrigeration systems. In some specialized applications, sub-cooling can be used to improve the efficiency of the system by ensuring all the refrigerant remains a liquid before entering an expansion valve.

(b) Basic Vapour Compression Refrigeration System with Refrigerant States:

A vapor compression refrigeration system utilizes a closed loop circulation of refrigerant to achieve cooling. Here's a breakdown of the cycle with explanations of the refrigerant's condition at each stage, referring to the terms explained in part (a):

1. **Evaporator Coil:** Warm air from the space being cooled is drawn across the evaporator coil by a fan. The refrigerant inside the evaporator coil is at a low pressure and a temperature **below** the saturation temperature of the refrigerant at that pressure. This allows the refrigerant to absorb heat from the warm air, causing the air to cool down. As the refrigerant absorbs heat, it evaporates and becomes a **superheated vapor**.
2. **Suction Line:** The low-pressure, superheated vapor refrigerant exits the evaporator and travels through the suction line towards the compressor.
3. **Compressor:** The compressor draws in the low-pressure refrigerant vapor and compresses it. This compression process increases the pressure and temperature of the refrigerant vapor.
4. **Discharge Line:** The high-pressure, high-temperature refrigerant vapor exits the compressor and travels through the discharge line towards the condenser.
5. **Condenser Coil:** The hot, high-pressure refrigerant vapor enters the condenser coil. Here, the refrigerant releases heat to the surrounding air (air-cooled condenser) or water (water-cooled condenser). As the refrigerant loses heat, it condenses back into a liquid state. Ideally, the refrigerant condenses completely at a temperature slightly **above** its saturation temperature at the condenser pressure.
6. **Liquid Line:** The high-pressure liquid refrigerant exits the condenser and travels through the liquid line.
7. **Expansion Valve (or Throttling Device):** The expansion valve is a small device that regulates the pressure of the refrigerant. As the high-pressure liquid refrigerant passes through the expansion valve, it experiences a sudden pressure drop. This pressure drop causes the liquid to partially vaporize (flashing) and its temperature to decrease significantly. The refrigerant exits the expansion valve as a mixture of liquid and vapor, with the liquid portion at a temperature **below** its saturation temperature at the lower pressure exiting the valve.
8. **Repeat:** The cold liquid-vapor mixture then enters the evaporator coil, and the cycle repeats continuously.

By understanding the superheated, saturation temperature, and sub-cooled states of the refrigerant, we can analyze the performance and efficiency of a vapor compression refrigeration system. 2018

Nov 2018

6. (a) State THREE types of damper that may be used to control the airflow in an air conditioning system. (3)

(b) Describe, with the aid of a sketch, an automatic fire damper installed in a vertical air duct or in those that pass through bulkheads designated as fire boundaries. (7)

You've got a great understanding of air conditioning dampers and fire safety! Here's the information again:

(a) Three Types of Airflow Control Dampers:

1. **Blade Dampers:** These are the most common type. They consist of a metal blade that pivots within the duct to regulate airflow. The blade angle can be manually adjusted or controlled by a motor for automated operation.
2. **Butterfly Dampers:** These resemble a butterfly valve, with a disc-shaped metal plate rotating on a central axis within the duct. The disc position controls the amount of airflow through the duct. They are often used for complete shutoff or to regulate high-pressure airflow.
3. **Volume Control Dampers (VCDs):** These are specially designed dampers that maintain a constant air pressure throughout the duct system regardless of the damper position. They are particularly useful for balancing airflow in complex duct networks.

(b) Automatic Fire Damper in Air Ducts:

An automatic fire damper is a crucial safety device installed in air conditioning systems to prevent the spread of fire and smoke through ventilation ducts. They are typically located:

- **Vertical air ducts:** These are vertical shafts within the building that carry conditioned air to different floors. Fire dampers are installed at regular intervals along the vertical duct to isolate any fire section.
- **Ducts passing through bulkheads designated as fire boundaries:** Bulkheads are vertical walls within a building that can act as fire barriers. Fire dampers are installed where air ducts penetrate these fire-rated bulkheads to prevent flames and smoke from traveling through the duct system to other compartments.

Functioning of a Fire Damper:

- **Normal Operation:** During normal operation, the fire damper blade remains open, allowing conditioned air to flow freely through the duct.
- **Fire Detection:** When a fire is detected (through heat sensors or smoke detectors), a signal is sent to a fusible link or electrical mechanism connected to the damper blade.
- **Automatic Closure:** The fusible link melts or the electrical mechanism activates, causing the damper blade to automatically close and seal the duct opening. This isolates the fire and smoke within the affected zone, preventing them from spreading to other parts of the building through the ductwork.

Importance of Fire Dampers:

Fire dampers play a vital role in building safety by:

- **Compartmentalization:** They compartmentalize the building by isolating fire and smoke within a specific zone, preventing them from traveling through the ventilation system.
- **Life Safety:** By containing the fire and smoke, fire dampers help protect occupants by providing them with more time to evacuate safely.
- **Reduced Property Damage:** Limiting the spread of fire and smoke minimizes damage to unaffected areas of the building.

Note: Fire dampers require regular inspection and maintenance to ensure they function properly in case of a fire emergency.

Nov 2018

7. The lifting arrangement shown in the figure, has two slings, A, with a SWL of 5 tonnes, four slings, B, with a SWL of 2.5 tonnes with a ring and beam each of which have a SWL of 12 tonnes .
Explain the suitability or otherwise of this arrangement for lifting a generator engine, including flywheel, weighing 8.5 tonnes that has certified lifting points, 2 at each end of the entablature, 6 m apart. (10)

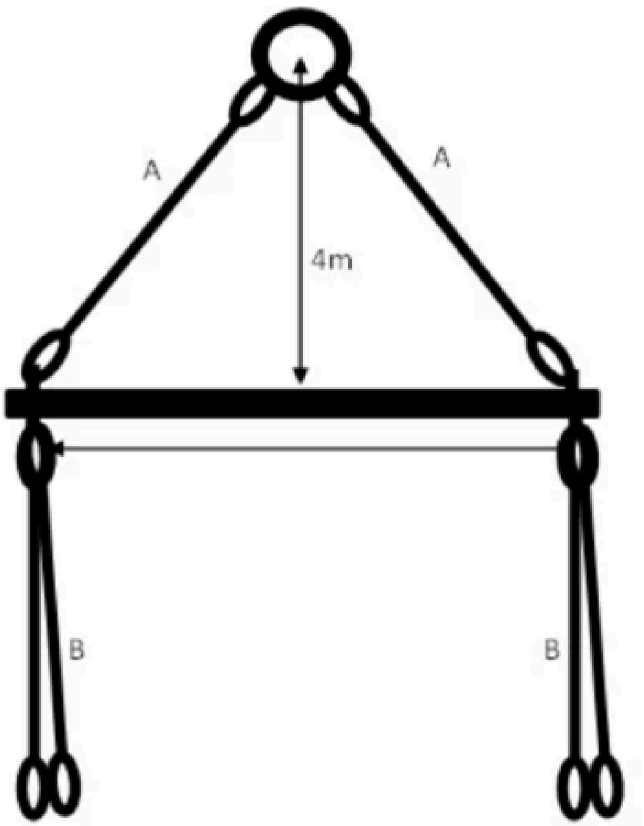

Fig Q7

Sept 2021May 2021Based on the information provided and the image of the lifting arrangement, the lifting arrangement **might be suitable** for lifting the 8.5-tonne generator engine, but a more detailed analysis is needed to confirm. Here's a breakdown of the factors to consider:

Available Lifting Capacity:

- Total capacity of slings A: 2 slings * 5 tonnes/sling = 10 tonnes
- Total capacity of slings B: 4 slings * 2.5 tonnes/sling = 10 tonnes

- Minimum capacity of ring and beam (whichever is lower): 12 tonnes

At first glance, it appears there's sufficient capacity:

- Minimum sling capacity (A or B) + ring/beam capacity = 10 tonnes + 12 tonnes = 22 tonnes
- This is greater than the weight of the engine (8.5 tonnes).

However, we need to consider additional factors:

- **Derating factor (if applicable):** Some slings might have a derating factor applied depending on the lifting angle. This reduces their safe working load (SWL) at angles other than vertical. Check the sling specifications for any derating factors.
- **Weight distribution:** Since there are slings at both ends (6 meters apart) with a spreader beam, the weight distribution might not be perfectly equal. This can affect the loading on each sling. A proper sling angle calculator should be used to determine the exact load on each sling considering the spreader beam configuration and lifting angle.
- **Lifting point limitations:** The certified lifting points on the engine might have a lower capacity than the slings or ring/beam. Verify the lifting capacity specified by the engine manufacturer for the designated lifting points.

Based on these considerations:

- If there's no derating factor for the slings at the intended lift angle,
- The weight is evenly distributed between the slings due to the spreader beam, and
- The engine's lifting points can handle the load,

then the lifting arrangement appears suitable.

Recommendations:

- Consult a qualified lifting professional to assess the specific lifting arrangement and ensure it complies with relevant regulations.
- Use a sling angle calculator to determine the exact load on each sling based on the spreader beam configuration and lifting angle. Refer to the image you sent for the spreader beam configuration details.
- Verify the lifting capacity of the engine's certified lifting points as specified by the manufacturer.
- Never exceed the SWL of any lifting component in the arrangement.

Additional Considerations:

- **Spreader Beam:** Ensure the spreader beam used has a sufficient capacity and is suitable for the lifting points on the engine. The spreader beam in the image appears to be a double beam spreader beam, which can help with equal distribution of the load between the slings.
- **Rigging:** Double-check all rigging components (shackles, hooks, etc.) for compatibility and adequate capacity.
- **Inspection:** Before lifting, ensure all slings, spreader beam, and other lifting equipment are thoroughly inspected for any signs of damage or wear and tear.

By carefully considering these factors and consulting with a lifting professional, you can ensure the safe and successful lifting of the generator engine.

Nov 2018

8. Describe the procedure that should be followed if an outboard motor has been submerged in sea water. (10)

Here's the procedure you should follow if an outboard motor has been submerged in seawater:

Immediate Actions:

1. **Safety First:** Ensure your own safety and the safety of others by turning off the engine (if still running) and disconnecting the battery to prevent electrical hazards.
2. **Retrieve the Engine:** If possible, retrieve the outboard motor from the water as soon as possible. Saltwater exposure can accelerate corrosion.

Prevent Further Damage:

1. **Do Not Start the Engine:** Resist the urge to start the engine. Starting a submerged engine can cause internal damage by forcing saltwater through the system.
2. **Flush with Fresh Water:** As soon as possible, thoroughly flush the outboard motor with clean, fresh water. This will help remove saltwater residue and prevent corrosion. You can use a garden hose with a moderate spray pattern to avoid damaging internal components.

Detailed Cleaning and Inspection:

1. **Drain Fluids:** Drain the engine oil, gear oil, and any other fluids that may have been contaminated with saltwater.
2. **Spark Plugs:** Remove the spark plugs and allow the cylinders to drain any trapped water. You can crank the engine slowly with the spark plugs removed to further expel water.
3. **Air Intake:** Inspect the air intake for any water ingress. Remove any water or debris that may have entered the air filter.
4. **Corrosion Prevention:** Apply a light coating of corrosion inhibitor spray to all metal surfaces after rinsing with fresh water.

Maintenance and Restart:

1. **Professional Inspection:** It's highly recommended to have a qualified outboard mechanic inspect the engine for any internal damage caused by the submersion. They can assess the condition of bearings, seals, and other critical components.
2. **Oil Change:** Replace the engine oil and gear oil with fresh lubricants after the inspection.
3. **Refill Fluids:** Refill any other fluids that were drained during the cleaning process.
4. **Test and Restart:** Only after a thorough inspection and any necessary repairs, attempt to restart the engine. Follow the manufacturer's recommended procedures for starting the engine after submersion.

Additional Considerations:

- **Freshwater vs. Saltwater Submersion:** While these steps provide a general guideline, the specific actions might differ slightly depending on whether the submersion occurred in freshwater or saltwater. Saltwater is more corrosive, so a more meticulous freshwater flush and inspection may be necessary.

- **Severity of Submersion:** The extent of the cleaning and inspection procedure may also depend on the severity of the submersion. A complete submersion for an extended period will likely require a more comprehensive inspection than a brief dunk.
- **Manufacturer's Recommendations:** Always refer to the owner's manual for your specific outboard motor model for any specific instructions or recommendations regarding submersion and recovery procedures.

Following these steps promptly after submersion can help minimize damage to your outboard motor and increase the chances of a successful recovery. However, a professional inspection by a qualified mechanic is highly recommended to ensure the engine's safety and performance after a saltwater submersion.

Nov 2018

9. (a) List THREE defects that may be found during an inspection of a fixed bladed propeller, stating the possible cause of EACH. (6)

(b) State the likely consequences if the defects stated in part (a) are not rectified. (4)

Fixed-Bladed Propeller Inspection Defects and Consequences

(a) Potential Defects During Inspection:

1. **Nicks or Dings on Leading Edges:**
- **Possible Cause:** Impact with floating debris, grounding incidents, or cavitation erosion.
- Nicks or dings can disrupt smooth water flow over the blade, affecting propeller efficiency and potentially causing vibration.
2. **Bent or Twisted Blades:**
- **Possible Cause:** Hitting underwater obstacles, collision with another vessel, or severe vibration.
- Bent or twisted blades can cause significant imbalance, leading to excessive vibration, reduced thrust, and potential damage to bearings and shaft.
3. **Surface Cracks:**
- **Possible Cause:** Metal fatigue from cyclic loading, stress concentration points due to nicks or repairs, or corrosion.
- Cracks can compromise the structural integrity of the blade, potentially leading to blade failure and catastrophic consequences.

(b) Consequences of Unrectified Defects:

1. **Nicks or Dings:**
- **Reduced propeller efficiency:** The propeller will require more power to maintain the same vessel speed.
- **Increased vibration:** Uneven water flow over the blades can cause vibration, potentially damaging other components.
- **Potential for further damage:** Nicks can worsen over time due to erosion or fatigue, leading to more serious issues.
2. **Bent or Twisted Blades:**

- **Severe vibration:** This can damage bearings, shaft alignment, and other engine components.
- **Reduced thrust:** Bent or twisted blades may not generate optimal thrust, affecting vessel performance.
- **Loss of control:** In extreme cases, severe blade imbalance can lead to difficulty steering or maneuvering the vessel.

3. **Surface Cracks:**

- **Blade failure:** If left unrepaired, cracks can propagate and lead to complete blade failure. This can cause significant damage to the vessel, nearby equipment, and potential injuries.
- **Unbalanced propeller:** A broken blade will cause severe imbalance and potentially damage other drivetrain components.

It's crucial to address any defects found during a fixed-bladed propeller inspection promptly to maintain propeller efficiency, prevent further damage, and ensure safe vessel operation.

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Nov 2018

10. With reference to the application of protective coatings to a vessel's hull:

(a) state the functions that the coating should perform; (3)

(b) state the legislation that applies to certain coatings and what certification is required to comply with it; (2)

(c) outline the process for re-coating the hull of a vessel in drydock. (5)

Protective Coatings for Ship Hulls: Functions, Regulations, and Re-coating Process

(a) Functions of a Ship Hull Coating:

A well-applied protective coating system for a ship's hull serves several critical functions:

- **Corrosion Protection:** The primary function is to protect the hull steel from corrosion caused by seawater exposure and atmospheric conditions. The coating acts as a barrier, isolating the steel from the corrosive environment.
- **Biofouling Control (Antifouling):** Marine organisms like barnacles, algae, and mussels can attach themselves to the hull, increasing drag and reducing fuel efficiency. Antifouling coatings are designed to deter or slow down the growth of these organisms, thereby maintaining smooth hydrodynamic performance.
- **Improved Fuel Efficiency:** A smooth, clean hull coated with an antifouling paint experiences less frictional resistance from water compared to a fouled hull. This translates to improved fuel efficiency and reduced emissions.
- **Aesthetic Appearance:** Coatings provide a uniform and aesthetically pleasing appearance to the hull. They can also be used for signage and identification purposes.

(b) Legislation and Certification:

International Maritime Organization (IMO) regulations play a significant role in ship hull coatings. The key regulation is the **International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS Convention)**. This convention aims to minimize the introduction of harmful organisms and chemicals into the marine environment through antifouling systems.

- **Compliance Requirements:** The AFS Convention regulates the use of certain biocidal compounds in antifouling coatings. Vessels may be required to use specific coating types that comply with the latest regulations.
- **Certification:** To demonstrate compliance with the AFS Convention, vessels may need to carry an **International Anti-Fouling System Certificate (IASC)**. This certificate verifies the type of antifouling coating used and ensures it meets the convention's requirements. Issuance of the IASC typically involves surveys by authorized classification societies.

(c) Re-coating Process in Drydock:

Re-coating a ship's hull in drydock involves a multi-step process to ensure a high-quality and long-lasting coating application:

1. **Preparation:** The vessel enters a drydock where the hull becomes fully accessible for inspection and work. All previous coating layers are carefully removed through mechanical abrasion (blasting or grinding) or chemical stripping. The exposed hull steel is then thoroughly cleaned and high-pressure washed to remove debris, contaminants, and salts.
2. **Surface Repair:** Any damages to the hull steel such as dents, cracks, or areas of corrosion are repaired by welding or applying epoxy fillers to ensure a smooth and sound surface for coating application.
3. **Coating Application:** Several layers of paint are applied to the prepared hull surface in a controlled environment with appropriate temperature and humidity conditions. The specific coating system used will depend on the vessel type, operating profile, and regulatory requirements. Typically, a primer coat is applied first, followed by multiple layers of antifouling paint and a topcoat for protection and aesthetics.
4. **Inspection and Quality Control:** Each coating layer is thoroughly inspected for thickness, uniformity, and absence of defects before applying the subsequent