058-01 - APPLIED MARINE ENGINEERING

FRIDAY, 04 March 2022

1400-1600 hrs

APPLIED MARINE ENGINEERING

Attempt ALL questions
Marks for each part question are shown in brackets

1. (a) Outline THREE disadvantages of using aluminium in vessel construction. (3)

   (b) Outline THREE advantages of using steel in vessel construction. (3)

   (c) Outline FOUR conditions necessary in the preparation of steel surfaces prior to painting, to ensure a good surface finish. (4)

2. With reference to the case hardening of bearing journals:

   (a) explain why this process may be carried out; (2)

   (b) describe EACH of the following processes:

      (i) induction hardening; (3)

      (ii) nitriding; (3)

   (c) explain why the processes described in part (b) are best suited to this application. (2)

3. (a) Explain EACH of the following terms:

      (i) plasticity; (2)

      (ii) sheer stress; (2)

      (iii) Young's modulus; (2)

      (iv) safety coefficient (factor of safety). (2)

   (b) State TWO factors that may influence the safety coefficient in operation. (2)

4. State, with reasons, a different welding/brazing/soldering process that is best suited to effect EACH of the following situations:

(a) joining two lengths of aluminium bronze seawater pipe, both pipes having the same diameter; (2)

(b) attaching a stainless steel handrail to a steel hull; (2)

(c) re-attach a section of broken flange on a cast iron pump casing; (2)

(d) attaching a brass flange onto a stainless steel pipe; (2)

(e) attaching a 1.0 mm steel section to 10 mm thick deckhead plate. (2)

5. A vessel has been laid up for a considerable time with shore power connected. Routine underwater hull inspections reveal an unusually high deterioration rate of the vessel's anodes. Assuming the dockside wiring, shore power connections and bonding systems are all in good condition and correctly connected:

(a) explain how this may occur; (8)

(b) state TWO devices that should be fitted to prevent this situation occurring. (2)

6. With reference to the cathodic protection of hull fittings:

(a) explain how sacrificial anodes achieve this; (2)

(b) state where sacrificial anodes would be fitted and why; (4)

(c) describe an impressed current system, stating the principle on which it works. (4)

7. Describe, with the aid of a sketch, a floatation device that produces an output signal to remotely control the liquid level in a tank. (10)

8. With reference to capacitance probe sensors:

(a) describe, with the aid of a sketch, how a capacitance probe produces an output which can be used to measure the liquid level in a tank. (7)

(b) state TWO different uses of this device on a vessel; (2)

(c) state ONE disadvantage of this type of probe. (1)

9. (a) Describe, with the aid of a sketch, the principle and operation of a potentiometer. (6)

(b) Explain how a potentiometer can be used to measure rotary movement. (4)

10. (a) Define EACH of the following terms:

(i) cascade control; (4)

(ii) split range control. (3)

(b) Describe possible problems associated with *split range control* used for the control of a main engine cooling system. (3)

1. (a) Outline THREE disadvantages of using aluminium in vessel construction. (3)

(b) Outline THREE advantages of using steel in vessel construction. (3)

(c) Outline FOUR conditions necessary in the preparation of steel surfaces prior to painting, to ensure a good surface finish. (4)

1. Outline three disadvantages of using aluminum in vessel construction.
2. Outline three advantages of using steel in vessel construction.
3. Outline four conditions necessary in the preparation of steel surfaces prior to painting, to ensure a good surface finish.

The relative importance of different factors (such as cost, weight, or strength) may vary depending on the type of vessel being built.

Here are some general ideas to get you started:

Disadvantages of using aluminum in vessel construction:

- Higher cost: Aluminum is generally more expensive than steel, which can be a major disadvantage for large vessels.
- Lower strength: Aluminum is not as strong as steel, so it may not be suitable for all applications. For example, it may not be strong enough to withstand the forces of heavy seas or ice.
- More difficult to weld: Aluminum can be more difficult to weld than steel, which can increase the cost and complexity of construction.

Advantages of using steel in vessel construction:

- Lower cost: Steel is generally less expensive than aluminum, which can be a major advantage for large vessels.
- Higher strength: Steel is stronger than aluminum, so it is better suited for applications where strength is important.
- Easier to weld: Steel is easier to weld than aluminum, which can reduce the cost and complexity of construction.

Conditions necessary for preparing steel surfaces prior to painting:

- Surface must be clean and free of dirt, grease, and oil. This is essential for ensuring that the paint adheres properly to the steel.
- Surface must be rough enough to provide a good "tooth" for the paint. This can be achieved by sandblasting or other methods.
- Surface must be dry. Moisture can prevent the paint from adhering properly.
- Steel must be at the correct temperature. Painting should not be done if the steel is too hot or too cold.

2. With reference to the case hardening of bearing journals:

   (a) explain why this process may be carried out; (2)

   (b) describe EACH of the following processes:

      (i) induction hardening; (3)

      (ii) nitriding; (3)

   (c) explain why the processes described in part (b) are best suited to this application. (2)

a)

Reasons for Case Hardening:

Case hardening is often applied to bearing journals for several key reasons:

- Improved Surface Hardness: The outer layer of the journal is significantly hardened, enhancing its resistance to wear and tear from rolling contact with other bearing components. This reduces friction and prolongs the lifespan of the bearing.
- Fatigue Resistance: Case hardening strengthens the surface against subsurface stresses and cracks caused by repeated loading and unloading. This improves the bearing's resistance to fatigue failure, a common cause of bearing degradation.
- Toughness Retention: While the surface is hardened, the core of the journal remains relatively soft and tough. This combination maintains the bearing's shock absorption capability and prevents brittle failure under high impact loads.
- Reduced Friction: The hardened surface offers smoother contact with other bearing components, leading to reduced friction and heat generation. This can improve energy efficiency and operational temperature control within the bearing system.

(b) Heat Treatment Processes:

(i) Induction Hardening:

- Process: An alternating current coil generates an electromagnetic field that induces localized heating in the journal surface. This allows for precise control of the hardened zone depth and temperature. Quenching can be done with water, oil, or even air depending on the desired properties.
- Advantages: Highly localized heating minimizes distortion and heat-affected zone, ideal for bearing journals. Fast heating and quenching offer excellent process control and repeatability. Can be easily automated for consistent results.

(ii) Nitriding:

- Process: The journal is exposed to a nitrogen-rich atmosphere at high temperatures (around 400-550°C). Nitrogen diffuses into the surface, forming a hard and wear-resistant iron nitride compound. No quenching is required.
- Advantages: Nitrided layer provides superior corrosion resistance and high-temperature performance compared to other case hardening methods. No quenching minimizes distortion and thermal stress. Suitable for applications with moderate impact loads.

(c) Suitability for Bearings:

Induction hardening and nitriding are particularly well-suited for case hardening of bearing journals due to their specific advantages:

- Precise Control: Both methods offer precise control over the hardened zone depth and temperature, ensuring optimal wear resistance and core toughness balance. This is crucial for maximizing bearing performance and lifespan.
- Minimal Distortion: Both processes minimize distortion due to localized heating or the absence of quenching, maintaining the critical dimensional accuracy of the journal for proper bearing operation.
- Fatigue Resistance: The hardened surface created by both methods enhances fatigue resistance against cyclic loading, a major concern for bearing components.
- Additional Benefits: Nitriding offers the bonus of corrosion resistance and high-temperature performance, while induction hardening allows for fast and automated processing.

Overall, induction hardening and nitriding provide effective and versatile solutions for case hardening bearing journals, contributing to their enhanced wear resistance, fatigue strength, and operational efficiency.

3. (a) Explain EACH of the following terms:

(i) plasticity; (2)

(ii) sheer stress; (2)

(iii) Young's modulus; (2)

(iv) safety coefficient (factor of safety). (2)

(b) State TWO factors that may influence the safety coefficient in operation. (2)

(i) Plasticity:

Plasticity refers to the property of a material to undergo permanent deformation (change in shape and size) under applied stress and retain that deformation even after the stress is removed. Unlike elastic materials, plastic materials do not fully return to their original shape. Imagine bending a paperclip; it bends permanently after force is applied, which demonstrates plasticity.

(ii) Shear Stress:

Shear stress is the internal force per unit area acting tangentially to deform a material. It arises from forces trying to slide one layer of material past another. Think of pushing your hands against opposite sides of a deck of cards – the cards experience shear stress trying to slide past each other.

(iii) Young's Modulus:

Young's modulus, also known as the modulus of elasticity, measures the stiffness of a material. It quantifies the relationship between applied stress and the resulting strain (deformation). A higher Young's modulus indicates a stiffer material, requiring more force to deform it by the same amount. Think of steel vs. rubber; steel has a higher Young's modulus and is stiffer than rubber.

(iv) Safety Coefficient (Factor of Safety):

The safety coefficient, often denoted by "F", is a design principle used to ensure the safe operation of structures and systems. It is a multiplier applied to the allowable stress (maximum stress a material can handle before failure) to determine the design stress the material should be subjected to. By using a safety coefficient greater than 1, we account for potential uncertainties and variations in material properties, loading conditions, and manufacturing processes. Imagine building a bridge; multiplying the allowed load by a safety factor of 2 ensures the bridge can handle twice the expected load, providing a margin of safety.

Factors Influencing Safety Coefficient:

(a) **Material Properties:** Variations in material properties like strength, ductility, and fatigue resistance can impact the safety coefficient. A material with lower strength might require a higher safety factor to compensate for its reduced capacity to handle loads.

(b) **Loading Conditions:** Uncertainties in applied loads, including static versus dynamic loads, magnitude, and frequency, influence the safety factor. Unpredictable or dynamic loads might necessitate a higher safety factor to account for potential overload scenarios.

4. State, with reasons, a different welding/brazing/soldering process that is best suited to effect EACH of the following situations:

(a) joining two lengths of aluminium bronze seawater pipe, both pipes having the same diameter; (2)

(b) attaching a stainless steel handrail to a steel hull; (2)

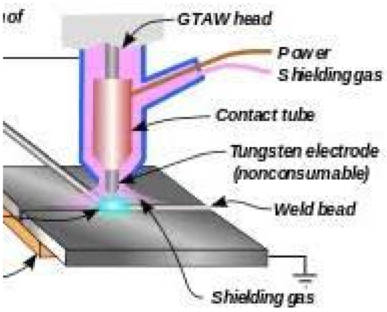
(c) re-attach a section of broken flange on a cast iron pump casing; (2)

(d) attaching a brass flange onto a stainless steel pipe; (2)

(e) attaching a 1.0 mm steel section to 10 mm thick deckhead plate. (2)

(a) Joining two lengths of aluminum bronze seawater pipe, both pipes having the same diameter.

The best process for this situation is gas tungsten arc welding (GTAW), also known as TIG welding. TIG welding is a precise and controlled process that is well-suited for joining thin materials, such as aluminum bronze. It is also resistant to corrosion, which is important for seawater pipes.



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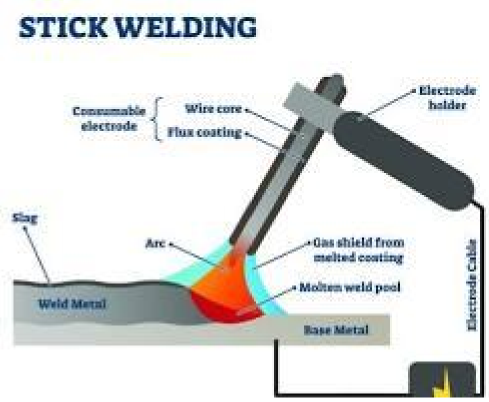
Gas tungsten arc welding (GTAW)

(b) Attaching a stainless steel handrail to a steel hull.

The best process for this situation is shielded metal arc welding (SMAW), also known as stick welding. SMAW is a versatile process that can be used to join a variety of metals, including steel and stainless steel. It is also a relatively inexpensive and portable process, which makes it a good choice for shipboard repairs.



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Shielded metal arc welding (SMAW)

(c) Re-attaching a section of broken flange on a cast iron pump casing.

The best process for this situation is brazing. Brazing uses a filler metal that has a lower melting point than the base metals. This allows the filler metal to melt and flow into the joint, without melting the base metals. Brazing is a good choice for cast iron because it is less likely to cause cracking.

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brighton-science.com

Brazing

(d) Attaching a brass flange onto a stainless steel pipe.

The best process for this situation is silver soldering. Silver solder is a type of solder that has a high melting point and is very strong. It is a good choice for joining dissimilar metals, such as brass and stainless steel.

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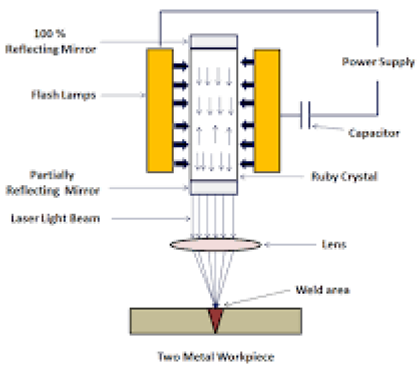
Silver soldering

(e) Attaching a 1.0 mm steel section to 10 mm thick deckhead plate.

The best process for this situation is laser beam welding. Laser beam welding is a high-energy process that can create very strong and narrow welds. It is a good choice for this situation because it can weld the thin steel section to the thicker deckhead plate without melting too much of either metal.



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Laser beam welding

5. A vessel has been laid up for a considerable time with shore power connected. Routine underwater hull inspections reveal an unusually high deterioration rate of the vessel's anodes. Assuming the dockside wiring, shore power connections and bonding systems are all in good condition and correctly connected:

(a) explain how this may occur; (8)

(b) state TWO devices that should be fitted to prevent this situation occurring. (2)

(a) Possible Explanations for High Anode Deterioration:

Even with seemingly perfect shore power and bonding systems, an unusually high anode deterioration rate on a laid-up vessel can occur due to several reasons:

1. Reduced Oxygen Levels: When a vessel is laid up, stagnant water near the hull can have reduced oxygen levels. This creates an environment conducive to anaerobic bacteria, which can accelerate corrosion by directly attacking the metal, leading to faster anode consumption.
2. Cathodic Disbondment: If the shore power system isn't fully isolated from the boat's internal electrical system, stray currents can flow through the hull, causing localized corrosion called cathodic disbondment. This can happen due to faulty wiring, grounding issues, or inadequate bonding connections.
3. Galvanic Interactions with Nearby Vessels: If other vessels with dissimilar hull materials are docked closely, galvanic corrosion can occur between the hulls through the conductive seawater. This can drain current from the vessel's anodes, accelerating their deterioration.
4. Improper Anode Selection or Positioning: Anodes may not be chosen for the specific water conditions or correctly positioned to offer adequate protection. For example, using zinc anodes in brackish water or placing them too far apart from the areas needing protection can lead to faster consumption.

(b) Devices to Prevent Anode Deterioration:

To protect against these scenarios and prolong anode life, two primary devices should be considered:

1. Cathodic Protection Monitoring System: This system continuously monitors the current flowing between the anodes and the hull, providing early detection of any abnormal changes. It can alert for issues like reduced oxygen levels, stray currents, or insufficient protection, allowing for timely corrective action to prevent excessive anode deterioration.
2. Isolation Transformer: This device electrically isolates the vessel's internal electrical system from the shore power supply, preventing stray currents from flowing through the hull and causing unintended cathodic disbondment. This ensures the cathodic protection system operates effectively with minimal anode consumption.

By implementing these devices and regularly monitoring the situation, you can maintain optimal cathodic protection for the vessel's hull, even during lay-up periods, significantly extending the lifespan of the anodes and reducing maintenance costs.

Remember, a thorough investigation into the specific circumstances and an assessment by a qualified marine electrician are crucial to accurately diagnose the cause of the accelerated anode deterioration and implement the most effective preventative measures.

6. With reference to the cathodic protection of hull fittings:

(a) explain how sacrificial anodes achieve this; (2)

(b) state where sacrificial anodes would be fitted and why; (4)

(c) describe an impressed current system, stating the principle on which it works. (4)

(a) Sacrificial Anodes: Guardians of the Hull:

Imagine these gallant knights, made of zinc or aluminum, standing guard on the hull, sacrificing themselves to protect the nobler metals around them. These are sacrificial anodes, the champions of cathodic protection for hull fittings. They work by creating a galvanic cell with the steel hull:

1. Potential Difference: Sacrificial anodes have a lower electrochemical potential than the steel hull. This creates a voltage difference between them.
2. Anode & Cathode Formation: The anode becomes the anode, readily releasing electrons and dissolving into ions. The steel hull becomes the cathode, attracting electrons.
3. Electron Flow: Electrons flow from the anode through the conductive seawater to the cathode (hull).
4. Cathodic Reaction: Electrons at the cathode react with oxygen and water to form harmless compounds like hydroxide ions.

This cycle essentially shifts the corrosion away from the hull onto the sacrificial anode. As the anode corrodes, it gradually shrinks, eventually needing replacement. But during its noble sacrifice, it protects the vital hull from the ravages of corrosion.

(b) Strategic Positioning: Protecting the Vulnerable:

Like wise generals placing their troops, sacrificial anodes are strategically positioned on the hull, focusing on areas most susceptible to corrosion:

- Propeller: The spinning propeller creates turbulence, accelerating corrosion. Anodes near the propeller ensure its protection.
- Rudder and Stern: These areas experience high water flow and stress, making them vulnerable. Strategically placed anodes shield them.
- Seawater Inlets and Outlets: Where water enters and exits the hull, corrosion risk is high. Anodes protect these crucial points.
- Bilge keels: These protrusions on the hull bottom are prone to corrosion, and anodes strategically placed underneath offer protection.

By placing anodes in these vulnerable areas, we ensure the vital parts of the hull remain shielded from corrosion, extending their lifespan and safeguarding the vessel's integrity.

(c) Impressed Current Systems: Engineered Protection:

For situations where sacrificial anodes aren't sufficient, or for more precise control, an impressed current system can be employed. This system operates based on the same principle of cathodic protection but uses an external power source:

1. Reference Electrode: A reference electrode measures the hull's potential against seawater.
2. Control Unit: The control unit analyzes the potential and adjusts the current output from a DC power source.
3. Anode: A specially designed anode, often made of platinum or graphite, releases current into the seawater.
4. Electron Flow: The current flows from the anode through the seawater to the hull, making it the cathode.
5. Cathodic Reaction: Similar to sacrificial anodes, electrons on the hull react with oxygen and water to form harmless compounds.

By adjusting the current output, the system can precisely control the cathodic protection over the entire hull surface. This offers advantages like:

- Tailored Protection: Adjusting the current allows for customized protection for different hull areas and materials.
- Longer Anode Life: Impressed current systems can use non-sacrificial anodes, which last much longer than sacrificial ones.
- Remote Monitoring: The system can be monitored and controlled remotely, simplifying maintenance and adjustments.

However, impressed current systems are more complex and require additional maintenance compared to sacrificial anodes. Choosing the right approach depends on the size and complexity of the vessel, specific corrosion risks, and operational requirements.

Remember, both sacrificial anodes and impressed current systems play crucial roles in protecting hull fittings from corrosion, ensuring the safety and longevity of vessels navigating the watery depths.

7. Describe, with the aid of a sketch, a floatation device that produces an output signal to remotely control the liquid level in a tank. (10)

Here's an example of a floatation device that produces an output signal for remotely controlling the liquid level in a tank, along with a sketch:

Device: Magnetic Float Level Switch with Integrated Transmitter

Sketch:

1. Tank: Depicts the storage tank containing the liquid being monitored.
2. Float: A hollow, buoyant cylinder (shown in red) floats atop the liquid surface.
3. Guide Rod: A vertical rod attached to the tank's top guides the float movement vertically.
4. Magnet: A permanent magnet is mounted inside the float, facing downwards.
5. Reed Switch: One or more reed switches (magnetically sensitive switches) are positioned alongside the guide rod at predetermined levels within the tank.
6. Wiring: Each reed switch connects to a dedicated wire running to the control unit.

Operation:

- As the liquid level rises, the float moves up along the guide rod.
- The magnet inside the float triggers the reed switch positioned at the corresponding level as it passes by.
- The activated reed switch completes the circuit for its associated wire, sending an electrical signal to the control unit.
- The control unit interprets the signal based on which reed switch was activated, indicating the liquid level reaching that specific point.
- Depending on the system configuration, the control unit can then activate pumps, valves, or other devices to maintain the desired liquid level in the tank.

Benefits:

- Non-invasive: No contact with the liquid, minimizing contamination or maintenance needs.
- Reliable: Simple and robust design with minimal moving parts.
- Customizable: Multiple reed switches can be used to create multi-level control.

Limitations:

- Accuracy: Limited to discrete level readings at the positions of the reed switches.
- Sensitivity: May not be suitable for highly precise level control requirements.

Alternative Options:

- Float Switch with Mechanical Lever: Instead of reed switches, the lever attached to the float can directly activate switches or valves mechanically.
- Hydrostatic Pressure Transmitter: Measures the pressure exerted by the liquid column, providing a continuous and more accurate level reading.

Choosing the right type of floatation device depends on factors like desired level control precision, system complexity, and cost considerations.

8. With reference to capacitance probe sensors:

(a) describe, with the aid of a sketch, how a capacitance probe produces an output which can be used to measure the liquid level in a tank. (7)

(b) state TWO different uses of this device on a vessel; (2)

(c) state ONE disadvantage of this type of probe. (1)

(a) Capacitance Probe Operation and Sketch:

Imagine a tank filled with liquid, and within it, a slender probe like a metal rod inserted. This is the essence of a capacitance probe sensor, and here's how it works:

Sketch:

- Electrodes: The probe itself acts as one electrode, and the tank wall or another immersed conductor serves as the other.
- Dielectric Constant: The space between the electrodes is filled with the liquid, which acts as a dielectric material with a specific dielectric constant (epsilon). This constant influences the capacitance formed between the electrodes.
- Capacitance Change: As the liquid level rises or falls in the tank, the volume of the dielectric (liquid) changes. This, in turn, affects the overall capacitance between the electrodes.
- Measuring the Change: An external device connected to the probe measures this change in capacitance.
- Level Conversion: Using pre-programmed equations and calibration data, the device converts the capacitance value into a corresponding liquid level reading.

Key Points:

- The dielectric constant of the liquid significantly impacts the sensor's sensitivity.
- Capacitance probes are contactless, offering non-invasive level measurement.

(b) Applications on a Vessel:

These versatile sensors find multiple uses on board:

1. Fuel Tank Monitoring: Accurately tracking fuel levels in tanks is crucial for fuel management and voyage planning. Capacitance probes provide reliable and continuous level readings, ensuring optimal fuel utilization.
2. Bilge Water Management: Monitoring bilge water levels is essential for ensuring the vessel's seaworthiness and preventing flooding. Capacitance probes offer accurate level data, triggering alarms or pump activation in case of excessive accumulation.

(c) Disadvantage:

One potential drawback of capacitance probes is their susceptibility to changes in the dielectric constant of the liquid. Materials like oil or seawater with varying conductivities or contaminants can affect the capacitance readings and require careful calibration or compensation techniques for accurate performance.

Remember, capacitance probes offer a valuable tool for liquid level measurement on vessels, but understanding their operating principles and potential limitations is crucial for their effective implementation. Choosing the right probe type and considering the liquid properties are essential for reliable and accurate level monitoring.

9. (a) Describe, with the aid of a sketch, the principle and operation of a potentiometer. (6)

(b) Explain how a potentiometer can be used to measure rotary movement. (4)

a) Principle and Operation of a Potentiometer:

Imagine a simple device with three terminals: a knob you can turn, and two connections. This is the essence of a potentiometer, a versatile resistor whose resistance changes smoothly as you rotate the knob. Let's delve into its principle and operation with the help of a sketch:

Sketch:

- Resistive Element: A long strip of conducting material (often nichrome or wire) acts as the heart of the potentiometer.
- Wiper Contact: A sliding contact (wiper) travels along the resistive element when you turn the knob.
- Terminals: Three terminals connect to the potentiometer:
  - A: Connects to one end of the resistive element.
  - B: Connects to the other end of the resistive element.
  - C: Connects to the wiper contact.

Operation:

1. Voltage Source: Apply a voltage across terminals A and B.
2. Voltage Division: As the wiper moves along the resistive element, the distance between it and terminals A and B changes. This creates a variable voltage divider, where the voltage drops across the portion of the element between A and C, and across the remaining portion between C and B.
3. Output Voltage: The voltage at terminal C (the output voltage) varies proportionally to the wiper position. When the wiper is closer to A, the output voltage is lower, and vice versa.

Key Points:

- The relationship between wiper position and output voltage is typically linear.
- Potentiometers can be used as variable resistors, voltage dividers, and sensors for rotary movement.

(b) Using a Potentiometer to Measure Rotary Movement:

This unique property of variable resistance makes the potentiometer a useful tool for measuring rotary movement. Here's how:

- Attach the Potentiometer: Mount the potentiometer to a fixed point and connect its shaft to the object whose rotation you want to measure.
- Calibrate the System: Define the full range of movement by setting zero and maximum output voltage values corresponding to the object's full range of rotation.
- Measure Voltage: As the object rotates, the potentiometer's shaft turns, changing the wiper position and, consequently, the output voltage.
- Convert to Angle: By measuring the output voltage and comparing it to the pre-defined calibration values, you can calculate the corresponding angle of rotation.

Applications:

This method has various applications, including:

- Joystick control: Measuring the tilt of a joystick in two axes for control in video games or robotics.
- Steering wheel sensors: Monitoring the angle of a car's steering wheel for accurate control.
- Robot joint position sensors: Tracking the rotation of robot joints for precise movement.

Remember, potentiometers offer a simple and reliable way to convert rotary movement into an electrical signal for measurement and control purposes. Understanding their principle and operation unlocks their versatility in various applications.

10. (a) Define EACH of the following terms:

(i) cascade control; (4)

(ii) split range control. (3)

(b) Describe possible problems associated with *split range control* used for the control of a main engine cooling system. (3)

(a) Definitions:

(i) Cascade Control:

Cascade control involves nesting two or more feedback loops to regulate a single process variable. The outer loop (primary loop) sets the desired value for the inner loop (secondary loop). This enables precise control and improved stability by responding to disturbances affecting the manipulated variable directly in the inner loop.

(ii) Split Range Control:

Split range control uses a single controller with multiple outputs to manage a process variable that needs different control strategies depending on its operating range. Each output controls a separate actuator, typically responsible for heating or cooling the process.

(b) Problems with Split Range Control for Main Engine Cooling:

1. Interaction Between Heating and Cooling: Coordinating the heating and cooling systems through a single controller can be challenging, especially during transitions between heating and cooling modes. Improper tuning could lead to overshooting, hunting, or instability.
2. Dead Zone Issues: Each output might have a dead zone, creating a small range around the setpoint where neither heating nor cooling occurs. This can cause sluggish response and temperature deviations if the dead zones are too large.
3. Complexities in Tuning: With multiple outputs and setpoints, tuning the controller gains and dead zones becomes more complex. Finding the optimal settings for both heating and cooling simultaneously can be time-consuming and require expertise.
4. Potential for Single Point Failure: A single controller failure could disrupt both heating and cooling, compromising engine safety and performance.
5. Limited Applicability: Split range control might not be suitable for all engine types or operating conditions. Some engines might require more flexibility or independent control of heating and cooling, making another control strategy more appropriate.

Alternatives to Split Range Control:

- Two separate PID controllers: This offers independent control of heating and cooling with simpler tuning but requires more hardware and coordination.
- Fuzzy logic control: This can handle more complex relationships between variables and operating conditions, but it requires expertise in fuzzy logic implementation.

Overall, split range control can be a cost-effective solution for basic engine cooling control. However, its limitations and potential problems should be carefully considered before implementation, and alternative control strategies might be better suited for specific requirements.