058-01 - APPLIED MARINE ENGINEERING

FRIDAY, 26 May 2023

1400-1600 hrs

1. With reference to carbon fibre used in marine construction:

   (a) describe the properties that make it suitable for EACH of the following:

   (i) hull construction; (2)

   (ii) mast construction; (2)

   (b) explain its undesirable properties for the applications in part (a); (3)

   (c) explain the safety considerations necessary when working with carbon fibre. (3)

2. With reference to the heat treatment of steel:

   (a) explain which steels this process is best suited to; (2)

   (b) explain EACH of the following processes, making reference to mechanical properties and internal structure:

   (i) hardening; (4)

   (ii) tempering. (4)

3. With reference to the hull of a vessel:

   (a) define the term *fatigue*; (3)

   (b) describe how fatigue stress occurs whilst in a seaway; (3)

   (c) state the effect of fatigue on the hull material. (4)

4. Describe, with the aid of sketches, FIVE defects that may be present on a weld produced using the covered electrode welding process. (10)

5. (a) Describe the problems associated with two dissimilar metals in contact in the presence of sea water. (4)

   (b) Describe THREE different methods that may be used to reduce the problems described in part (a). (6)

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. With reference to a PT100 probe (resistance thermometer):

   (a) explain the principle of operation by which it is able to give a temperature measurement; (3)

   (b) describe how the sensing element is constructed, explaining why it is called a PT100 probe; (4)

   (c) explain why these probes typically have three or four wires to connect them to the temperature indicating device. (3)

8. (a) State the relationship between *proportional band* and *gain*. (2)

   (b) The figure shows the level in a water tank is being controlled by a float and lever proportional system.

      (i) Describe how the gain of the control system can be increased and decreased. (2)

      (ii) Describe what happens when the flow out is increased. (2)

      (iii) Describe the effect of increasing the controller gain with respect to the steady state tank level when the outflow is increased. (2)

      (iv) Describe how the introduction of Integral action would affect this system. (2)

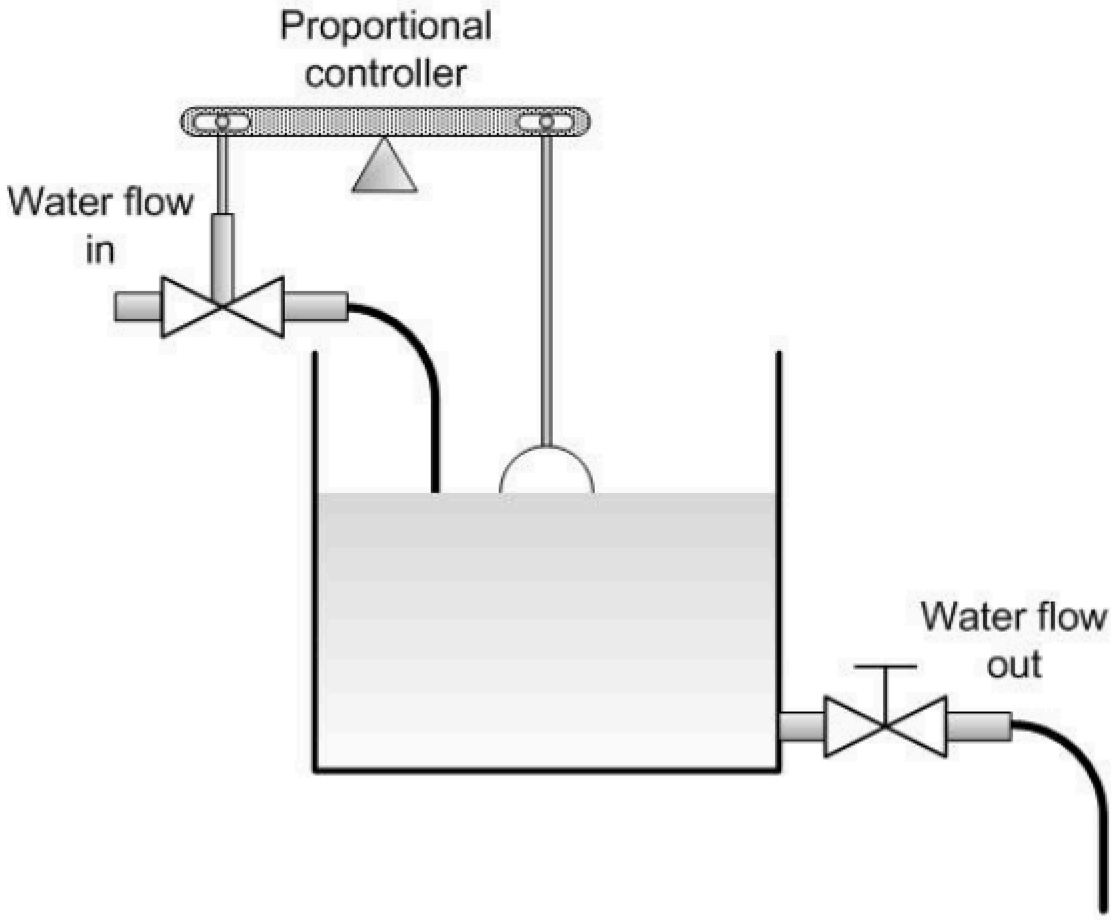

Fig Q8

9. (a) Explain the term *failsafe* in a control system, stating TWO examples where this term is applied. (4)

(b) Explain the term *failset* in a control system, stating TWO examples where this term is applied. (4)

(c) State what is meant by a 4:3 control valve. (2)

10. On passage at full sea speed, a high jacket water temperature alarm goes off. The header tank is full, there are no leaks in the systems, both the HT and SW pumps are running and in good condition, however the temperature is continuing to rise.

(a) State the immediate course of action that should be taken, explaining why. (2)

(b) From the information on the supplied system diagram, shown in the figure below, describe THREE possible actions that may bring the plant back to within normal operating parameters. (8)

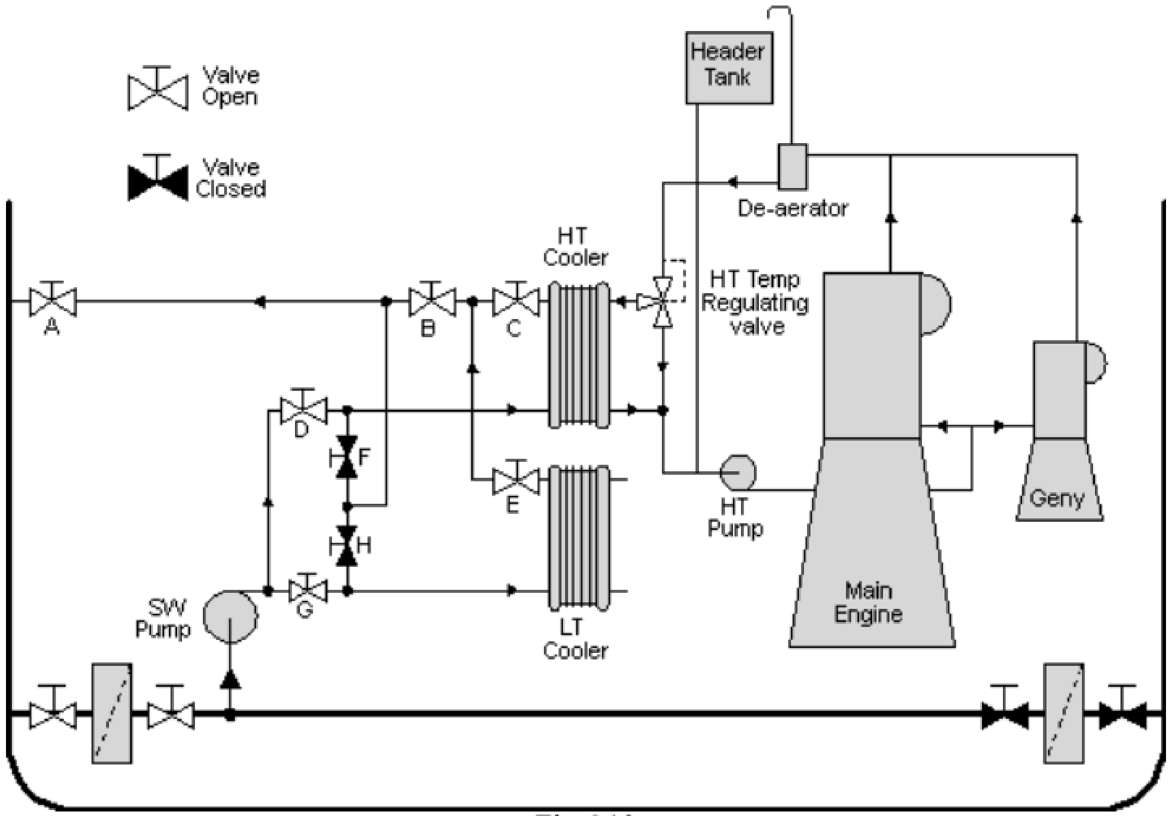

Fig Q10

May 2023

1. With reference to carbon fibre used in marine construction:

(a) describe the properties that make it suitable for EACH of the following:

(i) hull construction; (2)

(ii) mast construction; (2)

(b) explain its undesirable properties for the applications in part (a); (3)

(c) explain the safety considerations necessary when working with carbon fibre. (3)

Part (a): Describing the properties of carbon fiber for hull and mast construction

- Hull construction:
    - High strength-to-weight ratio: Carbon fiber is incredibly strong for its weight, making it ideal for building lightweight hulls that can withstand the stress of waves and currents. This can improve a vessel's fuel efficiency and performance.
    - Corrosion resistance: Carbon fiber is highly resistant to corrosion from saltwater and other marine environments, unlike metals like steel which can rust and deteriorate. This reduces maintenance costs and extends the lifespan of the hull.
    - Stiffness and dimensional stability: Carbon fiber composites have minimal thermal expansion and contraction, helping the hull maintain its shape and integrity even in changing temperatures.
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- Mast construction:
    - High stiffness and low weight: These properties allow for taller and lighter masts that can carry more sail area without bending excessively. This can improve a vessel's sailing performance and stability.
    - Fatigue resistance: Carbon fiber masts can withstand repeated cycles of stress without breaking, making them ideal for long voyages and harsh conditions.
    - Improved sail control: The stiffness of carbon fiber masts provides a more responsive feel to the sails, giving the crew greater control over the vessel.
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Part (b): Explaining the undesirable properties of carbon fiber for marine applications

- High cost: Carbon fiber is significantly more expensive than traditional materials like fiberglass or wood, making it a less economical choice for some applications.
- Brittle failure: While strong, carbon fiber can be brittle and prone to catastrophic failure if damaged. This can be a safety concern, especially for high-performance vessels.
- Repair difficulty: Repairing damage to carbon fiber can be complex and expensive, requiring specialized training and materials.

Part (c): Explaining safety considerations when working with carbon fiber

- Sharp fibers: Carbon fibers can be sharp and cause skin irritation or even puncture wounds if handled improperly. Proper personal protective equipment (PPE) like gloves and long sleeves is essential when working with carbon fiber.
- Dust hazard: Cutting or sanding carbon fiber releases dust particles that can be harmful if inhaled. Proper ventilation and respiratory protection are necessary to avoid health risks.
- Galvanic corrosion: When combined with metals, carbon fiber can create galvanic corrosion, which can damage both materials. Careful selection of compatible materials and proper insulation are necessary to prevent this.

May 2023

2. With reference to the heat treatment of steel:

(a) explain which steels this process is best suited to; (2)

(b) explain EACH of the following processes, making reference to mechanical properties and internal structure:

(i) hardening; (4)

(ii) tempering. (4)

Heat Treatment of Steel: Suits and Processes

(a) Steels Best Suited for Heat Treatment:

Heat treatment is particularly beneficial for specific types of steel, primarily those with medium to high carbon content (0.2-1.0%). These steels experience significant changes in their mechanical properties due to the heat-driven transformations in their internal structure. Some examples include:

- Hypoeutectoid steels (carbon content < 0.77%): These steels can achieve significant hardening through quenching, forming martensite with high strength and hardness.
- Eutectoid steel (0.77% carbon): This steel readily transforms into pearlite (a mixture of ferrite and cementite) during slow cooling, achieving a good balance of strength and ductility.
- Hypereutectoid steels (carbon content > 0.77%): These steels can achieve high wear resistance due to the presence of cementite (iron carbide). However, their weldability and ductility are limited.

Steels with very low carbon content (< 0.2%) and high-alloy stainless steels generally benefit less from heat treatment due to their inherent properties or limited transformation potential.

(b) Heat Treatment Processes Explained:

(i) Hardening:

- Process: Steel is heated above its critical temperature (around 723°C), austenitizing its microstructure (transforming it into austenite, a high-carbon phase). This is followed by rapid quenching (usually in water or oil), which traps the high-carbon austenite structure as a metastable phase called martensite.
- Mechanical Properties: Hardening significantly increases the strength and hardness of the steel but at the expense of ductility and toughness. Martensite is very strong and hard but also brittle and prone to cracking.
- Internal Structure: The rapid quenching prevents carbon atoms from diffusing and forming equilibrium phases like pearlite. Instead, austenite transforms into martensite, a distorted tetragonal lattice structure with high carbon content, leading to high strength and hardness.

(ii) Tempering:

- Process: Hardened steel is reheated to a lower temperature (typically between 150°C and 500°C) and then cooled slowly. This allows some of the martensite to transform back into less brittle phases like ferrite and cementite, depending on the tempering temperature.
- Mechanical Properties: Tempering reduces the hardness and strength of the steel compared to the hardened state but significantly improves its ductility and toughness. This makes the steel more resistant to cracking and failure under stress.
- Internal Structure: Tempering allows carbon atoms to diffuse and form more stable phases like ferrite and cementite. The specific phases formed and the degree of transformation depend on the tempering temperature, influencing the final balance of strength, ductility, and toughness.

Therefore, hardening and tempering are complementary processes. Hardening provides high strength and hardness, while tempering improves ductility and toughness, allowing for a tailored balance of properties for specific applications.

May 2023

3. With reference to the hull of a vessel:

(a) define the term *fatigue*; (3)

(b) describe how fatigue stress occurs whilst in a seaway; (3)

(c) state the effect of fatigue on the hull material. (4)

(a) Fatigue Definition:

In the context of a vessel hull, fatigue refers to a gradual weakening and eventual failure of the material due to repeated or cyclic stresses. These stresses are below the ultimate strength of the material but act over a prolonged period, causing damage to accumulate and micro-cracks to grow with each cycle. Eventually, the accumulated damage can lead to catastrophic failure even under relatively low loads.

(b) Fatigue Stress in Seaways:

Several factors contribute to fatigue stress in a vessel hull while navigating a seaway:

- Wave Loading: Waves create complex bending and twisting forces on the hull as it rises and falls with the water. These forces change direction and magnitude constantly, generating cyclic stresses.
- Vibrations: Engine vibrations, propeller forces, and other dynamic factors can induce additional cyclic stresses throughout the hull, further contributing to fatigue.
- Cargo Distribution: Uneven cargo distribution or shifting loads within the vessel can create localized stress concentrations and exacerbate fatigue in specific areas.
- Environmental Factors: Corrosion and erosion from seawater, as well as temperature and humidity fluctuations, can weaken the material and exacerbate the effects of fatigue stresses.

(c) Effects of Fatigue on Hull Material:

The accumulated damage from fatigue stress manifests in various ways on the hull material:

- Micro-crack Formation and Growth: Repeated stresses cause microscopic cracks to develop at weak points like weld seams, rivet holes, or areas with material imperfections. These cracks gradually grow with each cycle, reducing the overall strength and integrity of the hull.
- Loss of Material: As cracks propagate, small pieces of material can break off, leading to surface pitting, thinning of the hull plate, and eventual loss of structural integrity.
- Reduced Stiffness and Elasticity: The accumulation of micro-cracks and damage disrupts the material's ability to flex and absorb stress, making the hull less resilient and more susceptible to further damage or failure.
- Increased Stress Concentrations: Cracks and material loss create focal points where stress concentrates even more, accelerating further crack growth and potentially leading to sudden failure.

The effects of fatigue on the hull can be insidious, often progressing slowly until reaching a critical point. Regular inspections, monitoring for signs of damage, and employing strategies to mitigate fatigue stress are crucial for maintaining the structural integrity and safety of a vessel.

May 2023

4. Describe, with the aid of sketches, FIVE defects that may be present on a weld produced using the covered electrode welding process. (10)

Covered electrode welding is a versatile and widely used process, but even the most skilled welder can encounter imperfections. Here are five common defects you might find on a weld, along with simple sketches to visualize them:

1. Slag Inclusion:

- Sketch: Imagine a dark, irregular line embedded within the weld bead.

- Description: Small pieces of molten slag (residue from the electrode coating) become trapped within the weld metal as it solidifies.
- Causes: Improper cleaning of the joint, incorrect welding angle, excessive current.
- Effects: Weakened weld strength, potential cracking, corrosion risk.

2. Undercut:

- Sketch: Picture a groove at the toe of the weld, where the base metal dips below the level of the weld bead.
- Description: Excessive melting of the base metal at the edge of the weld, creating a groove or undercut.
- Causes: High welding current, excessive travel speed, incorrect electrode angle.
- Effects: Reduced weld cross-sectional area, weakened joint, increased stress concentration.

3. Porosity:

- Sketch: Imagine small, round voids or gas pockets scattered throughout the weld bead.
- Description: Gas bubbles entrapped within the molten metal during solidification.
- Causes: Moisture on the base metal or electrode, improper shielding gas flow, contamination.
- Effects: Weakened weld strength, potential leakage paths, reduced fatigue life.

4. Incomplete Fusion:

- Sketch: Picture a gap or lack of bonding between the weld metal and the base metal.
- Description: The weld metal doesn't fully penetrate and bond with the base metal, leaving unfilled areas.
- Causes: Low welding current, improper electrode manipulation, inadequate joint preparation.
- Effects: Weak joint, potential cracking, structural failure risk.

5. Spatter:

- Sketch: Imagine small, solidified droplets of metal scattered around the weld area.
- Description: Molten metal droplets ejected from the arc during welding, sticking to the surrounding surface.
- Causes: Incorrect electrode angle, excessive current, worn-out electrode.
- Effects: Aesthetically undesirable, potential surface damage, cleaning challenges.

May 2023

5. (a) Describe the problems associated with two dissimilar metals in contact in the presence of sea water. (4)

(b) Describe THREE different methods that may be used to reduce the problems described in part (a). (6)

Dissimilar Metals in Seawater: A Recipe for Corrosion Trouble

(a) Problems with Dissimilar Metals in Seawater:

When two dissimilar metals come into contact in the presence of seawater, a recipe for corrosion disaster is brewed. Here's why:

1. Galvanic Corrosion: The primary culprit is galvanic corrosion. Dissimilar metals have different electrochemical potentials, meaning they possess varying tendencies to give up electrons and corrode. The more active metal (lower potential) acts as the anode, readily losing electrons and dissolving into the seawater. The less active metal (higher potential) becomes the cathode, attracting these electrons and remaining protected. This "sacrificial" process rapidly corrodes the anode metal.

2. Increased Corrosion Rate: Seawater acts as an excellent electrolyte, facilitating the flow of electrons between the metals. This significantly accelerates the corrosion process compared to each metal exposed to seawater alone.

3. Localized Corrosion: The corrosion often concentrates at the point of contact between the metals, creating deep pits and grooves. This localized attack can weaken the structure and compromise the integrity of the components.

4. Stress Corrosion Cracking: In some cases, the combined effect of stress and the corrosive environment can lead to stress corrosion cracking. This can cause sudden and catastrophic failures, especially in critical components like propellers or shafts.

(b) Reducing the Problems of Dissimilar Metal Contact:

Fortunately, several methods can be employed to reduce or eliminate the problems associated with dissimilar metals in seawater:

1. Material Selection: Choosing metals with similar electrochemical potentials minimizes the potential difference and significantly reduces the driving force for galvanic corrosion. This can be achieved by using stainless steel alloys, copper-nickel alloys, or even plastic components in strategic locations.

2. Cathodic Protection: This method actively protects the more active metal by applying an external current that shifts its potential to become cathodic. Sacrificial anodes (made of even more active metals) or impressed current systems can be used to achieve this.

3. Electrical Isolation: In some cases, it's possible to physically isolate the dissimilar metals from each other through non-conductive coatings, gaskets, or washers. This prevents direct electrical contact and eliminates the pathway for galvanic currents to flow.

4. Protective Coatings: Applying specialized coatings like epoxy resins, polyurethanes, or zinc primers can create a barrier between the metal and the seawater, further mitigating corrosion. However, regular inspection and reapplication may be necessary.

By carefully considering these methods and choosing the appropriate approach for your specific application, you can effectively minimize the problems associated with dissimilar metals in seawater and ensure the longevity and integrity of your marine structures and equipment.

Remember, corrosion is a constant threat in marine environments, and proactive measures are crucial for keeping your vessels and components safe and operational. Don't hesitate to consult with experienced professionals and choose the solution that best suits your needs and budget.

May 2023

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)

Protecting the Underwater Warriors: Unveiling Cathodic Protection of Hull Fittings

(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.

May 2023

7. With reference to a PT100 probe (resistance thermometer):

(a) explain the principle of operation by which it is able to give a temperature measurement; (3)

(b) describe how the sensing element is constructed, explaining why it is called a PT100 probe; (4)

(c) explain why these probes typically have three or four wires to connect them to the temperature indicating device. (3)

(a) Temperature Measurement through Resistance:

Think of a PT100 probe as a miniature conductor whose electrical resistance changes precisely with temperature. This principle, known as resistive temperature detection (RTD), forms the core of its operation. Here's how it works:

1. Platinum Magic: The sensing element inside the probe is made of pure platinum, chosen for its remarkably linear and predictable relationship between temperature and resistance. As the temperature increases, the platinum atoms vibrate more, disrupting the orderly flow of electrons, thereby increasing the resistance.
2. Measuring the Change: An external device connected to the probe measures the resistance of the platinum element. This measured resistance directly corresponds to the temperature within the probe through the platinum's inherent temperature-resistance characteristic.
3. Conversion to Temperature: Finally, the measuring device utilizes this resistance value and converts it into a temperature reading using pre-programmed calibration equations specific to Pt100 probes.

This simple yet precise method allows PT100 probes to measure temperatures accurately and reliably across a wide range.

(b) Construction of the Sensing Element: The "PT" in PT100:

The heart of the PT100 probe lies in its sensing element, often a thin coil of pure platinum wire wrapped around a ceramic core. This construction offers several advantages:

- High Purity: Pure platinum ensures consistent and predictable temperature-resistance behavior, crucial for accurate measurements.
- Compactness: The coiled wire design creates a small and sensitive element, allowing for quick thermal response and versatility in placement.
- Durability: The ceramic core provides mechanical support and protects the delicate platinum wire from physical damage.

Now, the "PT" in PT100 stands for "Platinum," and the "100" signifies the nominal resistance of the element at 0°C, which in this case is 100 ohms. This standard naming convention allows for easy identification and interchangeability of these probes.

(c) The Mystery of the Wires: Three or Four?

While two wires might seem sufficient to carry the current and measure the resistance, PT100 probes typically have three or four wires. Here's why:

- Three-Wire Configuration: This setup uses three wires, one each for supplying current, measuring voltage across the element, and compensating for lead resistance. The lead resistance can introduce errors, and the third wire effectively cancels it out for accurate temperature readings.
- Four-Wire Configuration: This offers enhanced precision, especially for long lead lengths. Four wires are used, two for providing current and two for measuring voltage, completely eliminating the influence of lead resistance on the measurement.

The choice between three and four wires depends on the required accuracy, lead length, and cost considerations. In most cases, three-wire probes offer sufficient accuracy for common applications.

May 2023

8. (a) State the relationship between *proportional band* and *gain*. (2)

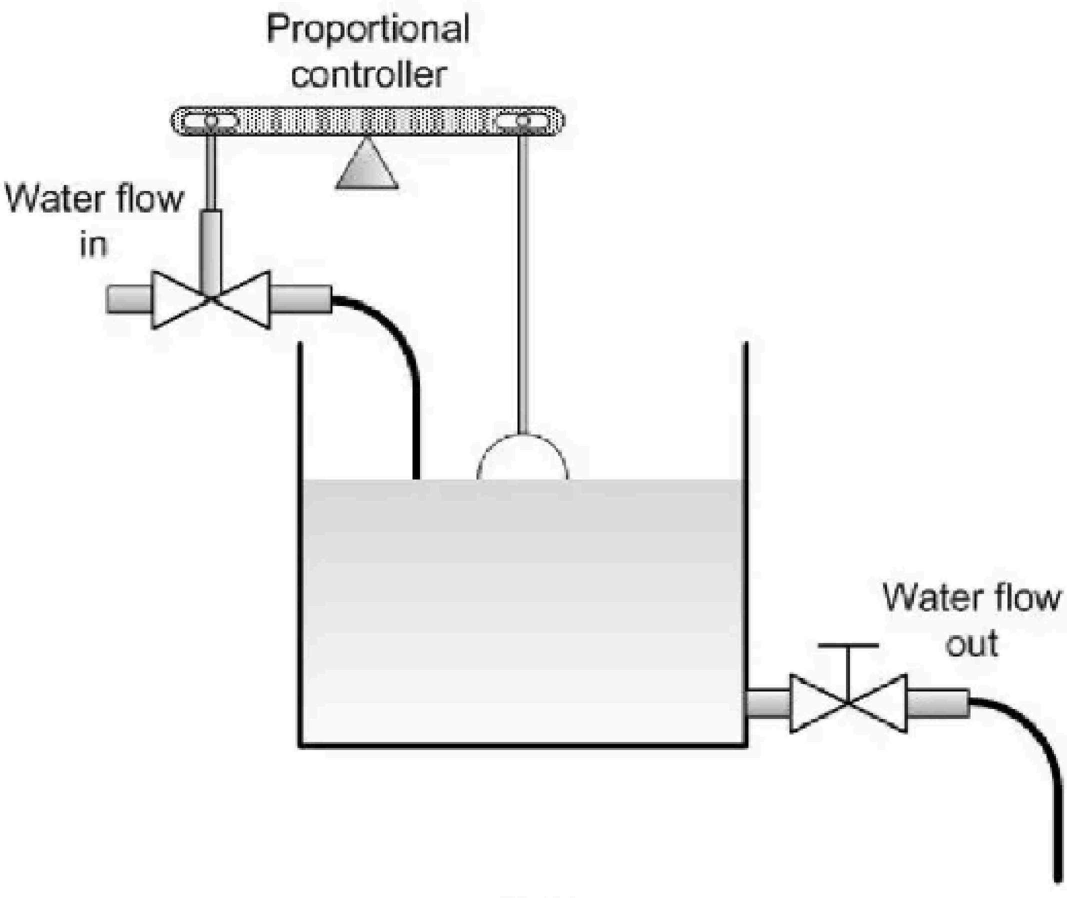
(b) The figure shows the level in a water tank is being controlled by a float and lever proportional system.

(i) Describe how the gain of the control system can be increased and decreased. (2)

(ii) Describe what happens when the flow out is increased. (2)

(iii) Describe the effect of increasing the controller gain with respect to the steady state tank level when the outflow is increased. (2)

(iv) Describe how the introduction of Integral action would affect this system. (2)



(a) Relationship between Proportional Band and Gain:

Proportional band (PB) and gain are inversely proportional to each other. This means that as the PB increases, the gain decreases, and vice versa. Mathematically, it can be expressed as:

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Gain = 1 / PB (expressed as a percentage)
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For example, if the PB is 20%, the gain is 5 (100 / 20 = 5). Conversely, if the gain is 3, the PB is approximately 33% (100 / 3 = 33.33%).

(b) Level Control in a Water Tank:

(i) Increasing and Decreasing Gain:

In the given lever system, the gain can be adjusted by modifying the length of the lever arm. A shorter lever arm increases the gain because a smaller movement of the float translates to a larger movement of the control valve, resulting in a more significant response to level changes. Conversely, a longer lever arm decreases the gain, as a larger movement of the float produces a smaller movement of the valve, leading to a less pronounced response.

(ii) Increased Flow Out:

When the flow out of the tank increases, the water level will start to drop. The float will move down, and the lever will pivot, opening the control valve further to allow more water inflow. However, with a proportional-only system, the valve opening will only reach a point where the inflow matches the increased outflow, and the water level will stabilize at a new, lower level.

(iii) Increasing Gain with Increased Outflow:

Increasing the gain (shortening the lever arm) in this scenario will make the system more responsive to level changes. The valve will open wider for smaller float movements, attempting to compensate for the increased outflow more aggressively. However, this can lead to hunting, where the water level oscillates around the desired level due to the system's overreaction.

(iv) Introducing Integral Action:

Adding integral action to the system can help address the limitations of proportional control. The integral term essentially remembers the past level deviations and continuously adjusts the valve position to eliminate them. This helps the system reach and maintain the desired level even with changes in outflow, reducing hunting and improving steady-state accuracy.

Remember that the specific behavior of the system will depend on various factors like the tank size, flow rates, and valve characteristics. This is a simplified explanation to illustrate the concepts.

May 2023

9. (a) Explain the term *failsafe* in a control system, stating TWO examples where this term is applied. (4)

(b) Explain the term *failset* in a control system, stating TWO examples where this term is applied. (4)

(c) State what is meant by a 4:3 control valve. (2)

(a) Fail-Safe:

In a control system, "fail-safe" refers to the design and operation of the system in a way that minimizes damage or risk when a component failure occurs. This ensures the system transitions to a known safe state even when unexpected malfunctions happen.

Examples:

1. Emergency Shutdown in Chemical Plants: If a sensor detects a hazardous gas leak, the system immediately activates the emergency shutdown sequence, safely isolating the leak and preventing further danger.
2. Aircraft Engine Thrust Reduction: If an engine failure is detected, the system automatically reduces thrust on the affected engine, maintaining flight stability and minimizing the risk of a crash.

(b) Failset:

"Failset" refers to the behavior of a system where, upon component failure, the system remains in its current state. While not actively transitioning to a safe state, this approach may be acceptable in specific situations where maintaining the current state is preferable to an uncontrolled change.

Examples:

1. Room Temperature Control: If the thermostat fails, the heating or cooling system might remain in its last active state (on or off), maintaining the room temperature until manual intervention.
2. Traffic Light Signals: If a power outage occurs, the traffic lights might stay in their last illuminated state (red, green, or yellow) until power is restored, providing static information to drivers.

Important Note: Failset is generally less desirable than fail-safe, as it doesn't guarantee a safe outcome in all failure scenarios. Its use should be carefully considered and only implemented if a fail-safe approach is impractical or poses additional risks.

(c) 4:3 Control Valve:

This refers to a control valve whose stroke or travel distance relates to its flow area change according to a 4:3 ratio. Mathematically, the flow area (A) varies with the valve stem position (x) as follows:

$A \propto x^4 / 3$

This characteristic leads to two key features:

1. High flow sensitivity at low openings: Small changes in stem position near the closed position result in significant changes in flow, making the valve suitable for precise control at low flow rates.
2. Limited flow gain at high openings: As the valve approaches its fully open position, further stem movement has a reduced impact on flow rate, providing a degree of "self-regulation" and preventing excessive flow overshoot.

Applications:

- High-precision flow control in chemical processes
- Throttle control in engine fuel systems
- Dosage control in medical equipment

Remember, the specific advantages and drawbacks of a 4:3 control valve depend on the intended application and its control requirements.

May 2023

10. On passage at full sea speed, a high jacket water temperature alarm goes off. The header tank is full, there are no leaks in the systems, both the HT and SW pumps are running and in good condition, however the temperature is continuing to rise.

(a) State the immediate course of action that should be taken, explaining why. (2)

(b) From the information on the supplied system diagram, shown in the figure below, describe THREE possible actions that may bring the plant back to within normal operating parameters. (8)

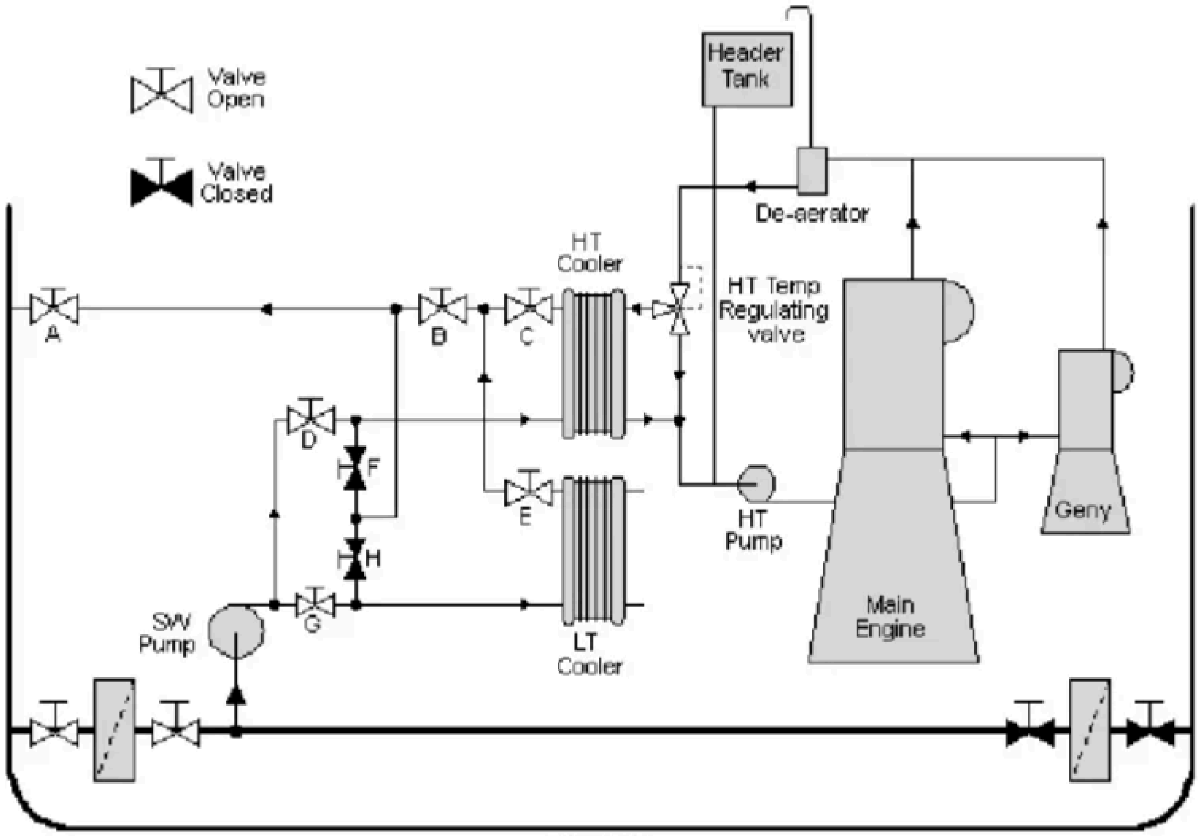

Fig Q10

Here are three possible actions you can take to bring the plant back to normal operating parameters, based on the information provided:

1. Isolate and Bypass the Freshwater Cooler:

- Looking at the diagram, locate the freshwater cooler (FC) component. This heat exchanger uses seawater to cool the jacket water.

- If the seawater flow or temperature is suspected to be abnormal, isolate the FC by closing valves V21 and V22 at the inlet and outlet, respectively.
- Simultaneously, bypass the FC by opening valves V19 and V20 to create a direct path for the jacket water to circulate back to the engine without going through the cooler.
- Monitor the jacket water temperature. If it starts to decrease, this indicates a problem with the FC, and further investigation or repairs may be needed.

2. Increase Jacket Water Circulation:

- Identify the jacket water pump (JWP) on the diagram.
- If the JWP flow is insufficient, consider increasing its speed if possible. This might be achievable manually or through an onboard control system.
- Alternatively, check if there's a bypass valve (V18) around the JWP. If so, partially closing it can force more water to flow through the pump, increasing circulation.
- Monitor the jacket water temperature and pump parameters to ensure safe operation within specified limits.

3. Utilize the Auxiliary Jacket Water Pump (if available):

- If your system has an auxiliary jacket water pump (AJWP), locate it on the diagram.
- Start the AJWP to provide additional cooling capacity to the jacket water circuit. This can be particularly helpful if the primary JWP is overloaded or malfunctioning.
- Ensure proper coordination with other crew members if the AJWP activation involves specific procedures or safety precautions.

Remember, these are just potential actions based on the limited information available. It's crucial to:

- Consult the vessel's operation and maintenance manuals for specific instructions and procedures.
- Prioritize safety by monitoring critical parameters like engine RPM, exhaust gas temperature, lube oil temperature, and jacket water pressure.
- Seek guidance from qualified personnel onboard or onshore if the situation is unclear or worsens.