Aug 2023

6. Explain, with the aid of a sketch, the securing of a controllable pitch propeller to the tailshaft. (10)

Securing a controllable pitch propeller to the tailshaft involves a combination of mechanical components and precise fitting to ensure smooth operation and efficient power transfer. Here's a breakdown of the key elements:

1. Taper and Key:

- The tailshaft features a tapered section at the end. The propeller hub has a corresponding tapered bore that fits onto the tailshaft.
- This taper provides a strong initial mechanical grip between the two components.
- A keyway is machined into both the tailshaft and the propeller hub. A key, typically made of high-strength steel, is inserted into the keyway to prevent the propeller from rotating independently of the shaft.

2. Propeller Nut and Washer:

- A large threaded propeller nut is screwed onto the threaded end of the tailshaft, further securing the propeller hub.
- A large washer sits between the propeller nut and the hub, distributing the clamping force evenly.

3. Hydraulic Oil Injection System (For Controllable Pitch Propellers):

- Controllable pitch propellers have an additional mechanism for adjusting the blade angle.
- An internal chamber within the propeller hub houses a mechanism for blade pitch adjustment.
- A hydraulic oil injection system is connected to this chamber. By controlling the pressure and flow of hydraulic oil, the blade angle can be adjusted.
- The propeller nut may have additional features to accommodate the hydraulic oil passage for blade pitch control.

4. Locking Mechanism:

- Once the propeller nut is tightened, a locking mechanism is typically employed to prevent it from loosening due to vibration or engine torque.
- This can involve locking pins, wedges, or special locking nuts that engage with threads on the tailshaft.

5. Pre-installation Checks and Measurements:

- Before installation, the taper on the tailshaft and the bore in the propeller hub are carefully measured and inspected for any wear or imperfections.
- A good fit between the taper and bore is crucial for proper load distribution and to minimize stress concentrations.

6. Final Tightening and Alignment:

- Specialized tools are used to tighten the propeller nut to a precise torque value specified by the manufacturer.
- This ensures a secure connection without exceeding the material's limits.

- Once secured, alignment checks are performed to verify the propeller is centered and running true on the tailshaft axis.

Additional Notes:

- The specific securing method and components may vary depending on the size, type, and manufacturer of the controllable pitch propeller and tailshaft.
- Always refer to the manufacturer's instructions and relevant safety regulations for proper installation procedures.

Nov 2018 9th

Nov 2018 9th

6. With reference to controllable pitch propellers:

   (a) describe a mechanism that changes the pitch of the blades; (7)

   (b) explain how the pitch of the blades is indicated. (3)

sept 2021

Sept 2021

6. With reference to controllable pitch propellers:

   (a) describe a mechanism that changes the pitch of the blades; (7)

   (b) explain how the pitch of the blades is indicated. (3)

Controllable Pitch Propeller Mechanisms and Indication

(a) Mechanism for Changing Blade Pitch:

Controllable pitch propellers (CPP) allow for adjusting the angle of the propeller blades while the engine is running. Here's a breakdown of a typical mechanism for changing blade pitch:

Components:

- **Hub:** The central part of the propeller that houses the pitch change mechanism.
- **Blades:** Hydrofoils that rotate and generate thrust. They can pivot within the hub to change their pitch angle.
- **Pitch Change Rod:** A shaft or linkage that connects the blade root to the pitch change mechanism within the hub.
- **Pitch Control Mechanism:** This mechanism is located inside the hub and can be:
  - **Hydraulic System:** The most common type. Uses pressurized hydraulic fluid to actuate pistons or cylinders that push or pull on the pitch change rods, adjusting the blade angles.
  - **Electric System:** Less common but gaining traction. Uses electric motors to drive gear mechanisms that rotate the pitch change rods.

Operation:

1. **Command Signal:** The operator on the bridge sends a signal (electrical or mechanical) to the pitch control system. This signal indicates the desired blade pitch angle.
2. **Hydraulic or Electric Actuation:** Depending on the system type, the signal activates either a hydraulic pump or an electric motor within the pitch control mechanism.
3. **Hydraulic Fluid Flow (Hydraulic System):** In a hydraulic system, pressurized fluid is directed to specific chambers within pistons or cylinders based on the desired pitch change.
4. **Rod Movement:** The pressurized fluid pushes or pulls on pistons or cylinders, which in turn transmit the force through the pitch change rods.
5. **Blade Pitch Adjustment:** The pitch change rods are connected to the blade roots, and their movement causes the blades to pivot within the hub, adjusting their pitch angle.
6. **Electric Motor and Gear Mechanism (Electric System):** In an electric system, the activated motor drives gears that rotate the pitch change rods, achieving the desired blade pitch adjustment.

(b) Pitch Blade Indication:

The operator needs to know the actual pitch angle of the propeller blades for optimal performance and control. Here are two common methods for indicating blade pitch:

- **Mechanical Pitch Indicator:** This is a dial gauge located near the bridge control system. It's connected to the pitch control mechanism via linkages or cables. As the blades move, the linkages rotate the gauge, displaying the actual pitch angle on the dial.
- **Electronic Pitch Indicator:** This is a more modern system that uses sensors within the hub to measure the actual blade angle. The sensor data is transmitted electronically to a display on the bridge, providing a real-time and accurate indication of the blade pitch.

Additional Considerations:

- Safety features like blade position interlocks might be incorporated to prevent unintended blade movement during engine start-up or shutdown.
- Redundant systems (e.g., backup pumps) could be included in critical applications to ensure continued pitch control even in case of a malfunction.

By employing mechanisms like hydraulics or electrics, controllable pitch propellers offer precise control over blade pitch, enhancing vessel maneuverability, efficiency, and performance across various operational scenarios. The use of either mechanical or electronic pitch indicators ensures the operator has accurate information about the actual blade angle for optimal control.

Sept 2020

6. Describe the advantages of using water jets instead of conventional propellers for vessel propulsion. (10)

Question 6. Many simply state advantages – the question says 'describe'. Many of the advantages claimed could be equally applied to CPP's and D/E drives, both of which are now considered conventional.

Here are some advantages of using water jets instead of conventional propellers for vessel propulsion:

Performance:

- **High Speed:** Water jets excel in applications requiring high speeds. Since they operate unimpeded by a protruding propeller, they experience less drag, allowing vessels to reach higher speeds compared to propeller-driven counterparts.
- **Shallow Draft:** Water jets have a shallow water intake, making them ideal for navigating in shallow rivers, canals, or near coastlines with varying depths. Propellers, on the other hand, risk damage if they operate in shallow waters.
- **Improved Maneuverability:** Water jets offer superior maneuverability due to their ability to direct the water flow through a deflection mechanism. This allows for quick changes in direction and precise maneuvering in tight spaces, like harbors or during docking procedures.
- **Reduced Cavitation:** Cavitation, the formation and collapse of vapor bubbles around a propeller blade, can cause noise, vibration, and damage to the propeller. Water jets experience less cavitation because the water intake is located below the hull, away from the air-water interface.

Safety and Operational Benefits:

- **Safer for Swimmers and Marine Life:** With no exposed propeller blades, water jets pose a lower risk of injury to swimmers or marine life that might come into contact with the vessel.
- **Reduced Noise Levels:** Water jets generally operate quieter than propellers, making them suitable for noise-sensitive environments or research vessels requiring minimal acoustic disturbance.
- **Lower Maintenance:** Water jets typically require less maintenance compared to propellers. They have fewer moving parts and are less susceptible to damage from debris or underwater collisions.

Other Advantages:

- **Improved Fuel Efficiency:** In some cases, water jets can offer improved fuel efficiency, particularly at high speeds. This is because they can convert more engine power into thrust compared to propellers that lose some efficiency due to drag.

- **Reversible Thrust:** Some water jet designs incorporate a reversing mechanism that allows for immediate thrust reversal. This can be helpful for quick stops and precise maneuvering.

However, it's important to consider some drawbacks of water jets as well:

- **Higher Initial Cost:** Water jets are generally more expensive to purchase and install compared to conventional propellers.
- **Lower Efficiency at Low Speeds:** While efficient at high speeds, water jets might be less efficient at lower speeds compared to propellers.
- **Higher Complexity:** The design and operation of water jets can be more complex compared to propellers, requiring specialized training for maintenance and repairs.

Overall, water jets offer significant advantages in terms of performance, maneuverability, safety, and noise reduction. However, their higher initial cost, lower efficiency at low speeds, and increased complexity need to be factored in when deciding between water jets and propellers for a particular vessel application.

Feb 2021

Feb 2021

6. With reference to controllable pitch propellers:

(a) explain why they should maintain a small amount of pitch when in the neutral position; (3)

(b) state, with reasons, the failsafe position; (4)

(c) explain how pitch may be restored should hydraulic system failure occur. (3)

feb 2024

6. With reference to controllable pitch propellers:

(a) explain why they should maintain a small amount of pitch when in the neutral position; (3)

(b) state, with reasons, the failsafe position; (4)

(c) explain how pitch may be restored should hydraulic system failure occur. (3)

Controllable Pitch Propellers: Pitch in Neutral, Failsafe, and Restoration

(a) Maintaining Small Pitch in Neutral Position:

Controllable pitch propellers (CPP) shouldn't be completely flat (zero pitch) when in the neutral position (blades not actively generating thrust). Here's why:

- **Minimum Drag:** A small pitch angle (slightly positive) helps minimize drag on the propeller when the engine is running but not actively propelling the vessel. With zero pitch, the blades act like a flat plate against the water, creating unnecessary drag and reducing efficiency.
- **Improved Maneuverability:** A slight positive pitch provides a small amount of braking effect, aiding maneuverability at low speeds or during stopping procedures. It helps slow the vessel down more effectively compared to a completely flat blade.
- **Faster Engine Response:** When transitioning from neutral to forward thrust, a small positive pitch angle allows the engine to respond quicker and generate thrust more rapidly. It reduces the time needed for the blades to reach the desired positive pitch for forward propulsion.

(b) Failsafe Position:

In the event of a complete hydraulic system failure in a CPP system, the blades should move to a failsafe position. This position is typically:

- **Full Feathered Pitch:** The blades are rotated to a position with a large negative pitch angle. This essentially puts the blades parallel to the water flow, offering minimal resistance and preventing them from creating drag or reverse thrust.
- **Reasoning:** This position minimizes the negative impact on the vessel's performance and maneuverability in case of hydraulic failure. It prevents the blades from acting like a brake or creating unwanted reverse thrust, which could be dangerous or hinder control.

(c) Restoring Pitch after Hydraulic System Failure:

Several methods can be employed to restore the pitch of the propeller blades in case of hydraulic system failure, depending on the specific design and available backup systems:

- **Emergency Pitch Control System:** Some CPP systems might incorporate a backup, non-hydraulic system (e.g., electric, mechanical) for controlling blade pitch. This allows the operator to adjust the pitch to a limited extent, even with a failed hydraulic system.
- **Manual Pitch Locking Mechanism:** In some designs, a manual locking mechanism might be available. This allows the crew to secure the blades in a specific pitch position (usually feathered) using manual tools, even with a hydraulic system failure.
- **Alternative Propulsion Systems:** Some vessels with CPP systems might have auxiliary propulsion systems (e.g., bow thrusters, stern thrusters) that can be used for limited maneuvering capabilities even if the main propeller is inoperable due to hydraulic failure.

It's important to note that the specific methods for restoring pitch and the available backup systems will vary depending on the design and complexity of the CPP system. Crew training on emergency procedures for handling hydraulic system failures is crucial for maintaining some level of control and ensuring vessel safety in such situations.

Nov 2021

6. With reference to a vessel with a single electro/hydraulic controllable pitch propeller, explain EACH of the following:

(a) how manoeuvring may be maintained if the control system fails; (5)

(b) the action to be taken should the hydraulic system irreparably fail whilst on route and the blades assume zero pitch. (5)

Question 6. Some do not understand the term Electro-Hydraulic. Some use engines to manoeuvre even though the question states a single CPP. There is more to maintaining manoeuvring than just switching to the local control. The question states that the CPP assumes zero pitch on failure of the hydraulics – this is therefore the fail safe position. Several appear to have a further spring in the hub to give pitch on the blade.

Maintaining Maneuverability and Actions in Case of Control System/Hydraulic Failure (Single CPP)

(a) Maintaining Maneuvering with Control System Failure:

Maintaining some level of maneuverability even with a control system failure in a single electro/hydraulic controllable pitch propeller (CPP) system depends on the available backup features:

- **Emergency Pitch Control System (Optional):**
    - Some CPP systems might have a secondary, non-hydraulic control system (electric, mechanical) for limited blade pitch adjustment. This allows the operator to potentially feather the blades (set them to a negative pitch angle) for minimal drag or even adjust them to a low forward thrust setting for basic maneuvering.
- **Manual Pitch Locking Mechanism (Optional):**
    - In some designs, a manual locking mechanism might be available. This allows the crew to secure the blades in a specific pitch position (usually feathered) using tools, even if the control system fails. This would eliminate drag and allow for some steering control with the rudder.
- **Rudder Control:**
    - The rudder remains functional even with control system failure. By skillfully using the rudder, the crew can maintain some degree of directional control, especially at lower speeds.

However, it's important to note that these are limited options, and maneuvering capability will be significantly reduced compared to normal operation.

(b) Action if Hydraulic System Fails and Blades Assume Zero Pitch:

If the hydraulic system fails completely and the blades go to zero pitch while underway, the following actions should be taken:

- **Stop Engine:** Immediately stop the main engine to prevent unnecessary wear and tear on the propeller and drivetrain components due to zero thrust generation.
- **Assess Situation:** Evaluate the vessel's position, surrounding traffic, and weather conditions. This helps determine the most appropriate course of action.
- **Alert Crew and Authorities:** Inform the crew of the situation and activate emergency procedures. Broadcast a distress signal (if necessary) to alert nearby vessels and coastal authorities of the situation and potential need for assistance.
- **Anchor Deployment (Optional):** If conditions allow and the water depth is suitable, consider deploying the anchor to help stabilize the vessel's position and prevent drifting.
- **Activate Backup Systems (if Available):** If the vessel has auxiliary propulsion systems like bow thrusters or stern thrusters, attempt to use them for limited maneuvering capabilities.
- **Prepare for Assistance:** Prepare to receive assistance from tugboats or other vessels if necessary.

Remember: The priority in this situation is to ensure the safety of the crew and vessel. By taking prompt action, maintaining communication, and utilizing available resources, the impact of the failure can be minimized while awaiting assistance.

Nov 2020

Nov 2020

6. With reference to controllable pitch propellers:

(a) describe a mechanism that changes the pitch of the blades; (7)

(b) explain how the pitch of the blades is indicated. (3)

Question 6. Several answer this question by describing the whole system, the question just asks about the mechanism for changing the blade angle. Of those that describe the mechanism, most mention longitudinal movement and angular but none actually explain how longitudinal is changed to angular. Several make no attempt

nov 2018 2nd

Nov 2018 2nd

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(a) describe a mechanism that changes the pitch of the blades; (7)

(b) explain how the pitch of the blades is indicated. (3)

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- **Blades:** Hydrofoils that rotate and generate thrust. They can pivot within the hub to change their pitch angle.
- **Pitch Change Rod:** A shaft or linkage that connects the blade root to the pitch change mechanism within the hub.
- **Pitch Control Mechanism:** This mechanism is located inside the hub and can be:
  - **Hydraulic System (Most Common):** Uses pressurized hydraulic fluid to actuate pistons or cylinders that push or pull on the pitch change rods, adjusting the blade angles.
  - **Electric System (Less Common):** Uses electric motors to drive gear mechanisms that rotate the pitch change rods.

Operation:

1. **Command Signal:** The operator on the bridge sends a signal (electrical or mechanical) to the pitch control system. This signal indicates the desired blade pitch angle.
2. **Hydraulic or Electric Actuation:** Depending on the system type, the signal activates either a hydraulic pump or an electric motor within the pitch control mechanism.
3. **Hydraulic Fluid Flow (Hydraulic System):** In a hydraulic system, pressurized fluid is directed to specific chambers within pistons or cylinders based on the desired pitch change.
4. **Rod Movement:** The pressurized fluid pushes or pulls on pistons or cylinders, which in turn transmit the force through the pitch change rods.
5. **Blade Pitch Adjustment:** The pitch change rods are connected to the blade roots, and their movement causes the blades to pivot within the hub, adjusting their pitch angle.
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(b) Pitch Blade Indication:

The operator needs to know the actual pitch angle of the propeller blades for optimal performance and control. Here are two common methods for indicating blade pitch:

- **Mechanical Pitch Indicator:** This is a dial gauge located near the bridge control system. It's connected to the pitch control mechanism via linkages or cables. As the blades move, the linkages rotate the gauge, displaying the actual pitch angle on the dial.
- **Electronic Pitch Indicator:** This is a more modern system that uses sensors within the hub to measure the actual blade angle. The sensor data is transmitted electronically to a display on the bridge, providing a real-time and accurate indication of the blade pitch.

Additional Considerations:

- Safety features like blade position interlocks might be incorporated to prevent unintended blade movement during engine start-up or shutdown.
- Redundant systems (e.g., backup pumps) could be included in critical applications to ensure continued pitch control even in case of a malfunction.

By employing mechanisms like hydraulics or electrics, controllable pitch propellers offer precise control over blade pitch, enhancing vessel maneuverability, efficiency, and performance across various operational scenarios. The use of either mechanical or electronic pitch indicators ensures the operator has accurate information about the actual blade angle for optimal control.

May 2021

May 2021

6. Describe, with the aid of a sketch, the operation of a transverse thruster that is hydraulically driven. (10)

Question 6. Generally poor answers. Several just describe the hydraulic control, describing operation must include how thrust is varied in magnitude and direction as well as control.

A hydraulically driven transverse thruster utilizes pressurized hydraulic fluid to generate a lateral thrust force, aiding in vessel maneuvering. Here's a breakdown of its operation:

Components:

- **Electric Motor:** This motor, typically located below deck, drives the hydraulic pump.
- **Hydraulic Pump:** Converts electrical energy from the motor into pressurized hydraulic fluid.
- **Reservoir:** Stores the hydraulic fluid and maintains its proper level.
- **Pipelines:** High-pressure hoses or steel pipes carry the pressurized fluid to and from the thruster unit.
- **Directional Control Valve:** Located near the bridge control system, this valve receives electrical or mechanical signals from the operator and directs the flow of hydraulic fluid.
- **Transverse Thruster Unit:** This underwater unit houses the propeller and the hydraulic motor that drives it.

Operation:

1. **Command Signal:** The helmsman on the bridge operates the controls (joystick, buttons) to activate the thruster. This sends a signal (electrical or mechanical) to the directional control valve.
2. **Valve Movement:** Based on the received signal, the spool or poppet within the directional control valve moves, opening specific ports to direct the flow of hydraulic fluid.
3. **Hydraulic Fluid Flow:** The valve directs pressurized fluid from the pump to one side of the hydraulic motor within the thruster unit. Simultaneously, it opens a passage for the fluid on the opposite side of the motor to return to the reservoir. This creates a pressure differential across the motor.

4. **Hydraulic Motor Rotation:** The pressure difference acts on the internal components of the hydraulic motor, causing it to rotate in a specific direction. This rotation is typically clockwise or counter-clockwise depending on the desired thruster direction.
5. **Propeller Rotation:** The shaft of the hydraulic motor is directly connected to the propeller within the thruster unit. As the motor rotates, it drives the propeller to spin in the same direction.
6. **Lateral Thrust Generation:** The spinning propeller pushes water perpendicular to the vessel's direction of travel, creating a lateral thrust force. Depending on the propeller rotation direction (clockwise or counter-clockwise), the thrust will push the vessel's stern to port or starboard, aiding in maneuvering during docking, station keeping, or low-speed maneuvering situations.
7. **Stopping the Thruster:** When the helmsman centers the control or selects "stop," the directional control valve moves to a neutral position, blocking the flow of fluid to the hydraulic motor. This brings the thruster to a halt.

Additional Considerations:

- **Pressure Relief Valve (Optional):** A pressure relief valve might be incorporated within the system to protect against excessive pressure buildup due to malfunctions.
- **Flow Control Valve (Optional):** In some designs, a flow control valve may be used to regulate the flow of hydraulic fluid and adjust the thruster's power output.

Overall, a hydraulically driven transverse thruster offers a reliable and efficient way for precise maneuvering by converting electrical energy into a controllable lateral thrust force through the use of hydraulics and a dedicated propeller unit.

Oct 2020

Oct 2020

6. With reference to propellers, explain EACH of the following:

(a) TWO advantages of having high skew; (5)

(b) TWO advantages of aft rake. (5)

Propeller Advantages: Skew and Rake

(a) Advantages of High Skew:

High skew refers to a propeller blade design where the cross-section of each blade is angled significantly off-axis relative to the rotational plane of the propeller. Here are two advantages of using propellers with high skew:

1. **Reduced Cavitation:** Cavitation is the formation and collapse of vapor bubbles around a propeller blade, which can cause noise, vibration, and damage to the blade. High skew disrupts the smooth flow of water across the blade face, making it more difficult for cavitation

bubbles to form and persist. This is particularly beneficial for propellers operating at high speeds or with high blade loads.

2. **Improved Efficiency at Oblique Angles:** Unlike a straight-bladed propeller, which is most efficient when pushing water directly aft, a high skew propeller can maintain better efficiency even when the vessel is not traveling in a straight line. This is because the angled blades can still grip the water effectively even at oblique angles, reducing efficiency losses during maneuvers or when steering.

However, it's important to note that high skew designs also have some drawbacks, such as increased drag at low speeds and slightly reduced overall propulsive efficiency compared to lower skew propellers.

(b) Advantages of Aft Rake:

Aft rake refers to the design where the tips of the propeller blades are angled slightly backward relative to the plane of rotation. Here are two advantages of using propellers with aft rake:

1. **Reduced Shaft Vibration:** Propeller rotation can induce vibrations that travel through the shaft and into the vessel. Aft rake helps to mitigate these vibrations by altering the way the blades interact with the water. The angled blades tend to enter and exit the water more smoothly, reducing the forces that contribute to shaft vibrations.
2. **Improved Clearance:** In vessels with limited propeller clearance between the hull and the bottom of the propeller, aft rake can provide some additional clearance. The angled blades are positioned slightly higher relative to the shaft axis, reducing the risk of the blade tips striking the hull, especially during rolling or pitching motions.

Aft rake also has some minor drawbacks. For example, it can result in a slight decrease in propulsive efficiency compared to a straight rake design.

In conclusion, both high skew and aft rake offer specific advantages for propeller design. High skew is beneficial for reducing cavitation and improving efficiency at oblique angles, while aft rake helps minimize shaft vibration and provide additional clearance. The choice of propeller design with specific skew and rake angles will depend on the vessel's operational needs and priorities.

Sept 18th 2020

Sept (18th) 2020

6. (a) State SIX advantages of controllabe pitch propellers. (6)

(b) State FOUR disadvantages of controllable pitch propellers. (4)

May 28th 2021

6. (a) State SIX advantages of controllabe pitch propellers. (6)

(b) State FOUR disadvantages of controllable pitch propellers. (4)

Controllable Pitch Propellers: Advantages and Disadvantages

(a) Advantages of Controllable Pitch Propellers (CPP):

1. **Improved Maneuverability:** CPP allows for quick and precise adjustment of blade pitch, enabling faster changes in speed and direction. This is particularly beneficial for docking, maneuvering in tight spaces, and quick stops.
2. **Optimized Engine Efficiency:** By adjusting the pitch to match operating conditions, CPP allows the engine to operate at its most efficient range across various speeds. This can lead to fuel savings and improved operational range.
3. **Reduced Cavitation:** With the ability to adjust pitch, CPP can operate at a lower pitch setting at high speeds, reducing the risk of cavitation, which can damage blades and cause noise and vibration.
4. **Reversible Thrust:** Some CPP designs incorporate a mechanism for reversing the pitch of the blades, allowing for immediate braking and improved maneuverability in confined areas.
5. **Reduced Engine Wear:** By eliminating the need for frequent gear changes or clutch operations, CPP can contribute to reduced wear and tear on the engine and drivetrain components.
6. **Improved Bollard Pull:** Bollard pull refers to a vessel's static pulling force. By adjusting the propeller pitch to a high thrust setting, CPP can maximize bollard pull, making it beneficial for towing, anchor handling, and other applications requiring high static thrust.

(b) Disadvantages of Controllable Pitch Propellers (CPP):

1. **Higher Initial Cost:** CPP systems are generally more expensive to purchase and install compared to conventional fixed-pitch propellers.
2. **Increased Complexity:** CPP systems involve additional mechanical components and a hydraulic or electric control system, which can be more complex to maintain and repair compared to simpler fixed-pitch designs.
3. **Single Point of Failure:** The entire pitch control system relies on the proper functioning of the hydraulics or electrics. A failure in this system can significantly impact the vessel's maneuverability and propulsion capabilities.
4. **Maintenance Requirements:** CPP systems require regular maintenance to ensure proper operation of the pitch control mechanism and associated components.

Overall, controllable pitch propellers offer significant advantages in terms of maneuverability, efficiency, and performance. However, their higher initial cost, increased complexity, and potential for single-point failures need to be considered when deciding between CPP and fixed-pitch propellers for a particular vessel application.

April 2021

April 2021

6. (a) Describe, with the aid of a sketch, a pilgrim nut. (5)

(b) Explain how the pilgrim nut is used to ensure correct fitting of a keyless propeller. (5)

Pilgrim Nut: Securing Keyless Propellers

(a) Description of a Pilgrim Nut:

A pilgrim nut is a specialized nut used in the marine industry for securely attaching keyless propellers, rudders, or other tapered components onto a shaft. It utilizes a hydraulically powered mechanism to achieve a precise and high-force fit.

Here are the key components of a pilgrim nut:

- **Body:** The main housing of the nut that contains the internal mechanism.
- **Screw Threads:** These threads are used to screw the pilgrim nut onto the shaft until it reaches the base of the propeller or fitting.
- **Loading Ring:** This ring sits within the body and is the key component for applying force.
- **Hydraulic Chamber:** This chamber is located behind the loading ring and can be pressurized with hydraulic fluid.
- **Piston (Optional):** Some designs may utilize a piston directly actuated by hydraulic pressure.

(b) Ensuring Correct Fitting with a Pilgrim Nut:

Here's how a pilgrim nut is used to ensure a secure and precise fit for a keyless propeller on a tapered shaft:

1. **Preparation:** The propeller and shaft are thoroughly cleaned and inspected for any irregularities.
2. **Positioning:** The pilgrim nut is screwed onto the shaft threads until the loading ring makes contact with the base of the propeller.
3. **Hydraulic Pressure Application:** Hydraulic fluid is pumped into the chamber behind the loading ring. This pressurizes the chamber and creates a force against the loading ring.
4. **Force Transmission:** The pressurized fluid pushes the loading ring outwards. This, in turn, pushes the propeller further up the tapered shaft, achieving a tight and secure fit.
5. **Pressure Monitoring and Advance Measurement:** The hydraulic pressure applied and the actual travel (advance) of the propeller along the taper are carefully monitored and compared to predetermined values. This ensures the propeller reaches the correct position for optimal performance and safety.

6. **Pressure Release and Locking (Optional):** Once the desired pressure and advance are achieved, the hydraulic pressure may be released. In some designs, a locking mechanism might be engaged to prevent the nut from loosening due to vibration or propeller thrust.

Advantages of Pilgrim Nuts:

- **High Clamping Force:** Pilgrim nuts provide a very high clamping force, ensuring a secure and reliable fit between the propeller and the shaft.
- **Precise Control:** The use of hydraulic pressure allows for precise control over the force applied and the resulting position of the propeller on the taper.
- **Repeatability:** The use of pressure gauges and predetermined values ensures consistent and repeatable results during propeller installation.
- **Keyless Design:** Eliminates the need for a keyway on the shaft and propeller, simplifying manufacturing and reducing potential stress concentrations.

Overall, pilgrim nuts play a crucial role in ensuring the safe and reliable operation of propellers on vessels by providing a strong and precise connection between the propeller and the shaft.

Feb 19th 2021

Feb 19th 2021

6. (a) Sketch an arrangement for a transverse, water jet thruster. (6)

(b) Explain how thrust is created in a water jet thruster. (4)

Transverse Water Jet Thruster Arrangement and Thrust Creation

(a) Arrangement of a Transverse Water Jet Thruster:

A transverse water jet thruster is a maneuverability-enhancing device typically mounted on the sides of a vessel below the waterline. Here's a breakdown of its arrangement:

- **Intake:** A submerged opening in the hull that allows water to enter the system. It's often protected by a grating to prevent debris from entering.
- **Water Pump:** A centrifugal pump powered by an electric motor or a hydraulic motor. It draws water in through the intake and pressurizes it.
- **Delivery Duct:** A sturdy pipe or channel that carries the pressurized water from the pump to the thruster unit.
- **Transverse Thruster Unit:** This underwater unit houses a directional nozzle and other components.
- **Directional Nozzle:** A movable nozzle within the thruster unit that can be directed to port or starboard. It controls the direction of the water jet for maneuvering.
- **Outlet:** The opening at the end of the directional nozzle where the high-pressure water exits the thruster unit.

(b) Thrust Creation in a Water Jet Thruster:

Water jet thrusters operate based on Newton's Third Law of Motion (for every action, there is an equal and opposite reaction). Here's how thrust is created:

1. **Water Intake:** The pump draws in water through the intake at the bottom of the vessel.
2. **Water Acceleration:** The pump impeller rapidly accelerates the water, converting kinetic energy into pressure.
3. **High-Pressure Flow:** The pressurized water is then channeled through the delivery duct to the thruster unit.
4. **Directional Nozzle Control:** The operator controls the directional nozzle within the thruster unit, directing the water flow to port or starboard.
5. **Jet Force:** The high-pressure water exiting the nozzle at high velocity creates a powerful jet force in the opposite direction of the water flow (per Newton's Third Law).
6. **Transverse Thrust:** This jet force pushes against the surrounding water, generating a lateral thrust force perpendicular to the vessel's direction of travel. By directing the nozzle port or starboard, the thruster can create a pushing force in the desired direction, aiding in maneuvering during docking, station keeping, or low-speed operations.

Additional Considerations:

- **Reversible Thrust (Optional):** Some water jet thruster designs may incorporate a reversing mechanism within the directional nozzle. This allows for reversing the water flow direction, creating a braking effect or thrust in the opposite direction for even more precise maneuvering control.
- **Gimbal Mounting (Optional):** In some installations, the thruster unit might be mounted on a gimbal, allowing for some angular movement of the nozzle. This provides additional flexibility in directing the water jet, especially on vessels with significant hull curvature.

Overall, transverse water jet thrusters offer a powerful and efficient way to enhance a vessel's maneuverability by utilizing a pump, directional nozzle, and the principles of fluid mechanics to generate a controllable lateral thrust force.

July 2021

July 2021

6. With reference to propellers, explain EACH of the following:

(a) TWO advantages of having high skew; (5)

(b) TWO advantages of aft rake. (5)

Propeller Advantages: Skew and Rake

(a) Advantages of High Skew:

High skew refers to a propeller blade design where the cross-section of each blade is angled significantly off-axis relative to the rotational plane of the propeller. Here are two advantages of using propellers with high skew:

1. **Reduced Cavitation:** Cavitation is the formation and collapse of vapor bubbles around a propeller blade, which can cause noise, vibration, and damage to the blade. High skew disrupts the smooth flow of water across the blade face, making it more difficult for cavitation bubbles to form and persist. This is particularly beneficial for propellers operating at high speeds or with high blade loads.
2. **Improved Efficiency at Oblique Angles:** Unlike a straight-bladed propeller, which is most efficient when pushing water directly aft, a high skew propeller can maintain better efficiency even when the vessel is not traveling in a straight line. This is because the angled blades can still grip the water effectively even at oblique angles, reducing efficiency losses during maneuvers or when steering.

However, it's important to note that high skew designs also have some drawbacks, such as increased drag at low speeds and slightly reduced overall propulsive efficiency compared to lower skew propellers.

(b) Advantages of Aft Rake:

Aft rake refers to the design where the tips of the propeller blades are angled slightly backward relative to the plane of rotation. Here are two advantages of using propellers with aft rake:

1. **Reduced Shaft Vibration:** Propeller rotation can induce vibrations that travel through the shaft and into the vessel. Aft rake helps to mitigate these vibrations by altering the way the blades interact with the water. The angled blades tend to enter and exit the water more smoothly, reducing the forces that contribute to shaft vibrations.
2. **Improved Clearance:** In vessels with limited propeller clearance between the hull and the bottom of the propeller, aft rake can provide some additional clearance. The angled blades are positioned slightly higher relative to the shaft axis, reducing the risk of the blade tips striking the hull, especially during rolling or pitching motions.

Aft rake also has some minor drawbacks. For example, it can result in a slight decrease in propulsive efficiency compared to a straight rake design.

In conclusion, both high skew and aft rake offer specific advantages for propeller design. High skew is beneficial for reducing cavitation and improving efficiency at oblique angles, while aft rake helps minimize shaft vibration and provide additional clearance. The choice of propeller design with specific skew and rake angles will depend on the vessel's operational needs and priorities.

March 19th 2021

6. With reference to a vessel with a single electro/hydraulic controllable pitch propeller, explain EACH of the following:

(a) how manoeuvring may be maintained if the control system fails; (5)

(b) the action to be taken should the hydraulic system irreparably fail whilst on route and the blades assume zero pitch. (5)

Maintaining Maneuverability and Actions During Control System/Hydraulic Failure (Single CPP)

(a) Maintaining Maneuvering with Control System Failure:

Maintaining some level of maneuverability even with a control system failure in a single electro/hydraulic controllable pitch propeller (CPP) system depends on the available backup features:

- **Emergency Pitch Control System (Optional):**
  - Some CPP systems might have a secondary, non-hydraulic control system (electric, mechanical) for limited blade pitch adjustment. This allows the operator to potentially feather the blades (set them to a negative pitch angle) for minimal drag or even adjust them to a low forward thrust setting for basic maneuvering.
- **Manual Pitch Locking Mechanism (Optional):**
  - In some designs, a manual locking mechanism might be available. This allows the crew to secure the blades in a specific pitch position (usually feathered) using tools, even if the control system fails. This would eliminate drag and allow for some steering control with the rudder.
- **Rudder Control:**
  - The rudder remains functional even with control system failure. By skillfully using the rudder, the crew can maintain some degree of directional control, especially at lower speeds.

However, it's important to note that these are limited options, and maneuvering capability will be significantly reduced compared to normal operation.

(b) Action if Hydraulic System Fails and Blades Assume Zero Pitch:

If the hydraulic system fails completely and the blades go to zero pitch while underway, the following actions should be taken:

- **Stop Engine:** Immediately stop the main engine to prevent unnecessary wear and tear on the propeller and drivetrain components due to zero thrust generation.
- **Assess Situation:** Evaluate the vessel's position, surrounding traffic, and weather conditions. This helps determine the most appropriate course of action.

- **Alert Crew and Authorities:** Inform the crew of the situation and activate emergency procedures. Broadcast a distress signal (if necessary) to alert nearby vessels and coastal authorities of the situation and potential need for assistance.
- **Anchor Deployment (Optional):** If conditions allow and the water depth is suitable, consider deploying the anchor to help stabilize the vessel's position and prevent drifting.
- **Activate Backup Systems (if Available):** If the vessel has auxiliary propulsion systems like bow thrusters or stern thrusters, attempt to use them for limited maneuvering capabilities.
- **Prepare for Assistance:** Prepare to receive assistance from tugboats or other vessels if necessary.

Remember: The priority in this situation is to ensure the safety of the crew and vessel. By taking prompt action, maintaining communication, and utilizing available resources, the impact of the failure can be minimized while awaiting assistance.

May 2024

6. With reference to propellers, explain EACH of the following terms:

(a) skew; (2)

(b) rake; (2)

(c) pitch; (2)

(d) slip. (4)

MArch 26th 2021

March 26th 2021

6. With reference to propellers, explain EACH of the following terms:

(a) skew; (2)

(b) rake; (2)

(c) pitch; (2)

(d) slip. (4)

Propeller Terminology Explained:

(a) Skew:

- Skew refers to the **angle** at which the propeller blade sections are twisted relative to the plane of rotation. Imagine looking at the propeller from the front. In a propeller with no skew, the blade sections would appear flat. With skew, the blade sections are angled **off-axis**, typically leaning either forward or aft.

(b) Rake:

- Rake refers to the **angle** of the propeller blades relative to a line perpendicular to the propeller shaft axis. There are three main types of rake:
  - **Zero Rake:** The blades are perpendicular to the shaft axis.
  - **Aft Rake:** The tips of the blades are angled slightly **backward** relative to the shaft axis.
  - **Forward Rake:** The tips of the blades are angled slightly **forward** relative to the shaft axis.

(c) Pitch:

- Pitch is a concept similar to the lead of a screw. Imagine the propeller advancing through a solid medium like a giant corkscrew. The **pitch** is the theoretical distance the propeller would advance in one revolution **if there were no water slippage** (explained in term (d) below). A higher pitch angle results in a larger theoretical advance per revolution, but requires more torque from the engine.

(d) Slip:

- In reality, propellers operate in water, which yields and does not provide a solid medium for perfect forward thrust. **Slip** refers to the difference between the theoretical advance (pitch) and the actual distance the vessel travels forward in one revolution of the propeller. Slip is expressed as a percentage of the pitch. For example, a propeller with 10% slip would travel 90% of its theoretical pitch distance per revolution. Slip is inevitable, but a well-designed propeller aims to minimize it for optimal efficiency.