Nov 2018 9th

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

(a) describe, with the aid of a sketch, the removal procedure; (7)

(b) state how it is determined, during reassembly, that the push fit is complete. (3)

Main Propulsion Shaft Hydraulic Sleeve Coupling: Removal and Reassembly

(a) Removal Procedure:

Removing a main propulsion shaft hydraulic sleeve coupling requires careful planning and execution due to the significant forces involved. Here's a general outline of the procedure:

Preparation:

1. **Safety First:** Ensure all safety protocols are followed, including lockout/tagout procedures to prevent accidental shaft rotation or hydraulic pressure release.
2. **Support and Alignment:** Properly support the propeller shaft and the machine connected to the coupling (e.g., gearbox) using jacks or other lifting equipment to maintain alignment during disassembly.
3. **Drain Hydraulic System:** If the coupling utilizes hydraulic pressure for actuation, ensure the system is drained and depressurized safely.

Disassembly:

1. **Disconnect and Remove Auxiliary Components:** Remove any sensors, piping, or other auxiliary components connected to the coupling housing.
2. **Loosen Fasteners (if applicable):** Some designs might have external fasteners (bolts, nuts) securing the coupling halves together. These need to be loosened and removed carefully.
3. **Hydraulic Pressure Application (if applicable):** In hydraulically actuated designs, specific procedures might involve applying controlled hydraulic pressure to separate the coupling halves.
4. **Heater Application (Optional):** In some cases, applying controlled heat to the outer sleeve can aid in expansion and easier separation. However, proper temperature control is crucial to avoid damaging the coupling components.
5. **Pulling Force Application:** Once the coupling is disengaged, a pulling force may be required to separate the two halves. Specialized pulling tools or a controlled hydraulic ram might be used for this purpose.

Important Notes:

- The specific removal procedure will vary depending on the coupling design and manufacturer's instructions. It's crucial to consult the relevant manuals for detailed steps and safety precautions.

- During disassembly, extreme caution should be exercised to prevent damage to the coupling components, shaft, or surrounding machinery.

(b) Determining Push Fit Completion During Reassembly:

Reassembly of a hydraulic sleeve coupling requires ensuring a proper push fit between the shaft and the inner sleeve. Here are some methods used to determine if the push fit is complete:

1. Measurement and Tolerance Checks:

- Consult the coupling manufacturer's specifications for the required dimensions of the shaft and the inner sleeve after assembly.
- Use precision measuring tools (calipers, micrometers) to verify that the achieved interference between the shaft and sleeve falls within the specified tolerance range. This ensures a tight and secure fit.

2. Gap Measurement (Optional):

- In some designs, there might be designated gap measurements between specific points on the coupling halves after assembly. Careful measurement with appropriate tools can confirm proper positioning and engagement.

3. Factory-provided Tools (Optional):

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement, force required for insertion, or other parameters to indicate proper engagement.

4. Visual Inspection:

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after assembly.

Overall:

A combination of these methods is typically used to ensure a proper and secure push fit during reassembly of a hydraulic sleeve coupling. Following manufacturer's instructions and employing the appropriate tools and measurements are crucial for a successful and reliable reassembly process.

Sept 2021

7. With reference to comparing modern water lubricated stern tube bearings with those that are oil lubricated:

(a) state THREE advantages; (3)

(b) state THREE disadvantages, explaining how EACH may be overcome. (7)

feb 2024

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(a) state THREE advantages; (3)

(b) state THREE disadvantages, explaining how EACH may be overcome. (7)

Modern Water Lubricated vs. Oil Lubricated Stern Tube Bearings

Here's a comparison of modern water-lubricated stern tube bearings with oil-lubricated designs:

(a) Advantages of Water-Lubricated Bearings:

1. **Environmental Friendliness:** Water-lubricated bearings eliminate the risk of oil spills into the environment, which can be devastating to marine ecosystems. This is becoming increasingly important with stricter environmental regulations.
2. **Lower Maintenance:** Water-lubricated bearings generally require less maintenance compared to oil-lubricated systems. Since they don't rely on oil changes and filter replacements, there's a reduction in associated costs and downtime.
3. **Simplicity:** Water-lubricated bearings often have a simpler design with fewer components compared to oil systems. This can make them lighter and potentially less expensive to manufacture.

(b) Disadvantages of Water-Lubricated Bearings and How to Overcome Them:

1. **Lower Load Capacity:** Water, as a lubricant, has a lower lubricating capacity compared to oil. This can limit the maximum load a water-lubricated bearing can handle.

- **Overcoming Lower Load Capacity:** Advances in bearing materials and designs are continuously improving the load capacity of water-lubricated bearings. Additionally, careful propeller design and optimization of shaft diameters can help manage loads within acceptable limits for water lubrication.

2. **Stricter Shaft Tolerance Requirements:** Water-lubricated bearings require tighter clearances between the shaft and the bearing material to maintain proper hydrodynamic lubrication with water. This necessitates more precise shaft manufacturing and maintenance tolerances.
- **Overcoming Stricter Tolerances:** Modern manufacturing techniques allow for the production of shafts with tighter tolerances. Regular shaft inspections and wear monitoring programs can help ensure clearances remain within acceptable ranges.

3. **Potential for Corrosion:** Exposure to seawater can lead to corrosion of bearing materials.
- **Overcoming Potential Corrosion:** Modern water-lubricated bearings often utilize special corrosion-resistant materials or coatings to minimize this risk. Additionally, proper sacrificial anode systems can be implemented to provide further protection against corrosion.

In Conclusion:

While water-lubricated bearings have some limitations, advancements in materials, design, and manufacturing are making them a more viable and environmentally friendly alternative to oil-lubricated systems for stern tube applications. Careful engineering considerations and maintenance practices can address potential drawbacks, making water lubrication a promising technology for the future of marine propulsion.

Sept 2020

Sept 2020

7. (a) Describe. with the aid of a sketch, how the alignment of a propeller transmission shaft system may be checked. (8)

(b) State the indications of a high bearing when the shaft is running. (2)

Question 7. Many attempt to describe aligning two shafts together rather than checking the alignment of the shafting. Candidates describe measuring along the shaft rather than the height of the bearings.

Propeller Shaft Alignment Check and High Bearing Indications

(a) Checking Propeller Transmission Shaft Alignment:

Ensuring proper alignment of the propeller shaft system is crucial for optimal performance, reduced wear and tear, and preventing vibration. Here are two common methods for checking shaft alignment:

1. Dial Gauge Method:

- This traditional method utilizes dial gauges to measure the relative runout (movement) of the shaft coupling flanges at various points.
- Dial gauges are magnetically attached to each flange, and the shaft is slowly rotated by hand.
- The runout at different points on the flange circumference is measured and compared to specified tolerances.
- Any deviations beyond acceptable limits indicate misalignment, which needs correction through adjustments of the engine mounts or gearbox position.

2. Laser Shaft Alignment:

- This modern method utilizes laser beam technology for more precise and efficient alignment checks.
- A laser transmitter is positioned on one shaft end, and a receiver is placed on the other.
- The laser beam projects onto the receiver target, and any misalignment is reflected in the position of the laser dot on the target.
- By following the system's instructions and adjusting mounts or gearbox position, the laser beam can be centered on the target, indicating proper alignment.

Additional Considerations:

- Regardless of the method used, shaft alignment should be performed by a qualified technician with the proper tools and expertise.
- Manufacturer's specifications for acceptable alignment tolerances and specific alignment procedures should be strictly followed.

(b) Indications of a High Bearing When the Shaft is Running:

A high bearing, also known as a seized or tight bearing, can cause several problems during shaft operation. Here are some indications that might suggest a high bearing:

- **Increased Vibration:** A high bearing can cause the shaft to run out of true, leading to increased vibration throughout the vessel. This vibration may be felt throughout the hull and might be noticeable visually.
- **Abnormal Shaft Temperature:** Friction from a high bearing can generate excessive heat. This can be detected by feeling increased temperature around the bearing housing or using specialized temperature monitoring instruments.
- **Unusual Noises:** Seized or tight bearings can produce grinding, scraping, or knocking noises as the shaft rotates with difficulty against the bearing surface.
- **Difficulty Turning the Shaft:** In severe cases, a very tight bearing may make it difficult or impossible to turn the shaft by hand.

Early detection and addressing a high bearing is crucial. Ignoring these symptoms can lead to further damage to the bearing, shaft, and surrounding components. If any of these indications are observed, the shaft should be stopped immediately, and a qualified mechanic should investigate the issue.

Feb 2021

Feb 2021

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

   (a) describe, with the aid of a sketch, the removal procedure; (7)

   (b) state how it is determined, during reassembly, that the push fit is complete. (3)

nov 2018 2nd

Nov 2018 2nd

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

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(b) state how it is determined, during reassembly, that the push fit is complete. (3)

Main Propulsion Shaft Hydraulic Sleeve Type Couplings: Removal and Reassembly

(a) Removal Procedure:

Removing a main propulsion shaft hydraulic sleeve type coupling requires careful planning and execution due to the significant forces involved. Here's a general outline of the procedure:

Preparation:

1. **Safety First:** Ensure all safety protocols are followed, including lockout/tagout procedures to prevent accidental shaft rotation or hydraulic pressure release.
2. **Support and Alignment:** Properly support the propeller shaft and the machine connected to the coupling (e.g., gearbox) using jacks or other lifting equipment to maintain alignment during disassembly.
3. **Drain Hydraulic System (if applicable):** If the coupling utilizes hydraulic pressure for actuation, ensure the system is drained and depressurized safely.

Disassembly:

1. **Disconnect and Remove Auxiliary Components:** Remove any sensors, piping, or other auxiliary components connected to the coupling housing.
2. **Loosen Fasteners (if applicable):** Some designs might have external fasteners (bolts, nuts) securing the coupling halves together. These need to be loosened and removed carefully.
3. **Hydraulic Pressure Application (if applicable):** In hydraulically actuated designs, specific procedures might involve applying controlled hydraulic pressure to separate the coupling halves. This should only be done following the manufacturer's instructions.
4. **Heater Application (Optional):** In some cases, applying controlled heat to the outer sleeve can aid in expansion and easier separation. However, proper temperature control is crucial to avoid damaging the coupling components.
5. **Pulling Force Application:** Once the coupling is disengaged, a pulling force may be required to separate the two halves. Specialized pulling tools or a controlled hydraulic ram might be used for this purpose.

Important Notes:

- The specific removal procedure will vary depending on the coupling design and manufacturer's instructions. It's crucial to consult the relevant manuals for detailed steps and safety precautions.
- During disassembly, extreme caution should be exercised to prevent damage to the coupling components, shaft, or surrounding machinery.

(b) Determining Push Fit Completion During Reassembly:

Reassembly of a hydraulic sleeve coupling requires ensuring a proper push fit between the shaft and the inner sleeve. Here are some methods used to determine if the push fit is complete:

1. Measurement and Tolerance Checks:

- Consult the coupling manufacturer's specifications for the required dimensions of the shaft and the inner sleeve after assembly.
- Use precision measuring tools (calipers, micrometers) to verify that the achieved interference between the shaft and sleeve falls within the specified tolerance range. This ensures a tight and secure fit.

2. Gap Measurement (Optional):

- In some designs, there might be designated gap measurements between specific points on the coupling halves after assembly. Careful measurement with appropriate tools can confirm proper positioning and engagement.

3. Factory-provided Tools (Optional):

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement, force required for insertion, or other parameters to indicate proper engagement.

4. Visual Inspection:

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after assembly.

Overall:

A combination of these methods is typically used to ensure a proper and secure push fit during reassembly of a hydraulic sleeve coupling. Following manufacturer's instructions and employing the appropriate tools and measurements are crucial for a successful and reliable reassembly process.

May 2024

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

(a) describe, with the aid of a sketch, the tightening procedure; (7)

(b) state how it is determined that the push fit is complete. (3)

Nov 2021

Nov 2021

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

(a) describe, with the aid of a sketch, the tightening procedure; (7)

(b) state how it is determined that the push fit is complete. (3)

Question 7. Some sketches are very poor and show little understanding of the mode of operation of the coupling, this is then reflected in the answer. Many think that the separation oil is only for lubrication.

Main Propulsion Shaft Hydraulic Sleeve Type Couplings: Tightening and Push Fit

(a) Tightening Procedure:

Tightening a main propulsion shaft hydraulic sleeve coupling requires careful attention to ensure proper engagement and a secure fit. Here's a general outline of the procedure:

Preparation:

1. **Cleanliness:** Ensure the coupling components (shaft taper, inner sleeve bore) are clean and free of any debris or contaminants that could affect the fit.
2. **Lubrication (Optional):** Some designs might specify the use of a specific lubricant on the tapered surfaces to aid assembly and prevent fretting corrosion. Follow manufacturer's instructions for lubricant type and application.
3. **Positioning:** Carefully position the inner sleeve onto the shaft taper, ensuring proper alignment.

Tightening:

1. **Hydraulic Pressure Application (Primary Method):** Hydraulic sleeve couplings typically utilize hydraulic pressure to achieve the necessary force for a tight fit. This is achieved through a dedicated hydraulic system integrated into the coupling design.
    - The specific procedure will involve connecting the hydraulic system to the coupling and carefully applying controlled pressure according to the manufacturer's instructions.
    - Pressure gauges and predetermined pressure values are used to ensure the correct force is applied for proper engagement.
2. **Mechanical Tightening (Optional - Some Designs):** In some coupling designs, there might be additional mechanical fasteners (bolts, nuts) that require tightening after hydraulic pressure application. These fasteners further secure the coupling halves together. Tightening torque values and sequence should strictly follow manufacturer's specifications.

Important Notes:

- The specific tightening procedure will vary depending on the coupling design and manufacturer's instructions. Consulting the relevant manuals for detailed steps and safety precautions is crucial.
- It's essential to ensure the hydraulic system is functioning properly and free of leaks before applying pressure.
- During the tightening process, proper safety protocols should be followed to prevent injury from unexpected movement or high-pressure systems.

(b) Determining Push Fit Completion:

Verifying a complete push fit after tightening a hydraulic sleeve coupling is critical for ensuring a secure connection. Here are methods used to determine proper engagement:

1. Pressure Gauge Reading:

- In hydraulically actuated couplings, the pressure gauge used during tightening will typically provide a direct indication of successful engagement. Reaching the designated pressure value specified by the manufacturer indicates the proper force has been achieved for a secure fit.

2. Measurement and Tolerance Checks:

- After tightening, consult the coupling manufacturer's specifications for the required final dimensions of the assembled coupling (e.g., overall length, specific gap measurements).
- Use precision measuring tools (calipers, micrometers) to verify that the achieved dimensions fall within the specified tolerance range. This confirms proper engagement and interference between the shaft and the inner sleeve.

3. Factory-provided Tools (Optional):

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement during the tightening process or utilize other parameters to indicate proper engagement.

4. Visual Inspection:

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after tightening.

Overall:

A combination of these methods is typically used to ensure a complete and secure push fit after tightening a hydraulic sleeve coupling. Following manufacturer's instructions, monitoring pressure readings, and utilizing appropriate measurement tools are crucial for verifying successful assembly.

Nov 2020

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

(a) how some angular misalignment of the shaft is accommodated; (5)

(b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. Most are OK with angular movement but struggle to explain how longitudinal movement is allowed. Some explain thrust bearings, several make no attempt.

Intermediate Shaft Roller Bearings: Accommodation of Misalignment

(a) Accommodation of Angular Misalignment:

Intermediate shaft roller bearings, while designed for optimal performance with minimal misalignment, can accommodate some degree of angular misalignment between the shaft and the bearing housing. Here are two main types of roller bearings that offer some tolerance for angular misalignment:

- **Cylindrical Roller Bearings:** These bearings have cylindrical rollers that line up parallel to the shaft axis. They can tolerate a small amount of angular misalignment (typically within a few degrees) by allowing the rollers to tilt slightly within the bearing cage. This tilting action helps distribute the load more evenly across the rollers even with minor shaft misalignment.
- **Spherical Roller Bearings:** These bearings incorporate rollers that are shaped like a barrel and rest on a concave bearing race. This design allows for a larger degree of angular misalignment (up to around 15 degrees) compared to cylindrical roller bearings. The spherical shape of the rollers and the conforming raceway enable them to self-align to accommodate slight shaft angularity.

It's important to note that exceeding the recommended angular misalignment limits for these bearings can lead to increased wear, reduced bearing life, and potential damage. Maintaining proper shaft alignment is crucial for optimal bearing performance and longevity.

(b) Accommodation of Longitudinal Movement of the Shaft:

Intermediate shaft roller bearings are typically not designed to accommodate significant longitudinal (axial) movement of the shaft. Here's why:

- **Roller Design:** Roller bearings rely on line contact between the rollers and the races for smooth rolling and load-carrying capacity. This design is optimized for radial loads (perpendicular to the shaft axis). Axial movement could cause the rollers to rub against the ends of the races, increasing friction and potentially damaging the bearing.
- **Internal Clearance:** Roller bearings typically have a specific internal clearance between the rollers and the races. This clearance allows for proper lubrication flow and heat dissipation. Excessive axial movement could reduce or eliminate this clearance, leading to binding, increased friction, and bearing failure.

Accommodation Methods (Limited Cases):

In some specific applications, intermediate shaft roller bearing arrangements might incorporate additional features to accommodate limited axial movement:

- **Thrust Bearings:** In some designs, a separate thrust bearing (typically a ball or roller thrust bearing) might be installed alongside the roller bearing. This dedicated thrust bearing takes on the responsibility of managing axial loads and allows the roller bearing to focus on radial loads.
- **Specialized Roller Bearing Designs:** Some manufacturers offer specialized roller bearing designs with features like crowned rollers or tapered flanges that can tolerate a small degree of axial movement. These bearings are typically used in specific applications where limited axial movement is unavoidable.

In conclusion, while intermediate shaft roller bearings offer some tolerance for angular misalignment, they are generally not designed for significant longitudinal shaft movement. Proper shaft design and alignment practices are crucial to minimize axial loads and ensure optimal performance and longevity of these bearings.

May 2021

May 2021

7. With reference to intermediate shaft bearings of the roller type, describe, with the aid of a sketch, EACH of the following:

   (a) how some angular misalignment of the shaft is accommodated; (5)

   (b) how longitudinal movement of the shaft is accommodated. (5)

Question 7. The question is all about roller type intermediate bearings. Many candidates describe thrust block and shaft alignment methods.

Intermediate Shaft Roller Bearings: Misalignment and Movement

Here's a breakdown of how intermediate shaft roller bearings handle:

(a) Angular Misalignment:

Intermediate shaft roller bearings can tolerate some degree of angular misalignment between the shaft and the bearing housing. However, the extent of this tolerance depends on the specific type of roller bearing:

- **Cylindrical Roller Bearings:** These bearings have cylindrical rollers aligned parallel to the shaft axis. They can accommodate a **limited** amount of angular misalignment (typically within a few degrees). This is achieved by allowing the rollers to **tilt slightly** within the bearing cage. This tilting action distributes the load more evenly across the rollers despite minor misalignment.
- **Spherical Roller Bearings:** These bearings offer a higher tolerance for angular misalignment compared to cylindrical roller bearings (up to around 15 degrees). They incorporate

barrel-shaped rollers that rest on a **concave bearing race**. This design allows for **self-alignment**. The rollers can tilt within the raceway, accommodating slight shaft angularity.

Important Points:

- Exceeding the recommended angular misalignment limits for these bearings can lead to:
    - Increased wear
    - Reduced bearing life
    - Potential damage
- Maintaining proper shaft alignment is crucial for optimal bearing performance and longevity.

(b) Longitudinal Movement of the Shaft:

Intermediate shaft roller bearings are generally **not** designed to accommodate significant longitudinal (axial) movement of the shaft for several reasons:

- **Roller Design:** Roller bearings rely on **line contact** between rollers and races for smooth rolling and load-carrying capacity. This design is optimized for **radial loads** (perpendicular to the shaft axis). Axial movement could cause the rollers to **rub** against the ends of the races, increasing friction and damaging the bearing.
- **Internal Clearance:** Roller bearings have a specific internal clearance between rollers and races. This clearance allows for proper **lubrication flow** and **heat dissipation**. Excessive axial movement could reduce or eliminate this clearance, leading to:
    - Binding
    - Increased friction
    - Bearing failure

Limited Accommodation Methods (Specific Cases):

In some specific applications, intermediate shaft arrangements might incorporate features for **limited** axial movement:

- **Thrust Bearings:** A separate **thrust bearing** (ball or roller) might be installed alongside the roller bearing. This dedicated bearing handles **axial loads**, allowing the roller bearing to focus on radial loads.
- **Specialized Roller Bearings:** Some manufacturers offer specialized roller bearing designs with features like **crowned rollers** or **tapered flanges** that can tolerate a small degree of axial movement. These are used in specific applications where limited axial movement is unavoidable.

In Conclusion:

While intermediate shaft roller bearings offer some tolerance for angular misalignment, they are generally not designed for significant longitudinal movement.** Proper shaft design and alignment practices are crucial to minimize axial loads and ensure optimal performance and longevity of these bearings.

Oct 2020

7. Explain THREE advantages of hydraulically fitted shaft coupling bolts compared to parallel, interference fit bolts. (10)

Explain THIREE advantages of hydraulically fitted shaft coupling bolts compared to parallel interference fit bolts.

Here are three advantages of hydraulically fitted shaft coupling bolts compared to parallel interference fit bolts:

1. Faster and Easier Installation:

- **Parallel interference fit bolts:** These require precise machining tolerances for both the shaft and the bolt hole to achieve the desired interference (tight fit). The installation process can be time-consuming and labor-intensive, often involving heating the bolt to expand it for insertion and then allowing it to cool and shrink to create the interference fit.
- **Hydraulically fitted bolts:** These utilize a hydraulic system to stretch the bolt, allowing for easier insertion into the shaft hole. Once in place, releasing the hydraulic pressure allows the bolt to contract and create a secure fit. This process is generally quicker and less labor-intensive compared to parallel interference fit bolts.

2. Reduced Risk of Bolt Damage:

- **Parallel interference fit bolts:** The heating and cooling process used for installation can introduce stress and potentially weaken the bolt material. Additionally, the tight fit can make it difficult to remove the bolt for inspection or maintenance without risking damage to the bolt or the shaft.
- **Hydraulically fitted bolts:** The stretching process used with hydraulic bolts is typically a colder process compared to heating methods used for parallel interference fits. This reduces the risk of introducing thermal stress into the bolt material. Additionally, the hydraulic system allows for easier removal of the bolt by simply reapplying pressure to extend it again. This reduces the risk of damage during disassembly.

3. More Precise and Predictable Fit:

- **Parallel interference fit bolts:** The actual achieved interference fit can vary slightly depending on factors like machining tolerances and temperature variations during installation. This can lead to inconsistencies in the tightness of the bolted joint.
- **Hydraulically fitted bolts:** The hydraulic system allows for a more controlled and precise application of force to stretch the bolt. This results in a more consistent and predictable interference fit, ensuring a secure and reliable connection between the shaft and coupling components.

Overall:

Hydraulically fitted shaft coupling bolts offer advantages in terms of faster installation, reduced risk of bolt damage, and a more precise and predictable fit compared to traditional parallel interference fit bolts. These benefits can lead to improved efficiency, reduced maintenance downtime, and increased reliability in shaft coupling applications.

Sept 18th 2020

Sept (18th) 2020

7. With reference to stern bearings, state the advantages and disadvantages of using EACH of the following:

(a) white metal; (5)

(b) plastic. (5)

Stern Tube Bearing Materials: White Metal vs. Plastic

Here's a breakdown of the advantages and disadvantages of using white metal and plastic as stern tube bearing materials:

(a) White Metal:

Advantages:

- **Low friction coefficient:** White metal bearings offer a low coefficient of friction, leading to improved efficiency and lower fuel consumption.
- **Embedability:** The soft nature of white metal allows it to embed small particles, preventing them from causing significant damage to the shaft.
- **Conformability:** White metal can conform slightly to minor shaft misalignment, aiding in smooth operation.
- **Relatively low cost:** White metal is generally a more cost-effective bearing material compared to some high-performance plastics.

Disadvantages:

- **Lower load capacity:** White metal has a lower load-carrying capacity compared to some modern plastics. This might limit its suitability for high-powered vessels.
- **Susceptibility to wear:** White metal bearings can wear down faster than some plastics, requiring more frequent maintenance or replacement.
- **Environmental concerns:** Traditional white metal alloys often contain lead, raising environmental concerns regarding disposal and potential pollution. Lead-free alternatives are available but might have slightly lower performance characteristics.

(b) Plastic:

Advantages:

- **High load capacity:** Modern high-performance plastics can offer excellent load-carrying capacity, making them suitable for high-powered vessels.

- **Good wear resistance:** Some plastics exhibit superior wear resistance compared to white metal, potentially extending bearing life and reducing maintenance requirements.
- **Environmentally friendly:** Certain plastics can be a more environmentally friendly option compared to lead-containing white metals.

Disadvantages:

- **Higher cost:** High-performance plastics can be more expensive than white metal.
- **Higher friction coefficient:** The friction coefficient of some plastics might be slightly higher than white metal, potentially leading to some efficiency losses.
- **Lower conformability:** Plastics generally have lower conformability compared to white metal, and they might be more sensitive to shaft misalignment.
- **Potential for shaft damage:** Some plastics, if not chosen carefully, can be more abrasive to the propeller shaft compared to white metal.

Choosing the Right Material:

The choice between white metal and plastic for stern tube bearings depends on several factors, including:

- **Vessel type and power:** High-powered vessels might benefit from the higher load capacity of some plastics.
- **Operating profile:** Frequent stops and starts might favor white metal's embedability properties.
- **Maintenance considerations:** The trade-off between wear resistance and cost needs to be evaluated.
- **Environmental regulations:** Lead-free white metal or environmentally friendly plastics might be preferred.

In conclusion, both white metal and plastic have their advantages and disadvantages for stern tube bearings. Careful consideration of the specific application and operational requirements is crucial for selecting the most suitable material.

April 2021

April 2021

7. Sketch a shaft coupling of the flexible diaphragm type, labelling the MAIN components. (10)

Flexible Diaphragm Coupling: Main Components

A flexible diaphragm coupling is a type of shaft coupling that utilizes a thin, elastic diaphragm to transmit torque between two shafts while accommodating some degree of misalignment. Here are the main components of a flexible diaphragm coupling:

1. Flanges:

- The coupling consists of two metallic flanges, each securely attached to one of the shafts that need to be connected.
- These flanges typically have machined features like hubs or bores for connecting to the shafts and may have drilled holes for bolting the two halves of the coupling together.

2. Diaphragm:

- The core of the coupling is a flexible diaphragm, typically made from high-strength alloy steel.
- This diaphragm is a thin plate, often formed into a specific shape (wavy, corrugated) to provide flexibility while maintaining strength.
- The diaphragm is attached to the outer diameter of one flange and the inner diameter of the other flange.

3. Fasteners:

- Bolts and nuts are used to securely fasten the two halves of the coupling together, clamping the diaphragm between the flanges.

Optional Components:

- **Sealing elements:** In some designs, sealing elements might be incorporated between the diaphragm and the flanges to prevent lubricant leakage or contamination ingress.
- **Spacer elements:** In some cases, spacer elements might be used between the flanges to adjust the overall length of the coupling or to provide a specific axial separation between the shafts.

How it Works:

When the shafts rotate, the torque is transmitted from one flange to the other through the deflection of the diaphragm. The flexible nature of the diaphragm allows it to absorb some degree of misalignment between the shafts, including:

- **Angular misalignment:** This occurs when the shafts are not perfectly aligned along the same axis.
- **Parallel misalignment:** This occurs when the shafts are not perfectly parallel but slightly offset.
- **Axial misalignment:** This occurs when there is a slight axial (end-to-end) movement between the shafts.

Advantages of Flexible Diaphragm Couplings:

- Compact design
- Simple construction
- Easy to install and maintain
- Accommodates some misalignment
- Low maintenance requirements

Disadvantages of Flexible Diaphragm Couplings:

- Lower torque capacity compared to some other coupling types
- Limited speed capability

- Not suitable for applications with large misalignment

Applications:

Flexible diaphragm couplings are commonly used in various industrial applications where a compact, low-maintenance solution is needed to connect shafts and accommodate some degree of misalignment. These applications can include:

- Pumps
- Fans
- Blowers
- Gearboxes
- Conveyors
- Printing machinery

Feb 19th 2021

Feb 19th 2021

7. Whilst a single screw vessel is on passage it is noticed that an intermediate shaft bearing is running hot.

   (a) State FIVE possible causes. (5)

   (b) Explain the procedure that should be followed in order to reach port for further investigation if there were no further causes. (5)

(a) Five Possible Causes of a Hot Intermediate Shaft Bearing on a Single Screw Vessel:

1. **Insufficient Lubrication:** This is the most common cause. Lack of lubricant due to a leak, blockage in the oil line, or incorrect oil viscosity can lead to increased friction and heat generation in the bearing.
2. **Excessive Load:** If the shaft is overloaded due to factors like heavy seas, fouled propeller, or engine over-revving, the bearing can experience excessive stress and heat buildup.
3. **Bearing Wear or Damage:** Normal wear and tear, fatigue cracks, or contamination within the bearing can increase friction and lead to overheating.
4. **Misalignment:** Misalignment between the connected shafts can put uneven pressure on the bearing, causing it to run hot and wear prematurely.
5. **Shaft Vibration:** Excessive vibration from the engine, propeller imbalance, or other sources can be transmitted to the bearing, leading to increased wear and heat generation.

(b) Procedure to Reach Port with a Hot Intermediate Shaft Bearing (Assuming No Further Issues):

1. Reduce Load on the Bearing:

- **Reduce Engine Speed:** This is the most crucial step to minimize heat generation in the bearing. Slowing down the engine reduces the load on the shaft and consequently on the bearing.
- **Minimize Maneuvering:** If possible, avoid sharp turns or sudden changes in course as these can put additional stress on the shaft and bearing.

2. Monitor Bearing Temperature:

- Continuously monitor the bearing temperature using available instruments. If the temperature continues to rise despite reducing the load, further action might be necessary.

3. Prepare for Potential Shutdown:

- Alert the crew and prepare for a possible engine shutdown if the bearing temperature becomes critical.
- Have emergency procedures and contingency plans readily available.

4. Communicate and Plan for Assistance:

- Inform shore-based personnel or relevant authorities about the situation and request assistance upon reaching port.
- Depending on the severity of the situation, consider requesting a tow or standby vessel for additional support.

5. Safe and Steady Operation:

- The primary goal is to reach port safely while minimizing damage to the bearing.
- Maintain a steady course and speed while closely monitoring the bearing temperature.

Important Notes:

- This is a general guideline, and the specific procedures might vary depending on the vessel, its operating manual, and the severity of the situation.
- Consulting a qualified marine engineer and following their recommendations is crucial for safe operation and minimizing potential damage.

Disclaimer: This information is for educational purposes only and should not be taken as professional advice. In case of a real-world emergency, always refer to the vessel's operating manuals and seek guidance from qualified personnel.

July 2021

7. Sketch an arrangement for the aft seal of an oil lubricated stern tube bearing. (10)

Aft Seal Arrangement for Oil-Lubricated Stern Tube Bearing

The aft seal in an oil-lubricated stern tube bearing plays a critical role in preventing seawater ingress and oil leakage. Here's a breakdown of a typical arrangement:

Components:

1. **Housing:** A robust housing is securely attached to the stern tube bossing of the vessel. This housing provides a secure enclosure for the sealing elements.
2. **Liner:** This is a wear ring made from a low-friction material (often white metal or a suitable plastic) that is fixed onto the propeller hub. The sealing elements make contact with the liner to create a tight seal.
3. **Primary Seal:** This is the first line of defense against seawater ingress. It can be one of several designs, such as:
   - **Lip seal:** A spring-loaded lip makes contact with the liner to create a sealing effect.
   - **Mechanical seal:** This utilizes rotating faces and a lubricating film to achieve a tight seal.
4. **Secondary Seal:** This provides additional protection against seawater ingress. It can be similar in design to the primary seal or might utilize a different sealing mechanism like a labyrinth seal with a series of grooves and clearances to impede water ingress.
5. **Oil Buffer Chamber:** This is a chamber within the aft seal housing located between the primary and secondary seals. The chamber is filled with oil at a pressure slightly higher than the seawater pressure outside. This creates a pressure barrier that helps prevent seawater from entering the stern tube.
6. **Drain Line:** A drain line allows any leakage from the primary or secondary seals to be collected and returned to the oil lubrication system. This prevents oil accumulation within the aft seal housing.
7. **Ventilation:** In some designs, a ventilation system might be incorporated to remove any moisture or vapors that could accumulate within the aft seal housing.

Operation:

As the propeller shaft rotates, the liner rotates with it. The primary and secondary seals make contact with the liner, creating a barrier against seawater. The oil buffer chamber maintains a slight positive pressure to further prevent seawater intrusion. Any leakage past the primary seal is collected and drained back to the oil system.

Importance of Maintenance:

Regular inspection and maintenance of the aft seal arrangement are crucial. Monitoring oil pressure in the buffer chamber, checking for leaks, and inspecting the condition of the liner and seals are essential to ensure continued functionality and prevent potential seawater contamination of the lubricating oil or oil leakage into the environment.

March 19th 2021

7. With reference to main propulsion shaft hydraulic sleeve type couplings:

   (a) describe, with the aid of a sketch, the tightening procedure; (7)

   (b) state how it is determined that the push fit is complete. (3)

Main Propulsion Shaft Hydraulic Sleeve Type Couplings: Tightening and Push Fit

Here's a breakdown of the tightening procedure and how to determine a successful push fit for a main propulsion shaft hydraulic sleeve type coupling:

(a) Tightening Procedure:

Tightening a hydraulic sleeve coupling requires careful attention to ensure proper engagement and a secure fit. Here's a general outline:

Preparation:

1. **Cleanliness:** Ensure the coupling components (shaft taper, inner sleeve bore) are clean and free of any debris or contaminants that could affect the fit.
2. **Lubrication (Optional):** Some designs might specify the use of a specific lubricant on the tapered surfaces to aid assembly and prevent fretting corrosion. Follow manufacturer's instructions for lubricant type and application.
3. **Positioning:** Carefully position the inner sleeve onto the shaft taper, ensuring proper alignment.

Tightening:

1. **Hydraulic Pressure Application (Primary Method):** Hydraulic sleeve couplings typically utilize hydraulic pressure to achieve the necessary force for a tight fit. This is achieved through a dedicated hydraulic system integrated into the coupling design.
   - The specific procedure will involve connecting the hydraulic system to the coupling and carefully applying controlled pressure according to the manufacturer's instructions.
   - Pressure gauges and predetermined pressure values are used to ensure the correct force is applied for proper engagement.
2. **Mechanical Tightening (Optional - Some Designs):** In some coupling designs, there might be additional mechanical fasteners (bolts, nuts) that require tightening after hydraulic pressure application. These fasteners further secure the coupling halves together. Tightening torque values and sequence should strictly follow manufacturer's specifications.

Important Notes:

- The specific tightening procedure will vary depending on the coupling design and manufacturer's instructions. Consulting the relevant manuals for detailed steps and safety precautions is crucial.
- It's essential to ensure the hydraulic system is functioning properly and free of leaks before applying pressure.
- During the tightening process, proper safety protocols should be followed to prevent injury from unexpected movement or high-pressure systems.

(b) Determining Push Fit Completion:

Verifying a complete push fit after tightening a hydraulic sleeve coupling is critical for ensuring a secure connection. Here are methods used to determine proper engagement:

1. Pressure Gauge Reading:

- In hydraulically actuated couplings, the pressure gauge used during tightening will typically provide a direct indication of successful engagement. Reaching the designated pressure value specified by the manufacturer indicates the proper force has been achieved for a secure fit.

2. Measurement and Tolerance Checks:

- After tightening, consult the coupling manufacturer's specifications for the required final dimensions of the assembled coupling (e.g., overall length, specific gap measurements).
- Use precision measuring tools (calipers, micrometers) to verify that the achieved dimensions fall within the specified tolerance range. This confirms proper engagement and interference between the shaft and the inner sleeve.

3. Factory-provided Tools (Optional):

- Some coupling manufacturers might provide specialized tools or gauges for verifying the push fit. These tools may measure displacement during the tightening process or utilize other parameters to indicate proper engagement.

4. Visual Inspection:

- While not the sole method, a thorough visual inspection can reveal any obvious gaps or misalignments between the coupling halves after tightening.

Overall:

A combination of these methods is typically used to ensure a complete and secure push fit after tightening a hydraulic sleeve coupling. Following manufacturer's instructions, monitoring pressure readings, and utilizing appropriate measurement tools are crucial for verifying successful assembly.

Nov 2023

7. (a) Sketch a flexible coupling that could be used for a main propulsion drive. (7)

(b) State THREE reasons for using a flexible coupling in propulsion drives. (3)

March 26th 2021

7. (a) Sketch a flexible coupling that could be used for a main propulsion drive. (7)

(b) State THREE reasons for using a flexible coupling in propulsion drives. (3)

Flexible Couplings for Main Propulsion Drives

(a) Flexible Coupling for Main Propulsion:

A common type of flexible coupling used for main propulsion drives is a **gear-type flexible coupling**. Here's a breakdown of its components and function:

- **Gear Teeth:** Each half of the coupling has interlocking gear teeth machined onto its outer circumference. These gear teeth are not designed for transmitting high torque like gears in a transmission, but rather to allow for some degree of misalignment between the shafts.
- **Elastomeric Sleeve:** A flexible elastomeric sleeve (often made from high-strength polyurethane or rubber) is sandwiched between the gear teeth of the two halves. This sleeve provides the flexibility needed to accommodate misalignment.

How it Works:

As the shafts rotate, the gear teeth on one half of the coupling mesh with the teeth on the other half. However, the elastomeric sleeve allows for slight relative movement between the two halves, accommodating:

- **Angular Misalignment:** This occurs when the shafts are not perfectly aligned along the same axis.
- **Parallel Misalignment:** This occurs when the shafts are not perfectly parallel but slightly offset.
- **Axial Misalignment:** This occurs when there is a slight axial (end-to-end) movement between the shafts.

(b) Reasons for Using Flexible Couplings in Propulsion Drives:

There are three main reasons for using flexible couplings in propulsion drives:

1. **Accommodate Misalignment:** Engine and gearbox alignment can be challenging to achieve perfectly, and slight misalignment can occur due to thermal expansion or hull flexing. Flexible couplings allow for some misalignment, preventing excessive loads and wear on bearings and shaft components.
2. **Dampen Vibration:** Marine engines and propellers can generate vibrations. Flexible couplings with elastomeric elements can help to dampen these vibrations, reducing noise and protecting other components from fatigue.
3. **Protect from Overload:** In some cases, sudden shock loads or overloads might occur in the drivetrain. The elastomeric element in a flexible coupling can absorb some of this shock, protecting the engine, gearbox, and propeller shaft from damage.

Additional Notes:

- While offering advantages, flexible couplings typically have a lower torque capacity compared to some rigid couplings.
- The specific design and material selection of the flexible coupling will depend on the power output of the engine and the specific application.

May 28th 2021

May 28th 2021

7. With reference to propulsion shaft intermediate bearings of the plain bearing type, explain EACH of the following:

(a) how change of alignment due to vessel condition is allowed for; (2)

(b) why the shaft must be able to move longitudinally; (4)

(c) why the aftmost bearing requires a complete bush but other bearings may have the bush only in the lower half. (4)

Intermediate Shaft Plain Bearings on Propulsion Shafts:

Here's a breakdown of the points regarding intermediate shaft plain bearings:

(a) How Change of Alignment Due to Vessel Condition is Allowed For:

Intermediate shaft plain bearings, while designed for optimal performance with minimal misalignment, can accommodate some degree of change in shaft alignment due to vessel condition. Here are two main factors that contribute to this:

- **Bearing Material:** Plain bearings typically use materials like white metal or lined steel that offer a certain degree of conformability. This allows the bearing surface to slightly deform and accommodate minor variations in shaft alignment.
- **Bearing Clearance:** Intermediate shaft bearings are designed with a specific clearance between the shaft and the bearing bush. This clearance allows for a thin film of lubricant to form and for some limited movement of the shaft within the bearing.

However, it's important to note that excessive misalignment can lead to increased wear, reduced bearing life, and potential damage. Maintaining proper shaft alignment through regular checks and adjustments is crucial for optimal bearing performance.

(b) Why the Shaft Must be able to Move Longitudinally:

There are two main reasons why the shaft needs some degree of longitudinal (axial) movement in a propulsion system:

- **Thermal Expansion:** As the engine operates, the propeller shaft and other components will experience thermal expansion. A small amount of axial movement in the shaft allows for this expansion and contraction without binding or putting excessive stress on the bearings and couplings.

- **Propeller Thrust:** The propeller generates thrust as it rotates, pushing the vessel forward. This thrust creates a small axial force on the shaft. The ability of the shaft to move slightly allows for this force to be transmitted without putting undue stress on the bearings.

Important Note:

While some axial movement is necessary, excessive movement can lead to problems like whipping of the shaft or propeller walk (propeller causing the vessel to steer off course). The design of the shaft line and bearings should allow for some controlled axial movement within acceptable limits.

(c) Why the Aftmost Bearing Requires a Complete Bush but Other Bearings May Have the Bush Only in the Lower Half:

The design of the intermediate shaft bearings often differs, specifically for the aftmost bearing compared to the forward bearings. Here's the reasoning:

- **Aftmost Bearing (Complete Bush):** This bearing experiences the greatest load from the propeller thrust. A complete bush provides better support for the shaft and helps distribute the load more evenly. Additionally, the complete bush design offers better shaft stability and helps prevent whipping.
- **Forward Bearings (Lower Half Bush):** These bearings experience less load compared to the aftmost bearing. A lower half bush allows for easier installation and removal of the shaft during maintenance or repairs. Additionally, with proper shaft alignment and support from the aftmost bearing, the lower half bush design is sufficient for these locations.

Summary:

The design of intermediate shaft plain bearings considers several factors to ensure optimal performance and longevity. Their ability to accommodate some misalignment and allow for controlled axial movement is crucial for proper shaft operation. Additionally, the design differences between the aftmost and forward bearings reflect the varying loads and maintenance considerations in the propulsion system.