10 September 2021

7. With reference to condition monitoring:

(a) explain how vibration analysis can be used as part of a planned maintenance system; (7)

(b) list SIX tests that can be carried out on crankcase oil in order to determine its suitability for further service. (3)

Condition Monitoring Techniques

(a) Vibration Analysis in Planned Maintenance:

Vibration analysis is a valuable tool used in planned maintenance systems to monitor the health of machinery onboard a vessel or in industrial settings. Here's how it contributes to a planned maintenance approach:

- **Early Fault Detection:** Vibration analysis can detect incipient faults in rotating machinery components like bearings, gears, or shafts long before they develop into critical failures. Unusual vibration patterns can indicate wear, misalignment, or imbalance, allowing for corrective action before major breakdowns occur.
- **Improved Maintenance Scheduling:** By monitoring vibration trends over time, planned maintenance can be scheduled based on actual equipment condition rather than arbitrary time intervals. This prevents unnecessary maintenance on healthy components and prioritizes attention for equipment showing signs of deterioration.
- **Reduced Repair Costs:** Early detection of faults through vibration analysis allows for proactive maintenance interventions. This can minimize the severity of damages and reduce overall repair costs compared to letting faults progress to critical failure.
- **Enhanced Equipment Reliability:** By addressing potential problems early on, vibration analysis contributes to improved equipment reliability. This reduces the risk of unexpected machinery breakdowns and ensures operational continuity.

(b) Crankcase Oil Tests for Suitability:

Crankcase oil analysis is an essential component of planned maintenance for engines. Here are six common tests performed on crankcase oil to determine its suitability for further service:

1. **Viscosity:** This test measures the oil's resistance to flow at different temperatures. Used oil can thin out or thicken, losing its lubricating properties.
2. **Wear Metals:** The presence of increased levels of metal particles in the oil indicates wear and tear occurring within the engine. Identifying the specific metals can help pinpoint the source of the wear.
3. **Contamination:** Oil analysis checks for contaminants like water, fuel, or coolant in the oil. These contaminants can adversely affect lubrication and damage engine components.
4. **Total Base Number (TBN):** This test measures the oil's remaining alkaline reserve, which neutralizes acids produced during combustion. Depleted TBN indicates a loss of the oil's ability to neutralize acids and protect against corrosion.
5. **Oxidation:** Oil naturally oxidizes over time, thickening and losing its lubricating properties. Oil analysis tests for oxidation products to determine the oil's remaining service life.
6. **Nitration:** High nitration levels in the oil can indicate excessive combustion temperatures or incomplete combustion. This can lead to increased wear and formation of sludge in the engine.

By analyzing the results of these tests, maintenance personnel can determine if the crankcase oil is still suitable for further service or needs to be changed. This proactive approach helps maintain optimal engine performance and extend equipment life.

28 may 2021

28 May 2021

7. With reference to plant monitoring as part of a planned maintenance system:

(a) list the various parts of a single main engine unit (piston, liner etc) that would be calibrated during full overhaul; (6)

(b) list the specific parts of the engine that would require examination, if a routine crankcase oil sample report indicated high levels of tin and lead. (4)

Plant Monitoring and Planned Maintenance in Main Engines

(a) Calibrated Parts During Main Engine Full Overhaul:

A full overhaul of a single main engine unit involves a comprehensive reconditioning process. Here are various parts typically calibrated during this overhaul:

- **Fuel Injection System:** This includes calibrating fuel injection pumps, nozzles, and governing mechanisms to ensure proper fuel delivery rate and timing across all cylinders.
- **Cylinder Components:** The piston rings may be replaced, and the cylinder liners may be honed to restore proper clearance and sealing between the piston and liner.
- **Valve Gear:** The valve lash (clearance between valve stem and actuator) is adjusted to ensure proper valve opening and closing during combustion cycles.
- **Turbocharger:** The turbocharger may be overhauled or replaced, calibrating wastegate actuation and ensuring efficient boost pressure delivery.

In addition to these, other calibrated components may include:

- **Temperature Sensors:** Engine coolant temperature sensors and exhaust gas temperature sensors are calibrated to ensure accurate readings for engine monitoring and control systems.
- **Pressure Sensors:** Lubricating oil pressure sensors and fuel oil pressure sensors are calibrated to provide reliable data for engine protection and performance monitoring.
- **Safety Devices:** Over-speed trip switches and low lubricating oil pressure alarms may be calibrated to ensure they activate at the correct setpoints in case of emergencies.

(b) Engine Parts Examined for High Tin and Lead in Oil Sample:

High levels of tin and lead found in a crankcase oil sample indicate potential wear in specific engine components containing these metals as bearing materials. Here are the specific parts that would require close examination:

- **Connecting Rod Bearings:** Connecting rod bearings are tri-metal bearings often containing tin and lead alloys. Excessive wear of these bearings would release tin and lead particles into the oil.
- **Main Bearings:** Similar to connecting rod bearings, main bearings support the crankshaft rotation within the engine block and may contain tin and lead alloys. High levels of these metals in the oil suggest potential wear on main bearings.

- **Camshaft Bearings:** Camshaft bearings support the camshaft rotation within the engine block and might also contain tin and lead alloys. Wear on these bearings could contribute to the elevated levels of these metals in the oil.

During inspection, these bearings would be visually examined for scoring, wear patterns, or delamination of the bearing material. Measurements may also be taken to check for excessive clearance between the bearing and its journal surface.

It's important to note that other engine components, though less likely, could also contain tin or lead alloys. A thorough engine inspection should be conducted to identify the source of the contamination and determine the necessary repairs or replacements.

19 feb 2021

19 February 2021

7. With reference to a vessel having no previous record of machinery maintenance:

(a) describe how a new planned maintenance system could be set up; (6)

(b) list FOUR reasons for keeping records of all maintenance. (4)

Setting Up a Planned Maintenance System for a Vessel with No Records

(a) Establishing a Planned Maintenance System (PMS):

Here's how to set up a new Planned Maintenance System (PMS) for a vessel with no previous maintenance records:

1. **Inventory and Data Collection:**
   - Conduct a thorough inventory of all machinery onboard the vessel, including engines, generators, pumps, navigational equipment, and auxiliary systems.
   - Gather any available manufacturer's recommendations for maintenance intervals and procedures for each piece of equipment. If manuals are unavailable, contact the manufacturer for guidance.
2. **Risk Assessment and Prioritization:**
   - Evaluate the criticality of each equipment item to vessel operation and safety. Prioritize maintenance tasks based on risk level. Critical equipment like main engines and steering gear will require more frequent attention than less critical systems.
3. **Develop Maintenance Schedules:**
   - Based on manufacturer recommendations, risk assessment, and industry best practices, develop maintenance schedules for each equipment item. These schedules should outline specific tasks to be performed at defined intervals (daily, weekly, monthly, yearly, etc.).
4. **Task Breakdown and Documentation:**
   - For each maintenance task, develop detailed procedures specifying the steps involved, tools required, and lubricants needed. Include safety precautions and acceptance criteria for completed tasks.
5. **Implementation and Monitoring:**
   - Implement the PMS by assigning maintenance tasks to qualified personnel. Ensure maintenance records are completed for every task performed, documenting findings and actions taken.

- Monitor the effectiveness of the PMS and adjust maintenance schedules or procedures as needed based on operational experience and equipment performance.

(b) Four Reasons for Keeping Maintenance Records:

Maintaining comprehensive maintenance records is essential for safe and efficient vessel operation. Here are four key reasons:

1. **Improved Maintenance Planning:** Detailed records of past maintenance work provide valuable insights for future planning. By analyzing trends in equipment performance and repair history, maintenance schedules can be optimized to prevent unexpected failures.
2. **Verification of Compliance:** Maintenance records serve as proof that the vessel is being maintained in accordance with regulatory requirements and classification society standards. This documentation is critical during port state control inspections.
3. **Troubleshooting and Fault Diagnosis:** When equipment malfunctions occur, maintenance records can facilitate troubleshooting and fault diagnosis. By reviewing past repairs and service history, engineers can pinpoint potential causes of problems more efficiently.
4. **Knowledge Transfer and Continuity:** Comprehensive maintenance records facilitate knowledge transfer between crew members. New crew can quickly understand the vessel's maintenance history and procedures, ensuring continuity of safe and effective equipment operation.

9 nov 2018

9 November 2018

6. (a) List SIX examples of *condition monitoring* that could be applied as part of a planned maintenance system. (6)

(b) Explain how condition monitoring can assist in expediting classification survey requirements. (4)

Condition Monitoring Techniques for Planned Maintenance

(a) Six Examples of Condition Monitoring in Planned Maintenance:

Planned maintenance systems leverage various condition monitoring techniques to proactively assess equipment health and schedule maintenance activities. Here are six common examples:

1. **Vibration Analysis:** Vibration sensors placed on machinery components like bearings and gearboxes detect changes in vibration patterns. Early detection of abnormal vibrations indicates potential problems like imbalance, misalignment, or wear, allowing corrective action before critical failure.
2. **Tribology (Oil Analysis):** Regular analysis of crankcase oil samples reveals the presence of wear metals, contaminants, and oxidation products. These indicators help determine oil suitability for further service and identify potential wear within the engine components.
3. **Thermography:** Thermal imaging cameras capture temperature variations on equipment surfaces. Unusual hot spots can indicate overheating components due to friction, blockages, or insufficient lubrication, prompting investigations and maintenance actions.
4. **Ultrasonic Testing:** This non-destructive testing technique uses high-frequency sound waves to detect cracks, voids, and other internal defects in critical components like pipelines and pressure vessels. Early detection of such defects allows for timely repairs and prevents catastrophic failures.

5. **Machine Performance Monitoring:** Modern machinery often includes built-in sensors that monitor parameters like oil pressure, fuel consumption, and engine RPM. By tracking these parameters over time, deviations from normal operating ranges can signal potential issues requiring attention.
6. **Machine Learning and Predictive Maintenance:** Advanced planned maintenance systems utilize machine learning algorithms to analyze condition monitoring data and predict equipment failures. This allows for proactive maintenance planning and optimization of resource allocation.

(b) How Condition Monitoring Expedites Classification Surveys:

Classification societies conduct regular surveys of vessels to ensure compliance with safety and operational standards. Condition monitoring data can significantly assist in expediting these surveys in several ways:

- **Reduced Scope of Inspections:** By demonstrating consistent condition monitoring practices and well-maintained equipment through documented data, classification societies may reduce the scope of physical inspections during surveys. This saves time and resources for both surveyors and the vessel operator.
- **Targeted Inspections:** Condition monitoring data highlights specific equipment with potential issues. Surveyors can direct their inspections towards these areas of concern, focusing their efforts on critical components identified as at risk.
- **Demonstrated Proactive Maintenance:** Comprehensive condition monitoring records demonstrate a proactive approach to maintenance. This can improve a vessel's classification status and potentially lead to favorable insurance rates.
- **Improved Communication and Transparency:** Sharing condition monitoring data with classification societies fosters transparency and communication regarding the vessel's overall health. This collaboration can facilitate a more streamlined survey process.

Overall, condition monitoring empowers a data-driven approach to planned maintenance, resulting in more efficient classification surveys and enhanced vessel safety.

16 nov 2018

16 November 2018

6. With reference to a vessel's maintenance:

(a) list FOUR reasons why it is desirable for machinery to be covered by a planned maintenance system; (4)

(b) state FOUR reasons why unscheduled maintenance may need to be performed; (4)

(c) state ONE example of acceptable unscheduled maintenance. (2)

26 feb 202126 feb 2021

26 February 2021

6. With reference to a vessel's maintenance:

(a) list FOUR reasons why it is desirable for machinery to be covered by a planned maintenance system; (4)

(b) state FOUR reasons why unscheduled maintenance may need to be performed; (4)

(c) state ONE example of acceptable unscheduled maintenance. (2)

Planned vs. Unscheduled Maintenance on a Vessel

(a) Benefits of Planned Maintenance for Machinery:

A planned maintenance system (PMS) offers several advantages for vessel machinery:

1. **Prevents Unexpected Breakdowns:** By proactively scheduling maintenance based on manufacturer recommendations and condition monitoring, a PMS helps prevent unexpected equipment failures at sea. This reduces the risk of accidents, delays, and loss of revenue.
2. **Optimizes Equipment Lifespan:** Regular maintenance tasks like lubrication, filter changes, and adjustments minimize wear and tear on machinery components. This extends the equipment's useful life and reduces the need for costly replacements.
3. **Reduces Repair Costs:** Early detection of potential issues through condition monitoring allows for timely corrective action. Addressing minor problems before they escalate into major failures keeps repair costs under control.
4. **Improves Operational Efficiency:** Well-maintained machinery operates more efficiently, consuming less fuel and performing at optimal levels. This translates to cost savings on fuel and enhances overall vessel performance.

(b) Reasons for Unscheduled Maintenance:

While a PMS minimizes unscheduled maintenance, certain situations may necessitate immediate attention:

1. **Sudden Equipment Failure:** Despite precautions, components can fail unexpectedly due to manufacturing defects, material fatigue, or external factors like excessive loads. Unscheduled maintenance becomes necessary to restore functionality.
2. **Accidental Damage:** Collisions, groundings, or exposure to harsh weather conditions can damage machinery requiring immediate repair to ensure vessel safety and seaworthiness.
3. **Unexpected Wear and Tear:** Operating conditions may be more severe than anticipated, leading to accelerated wear and tear on components. Unscheduled maintenance becomes necessary to address excessive wear before complete failure.
4. **Safety System Activation:** Safety systems like alarms and shutdowns may trigger due to abnormal operating parameters. Unscheduled maintenance is required to diagnose the cause of the activation and ensure continued safe operation.

(c) Example of Acceptable Unscheduled Maintenance:

One example of acceptable unscheduled maintenance could be replacing a blown fuse on a critical electrical circuit. This minor repair can be performed relatively quickly and does not require extensive disassembly of machinery. However, the incident should be investigated to determine the cause of the fuse blowing to prevent future occurrences.

3 November 2020

6. With reference to the ongoing machinery maintenance of a vessel:

(a) state FOUR reasons why reliance on breakdown maintenance is generally considered unacceptable; (4)

(b) list THREE examples of condition monitoring, stating the benefits of using condition monitoring as part of a planned maintenance system. (6)

Rethinking Breakdown Maintenance and Embracing Condition Monitoring

(a) Why Breakdown Maintenance is Unacceptable:

While breakdown maintenance might seem like a quick fix, it carries significant risks and costs for vessel operation. Here's why relying on machinery failure before taking action is generally unacceptable:

1. **Safety Hazards:** Unexpected equipment failure at sea can pose serious safety threats to the crew and the vessel itself. Loss of power during navigation or malfunction of critical machinery can lead to collisions, groundings, or loss of control.
2. **Increased Repair Costs:** By letting problems fester until failure, breakdown maintenance allows minor issues to escalate into major breakdowns. Repairing extensive damage is significantly more expensive than addressing problems early on.
3. **Operational Delays:** Sudden equipment failures can cause significant delays in voyages and disrupt shipping schedules. This can lead to loss of revenue and damage to the vessel's reputation for reliability.
4. **Environmental Impact:** Equipment failures can result in pollution incidents, such as oil spills or emissions exceedances. This can lead to environmental damage and regulatory penalties.

(b) Condition Monitoring Techniques and Benefits:

Condition monitoring offers a proactive approach to machinery maintenance, replacing reliance on breakdown maintenance. Here are three common examples of condition monitoring techniques used in planned maintenance systems:

1. **Vibration Analysis:** Vibration sensors placed on machinery components like bearings and gearboxes detect changes in vibration patterns. Early detection of abnormal vibrations indicates potential problems like imbalance, misalignment, or wear, allowing corrective action before critical failure. **Benefit:** Prevents catastrophic equipment failures and associated safety risks and repair costs.

2. **Tribology (Oil Analysis):** Regular analysis of crankcase oil samples reveals the presence of wear metals, contaminants, and oxidation products. These indicators help determine oil suitability for further service and identify potential wear within the engine components. **Benefit:** Optimizes lubrication schedules, extends engine life, and prevents internal component failures.

3. **Thermography:** Thermal imaging cameras capture temperature variations on equipment surfaces. Unusual hot spots can indicate overheating components due to friction, blockages, or insufficient lubrication, prompting investigations and maintenance actions. **Benefit:** Identifies potential overheating

issues before they lead to component damage or fire hazards.

By incorporating these and other condition monitoring techniques into a planned maintenance system, vessel operators can shift from reactive breakdown maintenance to proactive prevention, ensuring safer, more efficient, and environmentally responsible vessel operation.