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HYDRAULIC MARINE GEARBOX WITH BRAKE

Mr Vijay sankpal, AVP, D&D, Design and Development Department, Ghatghe Patil Industries LTD, Kolhapur, India.
Mr Rohan Potdar, Senior Manager, D&D, Design and Development Department, Ghatghe Patil Industries LTD, Kolhapur, India.
Mr Rahul Patil, Deputy Manager, D&D, Design and Development Department, Ghatghe Patil Industries LTD, Kolhapur, India.
Mr Sai Dheeraj Chowdary Engineer, D&D Design and Development Department, Ghatghe Patil Industries LTD, Kolhapur, India.

ABSTRACT

This paper describes a hydraulic marine gearbox with an integrated braking system designed at Ghatge Patil Industries to prevent unidentified propeller rotation when the gearbox is shifted to the neutral position. India's long coastline of nearly 8,000 km supports a wide range of boats, each with engines of varying power and torque, all equipped with gearboxes for maneuverability of boats using forward, reverse, and neutral gears. However, in some cases, even in neutral gear, the propeller keeps rotating with low output torque, which causes the uncontrolled transmission of the boat, failing the purpose of having a neutral gear setting. With its inbuilt brake, the proposed gearbox addresses this issue by stopping the propeller's rotation when the gearbox is shifted to neutral gear transmission. This paper thoroughly explores this innovative solution's functionality and development process.

Keywords - Hydraulic Brake, Design, Gear pair, Friction.

I. Introduction-

India's extensive coastline supports a variety of fishing boats equipped with marine gearboxes designed for maneuverability. Ghatge Patil Industries has developed a range of gearboxes to meet different torque and power requirements. These gearboxes facilitate forward propeller rotation in forward gear and reverse rotation in reverse gear, while the neutral gear disengages the engine from the propeller to stop the output torque provided to the propeller. Transitions between forward, reverse, and neutral gears are achieved through hydraulic actuation using oil pressure within the gearbox.

Ghatge Patil Industries manufactures gearboxes with different reduction ratios to lower the engine's input RPM, thereby generating higher torque, by maintaining constant power generation which is crucial for boats carrying heavy loads with less power. The reduction ratio is selected based on the specific application of each boat to ensure optimal performance under different operational conditions.

Application of Forward, Reverse, and Neutral gears in the hydraulic marine gearbox

Forward Gear: This gear engages the propeller to rotate forward, allowing the boat to move efficiently in a forward direction.

Reverse Gear: This gear engages the propeller to rotate in reverse, enabling the boat to move backward. This function is handy for parking and applying brakes to stop forward motion.

Neutral Gear: This gear disengages the engine from the propeller, keeping the boat stationary while allowing engine power to be used for other tasks, such as operating fishing equipment.

However, in certain situations, the propeller does not completely stop in neutral gear as intended. Ideally, it should stop rotation within 12 to 15 seconds after shifting to neutral. However, this does not always occur due to various reasons, such as moment of inertia, insufficient damping, or external forces like water currents acting on the propeller blades.

Problems arising from this condition

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- **Fishing net damage:** The uncontrolled propeller rotation can cause fishing nets to become entangled in the propeller blades, leading to permanent damage to the nets and significant financial losses to the clients.
- **Accidents and Safety Hazards:** Uncontrolled boat movement while in neutral gear poses a risk of accidents, potentially resulting in damage to boats and injuries to crew members, or, in severe cases, fatalities.

Innovative solution to address the above problem

To tackle this issue, the team at Ghatge Patil Industries brainstormed a solution and developed a brake mechanism to integrate with the hydraulic marine gearbox. This brake system applies external hydraulic force to stop the propeller's rotation in neutral gear. As a result, a new gearbox with an integrated braking system was designed and developed to effectively address this problem.

II. Design methodology-

We at Ghatge Patil Industries, start the design of the Hydraulic marine gearbox by determining the center distance of the gear pair based on the client's power and torque requirements. With these inputs, we calculate the required gear module, helical angle, and pressure angle of the gear pair. Then we finalize key specifications of the gears including the pitch circle diameter, face width, number of teeth, hardness, heat treatment, and material for both the output gear and drive pinion. These specifications are cross-verified against safety factors concerning IRS and ISO standards available for marine gearboxes.

Once the gear pair parameters are finalized, suitable shafts and clutch packs are designed for clutch actuation based on previous experience and validated through design calculations concerning safety factors against stress acting on them. These parameters are then used to create 3D models for reference and the development of a hydraulic marine gearbox. The design process proceeds with the selection of bearings and layout of the oil path for hydraulic gear actuation and lubrication, followed by selecting necessary sealing components like O-rings, seals, and gaskets to stop the leakage of oil.

Then the casing is designed considering the space required to fit the entire mechanism and the available space on the boat. A 3D assembly is created to verify the component fit and check for interferences. If any design problems are identified, adjustments are made accordingly. After the finalization of all components, a review with all concerned people is conducted for finalization of the hydraulic gearbox design, and a bill of materials (BOM) is generated, marking the transition to the gearbox development phase.

In parallel with the gearbox design, the brake disc for the output shaft is designed. The hydraulic force required to stop the output shaft in neutral gear is calculated, and the brake system design is made to ensure effective integration with the gearbox and proper mounting on the output shaft and providing the required amount of force to stop the propeller in neutral gear transmission of the gearbox.

III. Development of Gearbox-

Once the design of the hydraulic marine gearbox is finalized, the development process starts with categorizing components based on their raw material requirements like casting, forging, or bar materials. For casting components, patterns are developed using a 3D sand printer which is available in-house. Following the initial casting made using patterns, these components are checked against design specifications, and if discrepancies are found, pattern modifications are made using the 3D sand printer to save time. Once casting patterns are validated, the raw cast models of the components are produced.

For forging components, open-die or closed-die forging is decided based on component application and carried out with the help of subcontractors. Additionally, necessary bar materials are procured from the market. The required components are machined in-house at Ghatge Patil Industries. During this phase, essential bought-out components like O-rings, bolts, washers, bearings, and seals are purchased from the market through the purchase team.

The machining process involves rigorous inspection using a coordinate measuring machine (CMM) along with in-process inspection and final inspection is carried out. If deviations from the design are identified, corrections are made accordingly. Once all components are manufactured and validated, in-house assembly is carried out. During assembly, any interferences between components are detected then corresponding adjustments are made in the design of components. Components are also tested for their mechanical and chemical properties to ensure compliance with the required specifications. After assembly, the gearbox undergoes comprehensive testing to confirm that it meets the specified requirements. If issues are identified, necessary corrections are made to the initial design to ensure the final product is made with the intended performance standards.

IV. Working of Gearbox and Brake System-

The hydraulic marine gearbox operates using hydraulic actuation through oil pressure, where the position of the lever (forward, reverse, and neutral) determines whether the output gear rotates in a forward or reverse direction. In the neutral gear position, the gearbox disengages the output gear from the engine output, halting the transfer of power to the propeller to stop the boat motion.

Forward Gear: When the lever is set to forward gear, the clutch pack on the input shaft engages, connecting it to the engine output. As the input shaft rotates in synchronization with the engine output, it drives a pinion located on the input shaft and connected to the output gear. This engagement causes the output gear to rotate clockwise, which in turn drives the propeller forward, maneuvering the boat in forward motion.

Reverse Gear: When the lever is set to reverse gear, the clutch pack on the lay shaft is engaged, causing the lay shaft to rotate opposite to the engine's direction. The lay shaft drives a pinion located on the lay shaft and connected to the output gear, causing the output gear to rotate counterclockwise. This reversal of rotation results in the propeller moving backward, maneuvering the boat in reverse motion.

Neutral Gear: When the lever is set to neutral gear, both the input and lay shafts are disengaged from the engine output. This prevents any power transmission to the output gear, leaving the propeller without any input power. As a result, the boat remains stationary even when the engine is running, with no movement produced by the propeller.

Brake System in Neutral Gear:

The brake system is integrated into the hydraulic marine gearbox to prevent the unintended rotation of the propeller in neutral gear. When the gearbox is shifted to neutral gear, the brake system is simultaneously actuated through lubricated oil pressure. The brake disc is mounted on the output coupling, which connects to the propeller coupling.

Upon actuation of the brake, a braking (friction) force is applied to the brake disc through a hydraulic cylinder block, the brake disc is mounted on output coupling hence propeller does not rotate in neutral condition. The integration of this brake system ensures the boat remains stationary, effectively addressing the issue of uncontrolled propeller rotation in neutral gear.

V. Testing-

At Ghatge Patil Industries, each gearbox undergoes rigorous testing on a specialized test bed designed specifically for gearbox validation. During testing, the gearbox is connected to a power source, typically a motor or engine with corresponding output power and torque, and the propeller coupling of the gearbox is linked to another gearbox propeller coupling which is connected to a dynamometer. This setup allows for a comprehensive assessment of the gearbox under real-world conditions.

We initiate the testing by applying the motor's input power and torque to the hydraulic gearbox and carefully monitoring for noise generation and potential oil leakage. Misalignments in the components can lead to increased noise and vibrations, indicating an issue that requires attention. Similarly, improper fitting or defective sealing can result in oil leakage, signaling the need for further adjustments/corrections in the design of the gearbox.

The testing procedure involves operating the gearbox in all three gear positions—forward, reverse, and neutral:

Forward Gear Testing: In this phase, we validate the proper functioning of the hydraulic marine gearbox input and output shaft assembly.

Reverse Gear Testing: In this phase, we validate the proper operation of the hydraulic marine gearbox lay shaft and output shaft assembly.

Neutral Gear Testing: We validate that the gearbox successfully disengages the motor from the output shaft in neutral gear. Additionally, we test the brake disc to confirm its ability to effectively stop the output shaft and propeller from rotation when in neutral.

Through this methodical and thorough testing process, we aim to guarantee the quality and reliability of each gearbox produced at Ghatge Patil Industries, ensuring that it meets the performance standards and safety requirements essential for marine applications.

VI. Conclusion-

The development of the hydraulic marine gearbox with an integrated brake system by Ghatge Patil Industries effectively solves the challenges posed by uncontrolled propeller rotation in the neutral gear position. India's vast coastline and diverse fleet of boats require reliable and efficient marine gearboxes capable of operating under varying power and torque conditions. The newly designed gearbox not only facilitates smooth transitions between forward, reverse, and neutral gears through hydraulic actuation

but also integrates a braking mechanism to stop the propeller in the neutral gear position of the hydraulic marine gearbox.

The gearbox's design, which focuses on precise gear specifications, hydraulic actuation paths, and comprehensive assembly checks, ensures its quality and efficiency. The brake system, actuated hydraulically, provides an added layer of safety by preventing unwanted propeller movement in the neutral gear of the hydraulic marine gearbox, thereby reducing risks such as fishing net damage and accidents due to uncontrolled boat movement in neutral gear.

Rigorous gearbox testing under real-world conditions further validates its reliability and performance on the field. This testing procedure, which covers all gear positions and brake functionality, guarantees that each gearbox meets the required performance standards and safety requirements essential for marine applications. With this innovation, Ghatge Patil Industries has successfully developed a solution that enhances the operational control and safety of marine vessels, contributing to the advancement of the marine gearbox industry.

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