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Ship Roll Reduction Using Water-Flow Induced Coriolis Effect

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Abstract : Ships are subjected to motions which can disrupt on-board operations and damage equipment. Roll motion, in particular, is of great interest due to low damping conditions which may lead to capsizing. Therefore finding ways to reduce this motion is important in ship designs. Several techniques have been investigated to reduce rolling. These include the commonly used anti-roll tanks, fin stabilizers and bilge keels. However, these systems are not without their challenges. For example, water-flow in anti-roll tanks creates complications, and for fin stabilizers and bilge keels, an extremely large size is required to produce any significant damping creating operational challenges. Additionally, among these measures presented above only anti-roll tanks are effective in zero forward motion of the vessels. This paper proposes and investigates a method to reduce rolling by inducing Coriolis effect using water-flow in the radial direction. Motion in the radial direction of a rolling structure will induce Coriolis force and, depending on the direction of flow will either amplify or attenuate the structure. The system is modelled with two degrees of freedom, having rotational motion for parametric rolling and radial motion of the water-flow. Equations of motion are derived and investigated. Numerical examples are analyzed in detail. To demonstrate applicability parameters from a Ro-Ro vessel are used as extensive research have been conducted on these over the years. The vessel is investigated under free and forced roll conditions. Several models are created using various masses, heights, and velocities of water-flow at a given time. The proposed system was found to produce substantial roll reduction which increases with increase in any of the parameters varied as stated above, with velocity having the most significant effect. The proposed system provides a simple approach to reduce ship rolling. Water-flow control is very simple as the water flows in only one direction with constant velocity. Only needing to control the time at which the system should be turned on or off. Furthermore, the proposed system is effective in both forward and zero forward motion of the ship, and provides no hydrodynamic drag. This is a starting point for designing an effective and practical system. For this to be a viable approach further investigations are needed to address challenges that present themselves.

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