論　　文　　の　　要　　旨

題目：　Study of Ship Turning in Waves　（船の波浪中旋回運動の研究）

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Ship maneuverability is usually studied in calm waters. Although it is convenient to study the ship maneuvering in calm water first, ship maneuvering in waves should be investigated as the next step because a large number of ships actually do sail in waves. Particularly, for the safety of ships sailing in the sea, studying the effect of waves on ship maneuvering is important. However, the understanding of the wave effect on maneuvering may be limited. Next, in order to prevent marine accidents due to human mistakes in ship navigation, prior training of crew members using a ship-handling simulator is effective. In adverse weather condition, the captain navigates the ship so as to avoid large waves visually, so it is necessary for the simulator to realistically reflect the influence of steering on the ship motions in the waves. In other words, a ship-handling simulator that rationally incorporates the three features of wave fields, maneuvering motion, and wave-induced fluctuating motions is required. However, it is not easy to construct a simple calculation method that can be mounted on a computer of the simulator, and that can handle the wave-induced motions during ship maneuvering in irregular waves with reliable accuracy.

The main objective of this study is to establish a 6-DOF simulation method for a ship maneuvering in irregular waves by using Maneuvering Modelling Group (MMG) model including waves effect. Ship motion, according to the concept of the two time-scale concept, is assumed to be expressed as the sum of the maneuvering motion regarded as low frequency motion and wave-induced motion regarded as high frequency motion,. Free running model tests using a container ship model (KCS) and a VLCC model (KVLCC2) were carried out to evaluate the proposed maneuvering simulation method in regular wave and irregular waves respectively. Next, the drifting effect in ships' trajectories during turning in regular wave and irregular waves were investigated by using turning and drifting indices. Drifting indices (drifting distance and drifting direction) is an important tool in this thesis as indicator in analyzing experiment data, validating simulations' results. The comparisons of time histories of maneuvering and wave-induced motions between simulations and experiments' results also were made. Finally, an analytical study for steady turning in irregular waves by taking the drift effect due to wave-induced steady forces into account was performed in order to understand deeper the phenomena of a ship turning in irregular waves. Theoretical formulas for calculating drifting distance and drifting direction were created.

Through the research presented in this thesis, it is clear that the wave-induced steady forces significantly

influence the ship motions during turning in irregular waves with the reduction of ship approach speeds. Using the drifting indices, the data from the conducted model tests has experimentally shown the effect of slowly-varying second order wave forces is negligible since it is not a long-term motion, thus mean value is enough and assumed for the calculation for wave-induced steady forces in the proposed simulation method. Subsequently, it was found that the present method can simulate both the turning motion in the irregular waves and the wave-induced motions during turning with practical accuracy in short computational time, although there is some room for improvement in the low approach speed range (about 5 kn). Ultimately, it is concluded and confirmed that the drifting distance is proportional to the significant wave height and inversely proportional to ship approach speed based on the comparison made between theoretical formula, experiment and simulation.

The contents of the thesis are summarized as follows:

Chapter 1 presents research background and reviews state of the art literature on ship turning in cam water, regular waves and irregular waves to support the research topic. In this chapter also explains main purposes and problem identification for this study.

Chapter 2 describes a KCS container ship as a studied ship with a detail of ship particulars, and the model test outline for turning in calm water and regular waves, with one approach speed. Results from the model test is presented and analyzed in this chapter.

Chapter 3 describes a KVLCC2 tanker and KCS container ships as studied ships with a detail of ship particulars, and the model test outline for turning in calm water and irregular waves with varied approach speeds. Results from the model test are presented and analyzed in this chapter.

Chapter 4 establishes a 6-DOF simulation method for ship maneuvering in regular waves. By using the same ship model in chapter 2, evaluation of simulation method by comparing with free-running model tests in waves from chapter 2 is conducted.

Chapter 5 utilizes the same 6-DOF simulation method in chapter 4, with modification of technique and formula of calculating wave-induced steady forces and wave exciting force for ship maneuvering in irregular waves. By using the one of the ship model and wave condition in chapter 3, evaluation of simulation method by comparing with free-running model tests in waves from chapter 3 is conducted.

Chapter 6 derives a theoretical formula for drifting distance and drifting direction by considering the wave-induced drift motion during steady turning. Using the reference ship, wave condition and drifting indices' results from Chapter 5, the comparison is made in this chapter in order to understand further the phenomena of ship turning in irregular waves.

Chapter 7 summarizes the conclusions of this thesis and outlines the recommendations for further research.