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선박 정박과정의 시간변위 자동 시뮬레이션을 통한 일반 및 저속 수학모델의 비교 분석

† 정광식 · 정진우* · 김인규* · 이승건**

† 스트라스클라이드대학교 조선해양공학과, *부산대학교 조선해양공학과 대학원, **부산대학교 조선해양공학과 교수

Comparative Analysis between Mathematical Models for Normal and Low advance speeds of ships on Automatic Time-Domain Simulation of Berthing Operation

† Kwang Sic Chung · Jin-Woo Jung · In Gyu Kim* · Seung-Keon Lee***

† Department of Naval Architecture and Marine Engineering, University of Strathclyde, Glasgow G4 0LZ, UK

**Graduate school, Department of Naval Architecture and Ocean Engineering, Pusan National University, Pusan 609-735, Korea*

***Professor, Department of Naval Architecture and Ocean Engineering, Pusan National University, Pusan 609-735, Korea*

요 약 : 본 연구에서는 선박의 정박과정 중 거동을 분석하기 위하여 저속과 고속의 전진속도에 쓰이는 서로 다른 수학 모델을 비교하며 시간변위 시뮬레이션이 수행되었고 그 결과가 제시되었다. 시뮬레이션 프로그램 개발의 첫 번째 단계로 선박의 속도와 타각 제어를 위하여 일반적인 PD (Proportional Derivative) 제어기가 사용되었으며 시뮬레이션 모델로서 탱커가 사용되었다. 본 연구는 선박의 정박과정을 위한 효과적인 시간변위 시뮬레이션 프로그램을 개발하기 위하여 정박 시뮬레이션에서의 비교 분석 결과를 제시한다.

핵심용어 : 정박, 시간변위 시뮬레이션, PD 제어기, 전진속도

ABSTRACT : *In this study, the time-domain simulations have been performed for analysing the ship behaviour during berthing process with comparing the two different mathematical models for low and normal advance speed of a ship and the results have been presented. For the first step of programming, the traditional PD (Proportional Derivative) controller has been used for the control of speed and rudder and a tanker ship has been used as a simulation model. This study provides comparative results on the time-domain simulation of berthing operation of a ship for developing an effective simulation programme.*

KEY WORDS : *berthing, time-domain simulation, PD controller, advance speed*

1. Introduction

As sea trade cross the world is increasing these days, effective management of a harbour system is becoming an important issue. In particular, berthing operation of ships takes much time and requires various technical supports from harbour masters, pilots, and engineers. In this point of view, precise prediction and practice of berthing operation are required and development of a simulation tool is requested for planning and managing an effective harbour system.

With these reasons, the development of a time-domain simulation programme for ship berthing operation has been being performed with analysing ship behaviour during the simulation process. For the first step of programming, the traditional PD (Proportional Derivative) controller has been used with applying the two different mathematical models, one is for the low advance speed of ships (Kose, 1984) and the other is for the normal advance speed from MMG Reports and the simulations have been performed for a

† 교신저자 (학생회원), cks19@hanmail.net 051)510-2755

*공동저자 **종신회원, leesk@pusan.ac.kr 051)510-2441

tanker ship with different initial heading angles.

2. Mathematical Model

During the berthing process, ships are moving towards the quay with very slow speed and there are still many discussions on the mathematical model for low advance speed of ships. In this study, the model by Kose (1984) for low advance speed and the normal MMG-type model are applied. The major difference between the two mathematical models is on the expression of hydrodynamic forces and moment acting on a hull (Hasegawa & Kitera, 1993).

3. PD Control Algorithm

The traditional PD controller is used in this simulation programme and the algorithm is as follows.

$$\psi_{LOS} = atan\left(\frac{WT_y - y}{WT_x - x}\right) \quad (1)$$

$$\delta_{CTE} = K_{p1}(\psi_{CTE} - \psi) + K_{d1}(0 - r) \quad (2)$$

$$\delta_{LOS} = K_{p2}(\psi_{LOS} - \psi) + K_{d2}(0 - r) \quad (3)$$

$$\lambda = \frac{d_{CTE}}{\| y_0 - WT_y \|} \quad (4)$$

$$\delta_r = \lambda\delta_{CTE} + (1 - \lambda) \bullet \delta_{LOS} \quad (5)$$

4. Simulation and result

Fig. 1 shows the ship trajectory from the simulation applying Kose's mathematical model and Fig. 2 is the trajectory with the normal MMG model.

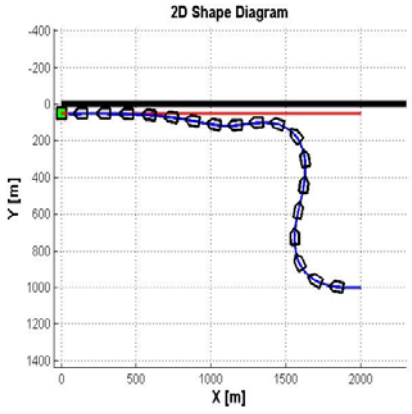

Fig. 1 Ship trajectory: Kose's model, initial heading angle -180 degree, initial ship speed 3 m/s

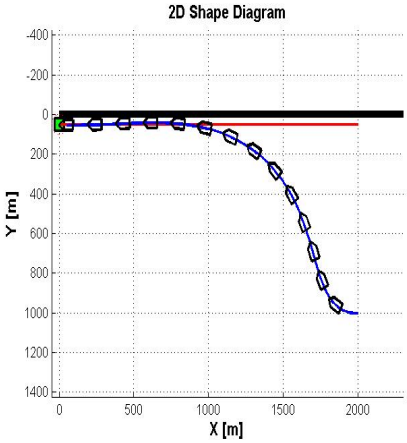

Fig. 2 Ship trajectory: MMG model, initial heading angle -180 degree, initial ship speed 3 m/s

5. Conclusion

The main conclusions drawn from the research presented in this paper can be summarised as follows:

· Time-domain simulations of ship berthing operation have been performed with Kose's model for low advance speed of ships and the MMG model for normal advance speed using the simulation programme under development with the traditional PD controller.

· Comparative analysis and result have been presented for the two different mathematical models with different initial heading angles of the ship on the simulations.

· Further research will be performed to improve the simulation programme of ship berthing operation with analysing the control algorithm for heading angle and ship speed.

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