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선박의 접안 시뮬레이션에서 조종수학모델의 영향에 관한 고찰

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A Study on the Influence of Mathematical Models of Manoeuvrability on the Simulation of Ship Berthing Operation

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요 약 : 최근 국제 무역량의 증가에 따라 항만 시스템의 안전하고 효과적인 운용이 중요한 과제로 부각되고 있다. 이러한 배경에서 선박의 접안과정에 대한 시간변위 자동 시뮬레이션 프로그램의 개발이 진행되어 왔고 선박의 속도와 방향 제어를 위해 PD (Proportional Derivative) 제어기가 이용되었다. 이번 연구는 선박 접안과정의 시간 변위 시뮬레이션 프로그램 개발 중 서로 다른 수학적 모델, 즉 선박의 전진속도가 저속일 경우를 위한 Kose (1984)의 모델과 일반적인 전진속도일 경우를 위한 MMG 모델을 이용하여 초기 선수 방향과 선박 위치의 다양한 변화를 적용한 시뮬레이션을 통해 각 방정식의 장점 및 단점을 분석하며 시뮬레이션 구현의 타당성을 검토한다.

핵심용어 : 접안, 시간변위 시뮬레이션, PD 제어기, 초기 선수 방향, 초기 선박 위치

Abstract : *As trade cross the world is increasing these days, safe and effective management of harbour system is becoming important issue. With this background, the development of automatic time-domain simulation programme for ship berthing operation has been being peformed and PD (Proportional Derivative) controller has been used to control the speed and the heading angle of ships. This paper provides feasibility study for developing the time-domain simulation programme for berthing operation of ships with analysing advantages and drawbacks of the two different mathematical models, one is for low advance speed of ships by Kose (1984) and the other is MMG model for normal advance speed, through the simulations with various initial heading angles and positions of the ship.*

Key words :*berthing, time-domain simulation, PD controller, initial heading angle, initial position*

1. Introduction

As trade cross the world is increasing these days, safe and effective management of harbour system is becoming 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 automatic simulation tool is requested for planning and managing effective harbour system (Chung et al. 2013).

2. Mathematical Model

Kose's Mathematical Model for this study is as follows.

$$X_H^* = X_{vr}^* v^* r^* + X_{uu}^* |u^*| u^* + X_{uvv}^* u^* v^{*2} / U^* + X_{vvr}^* |v^*| v^* r^* / U^* \tag{1}$$

$$Y_H^* = Y_v^* v^* U^* + Y_{vv}^* |v^*| v^* + Y_{vvvvv}^* v^{*5} U^{*3} + Y_r^* r^* + Y_{ur}^* u^* r^* + Y_{uvvr} u^* v^{*2} r^* / U^{*2} + Y_{vrr}^* v^* r^{*2} / U^* \tag{2}$$

$$N_H^* = N_{uv}^* u^* v^* + N_r^* r^* + N_{rrr}^* r^{*3} + N_{ur}^* u^* r^* + N_{vvr}^* v^{*2} r^* \tag{3}$$

where * means nondimensionalised values as follows.

$$X^*, Y^* = X, Y / \left(\frac{\rho}{2} L^3 g\right), \quad , \quad N^* = N / \frac{\rho}{2} L^4 g \tag{4}$$

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$$m^* = m/\left(\frac{\rho}{2}L^3\right) \quad , \quad I_{zz}^* = I_{zz}/\left(\frac{\rho}{2}L^5\right) \tag{5}$$

$$u^*, v^* = u, v/\sqrt{Lg} \, , \quad , \quad r^* = r/\sqrt{L/g} \tag{6}$$

$$\dot{u}^*, \dot{v}^* = \dot{u}, \dot{v}/g, \quad , \quad \dot{r}^* = \dot{r}L/g \tag{7}$$

3. Control Algorithm

Fig. 1 shows the PD (Proportional Derivative) control algorithm of berthing simulation of a ship.

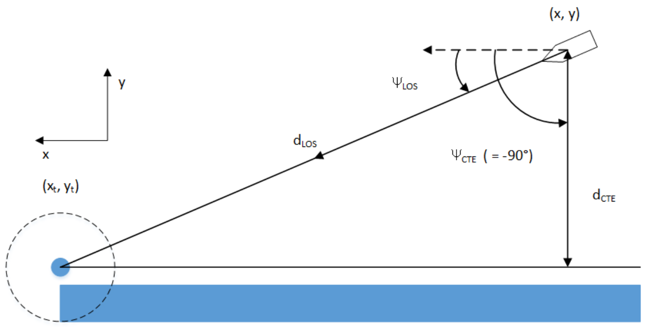

Fig. 1 PD control algorithm of ship berthing operation

4. Simulation

Fig. 2 shows the trajectory for berthing simulation of the tanker ship using PD controller with Kose′s mathematical model in case where the initial position of the ship is (-5L, 4L), the initial heading angle is -40 degree and the initial speed of the ship is 3 m/s. Also, Fig. 3 shows the trajectory of the berthing simulation with the normal MMG model.

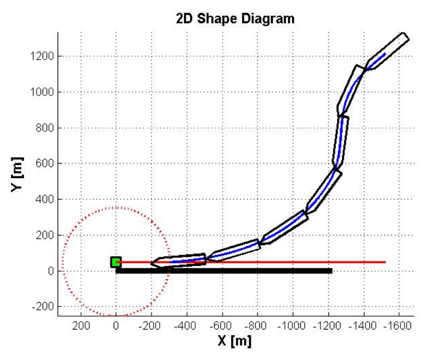

Fig. 2 Trajectory for berthing simulation of tanker ship using PD controller with Kose′s mathematical model: initial position (-5L, 4L), initial heading angle -40 degree and initial speed 3 m/s

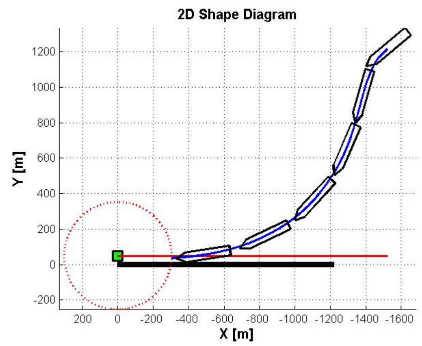

Fig. 3 Trajectory for berthing simulation of tanker ship using PD controller with normal MMG model: initial position (-5L, 4L), initial heading angle -40 degree and initial speed 3 m/s

5. Conclusion

The main conclusions drawn from this study are summarised as follows:

· Time-domain simulations of ship berthing operation have been performed with Kose′s mathematical model and the normal MMG model using PD control algorithm.

· Various initial heading angles and positions of the ship have been applied for the simulation and the results have been analysed.

· Further research will be performed for the speed control of ships in the simulation of berthing operation.

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