Model Experiments on Heading Control of FSRU using RMAC

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ABSTRACT
This paper is concerned with the heading control for an offshore floating storage and regasification unit (FSRU) using resolved motion and acceleration control (RMAC) algorithm. Recently MOERI has studied on conceptual design of turret moored FSRU through a collaborative national research project. A turret moored vessel tends to have slewing motion. This slewing motion may cause a considerable decrease in working hours during loading and unloading process because sloshing in the LNG containment tank and collision between FSRU and LNGC are possibly taken place during the process. In order to deal with this problem, we developed a heading control system for turret moored FSRU and conducted a series of model tests with three azimuth thrusters on aft part of the vessel. A Kalman filtering technique is applied to estimate the low frequency motion of vessel. RMAC algorithm is employed as a main heading control method and modified I controller is introduced to reduce the steady state errors of heading. Minimum power consumption algorithm is applied to allocate thrust.

KEY WORDS: FSRU; RMAC; heading control; turret; model test.

NOMENCLATURE

FSRU offshore floating storage and regasification unit
RMAC resolved motion and acceleration control
LNGC liquefied natural gas carrier

Subscripts
1 relative to surge motion
2 relative to sway motion
6 relative to yaw motion
E relative to environmental agents
T relative to propulsion system
H relative to high frequency motion
L relative to low frequency motion
a relative to actual states of vessel
d relative to desired states of vessel
e relative to error states of vessel

INTRODUCTION
Floating storage and re-gasification unit (FSRU) is a modern concept for floating offshore gas supplying plant units. FSRU has benefits compared to onshore re-gasification plats; small environmental impact on seashore, high securities on neighborhood residence area and low initial cost. Recently MOERI has studied on conceptual design of FSRU through a collaborative national research project with Korean Shipbuilders (DSME, SHI, HHIC, STX), KR and KOGAS. As a result of this study, a turret moored FSRU concept was derived (Fig. 1).

Turret moored vessels tend to have fish tailing (or slewing) motion. This fish tailing motion may cause a considerable decrease in working time during loading and unloading process because of sloshing in the LNG containment tank, possible collision between FSRU and LNGC and also discomfort for the crew. In order to deal with this problem, we developed a heading control system for turret moored FSRU. The heading control system is composed of motion estimator, controller and thruster system. Three azimuth thrusters are equipped on aft part of the vessel.

The environmental forces acting on floating vessel induce two distinct kinds of motions; high-frequency and low-frequency motions. High-frequency motions are mainly induced by waves so they have nearly