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Experimental Study on Dynamic Positioning Control for Semisubmersible Platform

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ABSTRACT

The paper is concerned with a dynamic positioning control for a semisubmersible platform model against external forces such as ocean current, wind and waves. A dynamic positioning system using thrusters is generally employed to control a given position. In such a control, it is difficult for thrusters to resist the wave frequency motion because the linear exciting force is very strong. The purpose of the control is to maintain a given position using thrusters that do not respond to this force in the wave frequency range. The problem was formulated in a framework of H_∞ control, and a controller was designed using a linear mathematical model obtained from nonlinear motion equations of the platform. Model tests were carried out and the designed controller performed well. Model experiments were conducted in oblique incident waves, and some successful results are shown.

NOMENCLATURE

A	:Projected area under water line × 2
A_{ij}	:Added mass
A_w	:Water plane area
b_{ij}	:Wave damping coefficient
b_{iiv}	:Drag coefficient in oscillating flow
$C_{Dx}, C_{Dy}, C_{Dz}, C_{DM}$	:Drag coefficient in steady flow
$F_{th1}, F_{th2}, F_{th3}$	:Thrust of thruster
F_{xD}, F_{yD}, M_{xD}, M_{yD}, M_{zD}	:External force due to drag and wave damping
F_{xt}, F_{yt}, M_{zt}	:Forces in x-, y-direction and moment around z-axis due to thrusters
g	:Gravity acceleration
G	:Plant transfer function
GM	:Metacentric height
GML	:Longitudinal metacentric height
I_{xx}, I_{yy}, I_{zz}	:Moment of inertia of platform
K	:H_∞ controller transfer function
K_{act}	:H_∞ controller transfer function with actuator dynamics
L	:Length of platform
l_{th}	:Distance from origin o to thruster (Fig. 3)
l_x, l_y	:Position of point of application of drag force in steady flow
m	:Mass of platform
(o, x, y, z)	:Moving coordinate system
(O, X, Y, Z)	:Space-fixed coordinate system
p, q, r	:Angular velocity (Fig. 3)
$T_{th1}, T_{th2}, T_{th3}$	:Time constant of thruster
$T_{u\to y}$	:Transfer function from u to y
u, v	:Translational velocity in x-, y- direction (Fig. 3)
u_a, v_a	:Relative velocity ($u_a = u - u_c$, $v_a = v - v_c$)
u_c, v_c	:Current velocity in x-, y- direction $\begin{bmatrix} u_c \\ v_c \end{bmatrix} = [\Omega]\times\begin{bmatrix} V_c \\ 0 \end{bmatrix}$
u_{wp} , v_{wp}	:Velocity of water particle
V_c	:Current velocity
$V_{in1}, V_{in2}, V_{in3}$	:Voltage input to thruster
W_2, W_4, W_6	:Weighting function
$\tilde{X}$, $\tilde{Y}$	:Surge and sway of a level without relation to pitch and roll
X_c, Y_c, ψ_c	:Input command of surge, sway and yaw
$(0, 0, z_G)$	:Position of center of gravity
z_T	:Distance from origin o to thruster in z-direction
$z_1, z_2, z_3, z_4, z_5, z_6$	:Controlled output
α	:Direction of current (see Fig. 3)
θ_0	:Direction of waves (see Fig. 3)
φ, θ, ψ	:Eulerian angles
ρ	:Water density

INTRODUCTION

Semisubmersible platforms have widely been operating for the exploration and development of ocean resources, and many such platforms are now in operation. They are required to maintain a given position within a range of 5% of depth to protect the riser tube from external forces induced by ocean current, wind and waves, and to control the position so that good work can be done in the sea and in digging trials. The ocean has drifting forces of current, wind and waves, and the linear exciting force of waves. A dynamic positioning system using thrusters is generally employed to maintain a given position or keep a station. The enormous amount of power needed makes it difficult to resist the wave frequency motion using thrusters and, in any event, because of small amplitude this motion need not be controlled. Therefore, we need only counteract the drifting force.

PID is the standard control for a dynamic positioning system (Linfoot et al., 1982). The parameters are easy to adjust on the spot to deal with any problem. This control algorithm is, however, dependent on the arrangement of the thrusters because it can deal with only a single-input single-output system. As it can't handle the effect of roll and pitch, we adopted the H_∞ control algorithm,

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KEY WORDS: Model experiments, semisubmersible platform, dynamic positioning control, H_∞ control.