Grounding Controlling for Ship Maneuvering in Shallow Water

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ABSTRACT
Quite amount of efforts have been made to rescue the grounded ships in the shallow water of ports or coastal lines in the recent decade due to the increasing of the vessel principal dimensions and vessel traffics. The major grounding reason is the restriction of water depth of the port or coastal water area during the ship maneuvering operation. The under keel clearance of a maneuvering ship in the port or coastal water zone should be such that the ship can move safely. Also as many pilots experienced that maneuvering controllability such as the rudder and propeller functions in shallow water is different from the ones in deep water. The shallower the water depth, the higher the inflow velocity at the rudder which will increasing the rudder normal force or create the partial vacuum in the region of the propeller. Therefore, the vessel maneuverability may become erratic or out of control. In current study, the factors which could be possible to affect the ship operating behavior in shallow water have all been included such as the under keel clearance, the squat, the sinkage and trim, the wave making resistance, the rudder normal force and propeller efficiency, the hydrodynamic hull lateral forces and yaw moments. The certain predicted results have been verified by the sea trial measurements. The reasonable agreements have been found for squat and turning circles. Therefore, the suggestion for the navigation simulator is that all the simulations should cover the water depth effects.

KEY WORDS: Shallow water; Maneuvering; Under Keel Clearance; Sinkage and Trim; Squat; Rudder Force; Turning Circle

INTRODUCTION
Ship usually has a couple of motion modes before it gets grounded such as the vertical motion mode in shallow water zone to touch down the ocean floor and suffer grounded, or, the plane motion mode to climb on the sea bed shelf and get grounded. In order to avoid the ship grounding, the study of ship maneuvering controllability in the complex topography of the sea floor in shallow water area is very necessary. If the ship navigation route is planning to go through narrow and shallow strait or loading and offloading the cargoes in the shallow port or coastal lines, then, the risk of grounding is always there. Furthermore, if the navigation simulator on the board sometimes does not give the hazard signals even through the water depth is already shallow enough to approach the grounding. Then, the grounding risk is much higher.

The grounding reason in the past is always considered as the water depth restriction (shallow water) with overloaded cargoes in port or misjudgment of the autopilot system. Therefore, if people can quickly and accurately predict the maneuverability of the ship in the shallow port or coastal lines, then, a lot of grounding accidents can be avoided. Hence, in current study, the maneuverability of the ship vertical motion modes and plane motion modes with the effect of the shallow water depth has been carried out.

METHODOLOGY
Vertical Motion Mode Clearance
For vertical clearance, the port navigation safety considerations require that the maximum draft allowed to be controlled to avoid vessel grounding. In another word, when a vessel transits a port area, she must have adequate clearance under the keel. The reason is that the shallow water depth of the port will affect the ship maneuverability and cause the ship squat and further to get grounded. The under keel clearance is recommended not to be less than 0.05 - 0.15 of the ship’s draft for hard bottom by Gablor (2006) who has also proposed the safe ship keel clearance as following:

\[ \Delta R_g \geq (H_i - \delta_n) - (T - \delta_r) \]  

Where, \( \Delta R_g \) is the safe keel clearance; \( H_i \) is depth of the water area; \( \delta_n \) is the errors in the determination of the water area depth; \( T \) is the ship draft; \( \delta_r \) is the error in the determination of ship’s draft.

International Commission for Reception of Large Ships (ICORELS) has recommended that the gross under keel clearance criteria should vary from 0.07 of the draft in the maneuvering and mooring area to 0.20 of the draft in the shallow water open sea.