Two-Ship Operating In Close Proximity
In Shallow Water Rough Sea

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ABSTRACT

Two-Ship operating in close proximity in shallow water rough sea has shown to be quite different in comparison to the deep-water situation based on the operation experience in the past. Therefore, in the current study, both the seakeeping characteristics of two-ship interactions in deep water and in shallow water in heavy storm are carried out in order to demonstrate the differences. The deep water and shallow water rough seas’ irregularity have been considered by using the TMA spectrum which combines JONSWAP spectrum with the shallow water and deep water effect transformation factors. A typical rough sea scenario, Hurricane Juan, has been selected to evaluate the two ship interaction seakeeping behaviors in deep water and in shallow water. The comparison results have been presented and discussed.

KEY WORDS: TMA spectrum; seakeeping; two ship interaction RAOs; deep water rough sea; shallow water rough sea.

INTRODUCTION

Two ships operating in close proximity can be found from the operation of ship to ship transfer for tankers, loading and offloading for offshore floating structures, and underway replenishment at sea for navy vessels either in deep water or in shallow water in the presence of waves.

The shallow water and deep water definitions are relatively based on the ratio of the operating water depth to the vessel loading draft. In other words, for the same water depth, the larger the vessel draft, the shallower the water. Therefore, for certain water zones, the larger vessel is relatively shallower with lower ratio of water depth to loading draft such as very large crude oil carrier, the ultra large container carrier, or large floating production storage. The smaller vessel is relatively deeper with higher ratio of water depth to vessel draft such as the shuttle tankers and the smaller supplied vessels that work in the ambient of larger vessels. Also, the ocean waves transform from Gaussian random process to non-Gaussian random process as they propagate from deep water to very shallow water, and the corresponding wave profile will vary from the symmetric crests and troughs to the high crests and the shallow-flat troughs. Therefore, the deep water theory cannot be directly applied to the shallow water case in general. Hence, in current study, the theory of the consideration of water depth effect for the shallow water wave and the shallow water wave spectra have been introduced to better reflect the reality of two floating structure interaction responses in the shallow water rough sea. Due to the complexity of the irregular wave-floating structure interactions, the floating structure responses in shallow water random sea are usually solved by combining regular wave interaction response amplitude operator (RAO) and shallow water wave spectrum to convert to the corresponding solutions. The shallow water Green’s functions have been employed to solve the boundary element problem for the Laplace equation to obtain the floating structure response RAOs. The TMA spectrum, which combines the JONSWAP spectrum and the shallow water effect transformation factor, has been presented to demonstrate the irregularity of shallow water rough sea. Two typical fine form vessels operating in closed proximity in deep water and shallow water zones suffering 100 year hurricane Juan at the sea has been simulated.

METHODOLOGY

SHALLOW WATER THEORY FOR IRRGULAR WAVES

Shallow water wave spectrum distribution is different from wave spectrum distribution in deep water. It will vary from the narrow-banded Gaussian distribution to Non-Gaussian distribution depending on the water depth and sea severity. Ochi (1998) has given the criteria for the Non-Gaussian random process and Gaussian random process.

Shallow Water Wave Spectrum

As the waves propagate into zone of finite depth of water and shallow water, the shape of spectrum will change with the water depth. The deep water spectrum, namely, the Bretschneider spectrum which accounts for the duration and fetch limitation in an empirical manner, the Pierson-Moskowitz spectrum which is for fully developed sea, and the JONSWAP spectrum which is developed under fetch-limited conditions, cannot be directly applied to represent the water of finite depth and shallow water irregular waves. Therefore, Kitaigorodskii et al.(1975) have been developing the wind-wave spectra in shallow water by combining the deep water spectrum with the non-dimensional water depth effect function $\Phi(\omega, h)$ as: