

Simulation of Radar Image due to Ship Generated Waves

Young Jun Yang⁽¹⁾, Sun Hong Kwon⁽¹⁾, Seung Geun Park⁽²⁾, Jun Soo Park⁽³⁾
 Department of Naval Architecture and Ocean Engineering, Pusan National University⁽¹⁾
 Busan, Korea

MIT (Marine and Information Technology) Group for High-Added Value Ships and Offshore Structures for Deep Sea Resources Exploration⁽²⁾
 Busan, Korea

Department of Naval Architecture, Ocean Engineering and IT, Kyungnam University⁽³⁾
 Masan, Korea

ABSTRACT

This study presents the characteristics radar image of ship generated ship wave. The Kelvin wave generated by Wigley Hull was investigated. The image of the generated ship wave image was simulated by radar image simulation scheme. The analyzed radar image was compared with the image obtained from the real radar image. It was found that the frequency distribution of energy in the wave number domain due to ship wave is different from that of wave images. However, the energy due to ship wave may influence the estimated value of the SNR (signal to noise ratio) which is very important factor in the wave monitoring.

KEY WORDS: X-band radar; Kelvin ship wave pattern; Fast Fourier Transform(FFT); Wigley hull; wave monitoring; spectrum; radar image simulation

INTRODUCTION

When it comes to the wave monitoring ship waves can be detected quite often. The major wave number due to ship wave does not coincide with that of wind waves. However, the energy due to ship wave may influence the estimation of SNR. If the energy due to ship wave are included in the estimation of SNR then the estimation of wave information may be wrong. To avoid this, we need to extract the wave energy due to ship wave so that we can come up with right wind wave statistics. Many researchers investigated the ship wave effect by numerical simulation (Noblesse, 1977;1978; Tuck et.al., 2000). However, they did not worked on the real sea data. The present study included the real sea data when the wave due to ship's presence.

The ship wave due to Wigley hull was generated. The radar image simulation scheme was applied on ship wave. Directional wave spectrum was obtained to figure out the characteristics of the ship wave. The radar images obtained from the field were analyzed. Two locations were selected depending on the presence of ship waves. The wave components due to ship wave were clearly decoupled. The ship wave frequency detected from the field data was in quite good agreement with that of simulated ship wave.

HAVELOCK SOURCE

Under the assumption of the ideal fluid and irrotational flow the velocity potential of unit Havelock source (Havelock, 1932) location (x,y,z) can be written as

$$G(x, y, z; \zeta) = -\frac{1}{4\pi^2} \operatorname{Re} \left[\int_{-\pi/2}^{\pi/2} \int_0^\infty e^{-ik(x \cos \theta + y \sin \theta)} \left\{ e^{-k|z-\zeta|} - \frac{k + k_0 \sec^2 \theta}{k - k_0 \sec^2 \theta} e^{k(z-\zeta)} \right\} dk d\theta \right] \quad (1)$$

where wave number, $k(\theta) = k_0 \sec^2 \theta$ and $k_0 = g/U^2$, g is gravitational acceleration and U is ship speed[meter/sec] of mono hull. Eq. (1) represents the local field while Eq. (2) shown below takes care of the far field region

$$G^F(x, y, z; \zeta) = -\frac{k_0}{\pi} \iint_R \sec^2 \theta e^{k_0(z+\zeta) \sec^2 \theta} \sin(k_0 x \sec \theta) \cos(k_0 y \sec^2 \theta \sin \theta) d\theta \quad (2)$$

The present study deals with ship wave with radar image. Therefore far field might be enough to be considered.

NUMERICAL SHIP WAVE PATTERNS

It is necessary to define the rate of beam width with respect to longitudinal coordinates. The Wigley hull was employed in this study. The mathematical expression of the Wigley hull is shown as

$$Y(\xi, \zeta) = \frac{B}{2} \left(1 - \frac{4\xi^2}{L^2} \right) \left(1 - \frac{\zeta^2}{H^2} \right) \quad (3)$$

where B is breadth of the ship, L is length of the ship, and H is draft of the ship.

The total potential can be represented as $\phi = \phi^{local} + \phi^{far}$. However, only far field potential is used at the present study.