論 文

Development of Passive-Type Radar Reflector for Fisheries

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〈CONTENTS〉

Abstract

This paper describes on the development of Passive-type Radar Reflector for Fisheries (PRR-F) based on the newly revised 2000 SOLAS regulations. The purpose of PRR-F is to provide it as the protection devices of a fishing net and a fishing field. The PRR-F is composed of corner cluster bundle of light galvanized iron, and it is inserted into floating styrofoam. Performance tests for the PRR-F are carried out in an anechoic chamber. The test results show that the reflected radar signal from PRR-F is large enough for the purpose.

◐ KEY WORDS : SOLAS 2000, passive-type radar reflector, fisheries, fishing net, fishing place

요 약

이 논문에서는 새로 개정된 2000 SOLAS 규정에 근거한 어업용 수동식 레이더 리프렉터(PRR-F) 개발에 관해서 기술했다. PRR-F의 목적은 어망이나 어장의 보호 장치로 사용하는 것이다. PRR-F는 가벼운 양철 재질의 코너 크로스터 묶음을 부유 스티로폼 안에 내장한 형태로 구성하였다. PRR-F를 전파흡수실에서 성능 실험한 결과, 레이더 반사된 신호의 크기가 개발 목적에 충분하였다.

◐ 핵심단어 : SOLAS 2000, 수동식 레이더 리프렉터, 어업, 어망, 어장

1. INTRODUCTION

On 14 April 1912, Titanic foundered and safety standards in the shipbuilding changed forever. Soon after the tragedy, the International Maritime Organization (IMO) was established to investigate maritime laws and regulations. The IMO prompted the first Safety Of Life At Sea (SOLAS) conference. SOLAS represented an international agreement to secure the protection of life at sea.

Then, the SOLAS chapter V is revised with several relevant resolutions in July 2000. These amendments entered into force on 1 July 2002 [1]~[4].

Collision avoidance is surely the most important part at sea traffic. Especially, small sized fishing net is surprisingly poor targets for radar reflection and is frequently in danger of being overrun by larger vessels, even under good conditions of visibility. Most of the small fishing net, with fiber and nylon material, do not possess enough reflective qualities to make them highly visible on a radar screen. In addition, small radar reflectors may not show up on a ship as radar, due to rain or background wave clutter.

In this paper, protection device of fishing net using corner reflectors is developed[5]~[7]. The basic implementation methodology is same as the paper 'Designing Passive-Type Radar Reflector for Small Ship' presented in this seminar program.

2. RCS THEORY

Assume the power density of a wave incident on a target located at rage R away form the radar is P_{Di}. The amount of reflected power from the target is

$$P_r = \sigma P_{Di} \quad (1)$$

σ denotes the target cross section (RCS). Define P_{Dr} as the power density of the scattered waves at the receiving antenna. It follows that

$$P_{Dr} = \frac{P_r}{4\pi R^2} \quad (2)$$

Equating Eqs. (1) and (2) yields

$$\sigma = 4\pi R^2 \left(\frac{P_{Dr}}{P_{Di}}\right) \quad (3)$$

and in order to ensure that the radar receiving antenna is in the far field, i.e., scattered waves received by the antenna are planar, Eq. (3) is modified

$$\sigma = 4\pi R^2 \lim_{R\to\infty} \left(\frac{P_{Dr}}{P_{Di}}\right) \quad (4)$$

The RCS defined by Eq. (4) is often referred to as either the monostatic RCS, the backscattered RCS, or simply target RCS. The backscattered RCS is measured from all waves scattered in the direction of the radar and has the same polarization as the receiving antenna. It represents a portion of the total scattered target RCS σ_t, $\sigma_t > \sigma$. Assuming spherical coordinate system defined by (ρ, θ, ϕ), then at range ρ the target scattered cross section is a function of (θ, ϕ). Let the angles (θ_i, ϕ_i) define the direction of propagation of the incident waves. Also, let the angles (θ_s, ϕ_s) define the direction of propagation of the scattered waves. The special case, when $\theta_s = \theta_i$ and $\phi_s = \phi_i$, defines the monostatic RCS. The RCS measured by the radar at angles $\theta_s \neq \theta_i$ and $\phi_s \neq \phi_i$ is called the bistatic RCS. The total target scattered RCS is given by

$$\sigma_t = \frac{1}{4\pi} \int_{\phi_s=0}^{4\pi} \int_{\theta_s=0}^{\pi} \sigma(\theta_s, \phi_s) \sin\theta_s \, d\theta \, d\phi_s \quad (5)$$

The amount of bacscattered waves from a target is proportional to the ratio of the target size to the wavelength, λ, of the incident waves. In fact, a radar will not be able to detect targets much smaller than its operating wavelength.

The analysis presented in this work assumes far field monostatic RCS measurements in the optical region. Thus, near field RCS, bistatic RCS, and RCS measurements in the Rayleigh region are not be considered. Additionally, RCS treatment in this work is mainly concerned with narrow band cases.

3. PRR-F MODEL

Fig .1 shows the three kinds of PRR-F model developed in the work. Photos for real shape of PRR-Fs are shown in Fig .2.

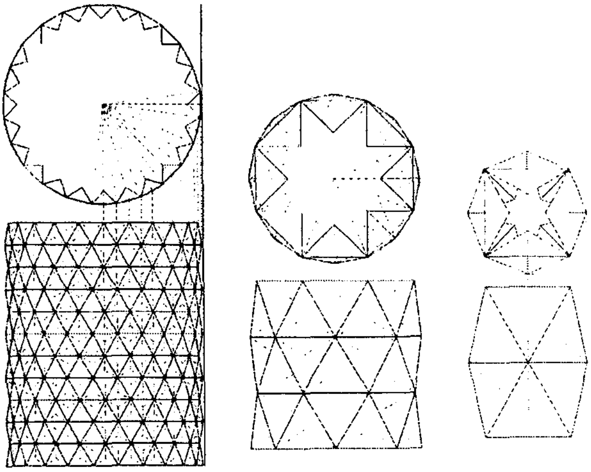


Fig . 1. Reflector models for fishing net : (Left) small sized corner cluster arrayed type, (Middle) large sized corner cluster arrayed type, (Right) large sized corner cluster arrayed type

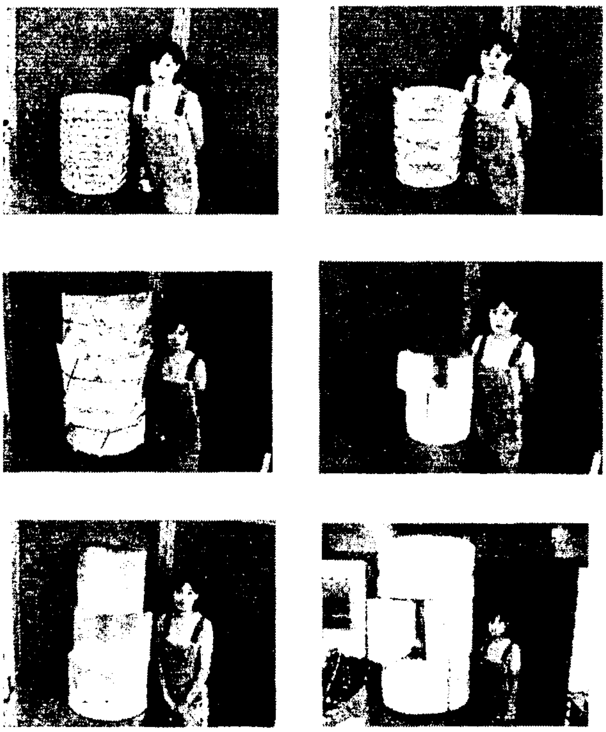
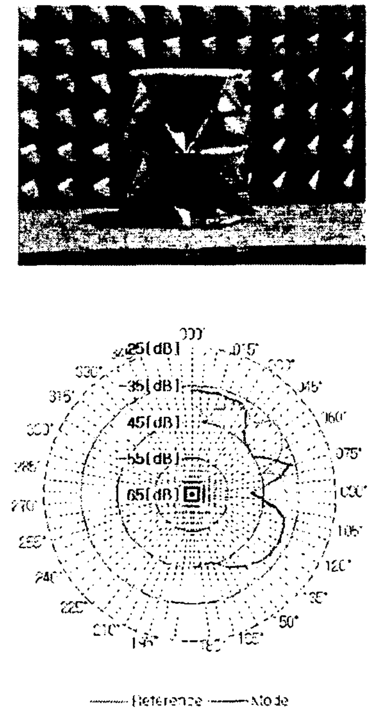


Fig . 2. Photographs of the end structure of PRR-Fs.

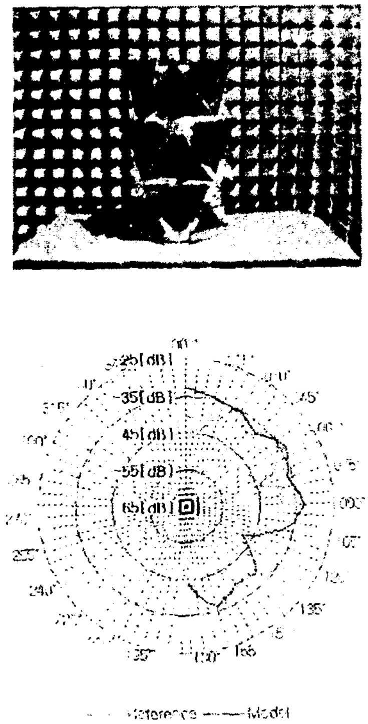
4. PRR-F TEST RESULTS

Performance tests for the PRR-F are carried out in the anechoic chamber of Korea Maritime University (KMU) in Korea. Fig.3 shows indoor RCS measurement at the anechoic chamber of KMU, Korea.

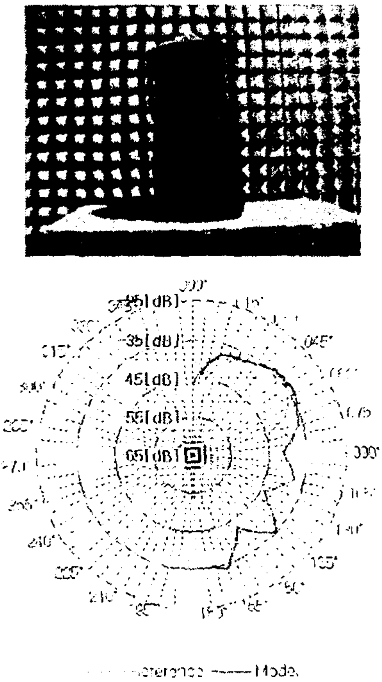
Fig . 3. Indoor RCS measurement



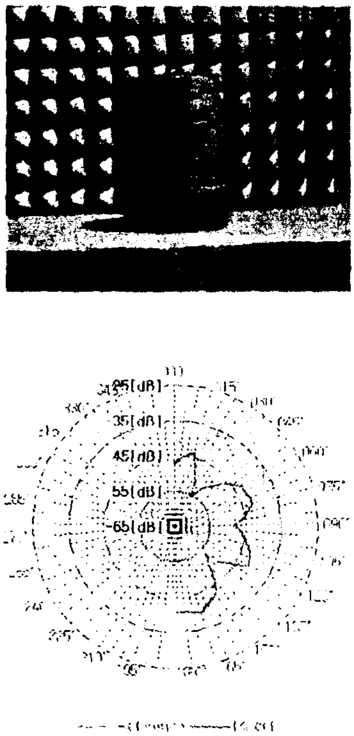
(a) 2-stage large sized corner cluster, r=19cm, l=43cm



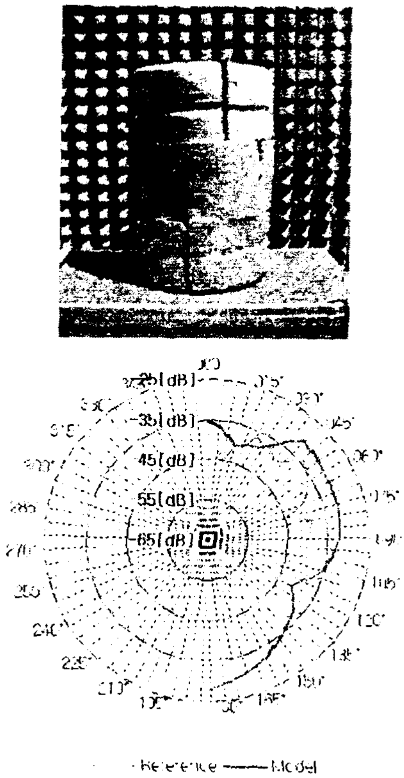
(b) 3-stage large sized corner cluster, r=26cm, l=93cm



(d) 3-stage zig-zag block, r=26cm, l=93cm



(c) 3-stage zig-zag block, r=19cm, l=43cm



(e) Extreme large 3-stage zig-zag block, r=39cm, l=140cm

Fig .4 RCS test results

RCS test results show that the RCS value of PRR is more large than the reference reflector (Davis Echomaster). In addition the RCS value much large enough for the purpose of PRR-F.

Since more detailed RCS tests are under proceeding in now, Full of the RCS polar plot is not shown in this paper. That results will be present next seminar.

5. CONCLUSIONS

A new Passive-type Radar Reflector for fisheries (PRR-F) is designed and developed in this study. As RCS test results, it is shown that the PRR-F provide practical insight on the implementation of PRR-F.

◈ REFERENCES ◈

[1]. IMO, Sub-Committee on Safety of Navigation 46th Session, Report to the Maritime Safety Committee, Annex 20: Draft Amendments to Chapter 13 of the HSC Code, 2000, 2000.7.

[2]. IMO 10th Session, Resolution A.384(Ⅹ), Performance Standards for Radar Reflectors, Adopted on 14 November 1977.

[3]. IMO 8th Session, Resolution A.277(Ⅷ), Recommendation on Performance Standards for Radar Reflectors, Adopted on 20 November 1973.

[4] Jeong-Bin Yim, H.R. Kim, K.D. Lee, "Research on the Required Specifications for the Ship's Sound Reproduction System According to SOLAS 2000," Proc. of Summer Meeting 2002, Acoustical Society of Korea, Vol.21, No.1(s), pp. 411-414, 2002.5.6.

[5] Woo-Suck Kim, Y.S. Ahn, I H. Kim, J.B. Yim, S.H. Park, "A Development of RADAR Reflector for Fishing Net Buoy," Proc. of the 26th Annual Spring Meeting on Navigation and Port Research 2002, Korean Institute of Navigation and Port Research, pp.177-184, 2002.3.29

[6] Jeong-Bin Yim, W.S. Kim, Y.S. Ahn, I.H. Kim, S.H. Park "A Study on the RCS Enhancement Method of Passive RADAR Reflector Through Shaping," Proc. of the 26th Annual Spring Meeting on Navigation and Port Research 2002, Korean Institute of Navigation and Port Research, pp.161-176, 2002.3.29

[7] Jeong-Bin Yim, W.S. Kim, Y.S. Ahn, I.H. Kim, S.H. Park, "Development Techniques on the Radar Reflector, Proc. of the Annual Spring Meeting on Maritime Industry, Institute of Maritime Industry, 2002.4.20