Available online at www.sciencedirect.com
ScienceDirect
Trans. Nonferrous Met. Soc. China 23(2013) 1002−1010
Transactions of Nonferrous Metals Society of China
www.tnmsc.cn

Cavitation and electrochemical characteristics of thermal spray coating with sealing material

Seong-Jong KIM[1], Seung-Jun LEE[1], In-Ju KIM[2], Seong-Kweon KIM[3], Min-Su HAN[1], Seok-Ki JANG[1]

1. Division of Marine Engineering, Mokpo Maritime University, Haeyangdaehak-ro 91 Mokpo-Si, 530-729, Korea;
2. Korea Institute of Industrial Technology, 89 Yangdaegiro-gil, Ipjang-myeon, Seobuk-gu, Cheonan-Si, 331-822, Korea;
3. Department of Electronic IT Media Engineering, Seoul National University of Science & Technology, 138 Gongneung-gil, Nowon-gu Seoul, 139-743, Korea

Received 9 April 2012; accepted 15 August 2012

Abstract: Steel applied in ocean environment is exposed to corrosion and cavitation and is subject to increasing damages. To prevent this, anti-corrosion thermal spray coating technique is widely used. The low-temperature thermal spray coating was performed with 85%Al−14.5%Zn−0.5%Zr for ship materials and various sealing materials were applied to improve its durability, and the electrochemical behavior and cavitation characteristics were observed. The results show that the sealing improves all the properties of the materials. Hybrid ceramic and fluoro-silicon sealing materials show good electrochemical characteristics, and the fluoro-silicon sealing material shows the best anti-cavitation characteristics.

Key words: thermal spray coating; sealing material; cavitation; electrochemical characteristics

1 Introduction

Since metal corrosion is greatly influenced by flow speed and turbulence flow, that is, when flow speed increases, corrosion is accelerated remarkably [1,2]. Corrosion protection with sacrificial anode clearly decreases life span, and corrosion protection by impressed current tends to increase current density. In the case of sacrificial anode method, design techniques to predict life span are inadequate [3]. If sufficient corrosion protection cannot be achieved, painting must be used, but defective parts of painting exist [4,5]. Thus, corrosion begins from the defective parts and expands to the whole metal due to the defect of coating. As a technique to solve this problem, cold spray coatings which apply corrosion protection coating to metal surfaces were used in various industrial structures. Cold spray coating forms porous metal coating by a process that molten metal is sprayed out from a round slit, the distributed metal droplets hit the steel surface and are laminated and cooled. In the related studies, LIMA et al [6] investigated the fracture toughness and cavitation resistance of thermal spray coating through indentations and found a correlation between the two variables: the higher fracture toughness got, the better cavitation characteristics became. KIM et al [7] studied the void control, abrasion resistance and corrosion resistance of the ceramic spray layer of alumina. In this study, low-temperature spray coating technology with excellent electrochemical characteristics and its cavitation resistance in marine environment was incestigated. Spray coating with 85%Al−14.5%Zn− 0.5%Zr alloy wire for corrosion resistance was applied to steel which was used as a ship material, and the electrochemical and cavitation characteristics of sealing materials were compared.

2 Experimental

High tensile steel with composition of 0.1617% C, 0.013% Si, 0.659% Mn, 0.0146% P, 0.0076% S, balance Fe, was used and its tensile strength, yield strength, elongation are 463 MPa, 312 MPa and 23%, respectively. For thermal spray coating, KMS−300 arc spray was used to coat the steel in the thickness of 500 μm or higher with 85%Al−14.5%Zn−0.5%Zr alloy, spray transfer speed of 10 cm/s, gas pressure of 49−58.8 N and wire feed speed of 12 m/min. Thereafter, sealing materials

Foundation item: Project supported by the Ministry of Education, Science Technology (MEST) and Korea Industrial Technology Foundation (KOTEF) through the Human Resource Training Project for Regional Innovation
Corresponding author: Seung-Jun LEE; E-mail: corr-pro@mmu.ac.kr; Seong-Kweon KIM; E-mail: kim12632@seoultech.ac.kr
DOI: 10.1016/S1003-6326(13)62559-5

such as water-soluble fluorine (hereinafter W−F), nano-fluorine (hereinafter nano), hybrid ceramic (hereinafter ceramic), salt-tolerant epoxy (hereinafter epoxy) and fluoro-silicon (hereinafter F−Si) were additionally applied [8]. In particular, F−Si has the adventages of long-term maintenance when applied to flooded and exposed areas of the marine environment under harsh conditions such as salt water, ultraviolet light and rain. In addition, the effect of adhesion for prevention of marine organisms such as barnacles is also excellent, and long-term protected by forming strong elastic film. The reference electrode and counter electrode were Ag/AgCl electrode and Pt electrode, respectively. All electrochemical experiments were conducted in natural circumstance (specific resistance 21.46 Ω·cm , pH 8.0, chloride concentration 16197×10^{-6}, dissolved oxygen content 7.7×10^{-6}). The multi-channel potentio/galvanostat WMPG−1000 was used for the corrosion test. The open circuit potential measurement was performed for 24 h to measure the potential behavior with time. Anodic and cathodic polarizations were tested from the open circuit potential to 3.0 V and −2.0 V at the scan rate of 2 mV/s. The corrosion potential and corrosion current density by Tafel analysis were obtained by polarizing ±0.25 V at the scan rate of 1 mV/s based on the open circuit potential. In accordance with the requirements of ASTM—G32 a ultrasonic vibration generator was used for the cavitation test, which generated a rated output of 20 kHz and supplied it to the vibrator; the distance of 1 mm was maintained using a filler gauge. An electronic balance that can measure down to 10^{-4} g was used to measure the mass before and after test. For microscopic analysis and evaluation after experiment, the corrosion pattern of the surface was observed with a 3D microscope.

3 Results and discussion

Figures 1 and 2 show the changes of surface morphology by sealing material after thermal spray coating with 85%Al−14.5%Zn−0.5%Zr alloy and compare the average roughness (R_a) using a roughness analysis program, respectively. The surface roughness R_a is the average of the absolute values from the center of height variation to the profile of the surface within the cutoff. The same cutoff was applied to all the specimens under different conditions to compare their measurements of average roughness. The unsealed surface of thermal spray coating layer was rough and many pores could be observed. The highest measured R_a

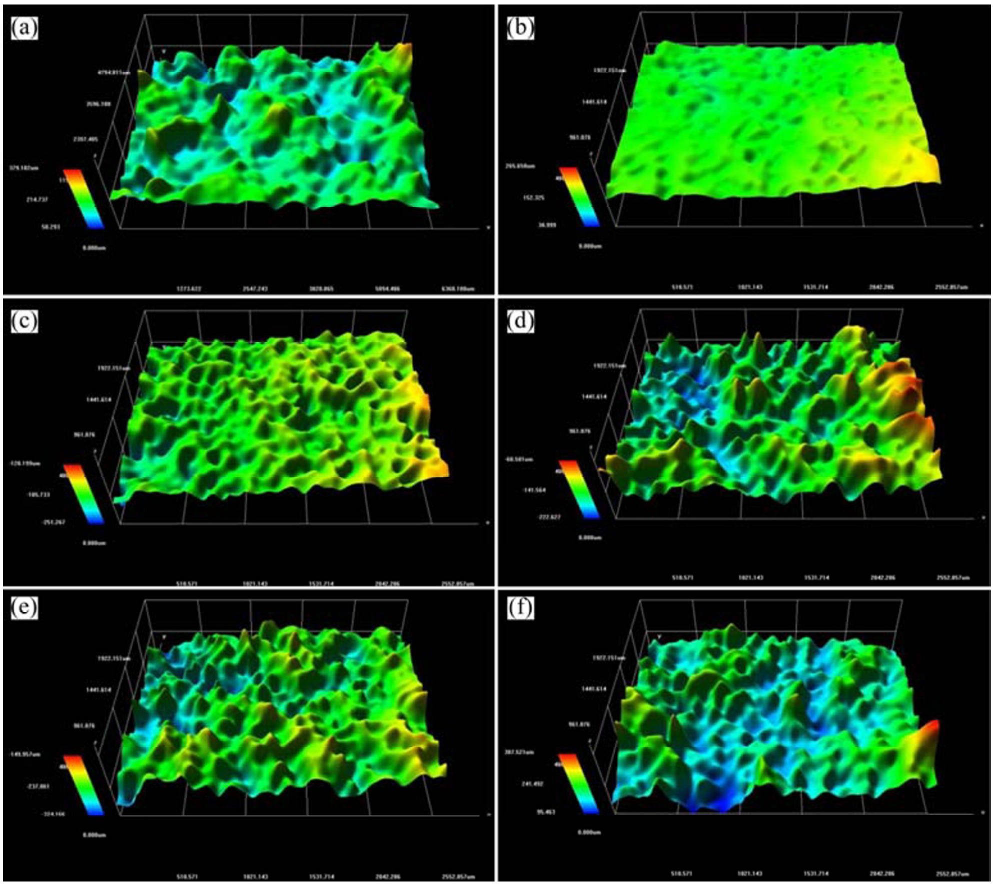

Fig. 1 Surface morphologies of 85%Al−14.5%Zn−0.5%Zr coating with various sealing materials: (a) Only thermal spray coated; (b) Epoxy; (c) Nano; (d) W−F; (e) Ceramic; (f) F−Si