Efficient Approach to Ship Hull Corrosion Monitoring: Paving the Way for Future Vessels

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Abstract

Although collisions, groundings and fires are among the dominant accidental causes of casulties to ships in operation, corrosion still remains the key monotonous degradation process that affects the structural integrity of the ship's hull in the long term. Despite the development and implementation of international standards promoted by the International Maritime Organization (IMO), Flag States and Classification societies, and the introduction of systems such as the Safety Management System, Common Structural Rules (CSR) and Performance Standard for Protective Coatings (PSPC), corrosion damage still represents a significant challenge in maintaining the expected life cycle of a ship of about 25 years.

Contemporary trends in the digitalization of the maritime industry and the development of advanced sensor and autonomous technologies enable a more efficient and proactive approach to corrosion monitoring. The integration of smart sensors, digital twins, real-time data analytics and artificial intelligence opens new possibilities for predictive maintenance, identification of critical degradation zones and optimization of inspection intervals. Special attention is drawn to underwater remotely operated vehicles (ROVs) and aerial drones, which, thanks to high-resolution cameras and advanced image processing algorithms, thickness measuring devices, represent a safer, faster and more economical alternative to traditional human inspections.

The subject of research in this paper are underwater remotely operated vehicles (ROV), autonomous underwater vehicles (AUV) and aerial drones which, in addition to enabling visual detection of corrosion zones and analysis of surface damage in real time, as wel las to measure the thickness of ship's hull structural elements. Although robotic systems offer increased safety, reliability of data compared to conventional inspections that require the work of human personnel in hazardous conditions, this investigation answers whether these advantages also apply to the thickness measurement and corrosion assessment of ship's hull structural elements.

Keywords: *corrosion; surface protection; rules and regulations; digitalization; remote inspection technique*

Izvod

Iako su sudari, nasukanja i požari među dominantnim slučajnim uzrocima oštećenja brodova u plovidbi, korozija i dalje ostaje ključni monotoni degradacioni proces koji dugoročno utiče na strukturnu cjelovitost brodskog trupa. Uprkos razvoju i implementaciji međunarodnih standarda koje promovišu International Maritime Organization (IMO), države zastave i klasifikaciona društva, te uvođenju sistema kao što su Safety Management System, Common Structural Rules i Performance Standard for Protective Coatings (PSPC), koroziona oštećenja i dalje predstavljaju značajan izazov u održavanju predviđenog životnog ciklusa broda od oko 25 godina.

Savremeni trendovi u digitalizaciji pomorske industrije i razvoju naprednih senzorskih i autonomnih tehnologija omogućavaju efikasniji i proaktivniji pristup praćenju korozije. Integracija pametnih senzora, digitalnih blizanaca, analitike podataka u realnom vremenu i vještačke inteligencije otvara nove mogućnosti za prediktivno održavanje, identifikaciju kritičnih zona degradacije i optimizaciju

intervala inspekcija. Posebnu pažnju privlače podvodna daljinski upravljana vozila (ROV) i aerodroni, koji, zahvaljujući visokorezolutivnim kamerama i naprednim algoritmima obrade slike, uređajima za mjerenje debljine, predstavljaju sigurniju, bržu i ekonomičniju alternativu tradicionalnim inspekcijama koje sprovodi čovjek.

Predmet istraživanja u ovom radu su podvodna daljinski upravljanih vozila (ROV), autonomna podvodna vozila (AUV) i aerodroni koji pored toga što omogućavaju vizuelnu detekciju korozionih zona i analizu površinskih oštećenja u realnom vremenu, koriste i za mjerenje debljine strukturnih elemenata brodskog trupa. Njihova integracija s digitalnim blizancima i sistemima zasnovanim na vještačkoj inteligenciji omogućava stvaranje prediktivnih modela degradacije i pravovremeno donošenje odluka o popravkama, čime se značajno doprinosi produženju životnog vijeka i strukturnoj otpornosti broda. Iako robotizovani sistemi nude povećanu sigurnost, pouzdanost podataka u poređenju s konvencionalnim inspekcijama koje zahtijevaju rad ljudskog osoblja u opasnim uslovima, ovaj rad daje odgovore da li se ove prednosti odnose i na mjerenje debljine i procjenu korozije strukturnih elemenata broda.

Keywords: *korozija; površinska zaštita; pravila i propisi; digitalizacija; tehnika daljinske inspekcije*