CORROSION IN BALLAST TANKS – EXPERIMENTAL SETUP TO ESTABLISH A REGRESSION BETWEEN THE CHEMICAL AND STRUCTURAL PARAMETERS OF GRADE A[1] STEEL AND THE OBSERVED RATE OF CORROSION[2]

Aerts Tiny and Aurélien Lorent

Hogere Zeevaartschool Antwerpen, Noordkasteel-Oost 6, 2030 Antwerpen, Belgium
E-mail: aertstiny@hotmail.com; sayn13@gmail.com

Corrosion in ballast tanks is a common problem in the shipping industry. The condition of the ballast tanks is one of the factors that determines the life expectancy of a merchant vessel. It is expensive and time consuming to keep protective coatings ship shape and/or to replace corroded parts. Therefore finding a durable solution and defining which parameters are detrimental to the corrosion rate of ship construction steel are valuable assets to increase the life expectancy of a vessel.

Corrosion means a deterioration of the metal caused by its environment and will result in subsequent loss of body mass. The experiment at the Antwerp Maritime Academy investigates the corrosion rate of steel in an aquatic environment by means of weight loss, thickness measurements, an experimental photographical approach and electrochemical methods such as the Tafel plot and linear polarization measurements.

This experiment at the Antwerp Maritime Academy is the continuation of an "in situ" research program exploring the chemical and microbiological parameters of corrosion on board of merchant navy ships. The "in situ" aspect turned out to be a decisive element and was maintained during the experiment. The team went on board of more than 30 ships effectuating hull repair jobs and they collected approximately 50 samples of steel.

The set-up of the project is as follows:
In 3 test tanks, filled with natural sea water, the samples are exposed to three environmental scenarios:
▪ completely and permanently submerged steel;
▪ steel in quasi dry condition (saturated atmosphere is reproduced);
▪ steel that is exposed to a water spray for 4 hours per day, simulating the dry/wet condition of ballast tanks;

The samples used in this project are predominantly grade A-steel , some are AH steel and one sample is a unique experimental corrosion resistant steel. All of the samples are exposed to uniform conditions. Temperature, pH and ORP (oxygen reduction potential) are monitored continuously.

At regular intervals, measurements are carried out to determine the rate and composition of the rust prevailing:

The weight measurement
All samples are weighed with an accuracy of 0.01g. The starting weight will be the reference to determine the rate of corrosion. The samples will be weighed again after 6, 12 and 18 months.

---

[1] Grade A steel is the most common ship construction steel usually mild steel containing 0.15 to 0.23 % carbon, and a reasonably high manganese content. Both sulfur and phosphorus in the mild steel are kept to a minimum (less than 0.05 %).

[2] A research project by Capt. Kris De Baere and Helen Verstraelen of the Antwerp Maritime Academy and Dr Silvia Lenaerts and Dr Geert Potters of the University of Antwerp. Research cooperators: Tiny Aerts, Aurélien Lorent, Tijl Pissierssens and Joris Timmermans, bachelor and master students of the Antwerp Maritime Academy.

The thickness measurement
The thickness is determined by using an ultrasonic device. The samples were measured day one and this will be repeated after 1, 2.5, 6.5 and 12 months.

Photographical analysis
This is a very experimental approach. Corrosion will be quantified based on discoloration and change in surface roughness of the samples. Sophisticated visual and statistical techniques will be applied. In the beginning the pictures will be taken every day and afterwards the frequency will decrease. Color histograms will be used to analyse the different corrosion products.

Electrochemical analysis
By means of a potentiostat the corrosion rate in mm per year is established. This test is done before the samples are exposed to H_2O and will be repeated after 6 months and 1 year. This method will be conducted by KDG.

At present, only an instinctive prognosis, based on the photographic data, can be presented. Currently the project is still in its infancy and the material available in this stage of the experiment is solely photographical. Following items can be visually observed:
- The samples that are alternating wet and dry, corrode faster than the always dry or always wet samples.
- Corrosion rate and the appearance of the rust are different for each sample.
- The corrosion resistant steel also shows a layer of rust. We suppose that the CRS (corrosion resistant steel) will go into a passive state and the oxidation layer will protect the underlying steel.

It is expected that the project will show that corrosion is depending on the chemical composition of the steel. Especially the impurities captivated within the crystal structure of the steel are suspected to be a detrimental factor. The accent lies on the enclosures because industrial standards only allow for small differences in chemical composition. This will be clarified by a chemical analysis of the samples and a thorough study of the crystal structure.