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The Capacity of Applying Electrical Resistance Probe in Natural Corrosion Tests of Vietnam

Pham Thy San, Le Thi Hong Lien, and Le Quoc Hung

Corrosion Research Center, Institute for Material Science, NCST of Vietnam
Nghia do, Cau giay, Hanoi, Vietnam

The Electrical Resistance Probe of carbon steel and weight loss coupons were exposed in atmosphere and in the lake water of Hanoi. The comparison of data received by two methods after one year exposure was presented. The correspondence of the data of these methods on the exposure time in both environments showed a capacity of using Electrical Resistance Probe in Vietnamese natural corrosion testing of Carbon steel.

Keywords : *the electrical resistance probe, weigh loss method, exposure time, carbon steel, environment.*

1. Introduction

Corrosion of metal is always considered as a serious problem for any country. In Vietnam, up to now, there are many State projects on Vietnam nature corrosion researches. In these projects, the main method was weigh loss. This spent a long time, a lot of money and labor cost. Nowadays, in the world, the corrosion sensors have been developing and using more and more.[1)-4)] We, therefore, initially studied the capacity of applying electrical probe in corrosion research of Vietnam. In this paper, we present some results achieved from corrosion sensor and weight loss coupons after one-year of testing in atmospheric and lake water of Hanoi.

2. Experimental

Exposure test were carried out in atmosphere and Hotay Lake water of Hanoi. Metal is carbon steel. Time of testing is one year.

For weight loss method in atmospheric condition, carbon steel specimens, 150x100x2 mm, were exposed in Hanoi atmosphere. The specimens were placed on racks at 45°, faced to the south. The specimens were taken off after 1, 2, 3, 4, 5, 6, 9 and 12 months of exposure. Electrical resistance probes were also placed on rack in the same direction and angle with the specimens'.

In lake water, carbon steel specimens, 150x100x4 mm, and electrical resistance probes were placed on racks, which were sticked between two bodies of the tourism ship, under the water. The specimens were taken off after 3, 6, 9 and 12 months of exposure.

The corrosion products were removed by chemical cleaning in accordance with ISO 8407,[5)] using the following solution: 500 mL hydrochloric acid (HCl) (ρ=1.19 g/cm^3); 3.5 g hexamethylenetetramine, distilled water to make 1000 mL at 25°C.

The corrosion rates were evaluated from the weight loss of specimens according ISO 8407[6)] and for the electrical resistance probe, the corrosion rate was calculated by the changes of electrical resistance. The data was average value of three probes. Electrical resistance probes of carbon steel were manufactured by "Corrosion Research Center" with thickness of 250 μm. The measurement method was direct. Current source is 400 mA. The Voltage received by Fluke Volt Meter. The measurements were implemented in the fields, 1 time every 1-2 week. From this data, we built the curve to express the corrosion versus exposed time. Fig. 1 showed schematic of Electrical resistance probe and principal circuit to measure resistance ratios.

$$\frac{V1}{V2} = \frac{Rtest}{Rref}$$

$$Rtest = \frac{V1}{V2} \times Rref$$

The value of Rref is not change.

The value of $\frac{V1}{V2}$ received by measurement.

So, We calculate the value of Rtest.

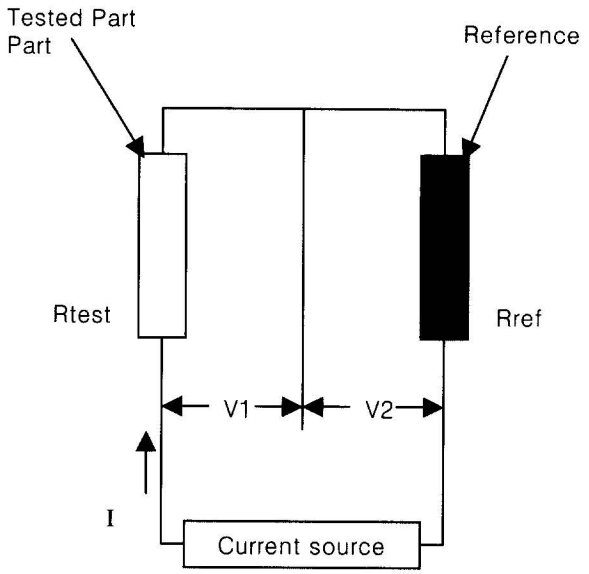

Fig. 1. Principal circuit to measure resistance ratios

$$Rtest = \frac{\rho \times Ltest}{Stest} = \frac{\rho \times Ltest}{Dtest \times Htest}$$

Ltest and Dtest are constant on exposure time. Then,

$$\frac{Rtest\ (t)}{Rtest\ (0)} = \frac{Htest\ (0)}{Htest\ (t)}$$

$$Htest\ (t) = Htest\ (0) \times \frac{Rtest\ (0)}{Rtest\ (t)}$$

Where:

ρ is the intrinsic electrical resistivity of material

Ltest : the length of tested part,

Dtest : The Width of tested part,

Htest : The Thickness of tested part,

Rtest(0) : Electrical resistance of tested part before test

Rtest(t) : Electrical resistance of tested part on exposure time.

Rref : Electrical resistance of reference part (painted).

3. Results and discussion

Figs. 2 and 3 showed the thickness degradations of carbon steel by corrosion in the atmosphere and in lake water by two methods through testing time. Fig. 4 and 5 showed the changes of corrosion rate versus exposure time.

These results showed that the curve created by two methods had the same manner; they were curves for both environments atmosphere and lake water. The differences between two types of data were small, in atmosphere the difference was about 3 μm and in lake water about 5 μm. These differences perhaps were caused by the rough of surface, which led to the unequal of thickness, we, therefore will continuously consider this problem. But in long exposure time (one-year) the errors were <10% for atmosphere and 5% in lake water.

The same manners of two data types showed that the sensors expressed the corrosion process exactly as the process happened on the weight loss coupons so we can

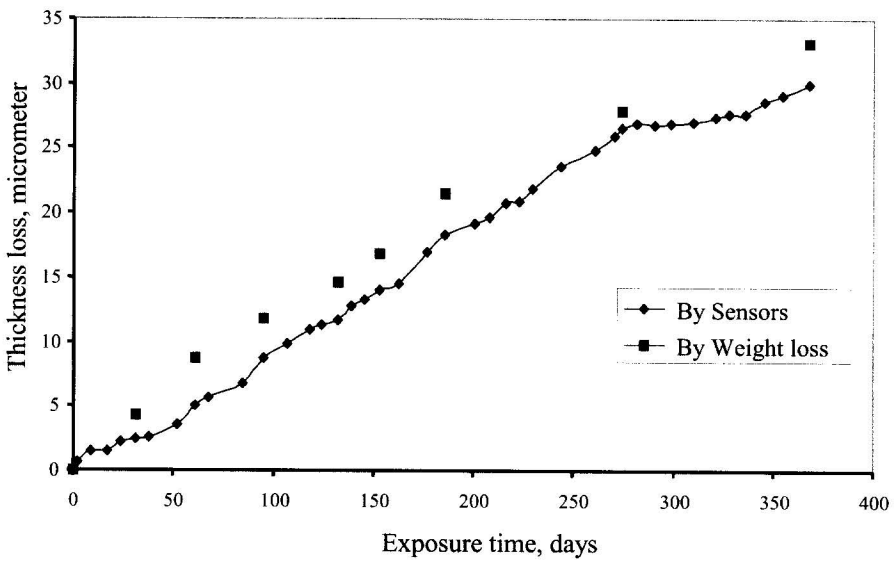

Fig. 2. The thickness degradation of carbon steel versus exposure time in Hanoi atmosphere

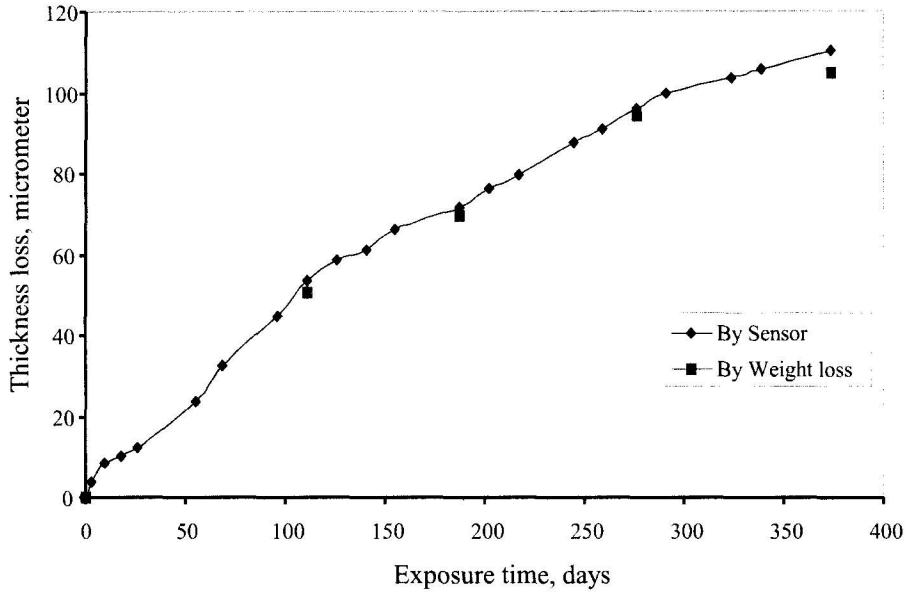

Fig. 3. The thickness degradation of carbon steel versus exposure time in Hotay Lake water

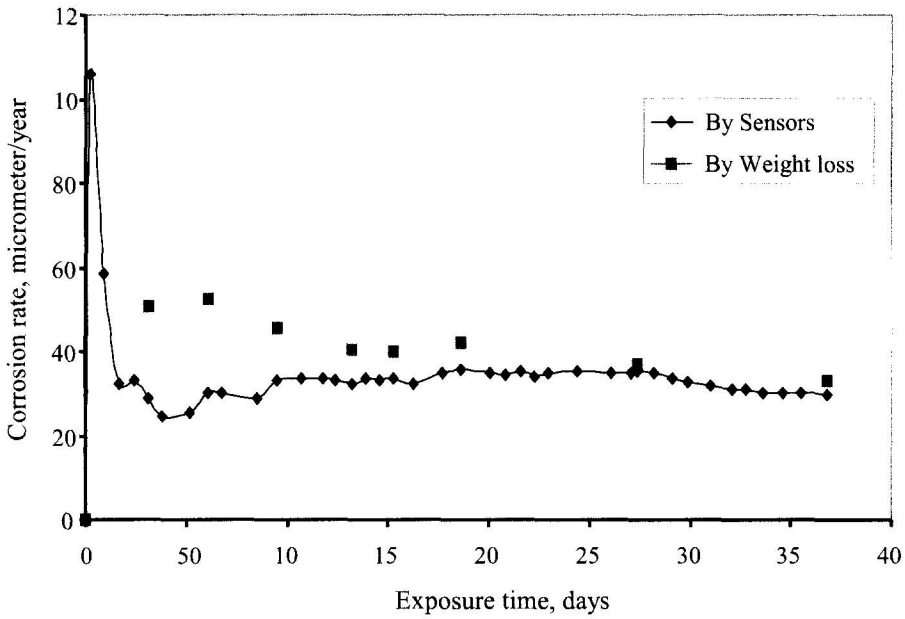

Fig. 4. The change of corrosion rate of carbon steel versus exposure time in Hanoi atmosphere.

use sensor to corrosion research. And further more, if we got environmental parameters, for example, the climate parameter or water compositions (temperature, relative humidity, chloride concentration, sunfurdioxide concentration, pH, diluted oxygen concentration, minerals...) on exposure time we could gather more information about the environmental parameter influence on corrosion process of carbon steel. And we could predict the tendency of corrosion and find out the protection methods.

In both environments, in the first time of exposures, when the carbon steel surface was active, the corrosion rates increased quickly and just after short time they started to decrease. When the rust layer reached to some thickness, the corrosion rate decreased little by little because this rust layer became a protective layer and it defended the aggressives of environment. The rust layers

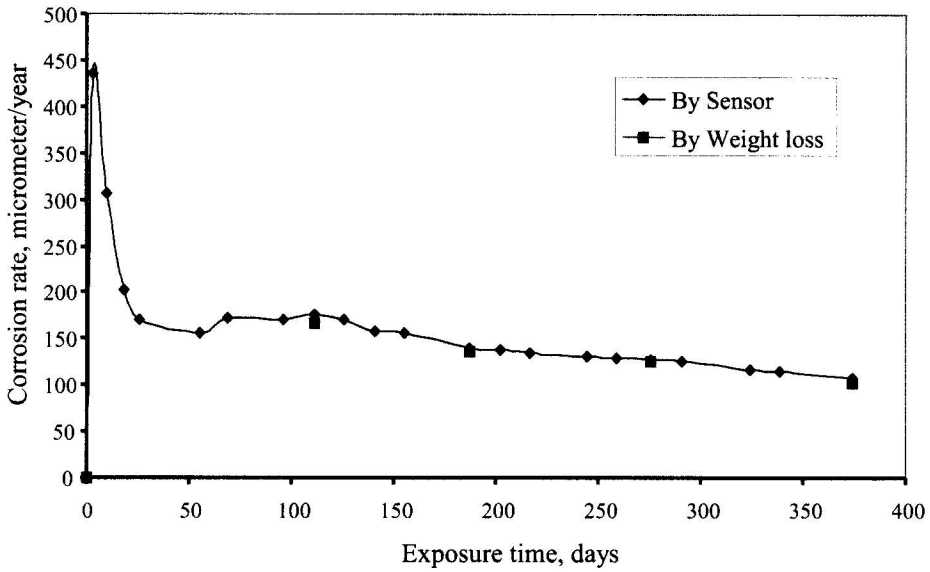

Fig. 5. The change of corrosion rate of carbon steel versus exposure time in Hotay lake water

were getting thicker and thicker and the defended capacity was also become more and more. In this case, the using sensor brought some advantages like showing us the pictures of the corrosion rate changes in different short periods, where as in the weight loss method we could not easily see them.

4. Conclusions

1) The electrical resistance probe expressed the same corrosion process of carbon steel like on the coupons of weight loss method. The differences between two types of data received by these two methods (weigh loss method and sensor) were small (<10%) in both nature environments: atmosphere and lake water. So we can use electrical resistance probe to corrosion research in nature environments of Vietnam.

2) Using the electrical resistance probe brought us some advantages like: simpler in field-tests... continuous examination of corrosion process, cost saving and an earlier prediction for corrosion etc.

3) The electrical resistance probe expanded the application ability as building the corrosion map of Vietnam, the corrosion map in the microclimate area...and researching the corrosion of the ships, bridges ... in lake water or river water. It will be a good tool in corrosion research.

References

1. A.Groysman and A. Hiram, in *13th ICC*, Paper 148.
2. K. A. Lichti, D. M. Firth, I. E. Minchington, and S. J. Swann, in *13th ICC*, Paper 412.
3. K. ϕomichev, *Zachita Metallov*, **30**, 419 (1994).
4. *Rohrback COSASCO System., 1998-1999 Corrosion Catalog.*
5. ISO 8407: Metals and Alloys - Procedure for removal of corrosion products from corrosion test specimens.
6. ISO 8407: Metals and Alloys - Procedure for removal of corrosion products from corrosion test specimens.