Quality Abnormality Prediction Technology Utilizing Rust Prevention Quantitative Evaluation Method by Model-Based Research

Teruaki Asada Katsunobu Sasaki Tatsuya Ezaki Tsutomu Shigenaga Akihide Takami

Technical Research Center, Mazda Motor Corporation

3-1 Shinchi, Fuchu-cho, Aki-gun, Hiroshima, 730-8670, Japan (E-mail: asada.te@mazda.co.jp)

KEY WORDS: Materials, Paint, Test/evaluation, Corrosion resistance, Coating

Corrosion of the coated metal material starts when the corrosion factor such as water and ions penetrates the rust preventive coating and reaches the base metal. After that, corrosion under the coating progresses due to the electrochemical reaction that consumes the electrons generated by the elution of the base metal. From the above-mentioned mechanism, it is considered that the anticorrosion function of the rust preventie coating can be organized by ① corrosion suppression period and ② corrosion progress rate (Fig. 1). The technology which enables quantitative evaluation of the anticorrosion function in a few minutes to a few hours using an electrochemical method has been put into practical use by the authors. The purpose of this study is to clarify the relationship between the polarization profile (current / voltage profile) when evaluating the corrosion suppression period and the failure mode of the electrodeposited coating film, and to predict the quality abnormality of the coating film. The case of using machine learning to analyze the polarization profile was also examined.

By analyzing the polarization profile based on the energization model, it was clarified that the cause of the abnormality of the electrodeposited coating film can be inferred. With a normal electrodeposition coating, it was difficult for water and ions to penetrate into the coating. Therefore, in the polarization measurement, the insulation was broken at the most vulnerable part at a high voltage of several hundred volts, and sudden energization occurred. On the other hand, in the case of film quality abnormality, water and ions permeated the entire coating film and reached the base metal, so that a weak current began to flow at a lower voltage than the normal coating film. It was also found that the inclination when energized became small. It was found that in the case of thickness abnormal, multiple convex shapes occur in the polarization profile. The reason why the polarization profile has a convex shape was discussed. Energization starts when water or an ions that has penetrated into the coating comes into contact with a site where the effective film thickness is locally reduced, such as spatter or iron powder. When this current value is below the threshold value, it is presumed that the gas generated by the electrolysis of water temporarily blocks the energization starting point, thereby lowering the current value and forming one convex shape. A technology has been developed to automatically determine the failure mode of the rust-preventive coating film by machine learning the characteristics of the polarization profile. The polarization profile was analyzed by the random forest method using a normal coating and coating with a typical failure mode, and normal or abnormal (abnormal film thickness, abnormal film quality) was judged. The predicted correct answer rate for normal and abnormal was 100 %. When the causes of the abnormality were further classified, the correct answer rate for the membrane quality abnormality was 74 %, and the film thickness abnormality was 79 %. In some cases, abnormal film thickness and abnormal film quality coexisted, resulting in a misjudgment of over 20% (Fig. 3).

In the future, it is thought that the predicted correct answer rate will be further improved by adding judgment criteria and explanatory variables. In this way, it was found that by applying machine learning to the polarization profile analysis, it is possible for experts to predict quality abnormalities without having to analyze the data in detail each time.

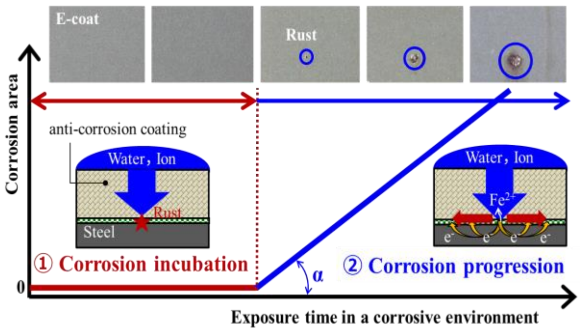

Fig.1 Functions of anti-corrosion coating

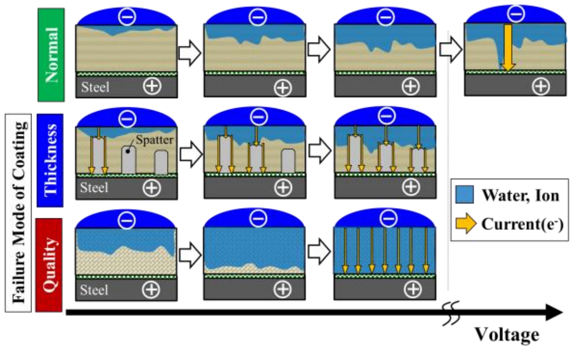

Fig.2 The Energization model in evaluation of typical failure mode and anti-corrosion coating

Failure mode		Correct answer rate		Example of Cyclic Corrosion Test results
Normal		100 %		
Abnormal	Abnormal of thickness	100 %	74 %	
	Abnormal of quality		79 %	

Fig.3 Failure mode of coating, correct answer rate in machine learning, example of Cyclic Corrosion Test (CCT) results