論文 / 著書情報
Article / Book Information

題目(和文)	大気腐食環境下における鉄鋼材料の水素吸収に関する電気化学的研究
Title(English)	Electrochemical Study on Hydrogen Absorption of Steel in Atmospheric Corrosion
著者(和文)	味戸沙耶
Author(English)	Saya Ajito
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11141号, 授与年月日:2019年3月26日, 学位の種別:課程博士, 審査員:多田 英司,西方 篤,須佐 匡裕,河村 憲一,林 幸
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11141号, Conferred date:2019/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

Electrochemical Study on Hydrogen Absorption of Steel in Atmospheric Corrosion

Tokyo Institute of Technology

Saya Ajito

In recent years, high-strength steels have been widely used in many industrial applications and have contributed to savings in energy and resources. However, the increase of steel strength leads to concern hydrogen embrittlement (HE). Since most of the steels are used in atmospheres, the HE is induced by the hydrogen atoms generated in atmospheric corrosion. In this study, in order to clarify hydrogen absorption mechanism into the corroding steel in atmospheric environments, simultaneous monitoring of hydrogen permeation current and corrosion potential of steel were performed during the drying of an NaCl droplet. The results of this work clarified that the hydrogen absorption of the steel occurred due to the negative shift of the corrosion potential during steel corrosion under the wet condition, and the lowering pH affected the hydrogen absorption soon before the droplet dried out. In addition, the effect of iron rust formation on the hydrogen absorption was investigated and clarified that the hydrogen absorption was suppressed by the formation of the iron rust. This was because the corrosion potential shifted to the positive direction due to the suppression of iron dissolution reaction and the enhancement of reduction reaction of the iron rust.

This doctoral dissertation consisted of seven chapters, and the summary of each chapter is as follows.

Chapter 1 “General introduction”

This chapter presented the importance of the applications of high-strength steel to industrial products such as vehicles for the savings in energy and resources and HE might be the drawback for the applications in atmospheric environments. I summarized previous studies about the hydrogen absorption of the steel in atmospheric environments in relation to the HE degradation and highlighted the significance of elucidating the mechanisms of the hydrogen absorption. The purpose and objectives of the dissertation were described.

Chapter 2 "Simultaneous measurement of corrosion potential and hydrogen permeation current during atmospheric corrosion of steel"

In this chapter, a simultaneous measurement system of corrosion potential and hydrogen permeation current was developed and applied to assess hydrogen absorption behavior into steel during the drying of an NaCl droplet. In this system, I utilized Kelvin probe technique for the corrosion potential measurement and Devanathan-Stachurski method for the hydrogen permeation current measurement. From the results of the measurements, when the droplet was put on the steel, the corrosion potential shifted to a negative value and the hydrogen absorption into the steel was initiated. In addition, soon before the droplet was dried out, the hydrogen permeation current showed a peak, although the corrosion potential did not change very much. It was considered that this peak was attributed to the decrease in pH by the hydrolysis reaction of concentrated ferric ions.

Chapter 3 "Measurement of pH in a thin electrolyte droplet using the Kelvin probe technique"

In this chapter, a novel pH measurement system was applied to investigate pH change in the thin electrolyte droplet above a corroding steel by using the Kelvin probe technique and a metal/metal oxide electrode. The pH value was clarified to decrease to ca. 5 near the anode due to the hydrolysis reaction of ferric ions and increase to ca. 12 near the cathode due to oxygen reduction reaction during steel corrosion process. Based on these findings, I have concluded that the peak of hydrogen permeation current into a corroding steel soon before the droplet dried out was caused by the decrease in pH near the anode due to the hydrolysis reaction of the concentrated ferric ions.

Chapter 4 "Hydrogen absorption behavior of pre-rusted steels under an NaCl droplet"

In this chapter, the hydrogen absorption behavior of the steel with iron rust was presented based on the results of the measurements of corrosion potential and hydrogen permeation current. In the initial stage of the rusting process, the corrosion potential shifted to a negative value due to the enhancement of iron dissolution reaction and the hydrogen absorption was increased. In contrast, as the whole surface of the steel was covered with the iron rust in the later stage of the rusting process, the corrosion potential shifted to a positive value due to the suppression of the iron dissolution reaction and the enhancement of reduction reaction of the iron rust, and the hydrogen absorption was decreased.

Chapter 5 “Hydrogen absorption behavior of steels with iron rust”

In this chapter, I investigated the hydrogen absorption mechanism of a rusted steel by measuring the corrosion potential and hydrogen permeation current of a model sample, which simulated the anode and cathode sites under the iron rust. The model sample was prepared by removing a part of iron rust on a rusted steel and it consisted of a bare steel as an anode and a rusted steel as a cathode. From the results of the model samples, the hydrogen absorption did not depend on the surface area ratio of the anode and cathode very much because the corrosion potential kept relatively a positive value. However, when the concentrated NaCl droplet was placed, the wet condition continued under the rust and the hydrogen absorption was increased. This result indicated that the hydrogen absorption was increased with the decrease in pH due to the enhancement of iron dissolution in the concentrated NaCl solution.

Chapter 6 “Mechanism of hydrogen absorption of steel in atmospheric environment”

In this chapter, the mechanism of hydrogen absorption behavior into a corroding steel in atmospheric environments was proposed based on the results of the corrosion potential, pH and hydrogen permeation current. Furthermore, the effect of the formation of iron rust on the hydrogen absorption into the corroding steel was also discussed.

Chapter 7 “General conclusions”

In this chapter, I summarized the key findings of this doctoral dissertation.