

論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	The Effect of Dynamic Solution Condition on the Failure of FRP Exposed to HCl
著者(和文)	Pradyawong Pradchar
Author(English)	Pradchar Pradyawong
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10310号, 授与年月日:2016年9月20日, 学位の種別:課程博士, 審査員:久保内 昌敏,伊東 章,淵野 哲郎,森 伸介,青木 才子
Citation(English)	Degree:, Conferring organization: Tokyo Institute of Technology, Report number:甲第10310号, Conferred date:2016/9/20, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
Doctoral Program

論文要旨

THESIS SUMMARY

専攻 :
Department of Chemical Engineering 専攻

学生氏名 : Pradchar Pradyawong
Student's Name

申請学位 (専攻分野) : 博士
Doctor of ()

Academic Degree Requested

指導教員 (主) : Prof. Masatoshi

Academic Advisor(main) Kubouchi

指導教員 (副) :

Academic Advisor(sub)

要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Fiber Reinforced Plastic (FRP) has gained attention because their high specific strength. Well-known applications are those that require lightweight materials with high mechanical properties, e.g., airplanes or automobiles. On the other hand, FRP is also widely used in chemical industry due to its high chemical resistant properties and ease of construction. Typical FRP chemical tank service lifetimes are expected to be 10–25 years. However, some accidents have been reported where the FRP chemical tank containing 35 mass% HCl has failed at a roof. These failures have occurred within a much shorter time period than the expected service life. The roof failure mechanism is still difficult to explain by isothermal condition. In normal operation, FRP composites are inevitably exposed to changing environmental conditions. These conditions usually involve large variations in temperature which could result in a dynamic solution condition in the vapor phase. Hence, more comprehensive study of material under wide range of temperature is important to extend knowledge of material failure.

“Chapter 1. Introduction” describes the background of this research with the knowledge on FRP material. The purpose of this research is (1) to prove that roof material is weaker than walls and bottom, (2) to prove that dynamic solution condition can accelerate material failure in the vapor phase, (3) to suggest the roof failure mechanism and (4) to propose life time prediction method for material under dynamic solution condition

“Chapter 2. Investigate of FRP Chemical Tank” describes the methodology to analyze FRP chemical tank. Used FRP storage tank which was investigated. Strength of roof material is 50% lower than the standard suggestion and also lower than walls and bottom materials. Chloride element is detected in roof material but calcium is disappeared. Microvoids and cracks are observed near surface inside the specimen.

“Chapter 3. Study of Material Property Under Isothermal Condition and Cyclic Solution Temperature” aims to clarify the effect of isothermal condition and cyclic solution temperature. Specimen is exposed to water, H₂SO₄ and HCl at various temperatures. The rate of mass uptake of specimen increases with increasing solution temperature. Strength of material in liquid phase of 35 mass% HCl under isothermal condition is lower than the vapor phase which is contracted to the roof failure of FRP chemical tank. Surprisingly, strength of specimen exposed to the vapor phase of 35 mass% HCl under cyclic solution temperature decreases lower than the liquid phase. Microvoids and cracks are observed in the white layer near surface inside the specimen exposed to the vapor phase under cyclic solution temperature which is also found in roof material of FRP chemical tank.

“Chapter 4. Study of Material Property Under Dynamic Solution Condition” focuses on the effect of temperature gradient, concentration gradient and cyclic solution concentration on material property. Strength of specimen exposed to 35 mass% HCl at 20°C and 50°C is 50% decrease in 4 weeks. Combining concentration gradient with temperature gradient can further accelerate the failure of material. In addition, specimen is immersed into two different chemical solution concentrations at 40°C. The result of mass uptake shows that after specimen is exposed to 35 mass% HCl and immersed into water, the rate of mass uptake is significantly increased. Crack and microvoid can be observed from the surface. Strength of material is slightly decrease to 20% of initial strength in 30 days. H₂SO₄ solution is also examined, however the strength of specimen does not affect. Depth of

crack increases with increasing exposure time. From these results, it can be seen that the effect of cyclic solution concentration plays an important role to accelerate the failure of material. When solution temperature increases, the concentration of HCl in the vapor phase is relatively high. When temperature of FRP chemical tank decreases lower than dew temperature, HCl and water in the vapor phase is dew at ceiling. After roof is heated by sunshine, HCl can easily evaporate resulting in concentration gradient. This phenomenon may take place every day during day/night time which can gradually decrease the material performance of roof material.

“Chapter 5. General Conclusion” concludes the main purpose of this study. FRP chemical tank analysis indicates that roof material is more damage than walls and bottom. Isothermal condition experiment cannot be used to explain the failure of material in the vapor phase. However, cyclic solution temperature experiment shows that strength in the vapor phase more damage than the liquid phase. Temperature and concentration gradients experiment can accelerate the failure of material. Cyclic solution concentration shows that it can significantly decrease material performance. Color change and cracks are observed during specimen is immersed into water after 35 mass% HCl. Life time prediction of material exposed to cyclic solution temperature is analyzed. From the equation, the decreasing tendency of strength has a good agreement with the experiment data which is analyzed from many used FRP chemical tank.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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