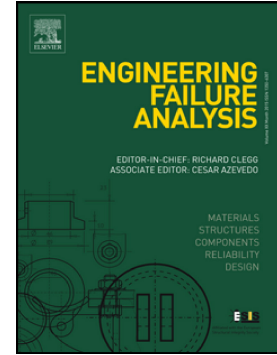


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Degradation behavior and lifetime estimation of fiber reinforced plastics tanks for hydrochloric acid storage

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Keywords: Fiber Reinforced Plastics, Diffusion, Degradation, Hydrochloric acid

Abstract

Fiber reinforced plastics (FRPs) are often used for chemical equipment because of their high chemical resistance, especially their resistance to acidic conditions. However, serious accidents have been reported when using such tanks with hydrochloric acid (HCl). We gathered FRP tanks used for 35% HCl storage from various chemical companies, and analyzed their changes in appearance, HCl penetration and residual flexural strength. We found that residual strength of FRP decreased to less than 50 MPa after 24 years of usage. The strength degradation at the tank roofs was more severe than at other positions in the tanks; in these parts the residual strength was 10–25 MPa after 20 years of usage. The strength degradation of FRP is caused by diffusion of HCl into the FRP. If the diffusion of HCl reaches the reinforced layer of the FRP tank, the FRP strength sharply decreases. Based on our comprehensive analysis of FRP tanks, the lifetime of current FRP tanks for 35% HCl storage is estimated at less than 20 years.

1. Introduction

Fiber-reinforced plastics (FRPs) have received considerable attention as an alternative material to steel and aluminum for use as storage tanks, pipes, and decks in chemical plants. When storing acidic media in particular, polymeric materials are indispensable, as steel and aluminum are easily corroded under acidic conditions. In such applications, FRP is used to avoid corrosion of metallic materials. FRP equipment can achieve very long-term use with minimal accidents, but some severe accidents have been reported for FRP chemical tanks storing hydrochloric acid (HCl). In the review of 242 accidents of storage tanks that occurred in industrial facilities, three cases were related to the failure of the tanks storing HCl (e.g. 2000 gal of HCl spilled from a tank) [1]. In addition, the roof of an FRP tank storing HCl tends to fail after more than 20 years of use (Fig. 1).

In general, FRPs for chemical equipment are usually composed of unsaturated polyester (UP) or

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