Studies on Fracture Behavior of Epoxy Composites

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ABSTRACT

Epoxies are now being used in many kinds of applications, such as adhesives, insulating materials, and molding compounds. In gas industry, epoxies are mainly used as the material for rehabilitation of steel pipes for gas distribution. In this particular application, long-term durability and high resistance to earthquakes are required for the purpose of keeping high reliability of the gas distribution.

In general, the properties of polymer composites are affected by the interface adhesion between reinforcements and polymer matrix. The interface adhesion is usually controlled by surface treatment of the reinforcements. In the studies, the fracture behaviors of epoxies reinforced with glass fibers and glass beads were systematically examined. The glass reinforcements were treated with different kinds of silane coupling agents, and the effect of the surface treatments on the fracture mechanisms were investigated. Different loading modes such as static loading and cyclic loading were considered. Special attention was paid to the effect of moisture absorption on the fracture mechanisms.

Extensive examination of fracture mechanisms showed that the using particular silane coupling agent that forms soft interface adhesion between reinforcements and polymer matrix results in improved durability of the epoxy composites. Especially after moisture absorption, the durability of the composites was significantly improved, and microscopic studied showed that the improved durability was the results of change of failure mechanisms. In the case of soft interface, the failure mechanism before moisture absorption was mainly microcracks as shown in Fig.1. On the other hand, after moisture absorption, dominant failure mechanism was shear yielding that was observed in large area at the crack tip (Fig.2), and the shear yielding was effective in absorbing energy that was applied to the specimens by static or cyclic load.

The above-mentioned results would be useful not only for the rehabilitation of steel pipes for gas distribution but also for improving the durability of wide variety of polymer composites used in gas industry.

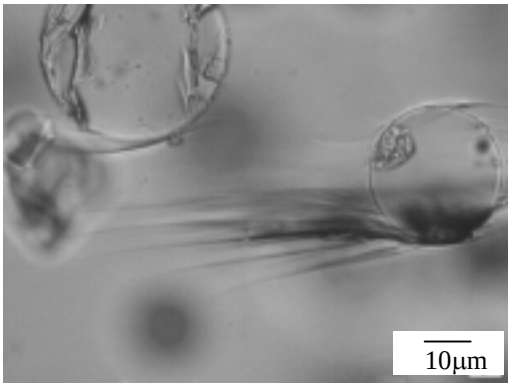

Figure 1 Microcracks observed at the crack tip of epoxy composite.

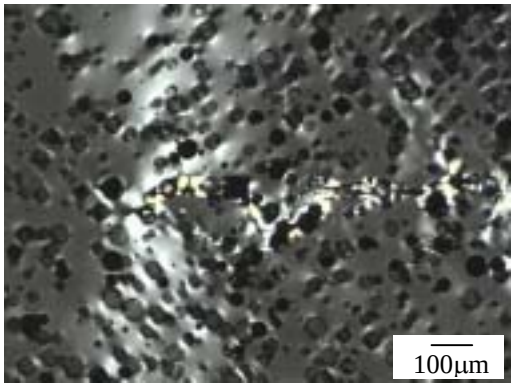

Figure 2 Shear yielding observed in large area at the crack tip of epoxy composite.

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List of awarded papers.

Title The Effect of Particle-Matrix Adhesion on the Mechanical Behavior of Glass Filled Epoxies: Part 1 A Study on Yield Behavior and Cohesive Strength
Authors Takafumi Kawaguchi, and Raymond A. Pearson
Journal Polymer, Vol.44, 4229-4238 (2003).

Title The Effect of Particle-Matrix Adhesion on the Mechanical Behavior of Glass Filled Epoxies: Part 2 A study on fracture toughness
Authors Takafumi Kawaguchi, and Raymond A. Pearson
Journal Polymer, Vol.44, 4239-4247 (2003).

Title The Moisture Effect on the Fatigue Crack Growth of Glass Particle and Fibre Reinforced Epoxies with Strong and Weak Bonding Conditions
: Part1 Macroscopic Fatigue Crack Propagation Behavior
Authors Takafumi Kawaguchi, and Raymond A. Pearson
Journal Composites Science and Technology, Vol.64, 1981–1989 (2004).

Title The Moisture Effect on the Fatigue Crack Growth of Glass Particle and Fibre Reinforced Epoxies with Strong and Weak Bonding Conditions
: Part2 A Microscopic Study on Toughening Mechanism
Authors Takafumi Kawaguchi, and Raymond A. Pearson
Journal Composites Science and Technology Vol.64 1991–2007 (2004).