EFFECT OF ENVIRONMENTS ON FRACTURE OF MATERIALS AND STRUCTURES

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ABSTRACT

Stress corrosion cracking (SCC) is defined as environment-induced subcritical crack growth under sustained tensile stress. This type of cracking continues to receive increased attention because it is one of the most widespread modes of failure of machines and structures. According to the general aim of the present conference, this paper emphasizes three aspects of stress corrosion cracking: the applications of fracture mechanics, the role of materials, and service failures and their prevention in actual structures.

To analyze and to prevent stress corrosion service failures in structures, it is highly useful to obtain detailed information concerning the effect of stress intensity on the growth rate of stress corrosion cracks in the relevant material-environment combinations. This paper presents a large body of such information, particularly concerning the stress corrosion crack growth of steels in hot water. The yield strength of the steels has a major influence on these growth rates, but certain steels exhibit exceptional resistance. Recent stress corrosion service failures in modern large power stations are analyzed with emphasis on the possible methods of failure prevention. The particular components discussed are retaining rings of generator rotors and large steam turbine rotors. For both types of components, acceptable and permanent solutions to the environment-induced cracking problems are presented. These illustrate also the importance of the close cooperation between specialists in the field of fracture mechanics, materials and structural design.

INTRODUCTION

It is generally acknowledged that the major use of fracture mechanics methodology is the application of quantitative fracture criteria (and the corresponding materials properties, such as fracture toughness $K_{IC}$) to actual structures and structural components. This is outlined in a simplified way in Figure 1, indicating that materials properties such as $K_{IC}$ which are obtained from compact tension specimens or from edge-cracked plates or from bending specimens in the laboratory can be used to calculate the burst speed of a flawed rotating disc or the burst pressure of a flawed pressure vessel. This is particularly easy when the materials involved have relatively high strength and low fracture toughness and thus, linear elastic fracture mechanics can be used.

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Fig. (1) - One of the main advantages of fracture mechanics is the ability to apply materials fracture criteria obtained with laboratory specimens to actual structural components such as rotating discs or pressure vessels and pipes.

It is the aim of this paper to show that the approach outlined above can profitably be extended to those situations where the combination of an "aggressive" environment and a "susceptible" material may result in costly stress corrosion service failures due to cracks which propagate at stress intensities way below $K_{IC}$. Four ways to prevent stress corrosion service failures may be quanti-