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Invited Lecture

STRUCTURAL INTEGRITY - A PROBLEM OF CRACKED COMPONENT

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Abstract:

Four typical cases of cracked components are considered. Two of them are well documented by failure analysis. Ship Schenectady, one of many fractured ships of Liberty type, failed due to steel susceptibility to cracking bellow transition temperature, the property identified in this case study analysis. Brittle fracture of heavy pressure vessel was analysed by fracture mechanics approach. Fatigue fracture of blades caused the failure of turbine. An analysis crack significance in welded penstock enabled to predict crack behaviour.

Key words: crack, transition temperature, service failure, pressure vessel, welded structure

1. Introduction

There are many situations in which cracked component can be responsible for the failure of structure. Anyhow, it is necessary first to define what is the crack in a component.

Planar discontinuity in material can be considered as a crack. Crack is presented by two neighbour opposite free surfaces without cohesion, e. g. with no forces between the surface atoms. It is defined in European Structural Integrity Society (ESIS) and American Society for Materials and Testing (ASTM) standards in different forms, mainly classified as free, surface and embedded cracks. Once defined crack notion opened next problem: how to detect crack in a structure. Nowadays series of non-destructive testing methods of different capacity and sensitivity are available. It is not clear yet what is the minimum size of a crack in component and is it possible to detect the crack of that size. Many components are introduced in service with the cracks in material, as manufacturing defect (plate rolling, welding, forging, casting), and many of them operate with the crack imitating and propagating in service. Next problems is whether these cracks will grow or will be arrested in applied stress field and environment. In many components the condition for crack growth are not existing. In the case that crack can grow in service, several modes can be recognized. In quasistatically loaded structure, crack driving force (CDF) can be introduced by stress field, and this force is responsible for crack growth. The crack growth rate depends on condition in which driving force acts. If the stress state corresponds to plane strain, instable fast catastrophic fracture is expected (brittle fracture). In the plane stress condition stable crack growth is ductile fracture. Variable loading can produce crack growth by fatigue, with increase of crack length for each cycle of applied loading. In the condition of elevated temperature one can expect crack imitation and growth by creep. Hostile environment can affect corrosion cracking, and if high stress is applied this is stress corrosion cracking. In some cases crack growth can be due to multiple effects, e.g. fatigue and creep, fatigue and corrosion.

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