# $J_C$-integral fracture parameter analysis and application for double-layer high-temperature components

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## ARTICLE INFO

## ABSTRACT

A $J_C$–integral fracture parameter for the safety assessment of components with more complex loadings was given in the paper, and it was carried out with 3D finite element method. Moreover, the cyclone separator of catalytic cracking unit, which is a typical double-layer high-temperature component, was taken as the practical application case. From the test results, it can be concluded that the high temperature fracture toughness $J_{IC}$ of cyclone separator has decreased significantly after long service. In this condition, the $J_C$–integral can provide us warranty to conclude whether the fracture of cyclone separator will occur under normal loading situation. By comparing the $J_C$–integral value with the experiment test value $J_{IC}$, the probability of fracture is very small under normal service situation unless there are very long cracks (over 100 mm) in the cyclone separator. Hence the $J_C$–integral can be regarded as an effective fracture parameter for evaluating the safety of double-layer high-temperature components.

## 1. Introduction

There are some key equipments designed in accordance with the conservative strength design method. They usually retire early for lack of corresponding flaw assessment methods so as to result in the waste of resources [1,2]. Therefore, it is necessary to apply fracture parameters to carry out safety assessment for defective components, such as stress intensity factor and J-integral fracture parameters [3]. The European developed a flaw assessment procedure (SINTAP), which is a method for the evaluation of structural integrity, addressing brittle fracture, ductile tearing and plastic collapse [4,5]. The finite element method has become one of the most effective methods to analyze the fatigue crack, though there are still some potential difficulties in modeling cracks (including mesh refinement level, crack advancement schemes, crack shape evolution, etc.), especially in three-dimensional model [6]. For the flaw assessment, besides the fracture toughness ($J_{IC}$) of engineering materials, the fracture parameter value under normal service conditions is required. Rice J-integral parameter [7], as the physical significance which is clear and easy to be implemented, has been recognized as one of the most important fracture parameters to estimate the safety of components. However, there are two essential preconditions for J-integral path independent: one is to assume that the components are small deformation, and the other is to ignore secondary stress. The preconditions restrict the applications of Rice J-integral theory in some practical engineering [8]. Refs. [9–11] pointed out that when secondary stress exists, Rice J-integral is no longer path independent and it is not an effective fracture parameter to describe the crack tip stress and strain fields, and successively proposed the $J^*$-integral and $J_w^*$-integral for components with more complex loadings.

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