



# Failure analysis on two austenitic stainless steels applied in cyclone separators of catalytic cracking unit

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## ABSTRACT

In this paper, several experiment approaches to the macro-mechanical properties, micro-structural morphology, phase identification, etc. were used for the failure analysis on two austenitic stainless steels applied in cyclone separator of catalytic cracking unit. The results show that the damage of material (310Cb) applied in cyclone separators within second regenerator (CSSR) is more serious than the material (0Cr19Ni9) applied in cyclone separators within first regenerator (CSFR). The damage of CSSR is mainly manifested as material embrittlement so that fracture occurs. However, its main damage causes do not result from carburizing or sulfurizing, but the precipitation of harmful  $\sigma$  phases and  $\text{Cr}_{23}\text{C}_6$  phases. Resulting in such phenomena, the internal cause is the high chromium (25 wt.%) of material, while external cause is the cyclone separators subjected to high temperature ( $>700\text{ }^\circ\text{C}$ ). It can be concluded that the material selection of CSSR is not more appropriate than CSFR. Assuming that the CSSR has the same lifetime as CSFR through taking some measures, the lifetime of the whole set regenerating system can be extended a lot. Because the main causes of failure are recognized, the corresponding measures to improve the lifetime of the whole set regenerating system can be given.

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## 1. Introduction

The gas–solid separation is an important issue in the production process of petroleum, chemical, metallurgy, energy [1]. The cyclone separator, for its advantages of simple structure, no moving parts, and high efficiency and so on, has become the first choice as the purification equipment of high temperature and high pressure gases. As the working temperature is very high and there are pressure, impact and corrosion factors, the damage causes of cyclone separators are complicated [2]. However, few investigations have been done on the damage causes of cyclone separators. It is because the cyclone separators are built inside the regenerators, if there are cyclone separators broken, the regenerators will be stop to weld, and then continue working. Generally, they will not be replaced in 10 or more years. Therefore, it is infrequent to have the opportunity to machine from cyclone separators for testing.

The regenerating system of catalytic cracking unit is composed of the first regenerator and second regenerator, in which there are several cyclone separators. The fracture position, actual looks and function of cyclone separators are shown in Figs. 1 and 2 respectively. Their loading situation includes self-weight, 0.3 MPa pressure and thermal loading (the working temperatures of first regenerator and second regenerator are about  $670\text{ }^\circ\text{C}$  and  $710\text{ }^\circ\text{C}$  respectively). In a chemical plant, a set of 1.4 million t/a catalytic cracking unit working after about 100,000 h, there is a cyclone regenerator within second regener-

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