Metallographic assessment of creep in cast tubes of heat resistant steels

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ABSTRACT

Catalytic reforming is rutinely used in oil refineries for the production of petroleum byproducts. The process takes place in tubes suspended in a furnace at high temperature. The tubes are fed with hydrocarbon and steam mixture in the presence of a catalyst. The reforming reaction takes place at a high temperature of the order of 900ºC. The high pressure in the tubes generates stresses causing creep of the tube material. The reformer furnace tubes are centrifugally cast and are manufactured from heat-resistant alloys, containing Ni and Cr. The heat resistant steel investigated in this study is a Nb-stabilized grade. The effect of Nb is to precipitate Nb4C3, which increases creep resistance and rupture strength. In the present investigation, tubes were removed from reformer furnaces after certain fractions of operation times and also after thermal shock events. Creep damage was assessed by metallographic techniques. Aging of the microstructure was quantified, as ductility reduction, by room temperature mechanical testing. The results indicate that aging is taking place progressively with operation time and is manifested by carbide precipitation in the grain ineriors.

Figure 1: Advanced creep damage in the form of chains of cavities

Creep damage has been classified according to VGB standard [2]. All creep categories have been observed: isolated cavities, dense cavities, oriented cavities (Fig.1) and advanced creep damage with the formation of grain boundary microcracks, which evolve as major cracks across the tube thickness.

The results provide further understanding on the effect of operating conditions of steam reformers on creep danage and the performance of advanced heat-resistant alloys.

References

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