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FURTHER CONSIDERATIONS FOR THE DETERMINATION OF SERVICE LIFE FOR DELAYED COKER DRUMS

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ABSTRACT

Delayed coker drums are unique in hydrocarbon processing facilities in that estimating their true design and service life has been problematic. Generally, pressure containing equipment in these facilities is designed using the notion of design life based on a required pressure thickness and corrosion allowance considerations. Hence, pressure containing equipment is routinely monitored by facility inspectors for wall thickness.

Although many analysts have ascribed coke drum failure to “thermal stress cycling ”, the difficulty posed by the operation of coke drums results in an inability to measure or calculate the magnitude of the thermo-mechanical “stresses” and the actual number of significant exposures, that is, cycles causing fatigue damage. As well, the use of Code construction practices has been generally misapplied, for this specific equipment, as the practices are intended to define a safe design life rather than a service life.

Indirect measures of service life based on shell bulge severity have fallen from favor by being ineffective. A trend to use a strain index method is somewhat more appealing but is based on static load and monotonic material property considerations rather than those properties indicative of thermal cyclic operation.

Recent work by the authors has shown that thermo-mechanical strain cycling can be characterized quantitatively and used to determine a cyclic service life for both undamaged and damaged coke drums. This paper discusses some of the engineering specifics to generate a high probability estimate of coke drum fatigue service life for a new drum, a damaged-stable drum, drums with weld overlay and for drums exhibiting incremental damage.

INTRODUCTION

The first modern delayed coker unit was constructed in Whiting, Indiana USA in 1929 and used to thermally crack heavy hydrocarbon feeds into lighter components such as naphtha and kerosene [1]. The chronic problems afflicting modern coke drums were also identified in the first industry survey, including [2]

- shell bulging
- shell cracking
- skirt-to-shell joint cracking

Some other unusual problems have also developed in more recent attempts to make coke drum operation safer and more reliable. Traditionally, drums have been constructed with a center entry inlet nozzle for oil feed and water quenching. To accommodate the automated slide valve, this center nozzle was relocated to the side of the inlet cone. Inadvertently, this relocation caused preferential distribution of the hot oil feed resulting in high temperature feed flowing vertically along the height of the drum while the remaining drum portions remained relatively cool. Much like the action of a bimetal strip, coke drums were observed by the authors to “lean / bow” as much as much as 36 inches [900 mm] at the top of the drum. The remedy has been to install two (2) side entry nozzles to balance the inlet flow.

The bulging of drum shells in the early years of operation was ascribed to rapid water quenching. Hence, a parameter called the “Unit Quench Factor” or UQF [minutes of quench time / tons of coke holdup] was identified which correlated drum bulging and cracking damage to water quench flow rates. Two highly varying philosophies of operation developed; a “normal” quench flow rate and a “proof” quench flow rate. The UQF parameter suggested that proof quenching was more damaging to drums in comparison to “normal” rates. Weil and Rapasky suggested a UQF ≤ 0.8 would eliminate bulging [2].