METHODS FOR REDUCING BULGING IN A COKE DRUM

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Abstract : Coke drums are the main part of Coker unit, in which thermal cracking of higher molecular hydrocarbon gets converted to lower molecular hydrocarbons. During the process of decoking the drums undergo cyclic variations in temperature range. The coke drum then separates lighter vapors out of the crude, including hydrocarbon gases. During quenching, the coke drum is inevitably subjected to a rapid drop in temperature because cooling water is injected directly into the coke drum. The temperature profile on the shell surface is uneven and can vary in each cycle of the quenching operation. Such a complicated thermal profile induces large strains in the shell portion of the coke drum, and eventually causes damage like bulging and/or cracking.. This project deals with the technique for manufacturing coke drums that are bulge resist.

Index Terms - **Bulge resists, Coke drum, circumferential welds, pressure vessels.**

I. INTRODUCTION

A coke drum is a kind of pressure vessel which utilizes heat and pressure to break higher molecular particle hydrocarbon into usable high review items like gas, diesel and coke. They are an essential piece of the Coker complex which is final destination for the cracking process used in the refinery. Amid this procedure of thermal cracking the coke drum experience a cyclic change in temperature which can extend from room temperature to as high as 700-900°C. One of the principle organizes in the creation of pet coke is extinguishing of the hot VR (vacuum residue) or the crude oil. This would help in cracking of the hot crude. In view of the quenching procedure the coke drum experience high numerous multiple local stress fields both in hoop and axial directions, which causes bulging and these bulges ordinarily keep on developing. It has been discovered that most bulging occurs circumferentially and happens close to the region of shell and weld seam [1].

II. CONVENTIONAL DESIGN METHODOLOGY

The regular technique for making or planning a shell of coke drum is as indicated by the thickness of the material to the particular required or composed weight. The weight are indicated as in expanding request where least thickness is intended to top of the drum and it increases as we move base of the drum , this is on the grounds that the hot VR is pumped from the base of the drum. These shells are later circumferential welded for the most part by utilizing submerged arc welding process. Later they experience die penetration test or Ultrasonic test for checking any imperfections in them. As the costing of any fabricated material is done based on its weight and thickness, the shells are comprised of various thicknesses just to remove the cost, this outcomes in a lofty decrease in the thickness of the shells when contrasted with another as appeared in Fig 2.1.

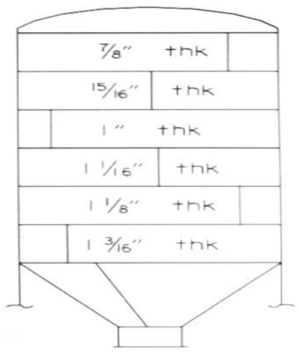

Fig 2.1 conventional design coke drum

III. PROBLEMS FACED IN CONVENTIONAL DESIGN

- As the coke drums or the pressure vessels experience the cyclic and permanent stress amid its constant working cycle they experience protruding on the shell part and at the region of the weld seam and the drum part. This bulging gets greater and greater amid the drums working life as appeared in Fig 3.1., which later prompts the development of crack at the place of the lump part. As the drums holds a lot of very risky and inflammable hydrocarbons, there would be an odds of spillage of the hydrocarbons from the coke drum.

- As the coke drums are made by welding circumferentially two unique shells, amid its working they experience high nearby pressure fields both in vertical and circumferential weld seam. This would make uneven pressure appropriation which brings about bulging.
- Another fundamental issue which prompts the disfigurement of the drums is because of the distinction in yield quality between the weld metal and the drum material.
- The least difficult strategy for weld break assurance is visual or color penetrant test from within the drum or Ultrasonic examination from the outside of the drum. In any case, since an average coke drum has more than 500 to 1000 feet of between plate welds, 100% review of welds for breaking can be unrealistic or dreary.[3]

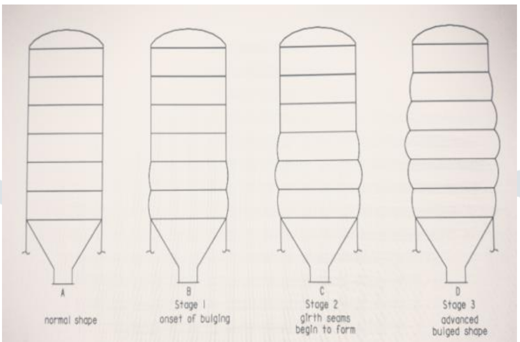

Fig. 3.1. stages of bulging in a coke drum

IV. UNIT QUENCHING FACTOR

4.1 Results of UQF performed on various coke drums.

Table 4.1: UQF calculation

Unit number	Water quenching time , min	Coke capacity tons	Unit quenching factor, mm	Relative severity of bulging distortion
1	80	370	0.21	Severe
2	100	380	0.26	Severe
3	90	380	0.23	Severe
4	125	180	0.69	Negligible
5	130	170	0.76	Negligible
6	135	170	0.76	Negligible
7	160	180	0.88	Absent
8	190	180	1.05	Absent

Table 4.1 displays unit quenching factor. In light of the examinations directed on the bulged coke drums, it was seen that high quenching rates are one reason that produce high thermal gradients as of - 12.22°C for every inch, while bring down quenching rates can create less angles which give less swelling impacts on drums. To gauge this impacts a unit quench factor (UQF) which is the ratio of 'water quenching time in minutes to the coke capacity of the drum in tons'Eq1. Utilizing these readings it was determined that if the UQF ≥0.5, the drum bulging would be insignificant or minimum and if the UQF is more prominent than 0.8 the bulging won't happen. Along these lines the estimation of UQF is proportional to the rate of the amount of water injected during the quenching of hot VR or crude oil. So if the quenching is slower the one can get a higher UQF which converts into less bulging. Yet, this would influence the decoking cycle which thus influence the production.

Equation

Unit quench factor (UQF) , which is the ratio of 'water quenching time in minutes to the coke capacity of the drum in tons'Eq1[2]

$$\text{UQF}=\frac{Water\ quenching\ time}{Coke\ drum\ capacity} \quad (1)$$

V. VERTICAL PLATE COKE DRUM

The vessel c wall thickness is chosen based on the calculated pressures on the extended temperatures expected in operation. This traditionally consequences in horizontally-organized guides varying in thickness from the bottom of the drum to the thinnest plates at the pinnacle. Even though they may be utilized in a temperature cycling duty, coke drums have no longer been generally designed to low cycle fatigue standards. Several coke drum sets have currently been designed and constructed the use of a methodology which features uniform thickness partitions of excessive yield strength plate, matched yields between plates and welds, and flush weld caps. These functions are meant to decrease stress concentrations all through the quench cycle and hence postpone the onset of bulge initiation and enlarge the beneficial existence of the vessel. Also currently, a novel construction approach has been pioneered, in which course plates are arranged vertically in the drum wall. Since the low cycle fatigue stresses because of the quench cycle are axial, fatigue cracking forever initiates in circumferential welds. A new restore/alternative method has been introduced which eliminates the circumferential seams altogether within the area of concern. Orienting the shell plates with their long path vertical accomplishes this, supplying an improved (up to greater than 40 ft.) shell duration without a girth seam. This section of the vessel can be located inside the areas that revel in the most extreme
Thermal cycles [4]

VI. STRESS ANALYSIS BETWEEN CONVENTIONAL AND VERTICAL PLATE COKE DRUM DESIGN

From the stress concentration analysis of conventional and vertical plate coke drum it was found out that vertical plate coke drum has fewer patches of stress concentrated areas as compared to the conventional design of coke drums. Refer fig 6.1 and fig 6.2.

One can see that the circumferential welded areas are the areas that experience the most uneven stress concentration, whereas vertical welded region experiences the least. [5]

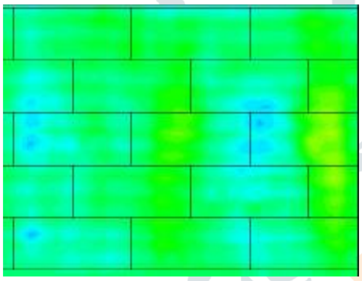

fig 6.1 drum with conventional design

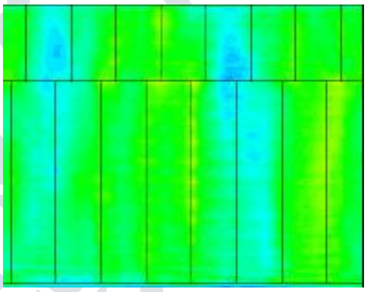

fig 6.2 drum with vertical plate design

VII. ADVANTAGE OF VERTICAL PLATE COKE DRUM

There are several significant advantages in a coke drum built with this technique:-

- Minimal circumferential seams reduce the opportunity for bulging and cracking.
- Elimination of circumferential or girth seam in the vessel shell of the coke drum eliminates the strength mismatch between weld and the base metal , thereby lessening the effects of thermal failure
- Depending on drum design, the circumferential welds that are required can often be located above the coke bed thereby minimizing the effect of the coke quench.
- Replacement sections are easily sub-assembled to allow retrofitting of existing coke drums.
- Stress concentration responsible for a variety of crack related failures can be minimised by this design.
- Increased Life Expectancy of Coke Drum by over 3X

VIII. ACKNOWLEDGEMENT

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