Source: http://www.isgec.com/processequipment/ba-pe-hitachi.php

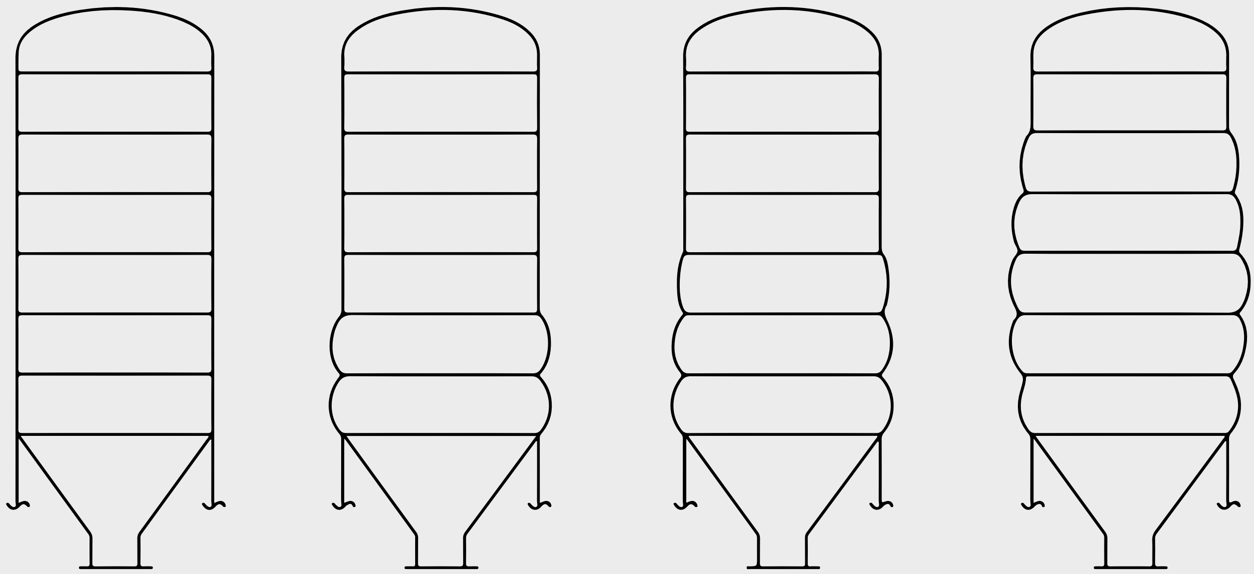
FABRICATION WELDING OF COKE DRUMS

Spring 2017, ISGEC Hitachi Zosen Ltd. in India achieved a milestone with the delivery of two coke drums from their Dahej construction site to the Indian Oil Corporation Ltd. refinery in Haldia in the state of West Bengal.
The coke drums are a crucial component of the so called delayed coker unit which is part of IOCL's Aishwarya distillate yield improvement project – a US$ 0.5bl investment. ISGEC Hitachi Zosen Ltd. specializes in the fabrication of critical process equipment for refineries, fertilizer & petrochemical industries, delivering across the world.
Amec Foster Wheeler acted as EPC.

Critical refinery process equipment

With the delayed coking process, refineries can re-use the residual material from hydro cracking by converting it into valuable lighter products such as gasolines and distillates. The residues are super-heated and fed into vertical pressure vessels, commonly known as coke drums. Here vapors are caught and refined, leaving behind a high density hydrocarbon residue – petroleum coke. To remove the petroleum coke for further processing and prevent it from self-ignition, it is water-quenched. As coke drums are continuously heated and quenched, they undergo severe thermal and pressure cycling causing plate and welds to be stressed with each cycle.

Bulging of coke drums – an old refinery plague



Bulging of coke drums. Source: Coke drum design by Coby W. Stewart, Aaron M. Stryk and Lee Presley, Chicago Bridge and Iron, 2006. https://www.cbi.com

Although the use of low-alloyed base materials such as 0.5Mo, 1.25Cr-0.5Mo, 2.25Cr-1Mo has noticeably improved the situation over the years, bulging of coke drums remains a problem that needs to be anticipated during their construction.
The severe operational thermal cycling causes plate and welds to be stressed with each cycle and, due to their different strengths, the drum may bulge and eventually crack in the vicinity of the circumferential weld seams. The rate of bulging increases with the severity of the quenching cycle and is augmented by the degree of overmatch in yield strength of circumferential welds versus base material. Bulging typically takes place in the first four to five shells above the cone section. Longitudinal weld seams appear to be unaffected, except where they intersect circumferential ones. There are several measures fabricators can take to prevent bulging and often combinations are applied:

» Choice of materials with higher creep strength and rate
» Maintaining a uniform wall thickness
» Limiting the mismatch in YS between steel and weld
» Blend grinding the weld profile
» Elimination of circumferential weld seams

Limitation of YS mismatch – a fundamental project requirement

The coke drums - with a diameter of 9 m, a length of 38 m and a weight of 550 MT each - are constructed from roll-bonded plate consisting of ASTM SA387 Grade 11 (normalized & tempered) steel with a wall thickness of 50mm and an internal lining of 4mm thick AISI 410S martensitic stainless steel. The roll-bonded plate was supplied by our mother company voestalpine.

Observing the imposed technical requirements and based on previous experience with similar projects, the following filler materials were recommended by voestalpine Böhler Welding in India:

SAW wire/flux: Union S2 CrMo / UV 420 TTR
SMAW: BÖHLER FOX DCMS Kb
GTAW: Union I CrMo

EPC, Foster Wheeler had set a very narrow requirements, which was tough to achieve. The critical requirement was, the fabricator shall arrange the plates, forgings and welding consumables for the vessel as such to minimize the difference in actual yield strengths at room temperature between adjacent components (plate vs. plate, plate vs. weld, forging vs. weld, forging vs. plate, etc.). The maximum difference in yield strength between adjacent components shall be within 10 %, which means, the YS of the all weld metal after the PWHT cycles shall meet ± 10 % of the actual YS of every plate supplied by the base metal supplier. The actual yield strength of commercially available weld metal exceeds the base metal YS typically by more than 10 %. After analyses of the batch chemical composition and mechanical properties of both steel and filler materials, a mismatch of ± 10 % was agreed upon with IHZL, under the condition voestalpine Böhler Welding would render support in establishing WPQR's for the critical sections of the drums and to be confirmed in a so called YS mapping chart.

Control of strength mismatch through the welding procedure was difficult, because of the many variables involved. Key factors of influence are heat input, layer thickness, number of beads, preheating, inter-pass temperature and post weld heat treatment. The chosen welding procedure aims at grain refining of the weld beads and the tempering of the heat affected zone (HAZ) in the base material.

For PQR qualification, parameters were strictly controlled in order to have proper bead sequencing and controlled heat inputs. Also proper tacking was done in order to control distortion that may affect mechanical properties. Other good welding practices were also followed. Plate mapping was performed based on the yield strength of the base material and the actual yield strength values of the welds. This required a great effort.

ISGEC HITACHI ZOSEN – WELDING OF COKE DRUMS PROJECT SUMMARY WITH CUSTOMER BENEFITS

Project summary with customer benefits

Filler material
SAW wire / flux combination: **Union S2 CrMo / UV 420 TTR** EN ISO 24598-A: S S CrMo 1 FB **SMAW: Böhler FOX DCMS Kb** EN ISO 3580-A: E CrMo1 B 4 2 H5 AWS A5.5: E8018-B2H4 **GTAW: Union I CrMo** EN ISO 21952-A : W CrMo1Si AWS A 5.28 ER80S-G
Base materials
Roll-bonded plate ASTM SA387 Grade 11, 50 mm thickness with 4 mm thick AISI 410S CRA layer
Weld types
Circumferential and longitudinal butt welds. Clad restoration welds (with EQ NiCr-3 and ENiCrFe-3 consumables)
Mechanical requirements: weld
YS: ± 10 % of the actual YS of the base metal after PWHT cycles TS: 520 MPa (min) Elongation ≥ 22 % CVN @ -18°C 41 J single minimum 54 J Average Preheat as per ASME Sec VIII Div 1 req. for 1 ¼ Cr – ½ Mo. Dehydrogenation Heat Treatment: 325-400°C for 2 hours min. and slow cooling

CUSTOMER BENEFITS

- Base material and filler materials from the same source
- Optimal fine-tuning of base and filler metal properties
- Main project requirement of <10 % YS mismatch dependably met
- Support in the establishment of WPQ'R's and YS mapping charts
- Onsite training of welders/operators
- Drums delivery on schedule

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