Improve Operational Availability

of CCR Reformers

Albert van den Bosch – Technical director

EPS Customer Solutions

Outline

- Target Operational Availability for CCR Reformers
- Methodology to improve Operational Availability
- Innovations and successful practices
- Results achieved for an user group
- Conclusions

Operational Availability - Target

- Target for Operational Availability (OA) of CCR Reformers:
  - Once per 6 year a planned TurnAround (TA) of 25 days duration
  - In between planned TA's, a minimum Operational Availability of 99%.

- Per TurnAround cycle of 6 years, the total number of Shutdown days is:
  - One planned TA: 25 days
  - Unplanned Shutdown days: 6 * 3.6 = 21.6 days
  - This means an average OA of minimum 97.9%

- This target is achieved by several CCR Reformers and is realistic.

Methodology

Methodology followed to achieve improved OA of CCR Reformers:

- Review the reason of past unplanned shutdowns. Have robust corrective actions been implemented?
- Review duration of planned TA, and carry out a risk based scope challenge.
- Carry out a "health check" of the unit operation.
- Review the performance monitoring applied in the unit
- Review the critical operating procedures

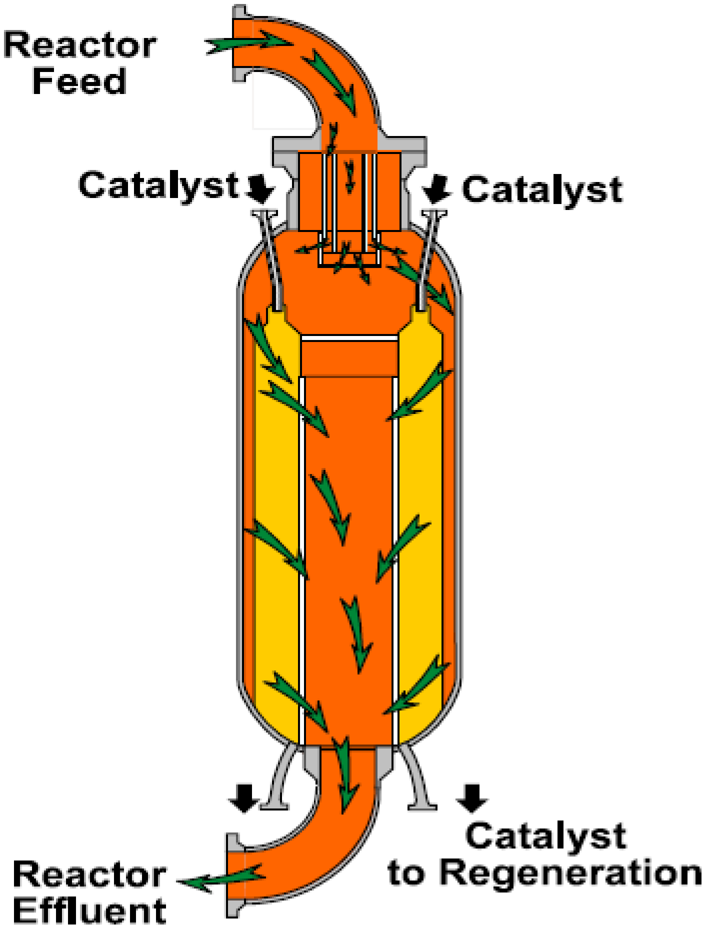
Examples of innovations

Examples of innovations for improvement of the OA of CCR Reformers:

1. Design of center pipes
2. Maintain a very low content of organic nitrogen in naphtha feed
3. Reactor inspection during planned TA without catalyst unloading
4. Development of an accept/reject criterion for damaged scallops
5. Selection of reactor Feed/Effluent exchangers
6. Abatement of Metal Catalysed Coking by presulphiding as part of start-up after a TA

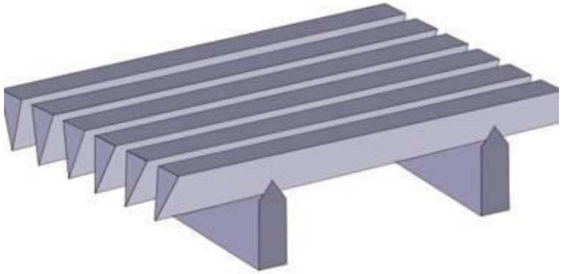
1. Center pipe design

- All CCR Reformers have radial flow reactors
- Some units have stacked, others have side-by-side reactors
- The center pipe is very critical to the unit availability: a small damage can result in catalyst migration to downstream equipment, which probable results in an unplanned shutdown of a few weeks.



1. Center pipe design

The exterior of a center pipe is made of V-wire screen. Typical material of construction is SS-321.



1. Center pipe design

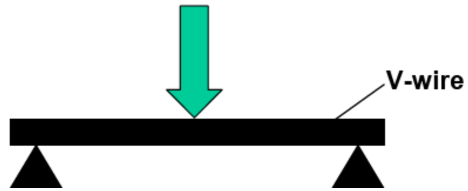
- In 2004 a survey has been carried out covering a user group of 20 CCR Reforming units.
- This group included 78 center pipes with 1240 years of service.
- Serious center pipe damage has occurred in 23 center pipes of 9 units.

COMMON PROBLEM: The V-wire screen made of SS-321 is aging over time and becomes brittle.

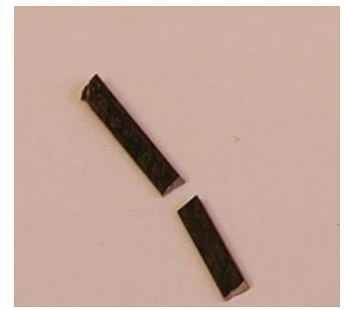
- Brittle screen is vulnerable to damage during a thermal shock or during TA work inside the reactor.
- Once damaged, the screen is very hard to repair due to inability to weld on brittle V-wires.
- Increasing the thickness of the V-wires does not help.

1. Center pipe design

Bending tests of used and new V-wires made of SS-321:



New SS-321 V-wire = ductile



Used SS-321 V-wire after 15 years of service = brittle

Development: A new Stainless Steel provides resistance against screen aging

1. Center pipe design

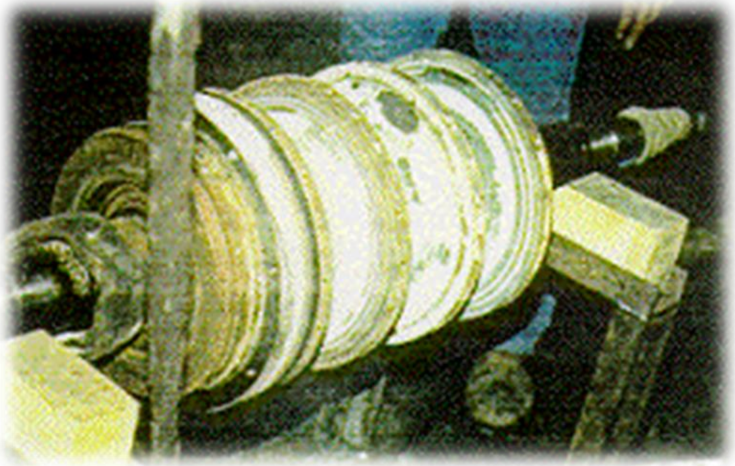
- Recent proof of success: in 2005 a CCR Reformer replaced all four center pipes. Then during the 2015 TA the four center pipes were inspected with following results:

Reactor	Screen material	Years in service	Screen magnetic?	“Ferrite” content of screen
R1	New SS	10	No	0.2 %
R2	New SS	10	No	0.2 %
R3	New SS	10	No	0.3 %
R4	SS-321	10	Yes	15.4 %

- By 2015, in a user group of 20 CCR Reformers, 15 units have preventatively replaced their center pipes by a new design with up-to-date screen material.

2. Abatement of NH_4Cl fouling

- When planning for a 6-year operating cycle, fouling of critical equipment (e.g. recyclegas compressor) by NH4Cl deposits shall be minimized.
- Experience shows that the content of organic nitrogen in the naphtha feed should be max. 0.2 ppmw.
- If naphtha HDT is already at its maximum severity, then reduce the endpoint of cracked naphtha.
- Use method ASTM-6069 for analysis of organic nitrogen in naphtha.



3. Limited reactor inspection

During a planned TA, it can be considered to carry out a limited reactor inspection *WITHOUT UNLOADING THE CATALYST*. This can be considered in case:

- Catalyst does not need to be replaced.
- Reactors do not need to be inspected internally.
- The reactors pass a "health check" for another 6 years of operation.

Benefits:

- Reduced TA duration and costs
- Avoiding separation of heel catalyst
- Reduced plot occupancy during TA

3. Limited reactor inspection

Execution:

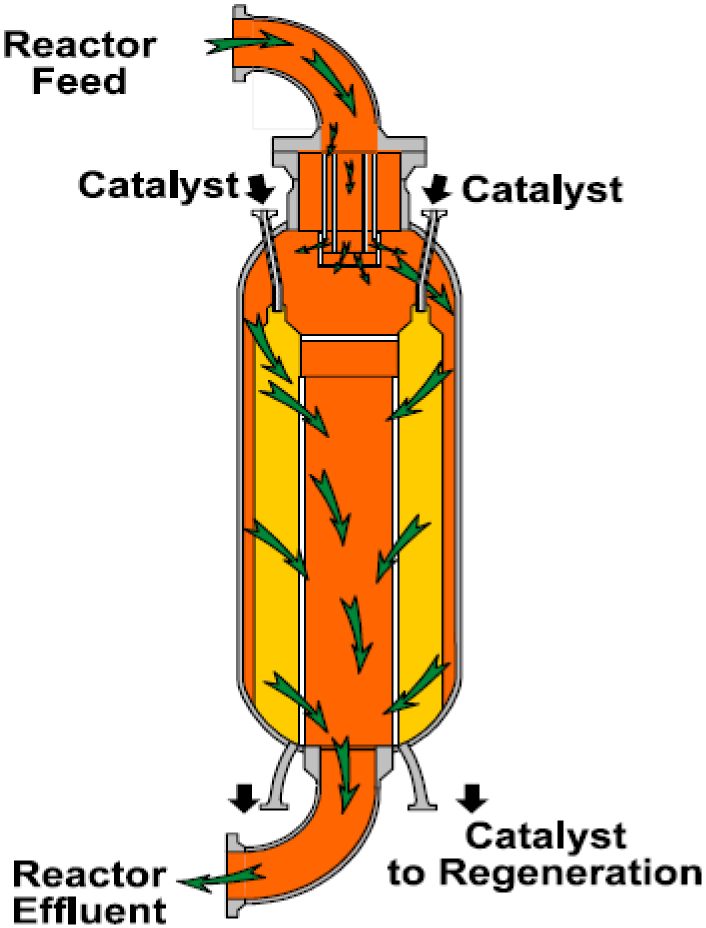
- Cool reactor down as normal, and switch atmosphere in the reactor circuit to nitrogen.
- Inert entry contractor to enter reactor on the cover deck of each reactor, and makes an assessment of 14 critical parameters. Activities are monitored by refinery staff via video link.
- If all critical parameters are OK, the reactor can be closed and recommissioned.

Experience:

- First application in 2001.
- Since then applied >10 times, good experience.

4. Scallop damage acceptance

- Scallops are the most common reactor inlet internals.
- On purpose, scallops are the weakest part of the reactor internals.
- Often the reactor performance was still good, while during a TA scallops are found damaged.
- Replacing scallops in stacked reactor means a considerable (emergent) work scope.



4. Scallop damage acceptance

- In 2001 an accept/reject criterion has been developed for emergent scallop damage.
- This has resulted in a risk based replacement of damaged scallops
- Experience has indicated no negative effect on the long-term reactor performance.

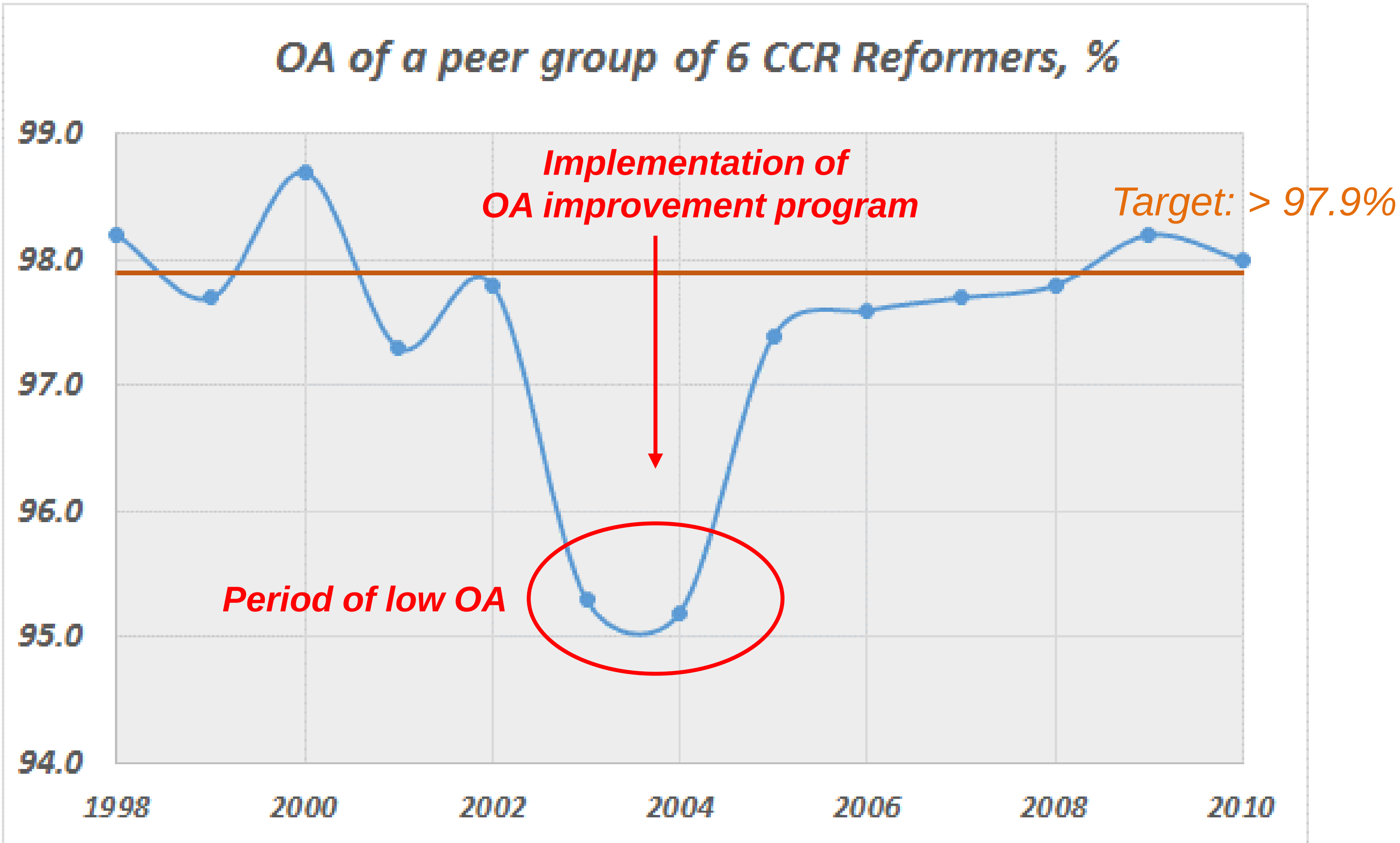
5. Selection reactor F/E exchanger

- CCR Reformers reactor Feed/Effluent exchangers are either “Texas Towers” or “Packinox” type.
- Experience has shown that the robustness of welded plate exchangers is substantially lower than tubular exchangers. Weak points are:
  - Resistance against thermal shock as occurs when the recyclegas compressor is re-started after a trip.
  - Surge conditions of the recyclegas compressor.
  - Catalyst losses from the last reactor.

6. Abatement of MCC

- Metal Catalysed Coking (MCC) is a serious threat for the Operational Availability of a CCR Reformer.
- One option for abatement of MCC is presulphiding the reactor section after a TA.
- The common procedure is to carry out this presulphiding after feed cut-in.
- Presulphiding just prior to feed cut-in will achieve a better passivation of the hot equipment of the reactor section.
- This improved procedure has been applied >10 times with good success.

Results of OA improvement program



Conclusions

- An average OA of 97.9% is achieved by several CCR Reformers, and is a realistic target.
- Several technical innovations and proven practices for OA improvement have been developed.
- For poor performing CCR Reforming units, a focused review can substantially improve the OA.

EPS → Effective, Profitable, Sustainable

albert.vandenbosch@epsconsultancy.com