Decoking Atmospheres on Alumina-Forming Alloys

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Introduction

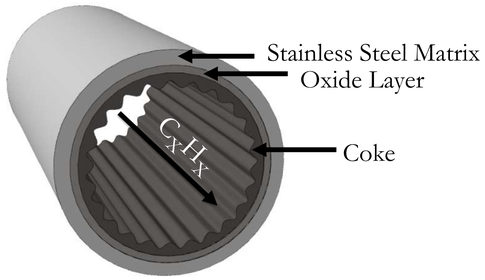

Figure 1: Representation of carbon buildup.

- Steam cracking of hydrocarbons is one of the most important process for manufacturing many base chemicals.
- Carbon buildup (or coking) on stainless steel tubes at high temperatures = high operational costs in ethylene production.
- What is the best atmosphere to decoke (or remove the carbon) these tubes?
- What is the effect of decoking atmosphere on the alloys?
- Two alloys were evaluated: Alumina-forming alloy (AFA) vs Chromia-forming alloy (CFA)

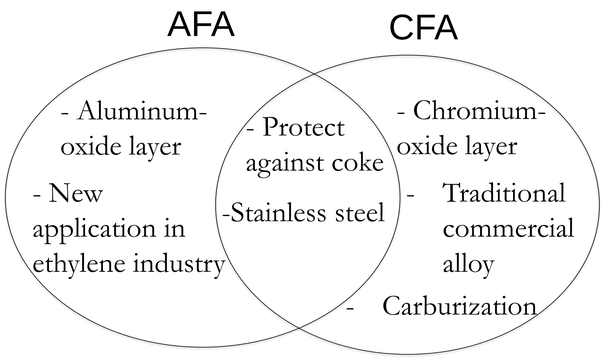

Figure 2: Alumina-forming alloys (AFA) vs Chromia-forming alloys (CFA)

Experimental Procedure

Pre-oxidation (obtain oxide layer)
- 100% Steam
- Temp: 850°C
- Time: 12 h

Coking (carbon deposition)
- 30:1 H_2:C_2H_6
- Temp: 950°C
- Time: 50 h

Decoking (removal of carbon)
- Variable atmosphere
- Temp: 850°C
- Time: 12 h

Decoking reaction:

$$O_2 + C = CO_2$$

- ↑ Oxygen = ↑ Decoking

Three decoking atmospheres were tested:
- 100% Steam $P_{O_2} = 10^{-6}\ atm$
- Steam – Air $P_{O_2} = 10^{-3}\ atm$
- 100% Air $P_{O_2} = 10^{-0.6}\ atm$

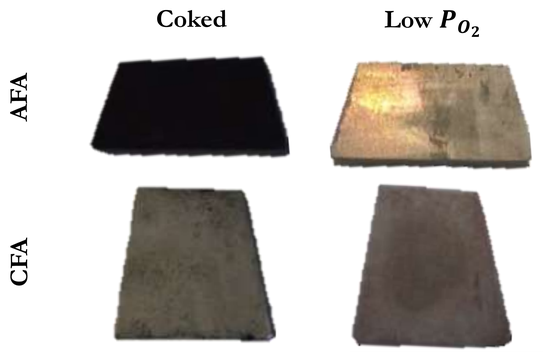

Figure 3: Images of coked and decoked procedure for AFA and CFA alloys.. Scale bar at ~2 cm.

Results

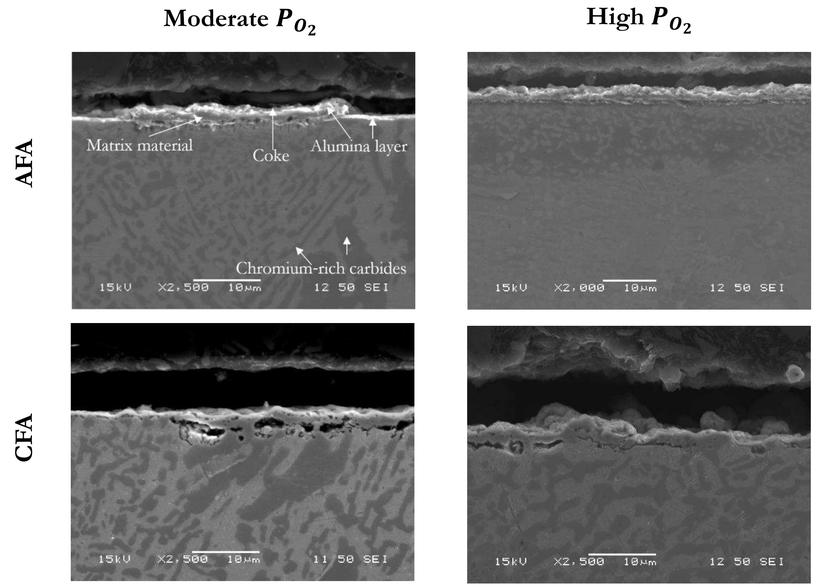

Figure 4: SEM microstructure after each decoking procedure for AFA and CFA alloys.

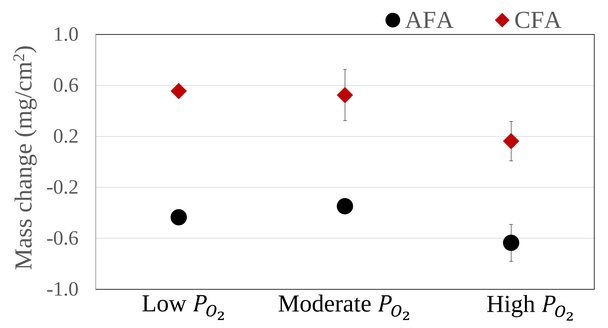

Figure 5: Average change of mass after each decoking treatment. Negative values indicate that mass decreased.

Analysis

- AFA alloy lost mass after being decoked in all three environments.
- CFA alloy gained mass after each decoking treatment, indicating further oxidation and possibly no carbon removal.
- SEM analysis indicates that AFA and CFA alloys did not change drastically in appearance.
- High PO_2 atmosphere removed .023% in AFA alloys and added .0066% in the CFA being the atmosphere with highest removal content

Conclusion

- In terms of carbon removal, the High PO_2 decoking atmosphere seems to have best results
- Future investigations on XRD is needed to characterize oxide layer change

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