Corrosion Study of Common Steels Exposed to 1,100+ Hours of Continuous PCC Operation:

Direct Comparison of Morphological and Chemical Tenacity During Test Campaign at the National Carbon Capture Center

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Introduction The objective of this study was to demonstrate the compatibility of four different steel materials at the surface level that had been continuously exposed to ION's solvent at different locations in the PCC test unit at the National Carbon Capture Center (NCCC) with their unique process temperatures, alkalinities and solution chemistries. Materials of construction have a large influence on CAPEX for PCC-based facilities that utilized high-pH amine-based solvents.

Experimental Stainless steels 304, 304L, 316 and carbon steel grade C1010 were inserted into various locations of the Pilot Solvent Test Unit (PSTU) at the NCCC while testing CO_2 capture with real coal-fired flue gas using ION Engineering's (ION) proprietary solvent. Nine sets of each steel (36 coupons in total) were exposed to over 1,100 hours of continuous PCC operation and compared to an unexposed set (4 coupons) as a negative control. The 40 coupons were analyzed by SEM, EDS and weight-loss methods.

Sample Coupons

Appearance of sets:
Wash tower (left), and bottom of absorber (right).

Reboiler return line (left) and top of regenerator (right)

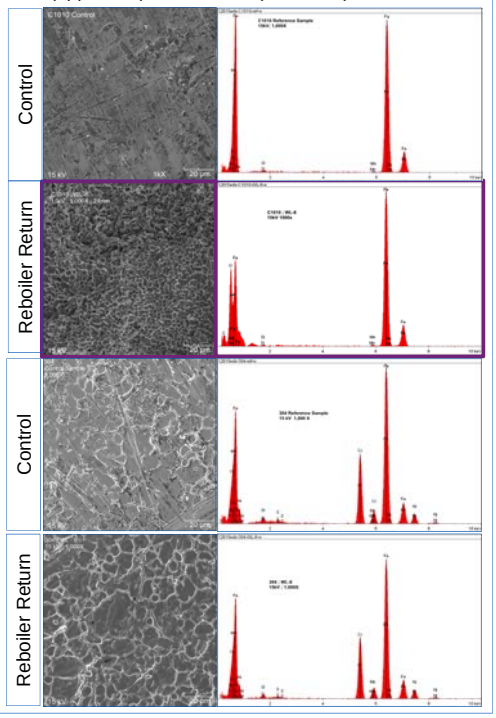
Mist separator (left) and cross heat exchanger (right)

Surface Composition 304 SS, weight%	Si	Mn	Fe	S	Cr	Ni
Reference	0.9	1.3	73	0.5	17	7.8
Bottom of ABS	0.8	1.2	73	0.5	17	8.2
Top of ABS	0.7	1.5	73	0.3	17	7.8
Wash Tower	0.8	1.4	73	0.4	17	8.0
Between REG Beds	0.6	1.4	73	0.3	17	8.3
Reboiler Return of REG	0.6	1.3	73	0.3	17	8.0
Bottom of REG	0.8	1.3	73	0.2	16	8.0
Top of REG	0.6	1.1	73	0.3	17	8.0
Mist Separator	0.7	1.2	73	0.3	17	8.1
LRXC	0.6	1.4	73	0.3	17	7.7

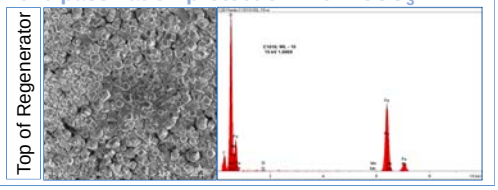
Surface Composition C1010, weight%	Si	Mn	Fe	C	O
Reference	0.4	0.5	99	-	-
Bottom of ABS	0.7	0.4	99	-	-
Top of ABS	0.5	0.4	99	-	-
Wash Tower	0.5	0.5	99	-	-
Between REG Beds	0.5	0.4	99	-	-
Reboiler Return of REG	0.2	0.4	63	4.0	10
Bottom of REG	0.3	0.4	45	2.3	14
Top of REG	0.2	0.2	56	7.2	36
Mist Separator	0.2	0.2	64	4.0	32
LRXC	0.2	-	50	3.9	13

SEM and EDS results:

C1010 (upper two) and SS 304 (lower two):



C1010 passivation protection with $FeCO_3$?



Weight-loss summary of the forty (40) coupons		
Material	Corrosion Rate (CR)	NCCC Location
C1010	Low	Bottom of Absorber, Top of Absorber, Wash Tower, and Controls
304		
304L		
316		
C1010	Low	Between Beds of Packing in Regenerator
304		
304L		
316		
C1010	High	Bottom of Regenerator (reboiler return)
304	Low	
304L		
316		
C1010	High	Bottom of Regenerator (submerged sump)
304	Low	
304L		
316		
C1010	Moderate	Top of Regenerator
304	Low	
304L		
316		
C1010	Moderate	Mist Separator
304	Low	
304L		
316		
C1010	High	Rich/Lean Solvent Heat Exchanger
304	Low	
304L		
316		

Conclusions None of the stainless steel coupons showed concerning amounts of corrosion with ION's solvent after PCC operation, and thus the need for higher-grade (i.e. Ni or Ti-based) materials is unnecessary. The carbon steel showed prohibitive CRs at the three hottest locations, but completely acceptable in the colder locations. Based on this data, carbon steel may be a potential material candidate for the absorber-side equipment. The low corrosion rate for C1010 between regenerator beds was unexpected since considerable corrosion occurred in a nearby location with process conditions that were similar.

References

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- ASTM-G1 & G4 and NACE Recommended Practice RP-0775.

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