

# Effect of Alloy Composition on the Oxidation Behaviour and Cr Vaporization of High-Cr Steels for SOFC Cathode Air Pre-heater

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# Introduction Cathode Air Pre-Heater (CAPH)







## Material and Methods



#### *Material:* Inconel 625; AluChrom 318; Uncoated SS309; Aluminised SS309 (1 μm Al).

(wt.%)	Fe	Cr	Mn	AI	Ni	Si	Nb	W	Со	others
Inconel 625	5.0	20-23	0.5	0.4	Bal.	0.5	4.15	-	1.0	Ti 0.4; Mo 8-10; P 0.015; S 0.015
AluChrom 318	Bal.	18.8	0.21	3.58	0.24	0.32	0.73	2.02		Hf 0.06; Y 0.07; Zr 0.03; Cu 0.03 C 0.01; N 0.01
SS309	Bal.	22-24	2.0		12-15	0.75				C 0.2; P 0.045; S 0.03
Aluminised SS309	1 μm aluminium coated was deposited on SS309 surface by PVD technique.									

#### • Experiment:

- High Temperature Oxidation Test: Normal Tubular Glassware
- > Quantification of Cr Evaporation: Denuder Technique
- Test Condition:
  - > 850 °C; 6.0 L/min Air Flow; 3 vol%  $H_2O$



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## High Temperature Oxidation Test







### Denuder Technique for Cr Quantification



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### **Corrosion Testing**





## **Corrosion Testing**





## Corrosion Testing – Inconel 625







#### SEM/EDX: Inconel 625





### Corrosion Testing – SS309







#### SEM/EDX: SS309



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## Corrosion Testing – Aluminised SS309







### SEM/EDX: Aluminised SS309





## Corrosion Testing – AluChrom 318







### SEM/EDX: AluChrom 318





## XRD Analysis for Al-containing Steels





#### (a) XRD for Aluchrom 318

#### (b) XRD for Aluminised SS309

- The formation of a surface scale of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> was observed for both materials.
- The peak intensity of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> for AluChrom 318 shows an increasing trend.
- The XRD peaks of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> for aluminised 309 almost disappeared after 2000 hours.
- For aluminised 309, the peaks spinel and  $Cr_2O_3$  started to appear after 500 hours exposure.
- The alumina layer formed on Aluchrom 318 is much stronger than that on aluminsed 309.

### Conclusions



		Small amount of mass gain	
	Inconel 625:	<ul> <li>The surface is completely covered with Cr<sub>2</sub>O<sub>3</sub></li> </ul>	
		Large amount of Cr evaporation	
		• The spinel layer is very porous and brittle.	
	SS309:	• A dramatic mass decrease due to spallation of spinel layer.	
-		Large amount of Cr evaporation	
		• $\alpha$ -Al <sub>2</sub> O <sub>2</sub> layer produced on top of SS309	
	Aluminized SS200.	<ul> <li>Very small amount of Cr evaporation</li> </ul>	$\land$
	Aluminised 55509:	• $\alpha$ -Al <sub>2</sub> O <sub>3</sub> layer started to peel off after 500 hours exposure	
		• $\alpha$ -Al <sub>2</sub> O <sub>3</sub> layer produced on top of AluChrom 318	
	AluChrom 318:	Very small amount of Cr evaporation	
		• $\alpha$ -Al <sub>2</sub> O <sub>3</sub> layer could last over 2,000 hours.	
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