IEA CLEAN COAL CENTRE WORKSHOP
Advanced ultrasupercritical coal-fired power plants
19-20 September 2012

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High Temperature Corrosion and Steam Oxidation of Candidate Materials for 700C class A-USC

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Contents

1. Background
2. Research Approach
3. Fire-side Corrosion
4. Steam Oxidation
5. Summary

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Hitachi's Approach on Low CO_2 Emission

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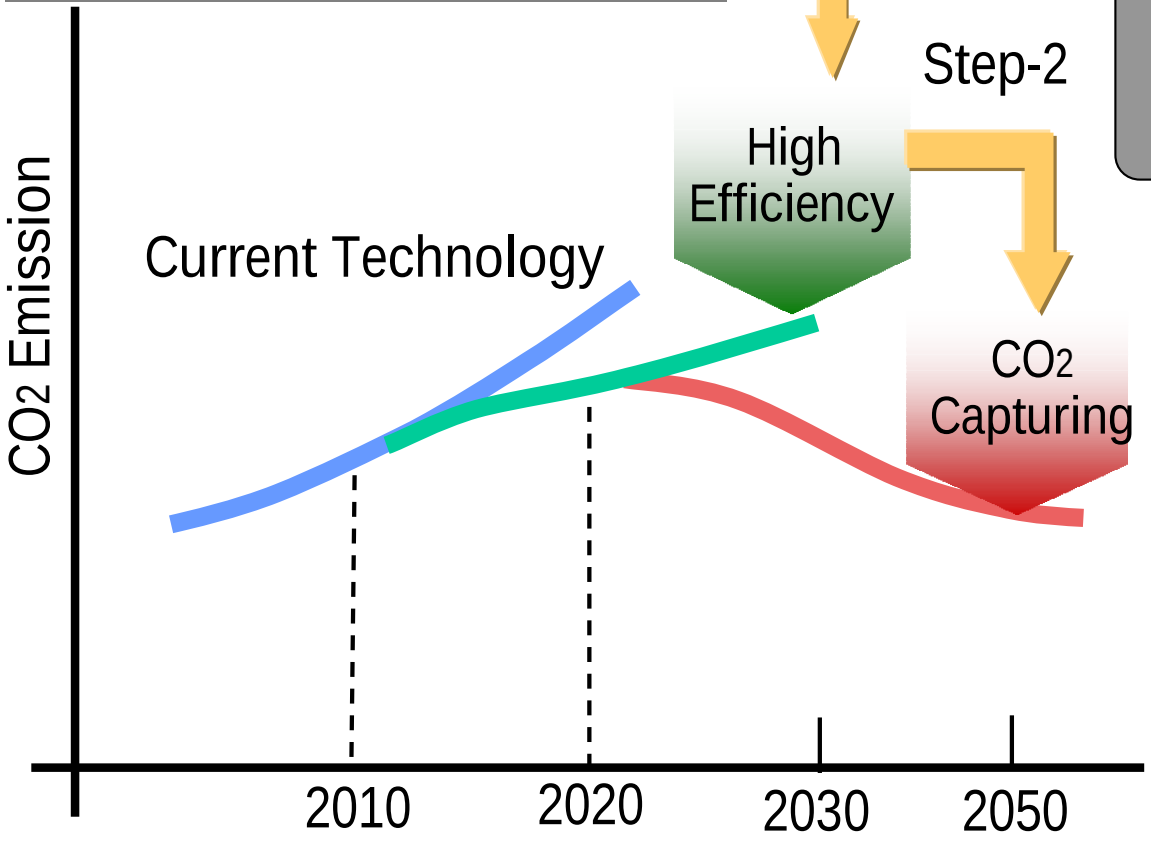
Current Thermal Power Plant

Step-1

High Efficiency

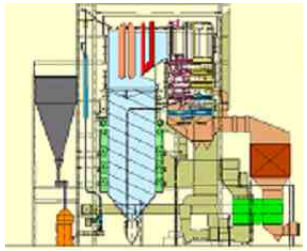
Step-2

CO_2 Capturing

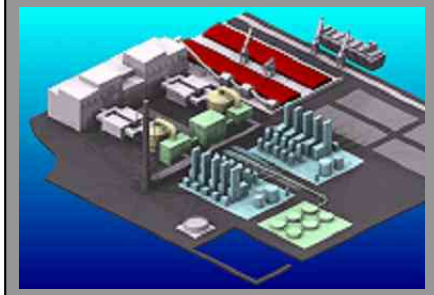


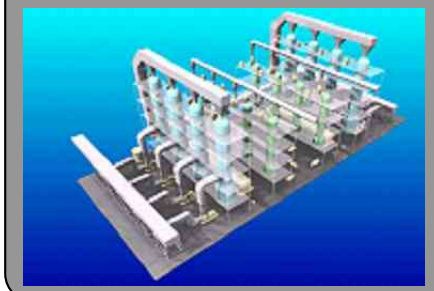
High Efficiency

- 700C A-USC
- IGCC



Direct CO_2 Capturing





- Chemical Scrubbing
- Oxy-fuel Combustion
- IGCC-CO2
- CLC

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Advancement of Steam Condition

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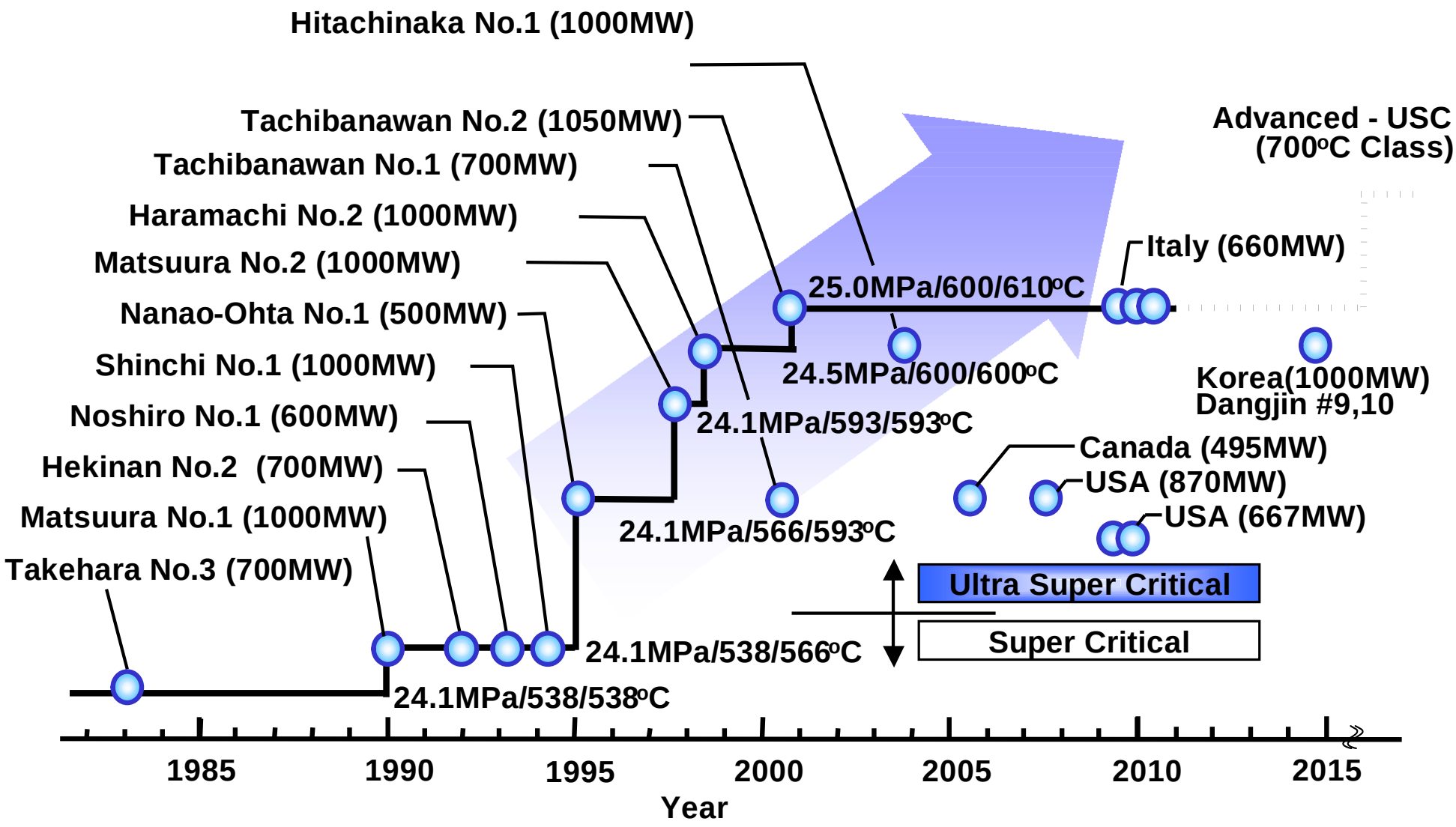

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Schedule of Japan National Project: Boiler Technology

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Item \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Design of System	Optimized heat balance and boiler/turbine structure Economical evaluation								
Boiler	Material development (for tube/ S.H. and R.H)					Long time creep rapture test			
	Welding procedure test								
	Evaluation of material mechanical characteristics								
Actual loading test			Facility planning	Plant design		Manufacturing & installation		Boiler tube/ turbine spin test & evaluation	

Target :

700C/35MPa, 46-48%

Candidate Material:

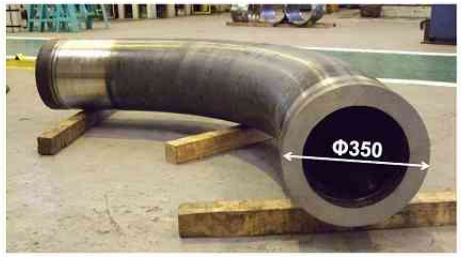
Ferrite: 9Cr steel (<650C)

Austenitic:18-8 series, 25Cr20Ni (Tube)

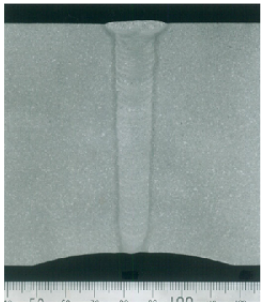
Fe-Ni based: HR6W

Ni based: Alloy617,740, 263,141,HR35

Pipe Trial Bending
Alloy 617



By courtesy of Babcock-Hitachi K.K.



Narrow-gap HST※ Welding

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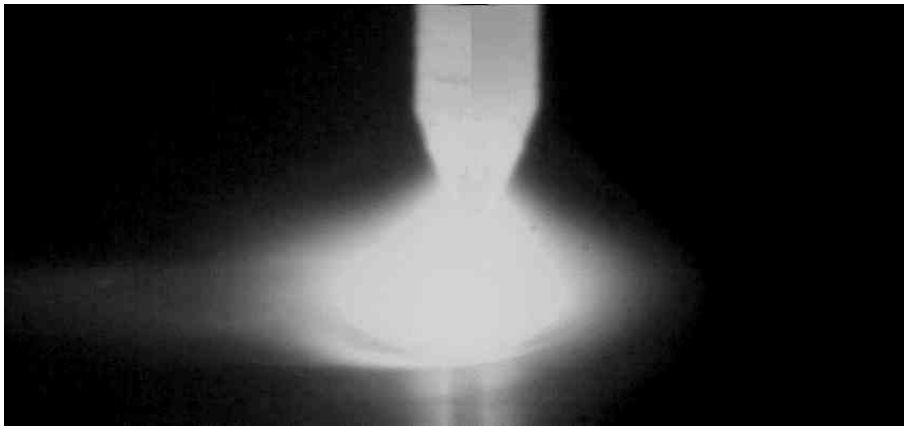
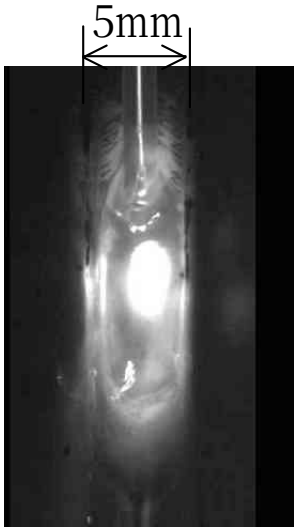
High-speed TIG

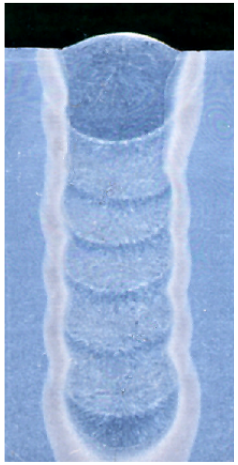
Stub Welding



Welding speed:300mm/min

Hot-wire Laser TIG





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Main Material Issues of Boiler

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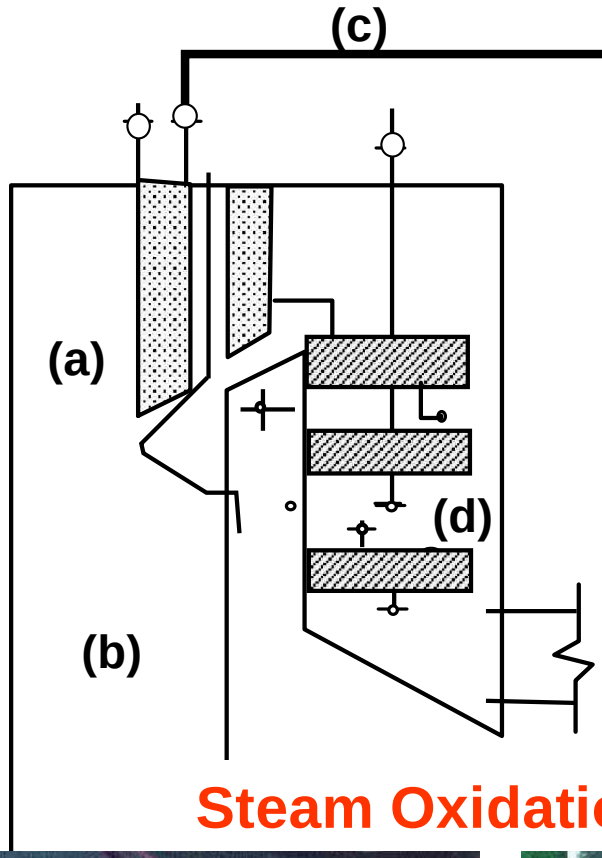
(a)SH/RH
- Creep
- **Fireside Corrosion**
- **Steam Oxidation**
- Overheat by steam oxidation scale

(b)Furnace Waterwall
- Corrosion Fatigue
- Sulfidation
- Circumferential cracking



(C) MSP HRP, Header
- Creep
- **Steam oxidation**
- TypeⅣ crack
- Thermal Fatigue

(d) ECO, PrySH
- Pitting
- Erosion
- Thermal Fatigue

Fireside Corrosion

Steam Oxidation

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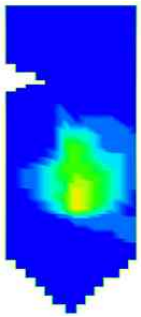
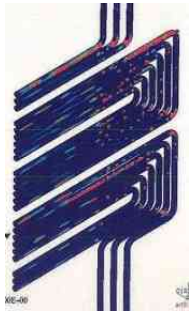
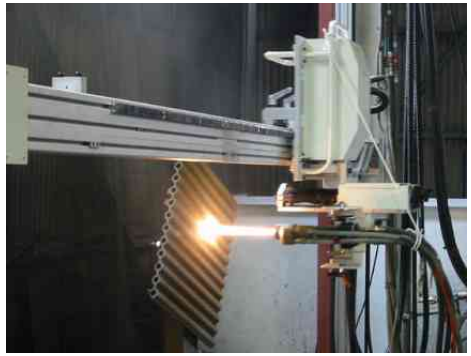
Corrosion Technologies

- Corrosion Database
  Laboratory test, In-plant Test, Investigation of operating plants
- Estimation, Environmental
  Corrosion rate , Gas Composition, Metal/Gas Temperature, Ash deposition by CFD
- Protect methods
  Thermal Spray, Weld-overlay, Chromizing

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Fire-side Corrosion(1)

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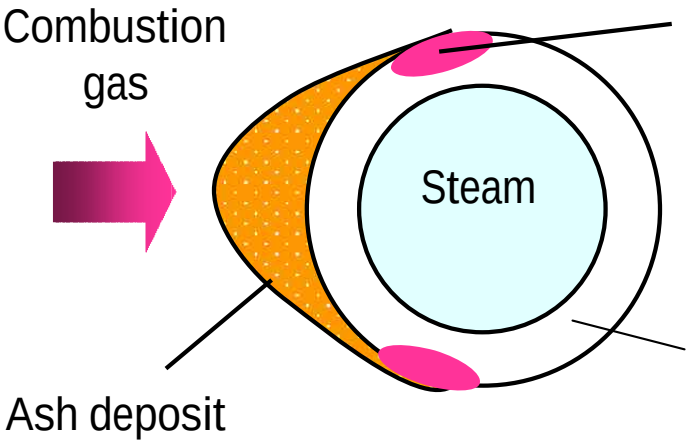


Thinning point

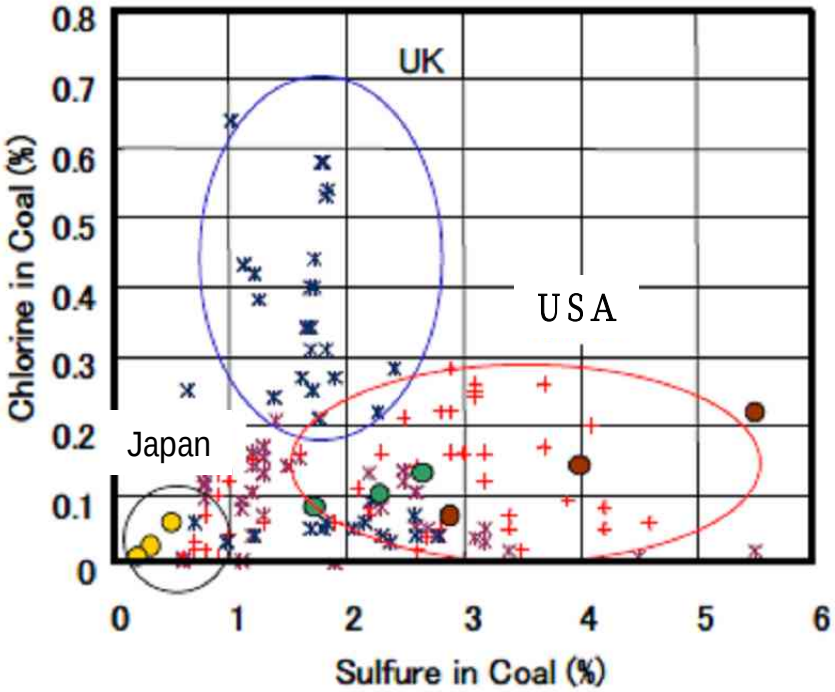
Formation of molten salt
M3Fe (SO4)3 M : K,Na

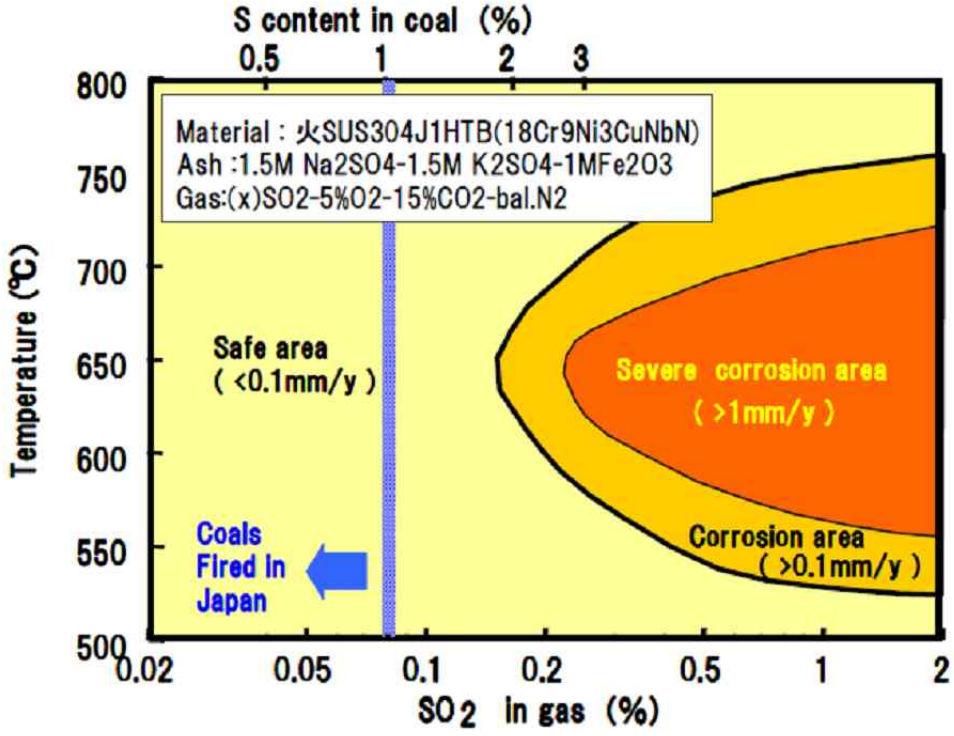
Melting point:550-620ºC

Tube

Influence factors

Temperature: Metal, Gas
Material: Cr, Mo
Gas: SO2(SO3), HCl ,H2S





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Fire-side Corrosion(2) Ni-based Alloy

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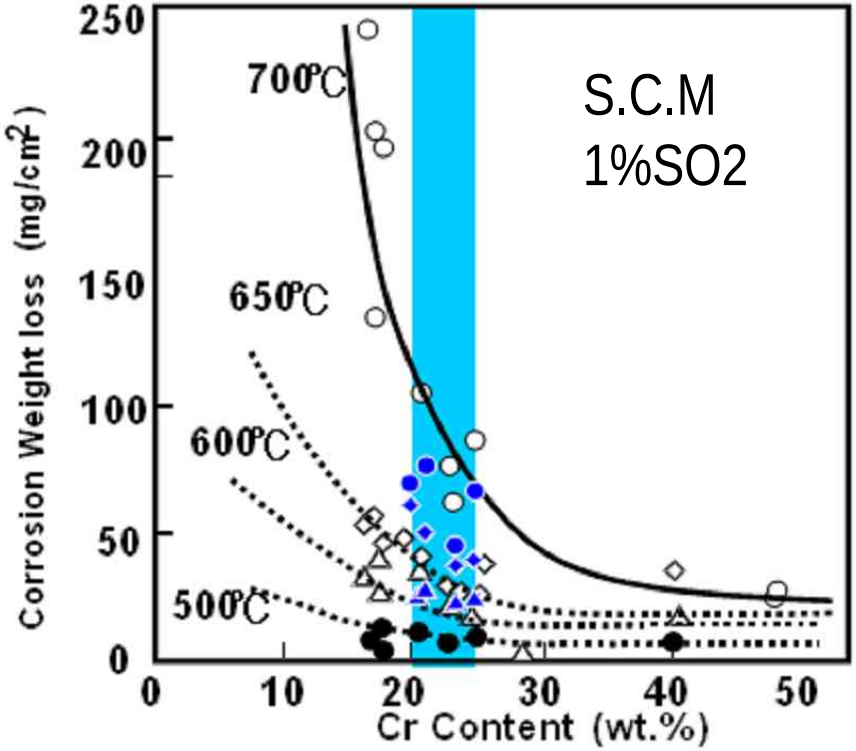
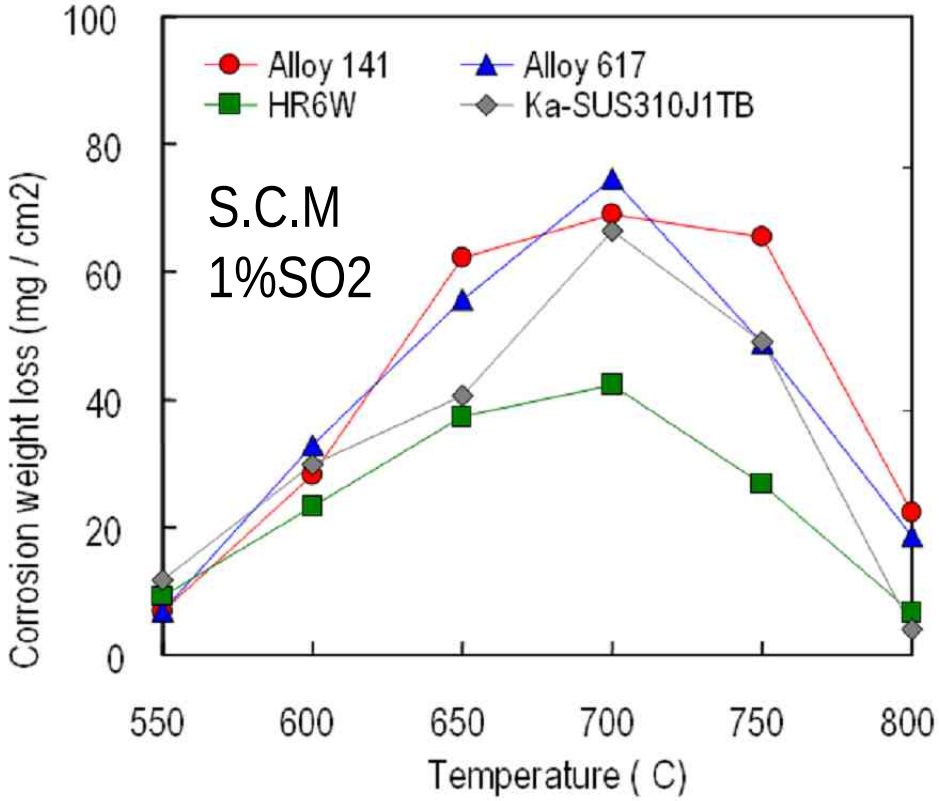
Ni-based alloy for A-USC





S.C.M: Standard Corrosion mixture 1.5M Na2SO4-1.5M K2SO4-1M Fe2O3

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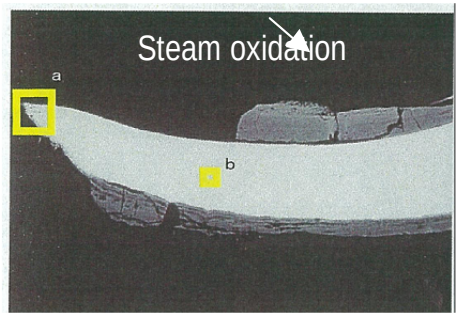
Steam Oxidation(1)

(a) Scale Growth: Metal temperature increase
(b) Scale Exfoliation: Turbine erosion, Tube
(c) Internal oxidation: Decrease of creep strength

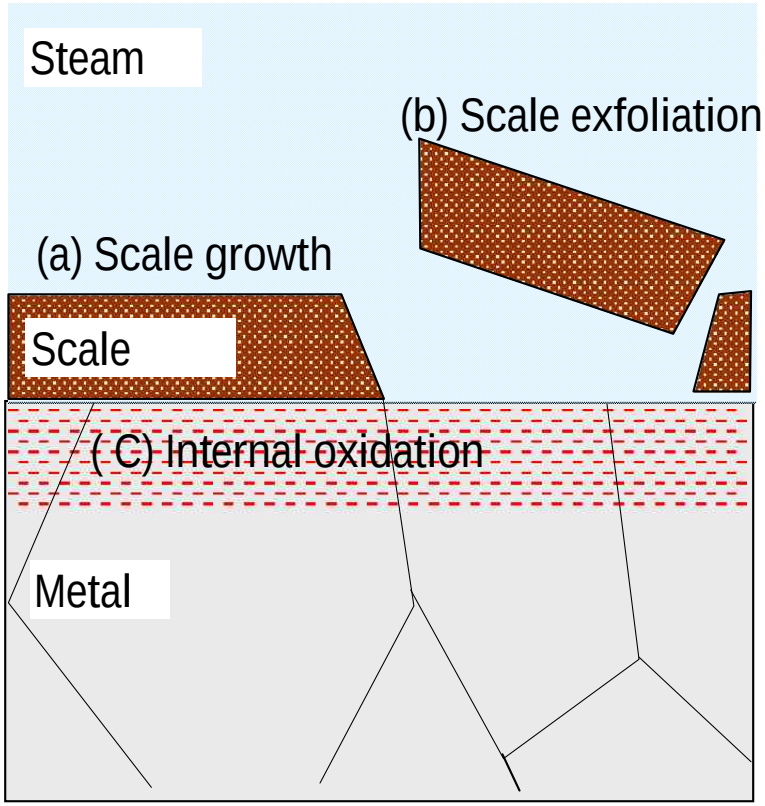
Creep Damage



Scale Exfoliation

tube

pipe



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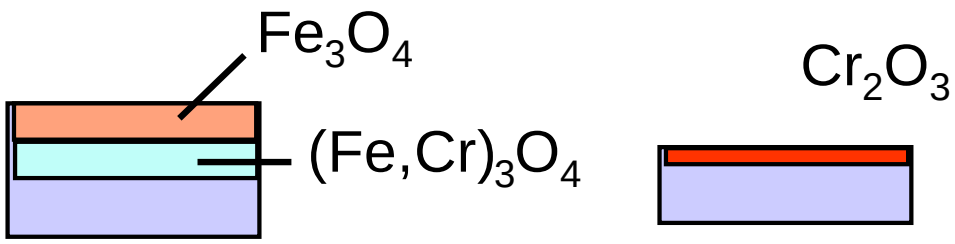
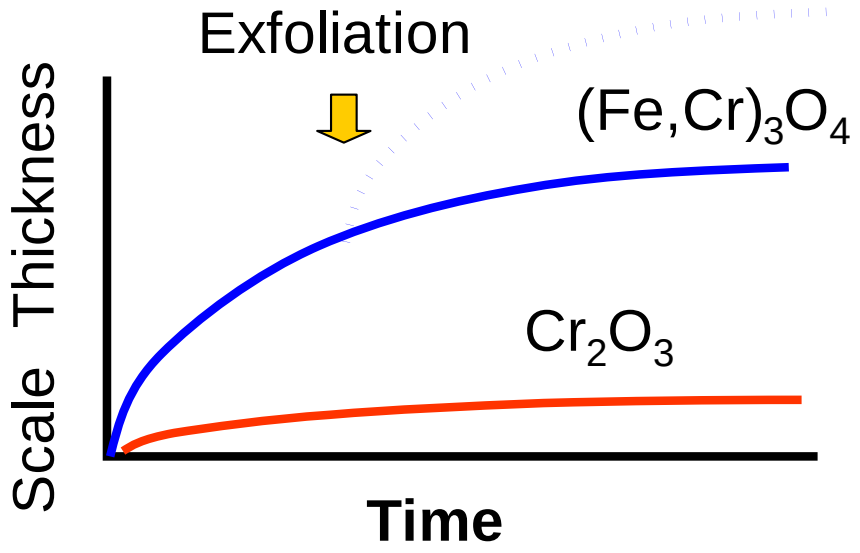
Steam Oxidation(2)

Time dependency

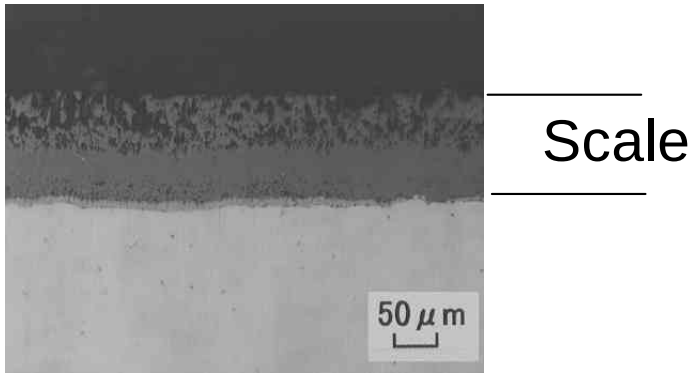
$$y^2 = Kp \cdot t$$

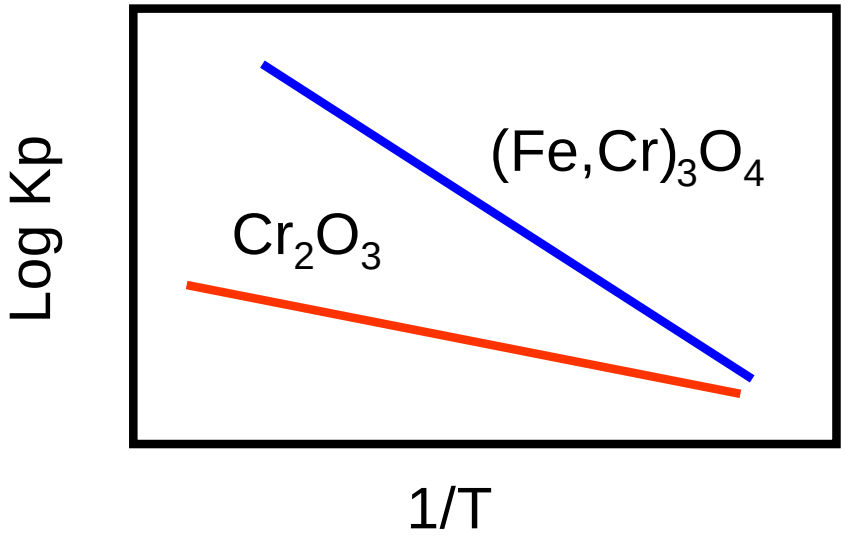




Temperature dependency

$$Kp = A \cdot exp(-Q/RT)$$





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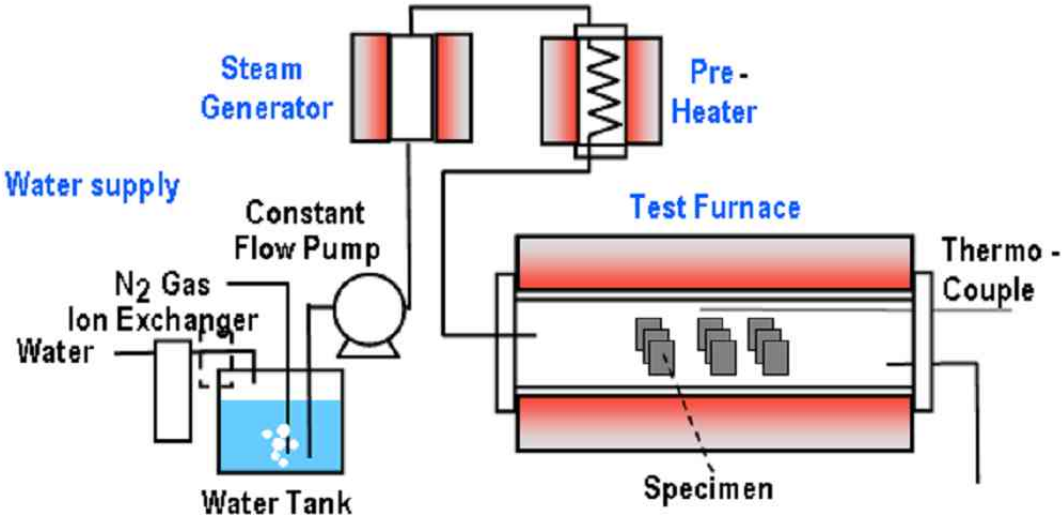
Steam Oxidation(3) Approach

Steam oxidation control technologies

- Corrosion Database
  - Laboratory test, Investigation of operating plants
- Estimation
  - Oxidation rate for candidate materials
- Protect methods
  - shot blasting for austenitic stainless steels, Si content control for 9Cr



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Steam Oxidation(4) shot blasting

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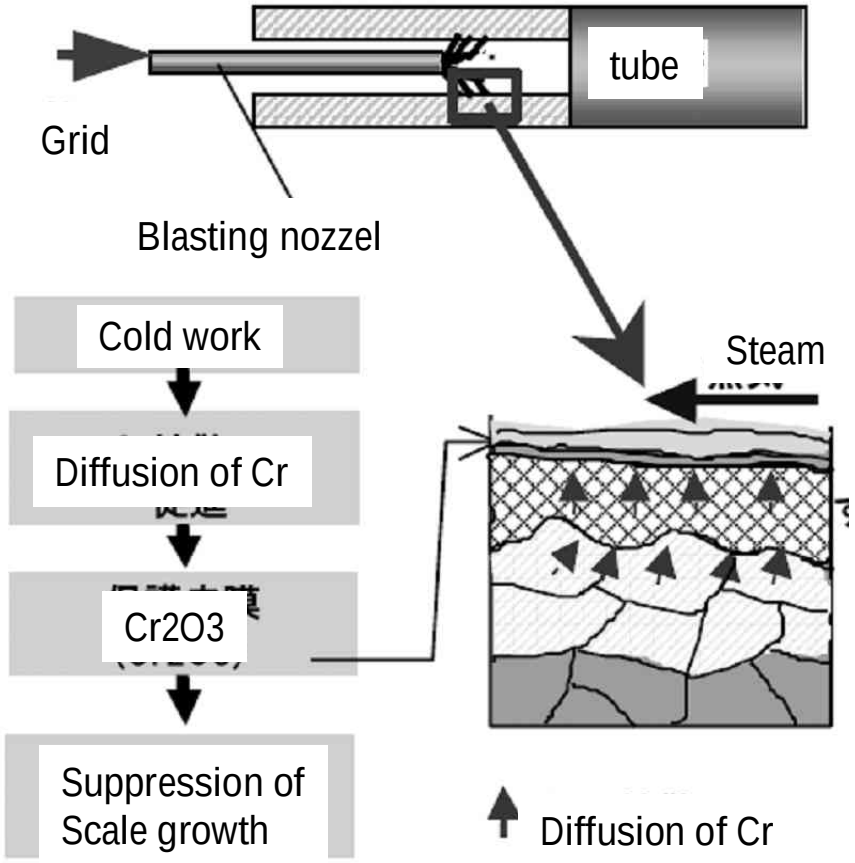

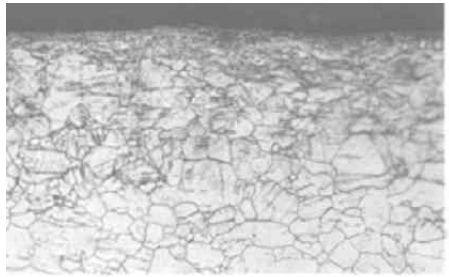

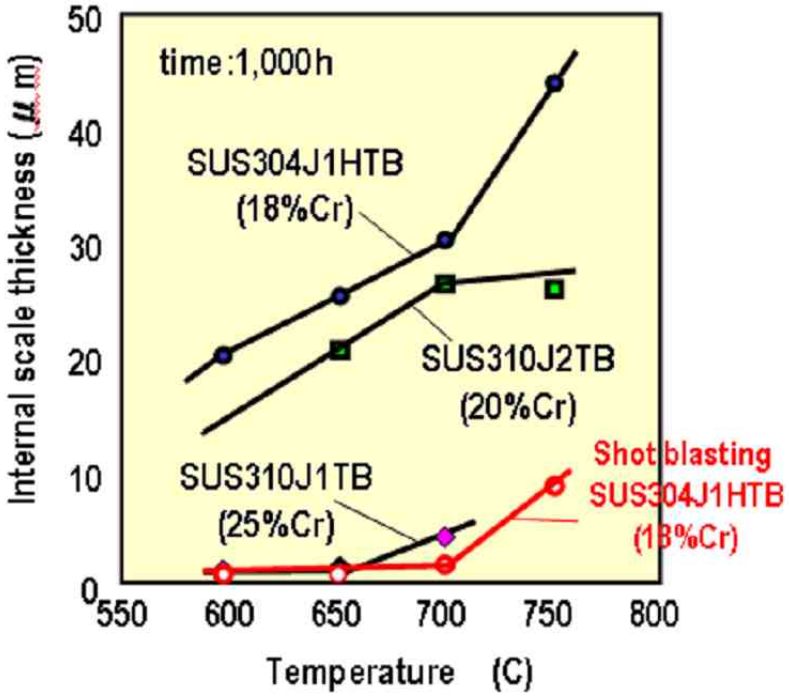

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Steam Oxidation(5) Ni-based alloys

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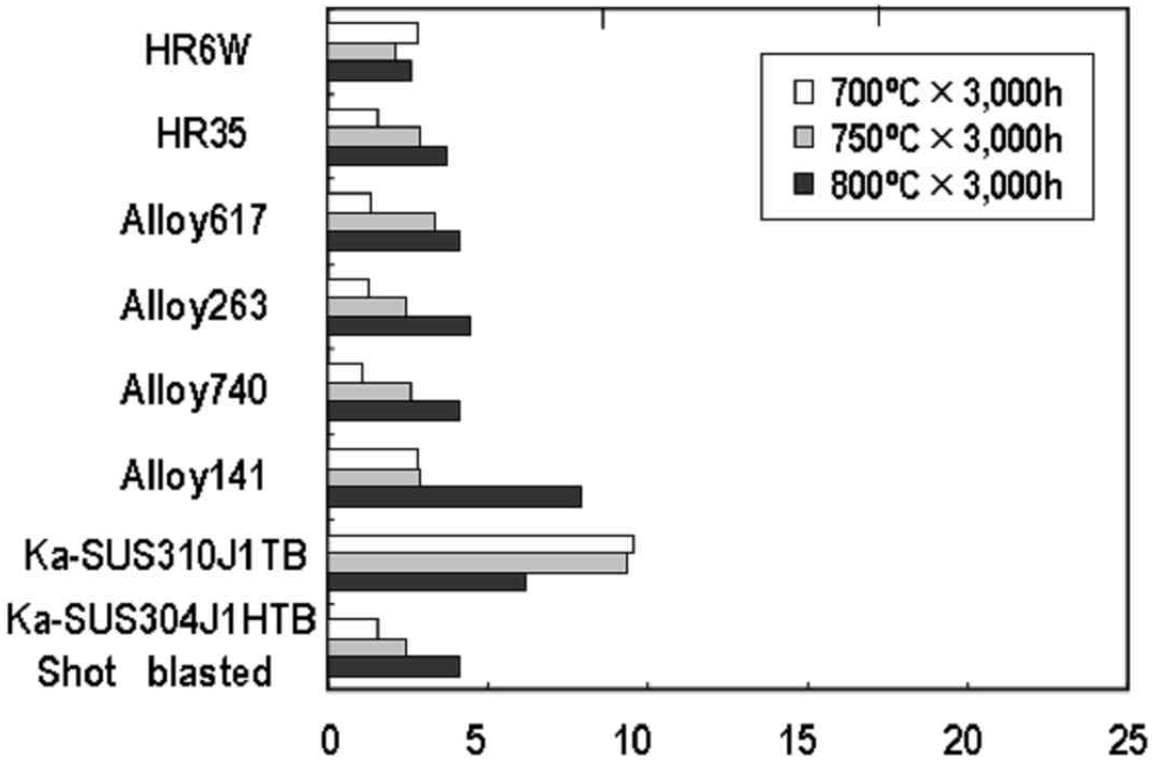

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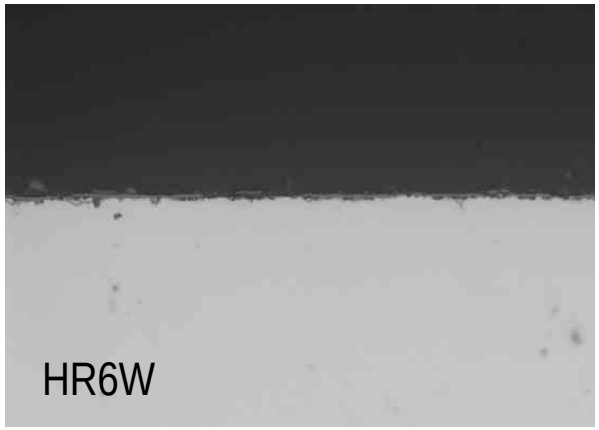

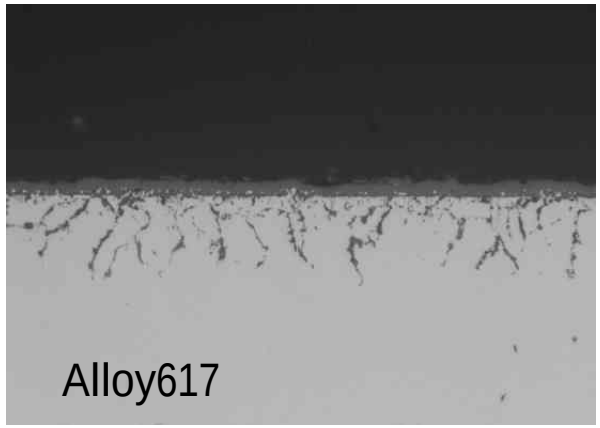

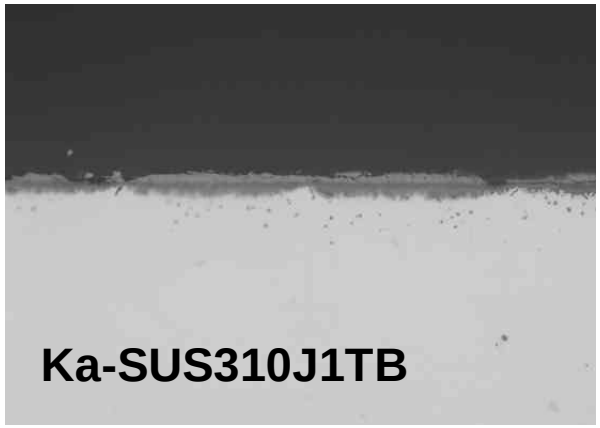

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Summary

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A-USC was chosen by Japan's 'Cool Earth-Innovative Energy Technology Program which was launched in 2008 to contribute to substantial CO_2 emissions reductions.

- Material development:
  Ni-based, Fe-Ni based, New 9Cr steels(<650C, Piping)
- Fireside Corrosion
  - Ni, Fe-Ni based alloy shows similar corrosion behavior to conventional austenitic stainless steel
- Steam Oxidation
  - Ni based alloy shows slight internal oxidation, which don't impact creep strength.
  - shot blasting is effective to control oxidation for austenitic stainless steels

Future Works
- fireside corrosion behavior in the case of biomass co-firing
- scale stability after long-term operation
- control steam oxidation of 9Cr steels

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