

4TH EDITION

Technology Development for Improving Performance of Cracking Furnace

14-15 September 2022

Gulf Hotel and Convention Centre, Kingdom of Bahrain



Kubota Saudi Arabia

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Content

- Key factors to improve the performance
- Overview of AFTALLOY
- Operation Results in Commercial Furnace
- “AFTALLOY+MERT” Technology
- Summary

Key factors to improve the performance

How to prevent the coking and carburization?

Cracking Tube

Gas Temp.: 600~850 Deg. C

Tube Metal Temp.: 900~1100 Deg. C

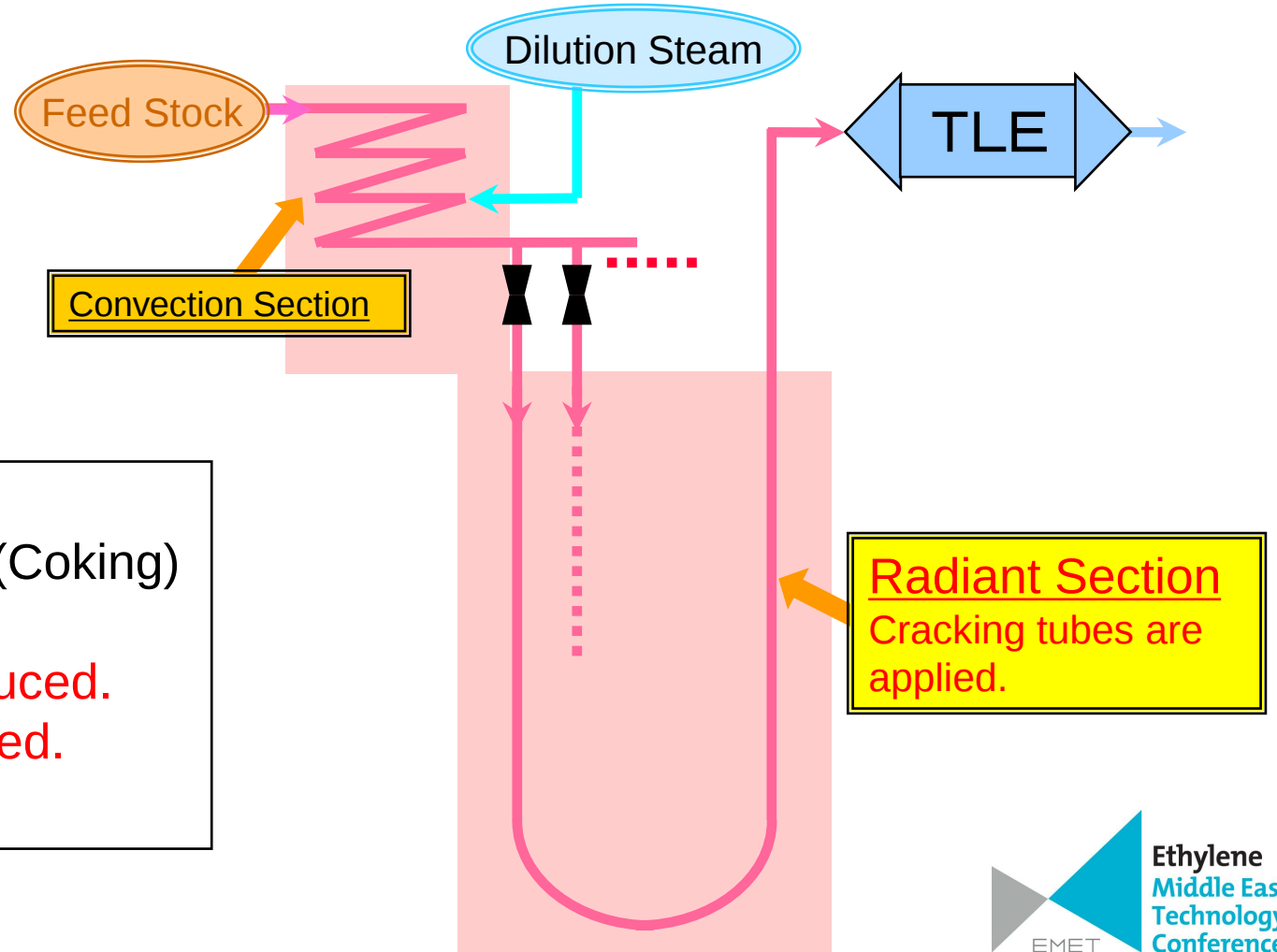
Tube Inside Pressure: 0.1~0.2MPa

High temperature and Low pressure
Coke is deposited at inside during operation (Coking)

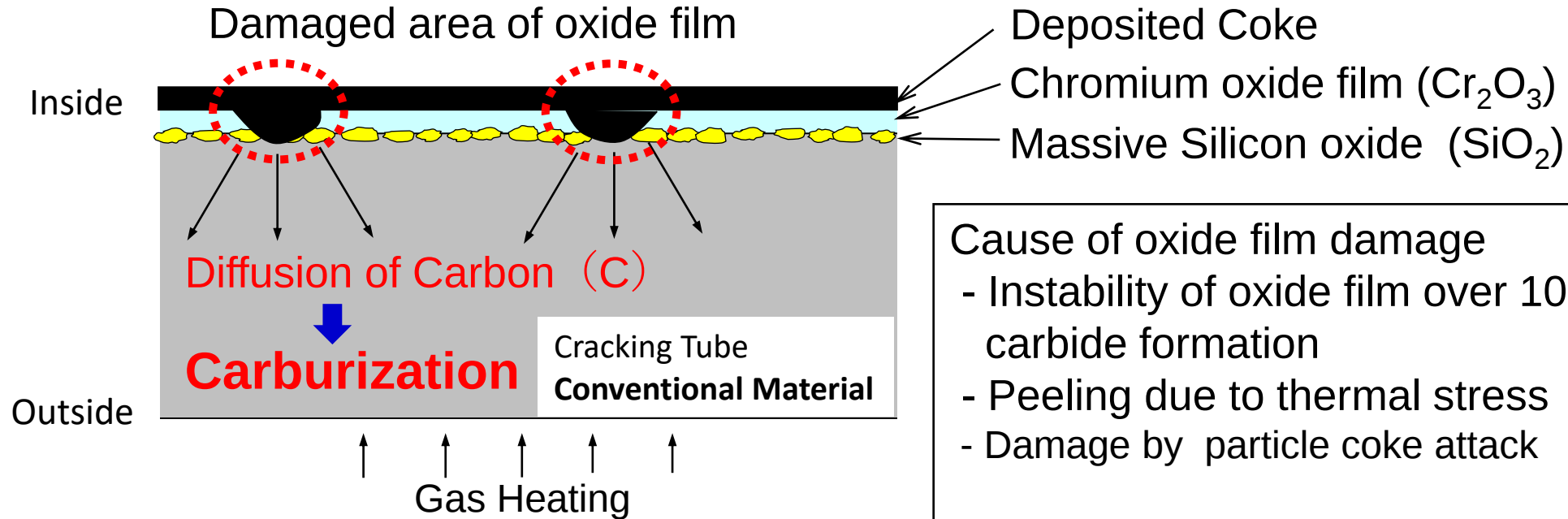


Decoking shall be done ⇒ **Productivity is reduced.**
Carburization occurs. ⇒ **Tube shall be replaced.**

* Creep damage is not so severe.



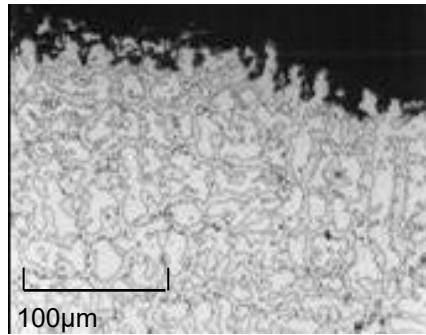
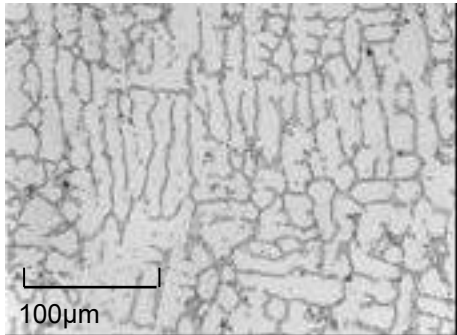
Mechanism of coking and carburization



Cause of oxide film damage

- Instability of oxide film over 1080 °C by Chromium carbide formation
- Peeling due to thermal stress
- Damage by particle coke attack

→ **Stable and highly adhesive Oxide film at high temperature is desired.**



Middle of Thickness (No Carburization) Inside Surface (Carburization)

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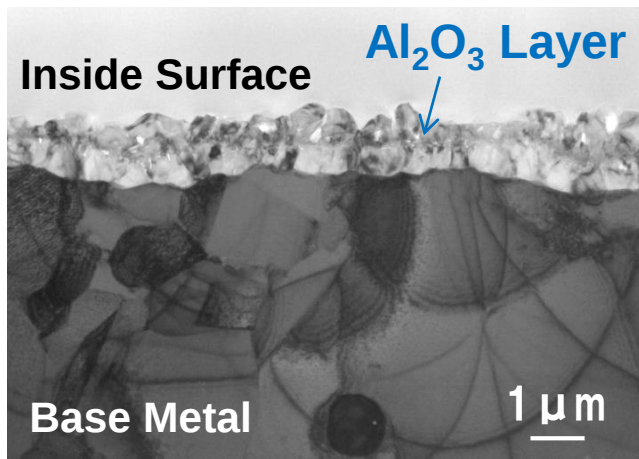
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Overview of AFTALLOY

AFTALLOY: Alumina Forming Tube ALLOY



AFTALLOY is next generation cracking tube technology to form Al_2O_3 layer on inside surface of cracking tubes.



Chemical Compositions of Base Metal (wt%)

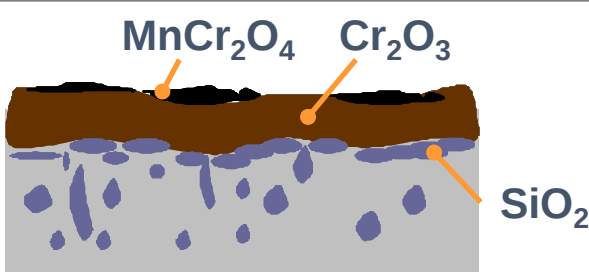
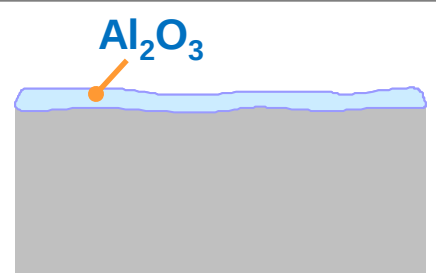
C	Si	Cr	Ni	Ti	Al	Other
0.4-0.6	<1.0	22-28	29-37	<0.5	2.0-4.0	Add.

Al_2O_3 layer is formed by controlled heat treatment in manufacturing process and guaranteed by inspection to ensure the Al_2O_3 layer is formed uniformly in certain quality.

What is excellent point of AFTALLOY?

The oxide film formation is different from the conventional materials.

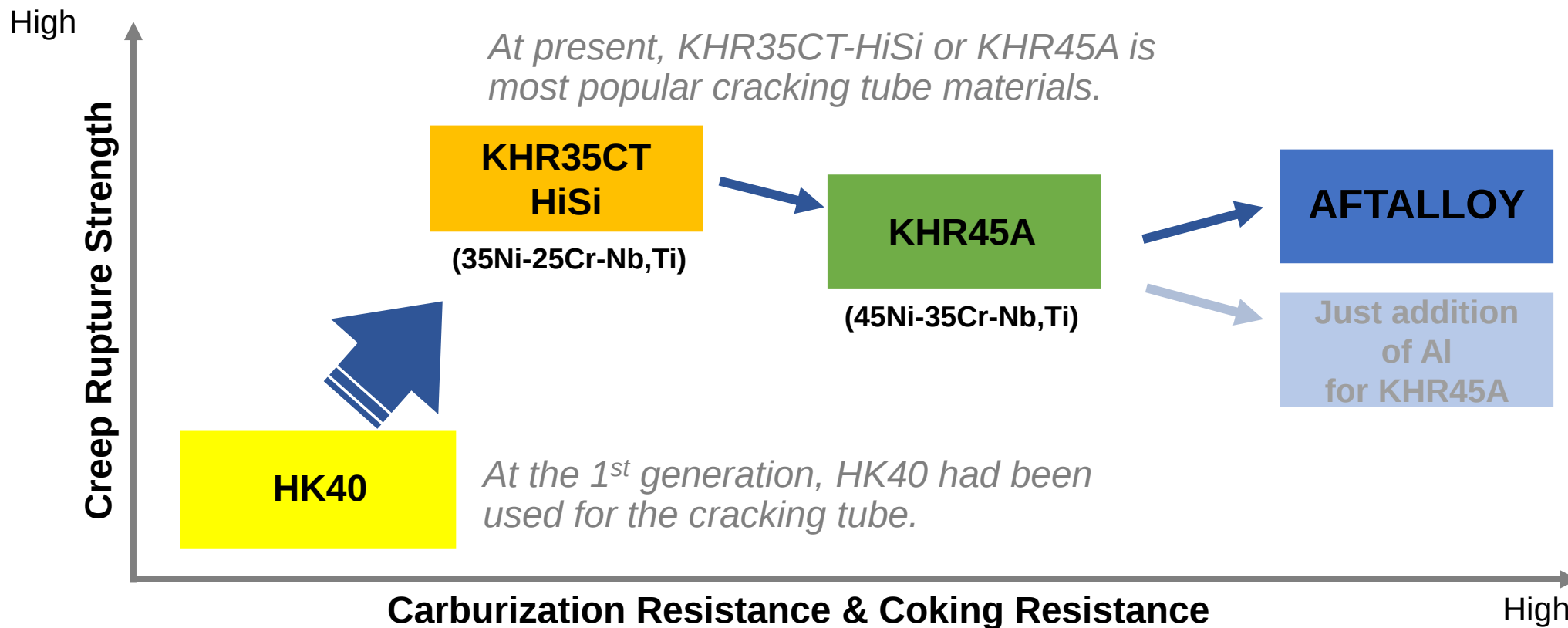
Comparison Table of Oxide Film

	Conventional Material KHR45A: 45Ni-35Cr+Nb+MA KHR35CT HiSi: 35Ni-25Cr+Nb+MA	AFTALLOY
Configuration		
Phase	Cr, Si oxide	α -Al ₂ O ₃
Layer	Composite layer	Single layer
Thickness	5 - 10 μ m	0.3 - 3 μ m
Stability	Unstable over 1080 °C	Stable

The oxide film of the single layer with α -Al₂O₃ has excellent properties such as carburization resistance, coking resistance and oxidation resistance.

Excellent Properties of AFTALLOY

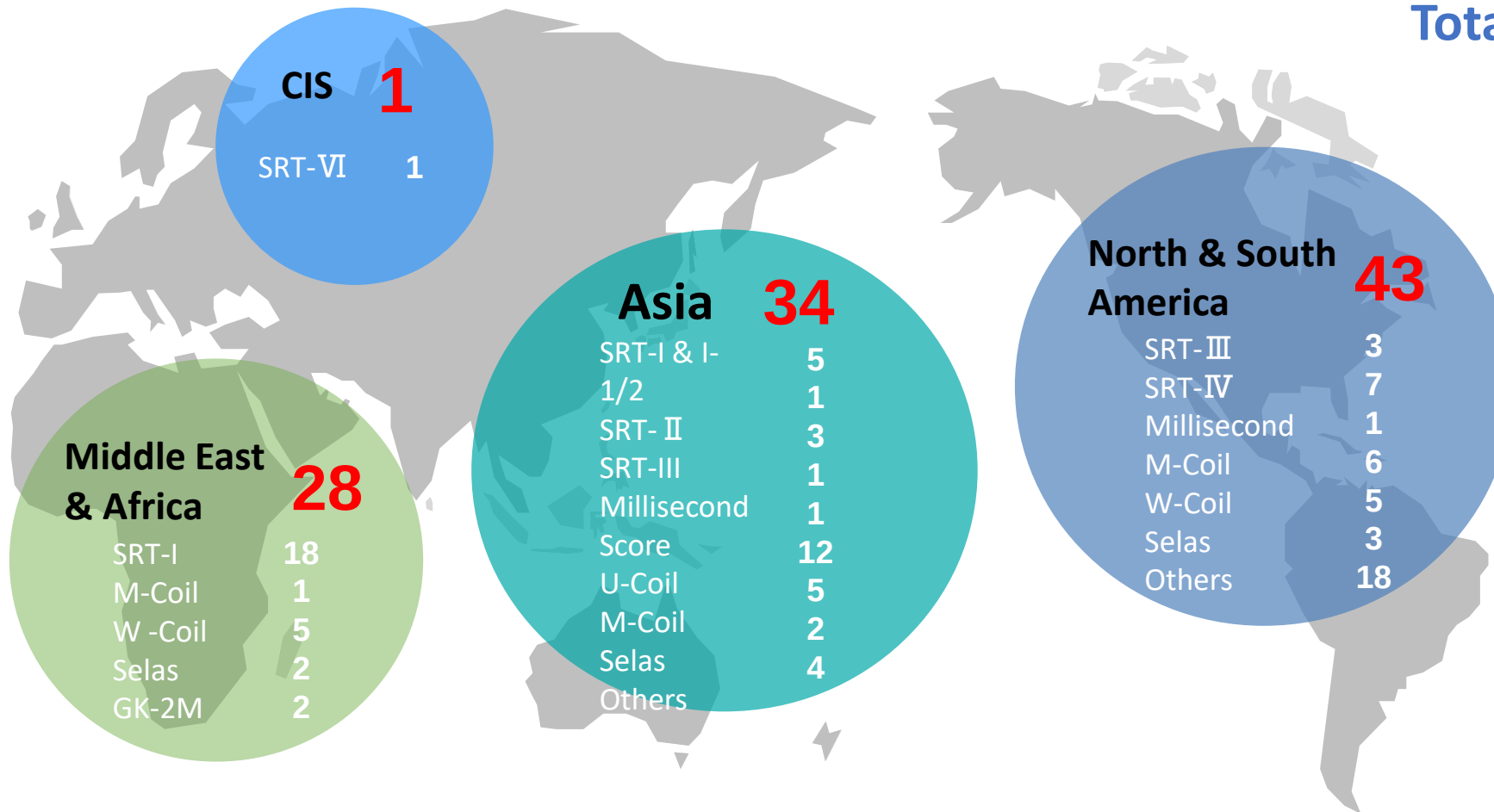
- Coking Resistance : Better than KHR45A → **Longer Run Length**
- Carburization Resistance : Better than KHR45A → **Longer Tube Life**
- Creep Rupture Strength : Better than KHR45A → **Less Deformation/Bowing**



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AFTALLOY Installed Commercial Furnaces



Total supply number (Order base)

106 furnaces

Ethane Feed 97

Multi Feed 6

Naphtha Feed 3

*Including AFTALLOY+MERT

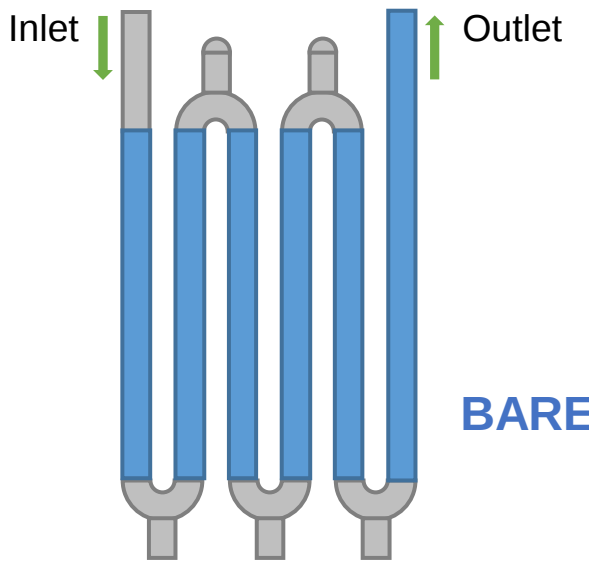
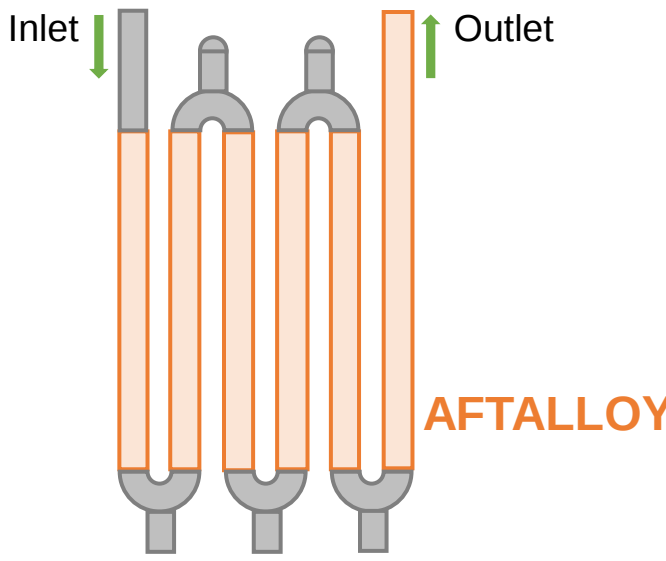
*Including furnaces under production

As of Dec. **2021**

<Case-1> Commercial Experience of AFTALLOY

Furnace Design: Technip (S&W) / M-Coil

Feed Stock : Ethane, Operation : Same Conversion

	Sister Furnace	AFTALLOY Furnace
Tube Type	Conventional Bare	AFTALLOY
Coil Configuration	 Inlet #1-3: KHR35CT-HiSi (35Ni-25Cr) Outlet #4-6: KHR45A (45Ni-35Cr)	

<Case-1> Operation Result of AFTALLOY

AFTALLOY could achieve more than 4 - 5 times longer run length compared to conventional bare coil in this case.

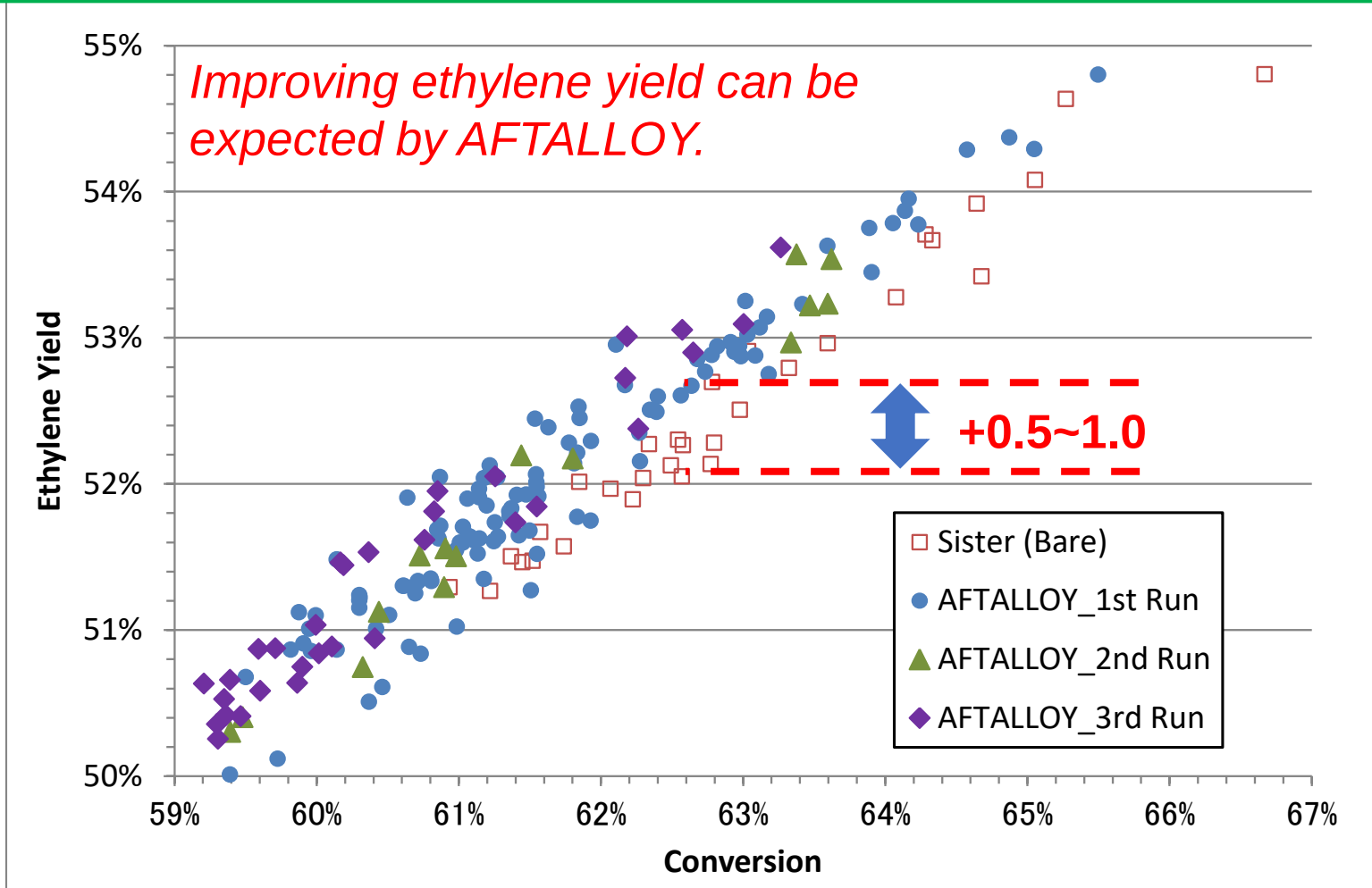
Operation Condition & Run Length

	Sister Furnace	AFTALLOY 1st Run	AFTALLOY 3rd Run
Ave. Feed Rate against Design Value (%)	101.1	99.4	98.6
Ave. Dilution Steam Ratio	Approx. 0.3	Approx. 0.3	Approx. 0.3
Ave. DMDS (ppm-wt)	Approx. 100	Approx. 100	Approx. 100
Ave. Coil Inlet Temp. (°C)	674.2	669.6	667.5
Ave. Coil Outlet Temp. (°C)	836.4	835.9	830.5
Run Length (Days)	32	147	152
Reason for Decoking	CPR Limit	CPR Limit	CPR Limit

<Case-1> Conversion vs. Ethylene Yield

AFTALLOY indicated some possibility of improving the ethylene yield.

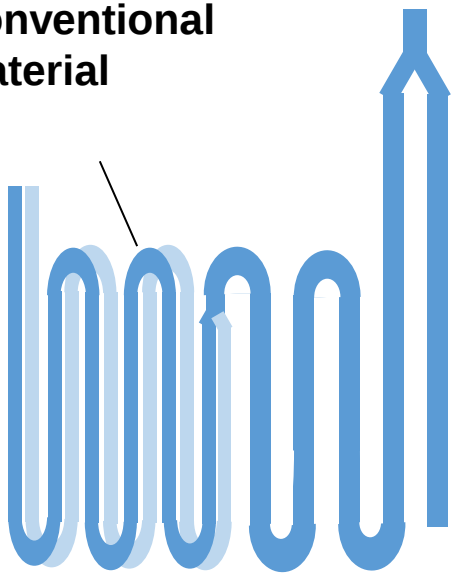
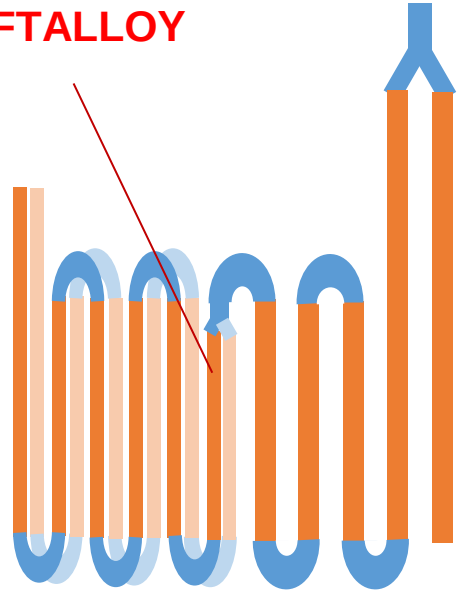
Dense and inert Al_2O_3 prevents side reactions and saves Ethane, and contributes to energy savings.



<Case-2> SRT-1.5 Furnace (Customer ID: D)

Furnace Design: Lummus/ SRT-1.5

Feed Stock : Ethane, Operation : Same Conversion

	Before Replacement	After Replacement
	Original	AFTALLOY
Coil Configuration	Conventional material 	AFTALLOY 

<Case-2> Operation Results of AFTALLOY

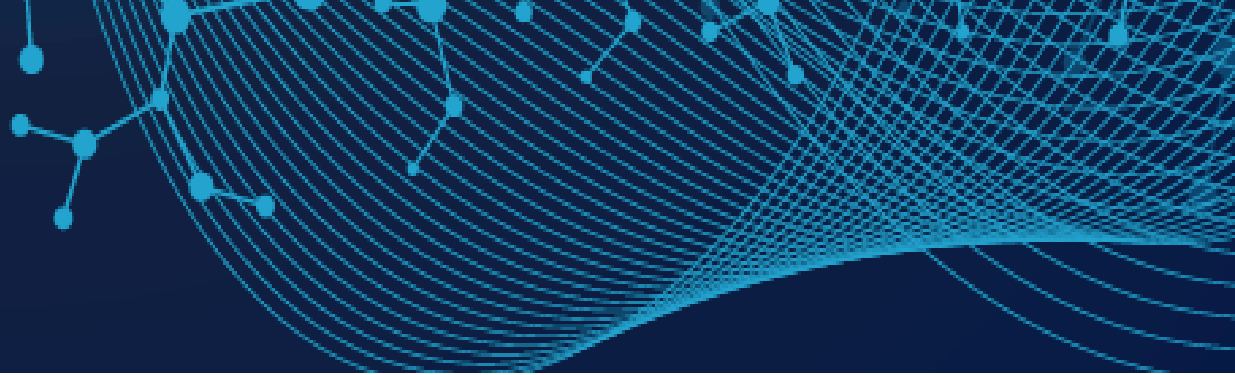
Even under the more severe operating condition (Higher Feed Flow & Less Steam Ratio), AFTALLOY had been able to maintain the longer run length compared with Original Bare.

	Original (Bare)	AFTALLOY					
Run Cycle ¹⁾	-	2nd	3rd	5th	6th	7th	8th
Feed Rate (t/h)	21.1	24.3 (+15%)	22.7 (+8%)	24.5 (+16%)	24.1 (+14%)	23.9 (+13%)	27.1 (+29%)
Steam Ratio	0.53	0.33	0.32	0.30	0.31	0.31	0.31
COT (°C)	850	855	855	849	855	855	850
Run Length (Day)	56	81²⁾	88²⁾	84²⁾	81²⁾	74²⁾	83²⁾
Reason of Decoking	TMT Limit	Scheduled ²⁾	Scheduled ²⁾	Scheduled ²⁾	Scheduled ²⁾	Scheduled ²⁾	Scheduled ²⁾

Repeatability of performance was confirmed.

1) 1st & 4th run were terminated due to un-stable operation condition and fouling in TLE

2) Expected run-length is 140days



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Overview of AFTALLOY+MERT

MERT



- 20-50% better heat transfer
- Coke inhibition

【Mainly reduce pyrolytic coke】

+

AFTALLOY



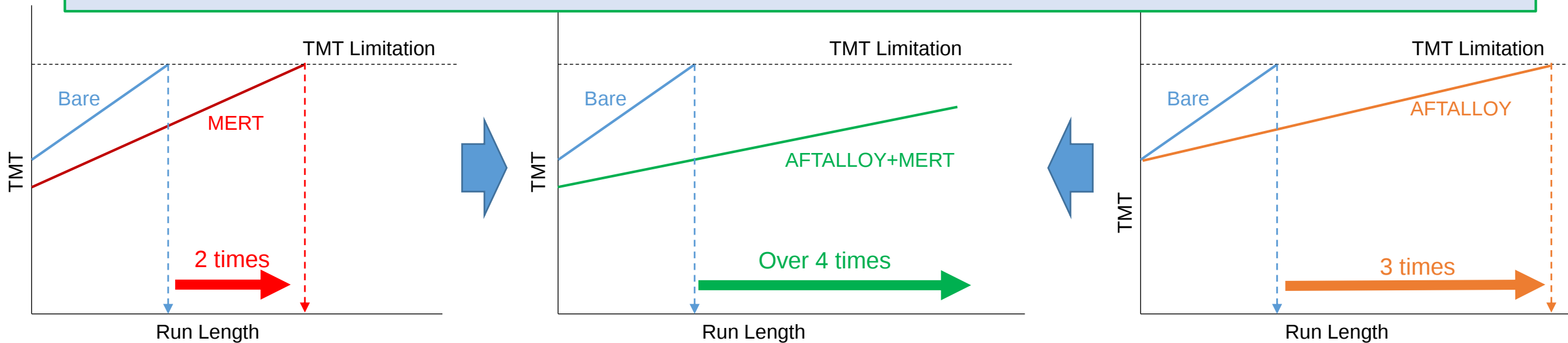
- Excellent carburization resistance
- Coke inhibition

【Mainly reduce catalytic coke】

- **AFTALLOY+MERT is the combined technology of MERT and AFTALLOY.**
- **Further run length extension & tube life extension could be expected by AFTALLOY+MERT.**

Expected Benefits of AFTALLOY+MERT

AFTALLOY+MERT provide longer run length and longer tube life because of lower TMT operation.



Feature of AFTALLOY+MERT

Al_2O_3 Film is formed on both base metal and AFT+MERT elements.

AFTALLOY+MERT Element:

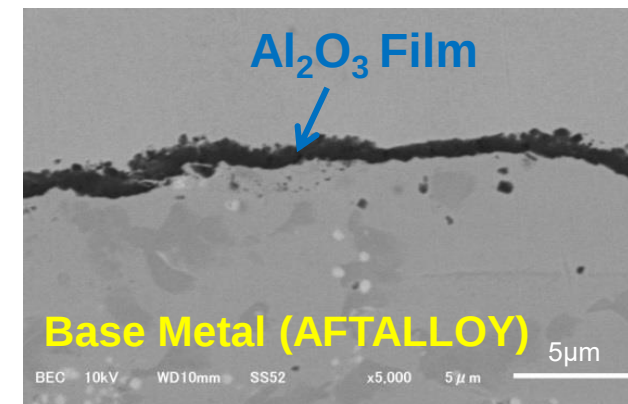
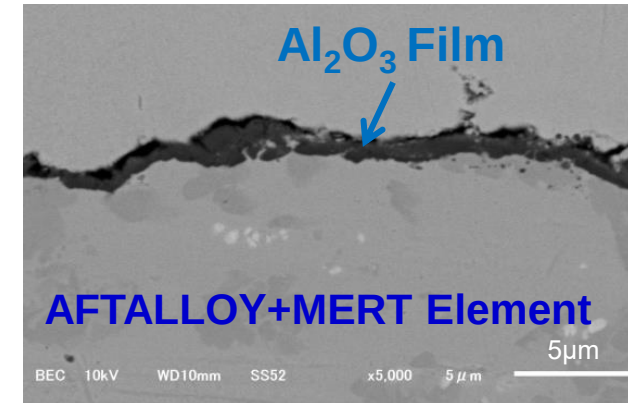
45Ni-35Cr - **3~4Al** - Others
(KHR45A Mod.)



AFTALLOY+MERT

Base Metal:

AFTALLOY (KHR35AF)
35Ni-25Cr- 2~4Al - Others



NOTE: This photograph shows Slit-MERT type of AFTALLOY+MERT.
Both normal MERT type and X-MERT type are also applicable to AFTALLOY+MERT.

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1. **AFTALLOY** could show “**Excellent carburization resistance**” and “**Excellent coking resistance**” (Mainly reduce catalytic coke) by the stable alumina film formed on the inside surface of the tube. **AFTALLOY** is more effective to gas cracking furnace, because the catalytic coke is dominant in gas cracking.
2. **AFTALLOY+MERT** is the combined technology of MERT and AFTALLOY. **AFTALLOY+MERT** would be suitable for the customers who want to get **further run length extension** and/or **further longer tube life** compared to the conventional MERT.

Thank you very much. شكرا جزيلا لك.

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Kubota

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