Status of Water Conditioning for Once-through Boiler in Japanese Fossil Power Plants

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IAPWS PCC 2012

October, 2012

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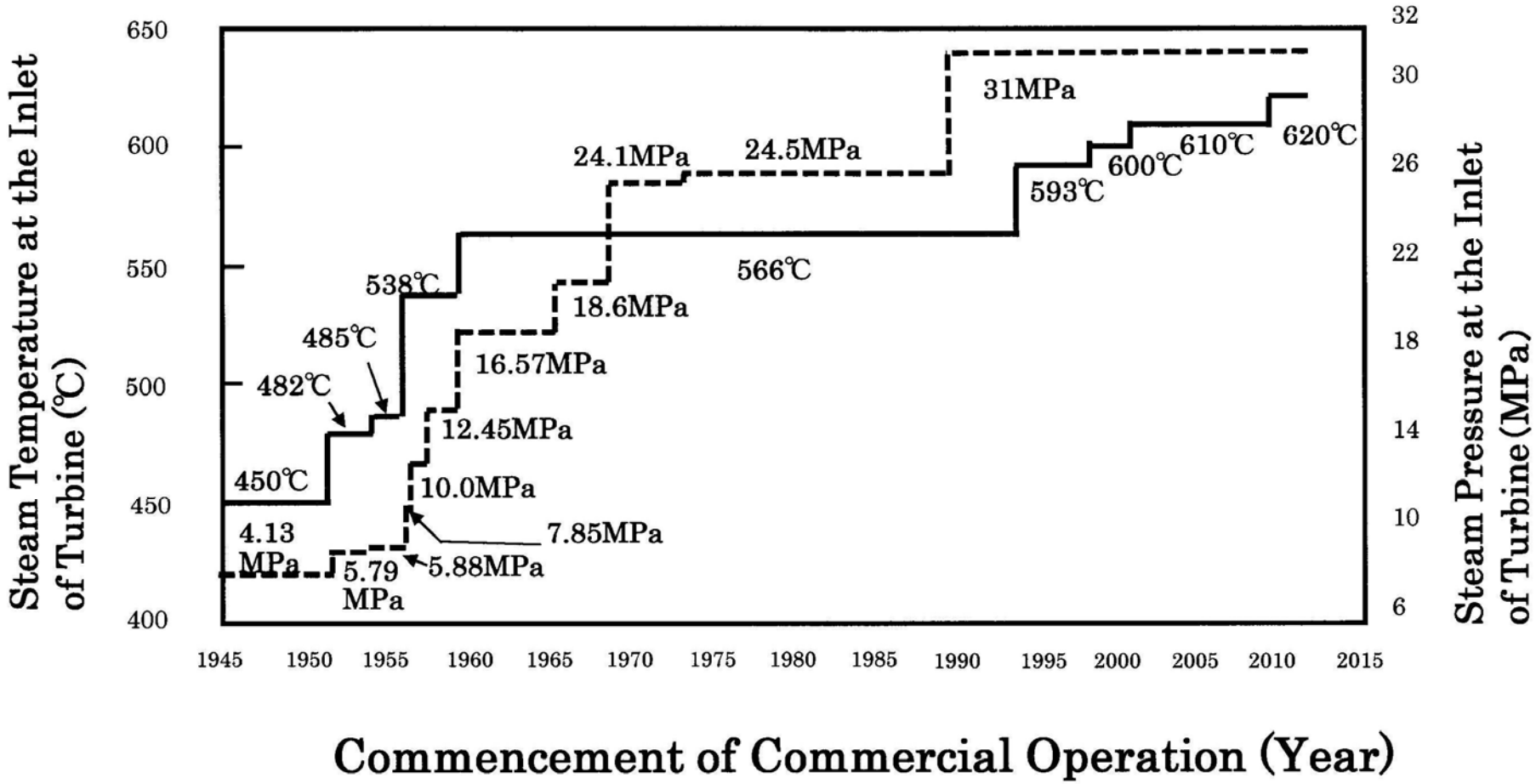
Transition of Steam Generating Condition of Japanese Thermal Power Plants



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1. The latest Trend of Thermal Power Plant Installations in Japan (1)

For about 30 years in 1980 and afterwards, 25 plants of Ultra Super Critical steam pressure and 16 plants of combined cycle/HRSG were installed as of April 30, 2012.

Note :

[Definition]

- Super Critical steam pressure power plant: Pressure ≧24.1MPa, Temp. ≧ 566℃
- Ultra Super Critical steam pressure power plant : Pressure ≧31MPa or Temp. ≧ 593℃

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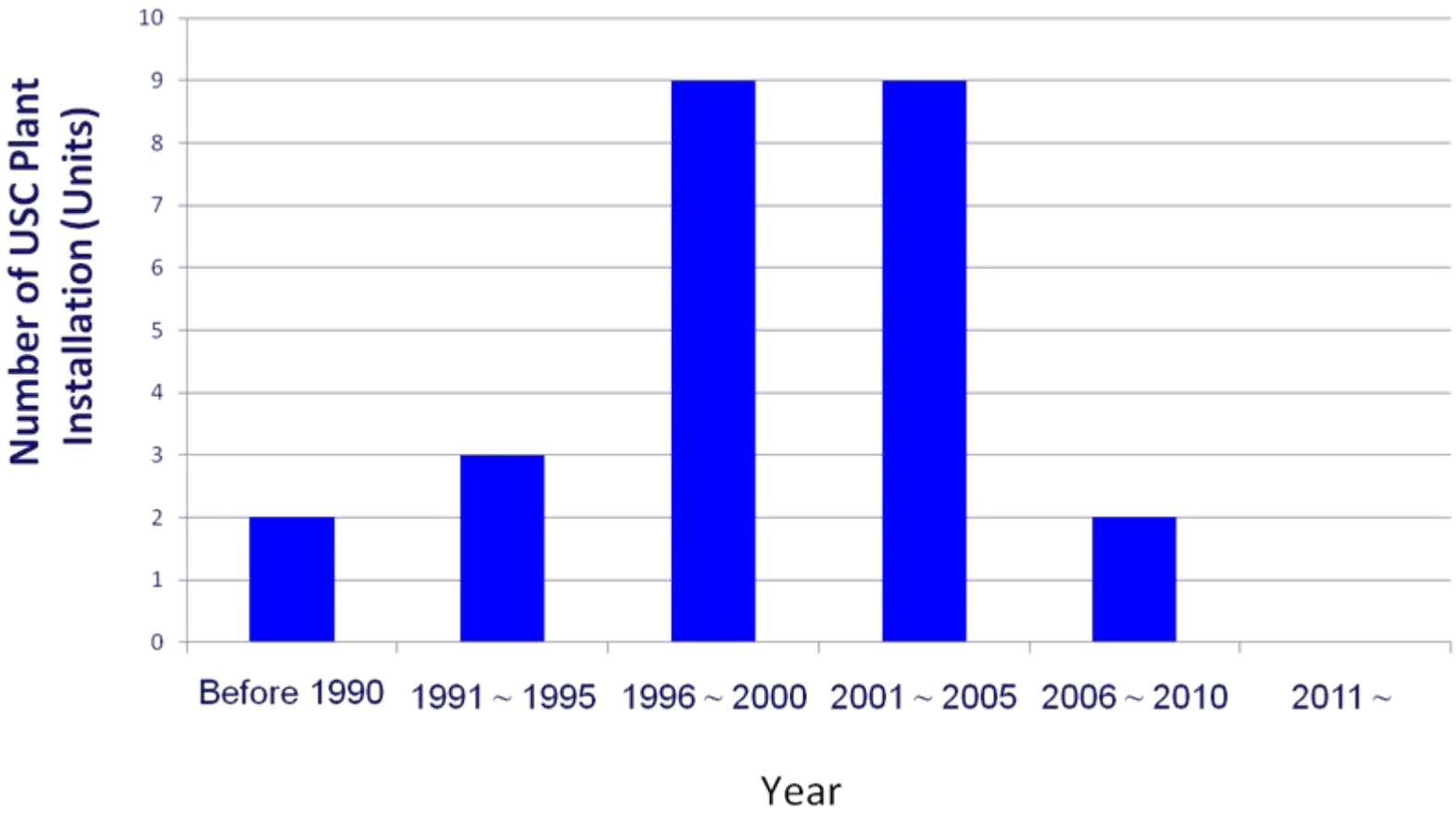
Trend of USC Plant Installation



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Typical USC Plants operated in and after 1989 in Japan

Electric Power Company	Plant Name	Unit No.	Output [MW]	Main Steam Pressure [MPa]	Main Steam Temp. [ºC]	Reheater Steam Temp. [ºC]	Commercial Operation
Chubu	Kawagoe *1)	1	700	31 *2)	566	566/566	1989/6
J-Power	Tachibanawan Karyoku	1	1,050*3)	25	600	610	2000/7
J-Power	Isogo	Shin 2	600	25	600	620 *4)	2009/7
Kansai	Maizuru *5)	2	900	24.5	600	598	2010/8

Note : *1) : First USC Plant in Japan. *2) : Maximum Main Steam Pressure.
* 3) : Maximum Output. *4) : Maximum Reheater Steam Temp.
*5) : The newest Plant.

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2. Feed Water Treatment for Once-through Boiler
2-1.Oxygenated Treatment (1)

Since oxygenated treatment (OT) was applied for the first time at Chita Daini Unit 1 in 1990, oxygenated treatment has been applied to domestic 53 plants in our country as of July, 2012 including ultra supercritical, supercritical and subcritical pressure steam power plants.

The following benefit were obtained by introduction of the oxygenated treatment.

- Mitigation of pressure drop in boiler and high-pressure heater regions
- Extension of a chemical-cleaning interval

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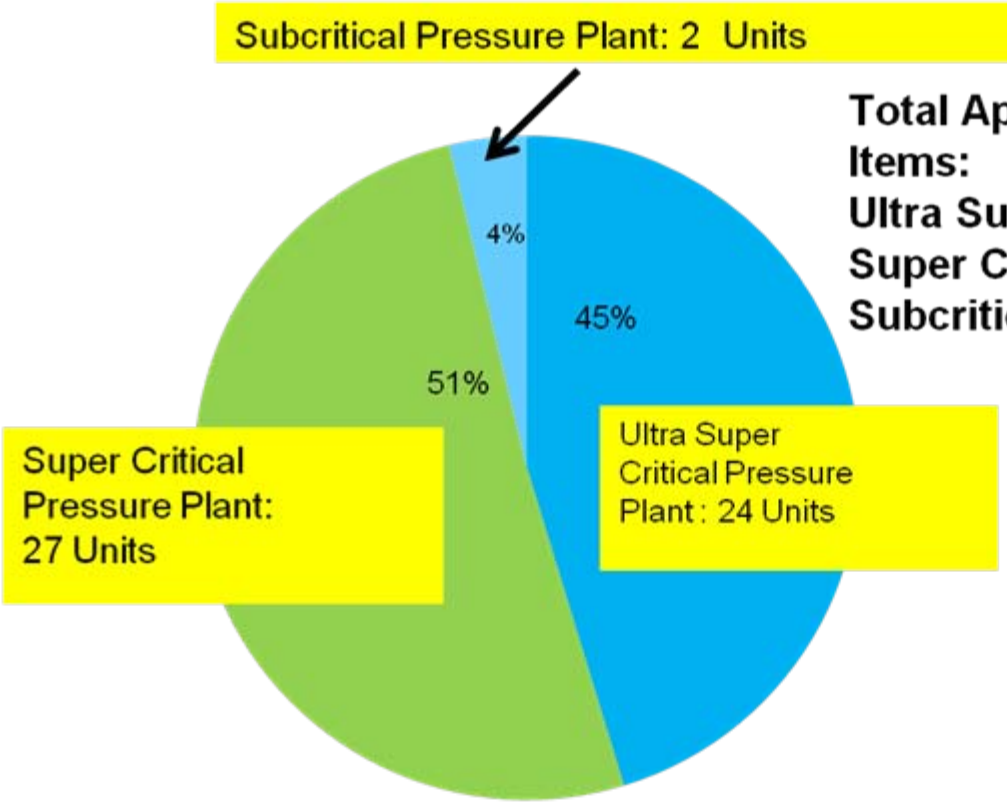
2. Feed Water Treatment for Once-through Boiler
2-1.Oxygenated Treatment (2)

Oxygenated Treatment Application Plants



Total Application Plants : 53 Units
Items:
Ultra Super Critical Plant: 24 Units
Super Critical Plant : 27 Units
Subcritical Plant : 2 Units

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2. Feed Water Treatment for Once-through Boiler
2-1.Oxygenated Treatment (3)

Due to excellent performance of OT, the number of OT application plants has been increasing.

- With increasing the plant operation period, it is supposed that the number of chemical cleaning application to OT plants will increase.
- Although the standard for provisional chemical-cleaning method was created, the creation of more precise standard for chemical cleaning method is desired including powdered scale.
- As described later, the root cause elucidation of powdered scale problem and the establishment of it's countermeasure is desired.

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2. Feed Water Treatment for Once-through Boiler
2-1.Oxygenated Treatment (4)

- Some units among domestic 53 units employing OT have experienced the boiler tube failures caused by the formation of powdered Scale.
- The above tube failures mainly occurred in the transition zone from the sub-critical pressure condition to the super-critical one, i.e. the mixing parts which the primary water wall was intersected with the secondary water wall.
- The establishment of countermeasures based on the elucidation of mechanism has been an important subject.

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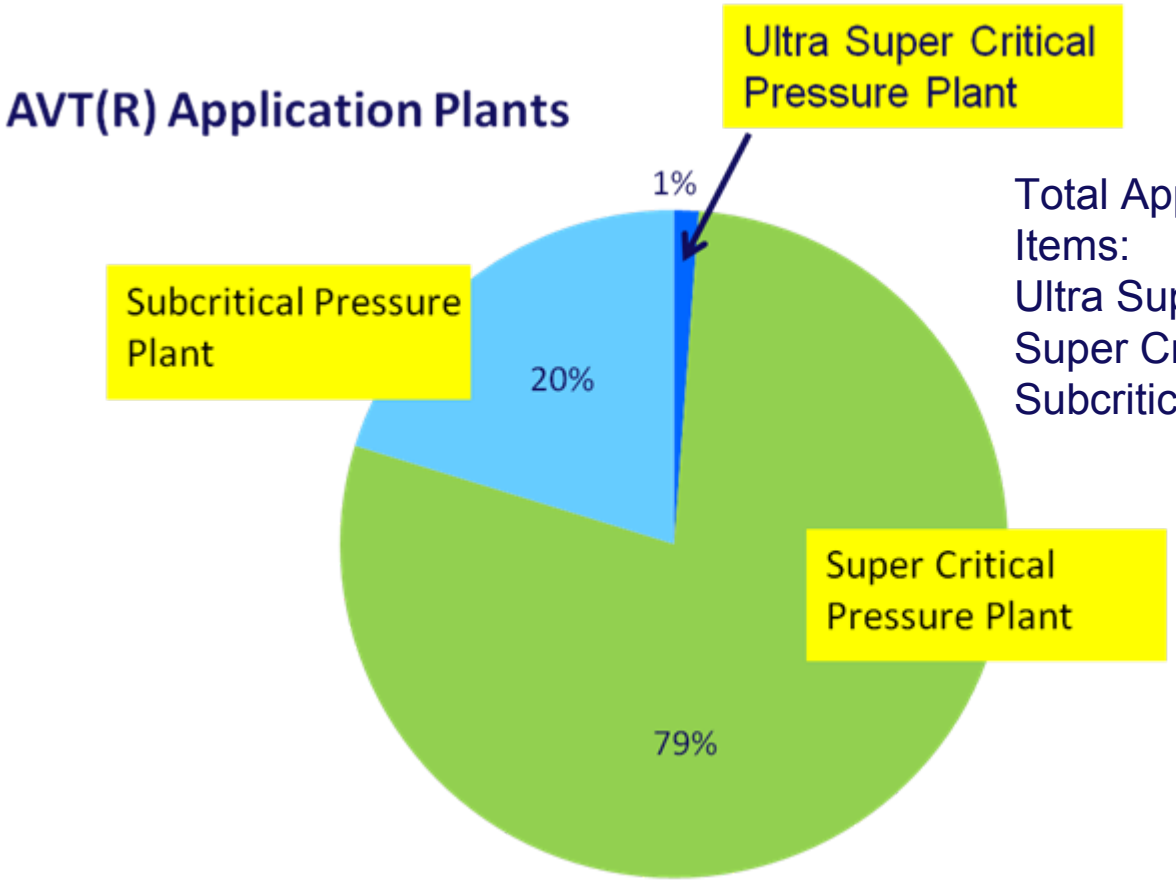
2. Feed Water Treatment for Once-through Boiler
2-2.AVT(R) and AVT(O) (1)



Total Application Plants : 84 Units
Items:
Ultra Super Critical Plant : 1 Unit
Super Critical Plant : 66 Units
Subcritical Plant : 17 Units

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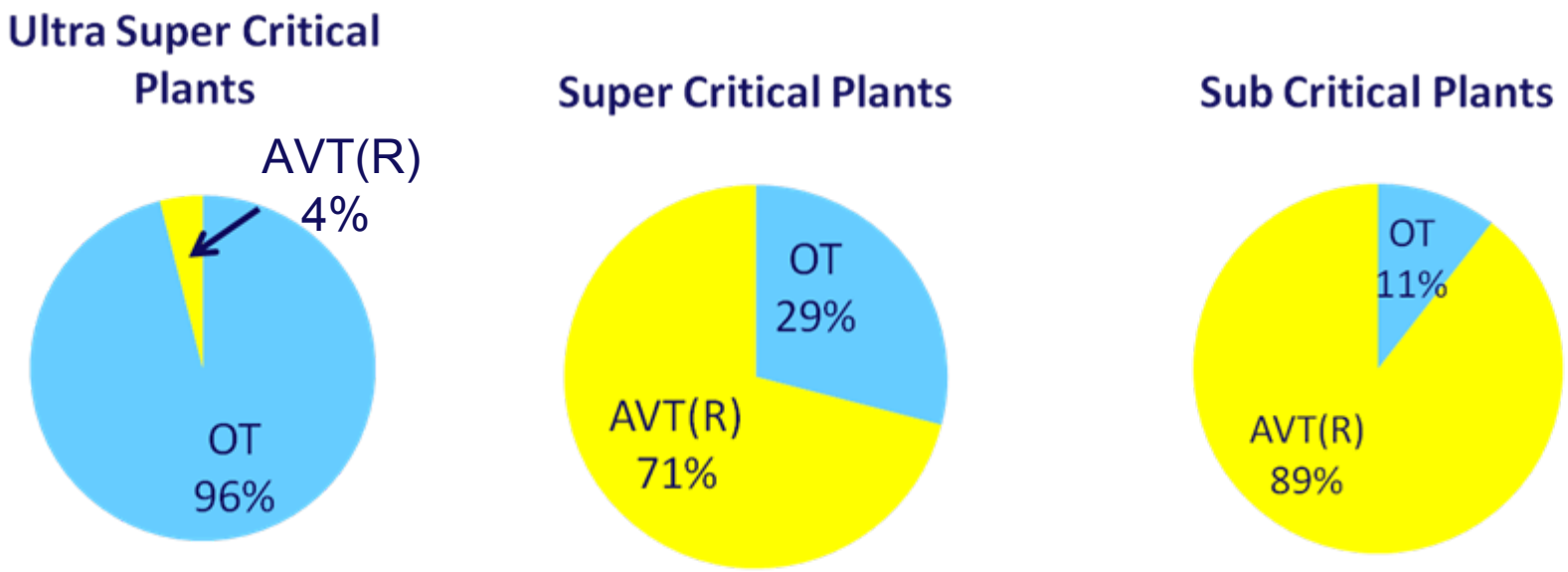
2. Feed Water Treatment for Once-through Boiler
2-2.AVT(R) and AVT(O) (2)



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2. Feed Water Treatment for Once-through Boiler
2-2.AVT(R) and AVT(O) (3)

- As a boiler feed water treatment, AVT (R), which uses ammonia for pH control and uses hydrazine for a deoxidizer, has been used.
- However, Hydrazine was designated as the toxic chemical substance in 1994. The direction for preventing healthy damage was released from the Ministry of Health, Labor and Welfare.
- The survey of hydrazine substitutes has been conducted. Research on AVT(O) application has also been carrying out at laboratories and at actual plants. These results showed that comparing with the conventional AVT(R), the effect of corrosion control of AVT(O) was almost equivalent, or excellent.

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AVT(R) and one of example of Tentative Japanese AVT(O)

	AVT(R)	AVT(O)	OT
Material System	All-Ferrous, Mixed Metals	All-Ferrous	All-Ferrous
pH at 25˚C	All-Ferrous：9.3 ～ 9.7	9.2 ～ 9.6	6.5 *3) ～ 9.3
	Mixed Metals：9.0～9.4 *1)		
	Mixed Metals：8.5～9.0 *2)		
Cation Conductivity	<0.02 mS/m (<0.2 μS/cm)	<0.02 mS/m (<0.2 μS/cm)	<0.02 mS/m (<0.2 μS/cm)
O_2（ at the Inlet of Economizer）	<7	<10	20 ～ 200
Fe (μg Fe/L)	<10	<5	<5 *4)
Cu (μg Cu/L)	<2	<2	<2
N_2H_4 (μg N_2H_4/L)	>10	0	0
SiO_2 (μg SiO_2/L)	<20	<20	<20

Note : *1) : In the case Cu alloys are used as LP Feed Water Heater tube.
*2) : In the case Cu alloys are used as LP and HP Feed Water Heater tubes.
* 3) : pH under NWC condition. NWC operation is not carried out. pH under CWT: 8.5~9.3 *4) : 2μg Fe/L or less is desirable

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3 . Steam Oxidation in USC and UC Pressure Steam Plants

There were some cases that USC and SC plants experienced the tube failures and the erosion-corrosion of turbine blades caused by the steam oxidation.

【 Boiler Damage 】

- The overheat of re-heater tubes was caused by the scale growth of low alloy steel.
- The overheat of super-heater tubes was caused by the voids growth in the steam oxidation scale of 9Cr ferrite steel.
- The overheat of super-heater tubes was caused by the exfoliation and deposition of the steam oxidation scale of stainless steel.

【 Erosion-corrosion of the steam turbine 】

- The erosion-corrosion of turbine blades etc. was caused by the exfoliation and scattering of steam oxidation scale.

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4. Conclusions

Due to improvement in the thermal efficiency by introduction of USC and SC plants, the big economical benefit has been produced. Moreover, drastic reduction of maintenance costs has been achieved by application of OT.

However, in order to aim at the further improvement, it is necessary to cope with the following subjects.

1. Creation of the standard for more precise chemical cleaning method including powdered scale.
2. Establishment of countermeasure against the powdered scale problem.
3. Establishment of countermeasure against a steam oxidation scale in USC and SC Plants.
4. Application of AVT(O) to SC and Subcritical plants.

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