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One of the concrete action plans which supply 700°C class A-USC technology to a coal fire power market

Hitachi, Ltd.

Eiji Saito

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1. Development outline of coal-fired power generation
2. Strategy toward the realization of A-USC
3. Progress of A-USC material and manufactures
4. Summary

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1.1 Energy Balance

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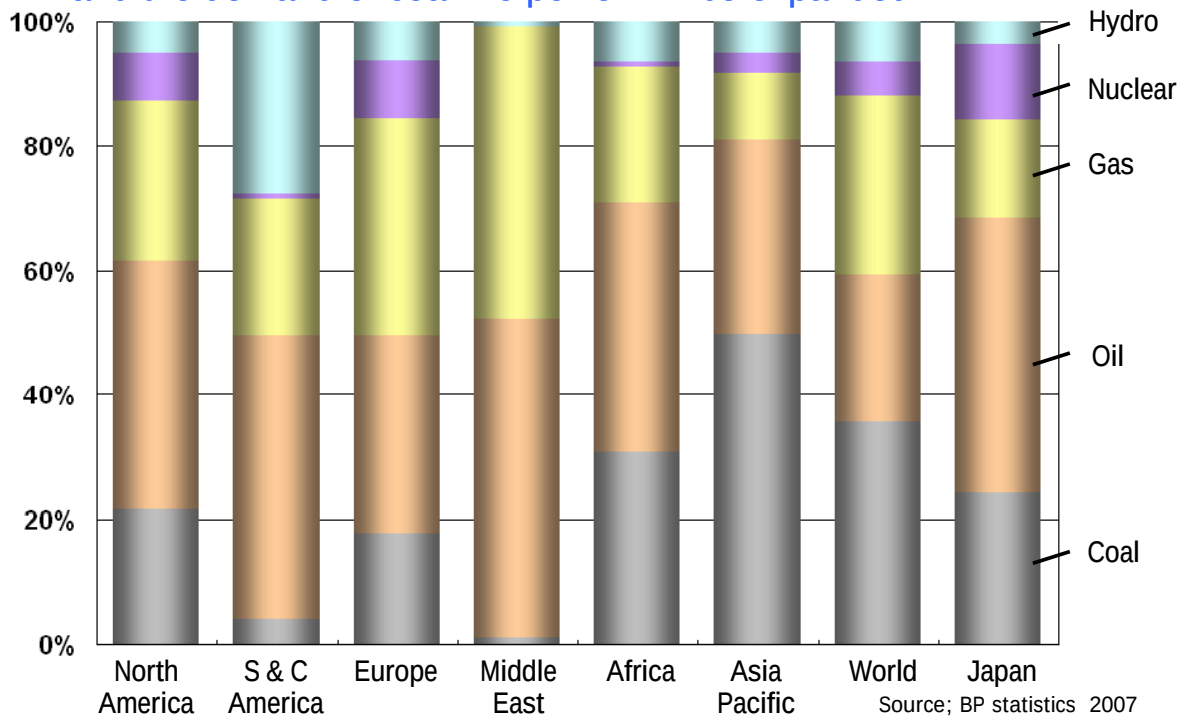
- The use of coal in Japan occupied ¼ of the entire energy.
  Now, JP Government plan to abandon Nuclear power until 2030 and the demand of coal fire power will be expanded.



Source; BP statistics 2007

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1.2 Improvement of Steam Condition

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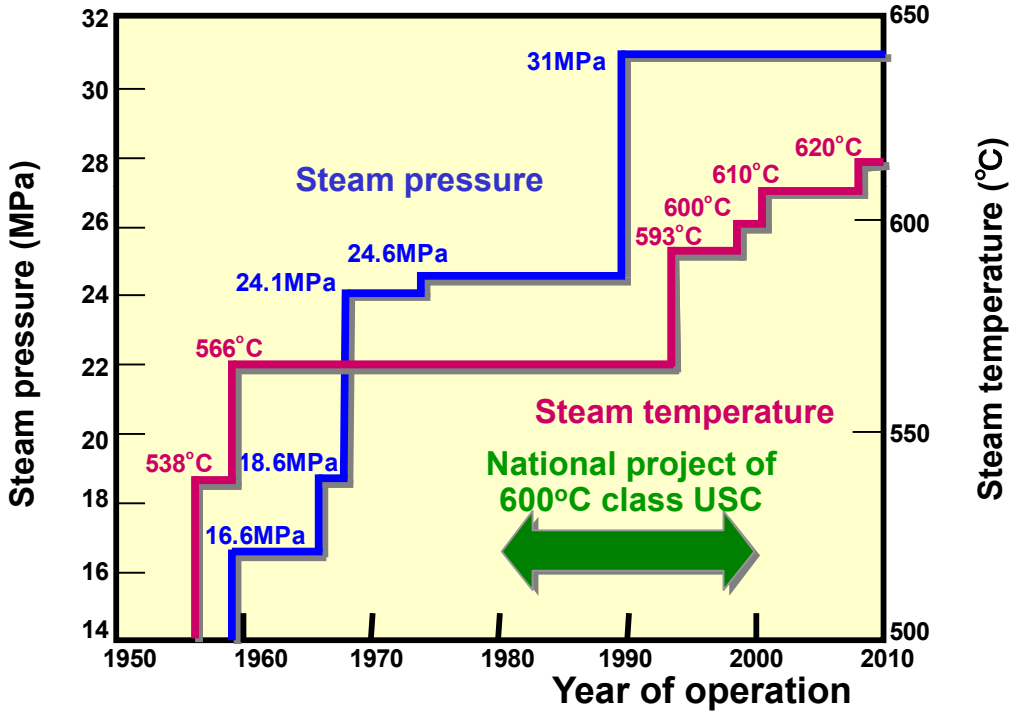
- The steam condition improved rapidly in the 90's in Japan.



Source; JSME report P-SCD353 2007

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1.3 Efficiency Comparison for Coal Fired Power

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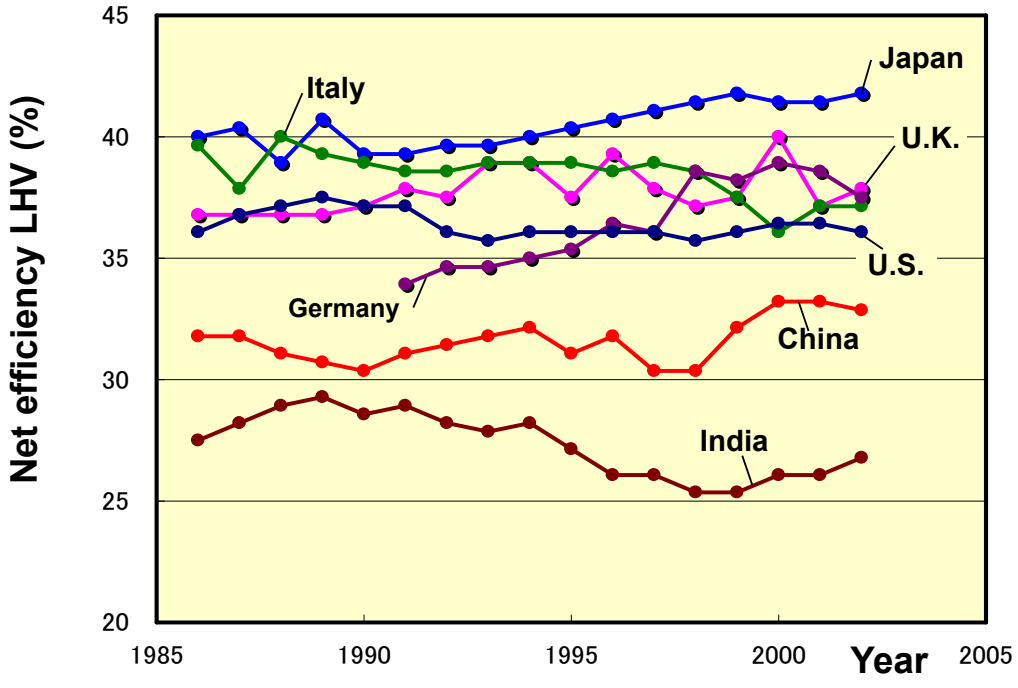
- The coal fired power station in JP is operated the most efficient.



Source; IEA Energy Balances of OECD and non-OECD countries 2004

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1.4 Cumulative Capacity of USC Plants by Hitachi

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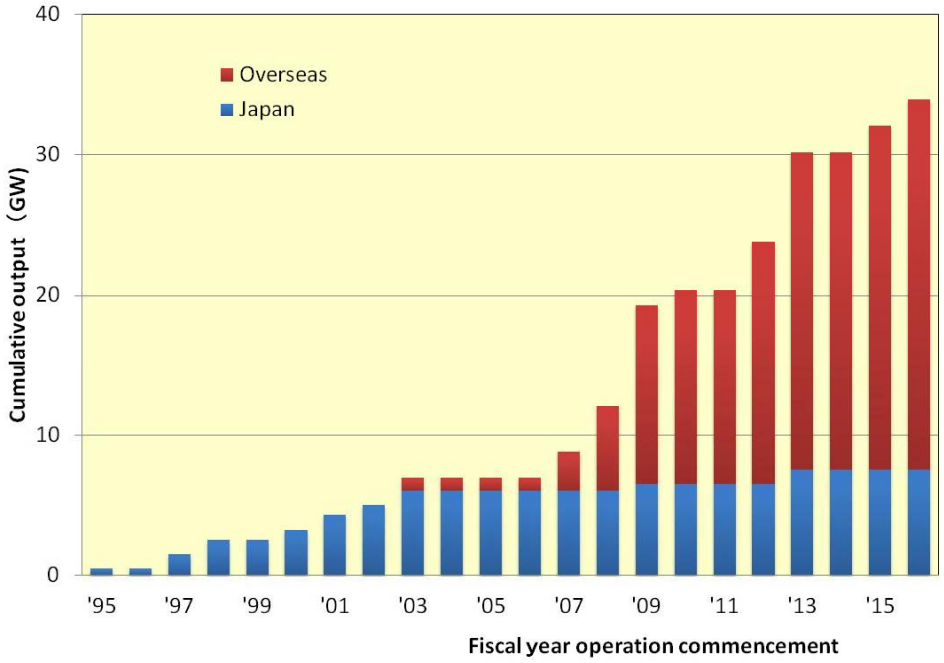
- We have won orders for a total of 38 USC coal-fired power plants to date, representing a total output of about 34GW.
  Use of this technology has helped to improve the efficiency of each plant.



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2.1 Schedule of Japan National Project

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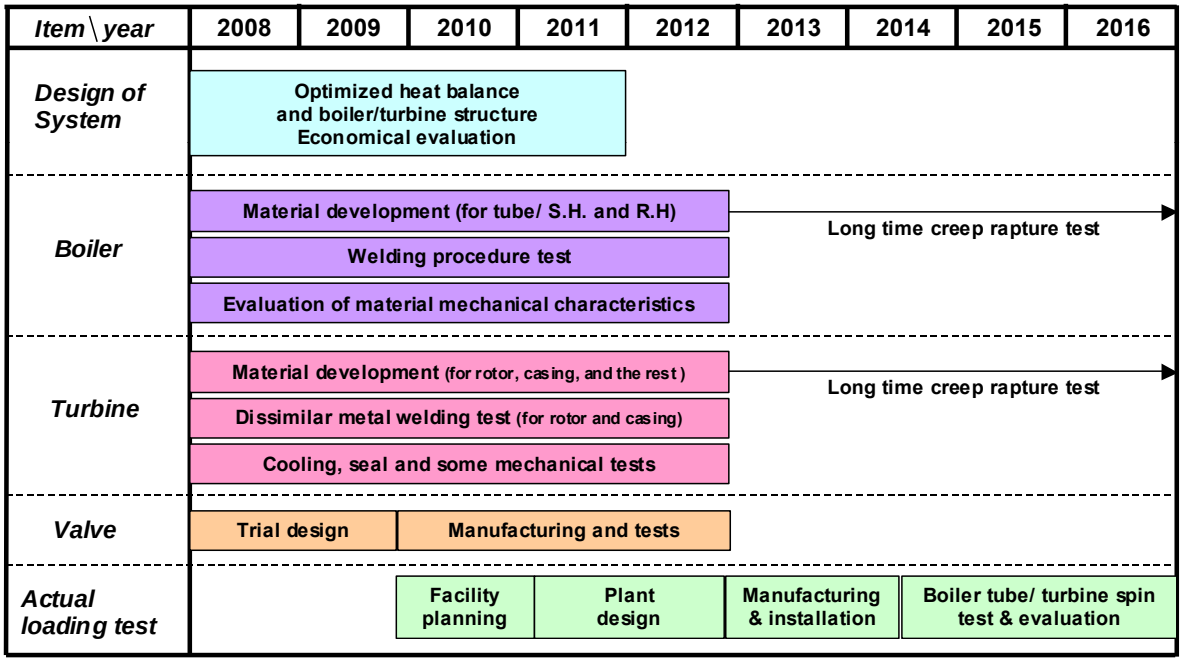
- A-USC development was selected as one of the national projects, and its commercialization is expected by 2020.



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2.2 Technical Difficulties

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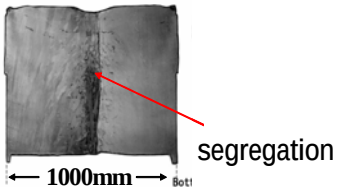
- The use of 600ºC class is a limit in the high strength ferrite steel.
- The developments of Ni base alloys are critical to establishing the technical feasibility of 700ºC class A-USC plant concept.

Development tasks of the Ni base alloys compared with the ferrite steel are as follows;

- Much more expensive
- The segregation is caused easily in manufacturing
- Not easy to forge because of poor hot workability
- Low proof strength
- High linear coefficient of expansion



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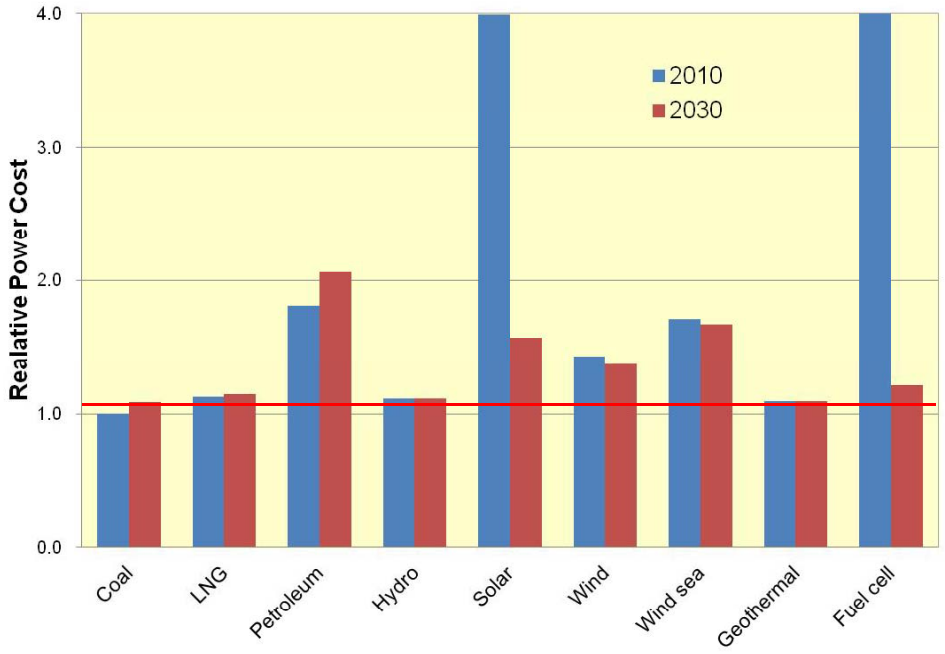
2.3 Fuel Economics in Japan

- In the trial calc of JP government, coal fire's power cost is the lowest. Even if A-USC technology is introduced in 2030, as compared with other power supplies, it is unchanging with coal fire power being cheap.



Source: 'National Policy Unit' in Japan
http://www.npu.go.jp/policy/policy09/pdf/20111221/hokoku.pdf

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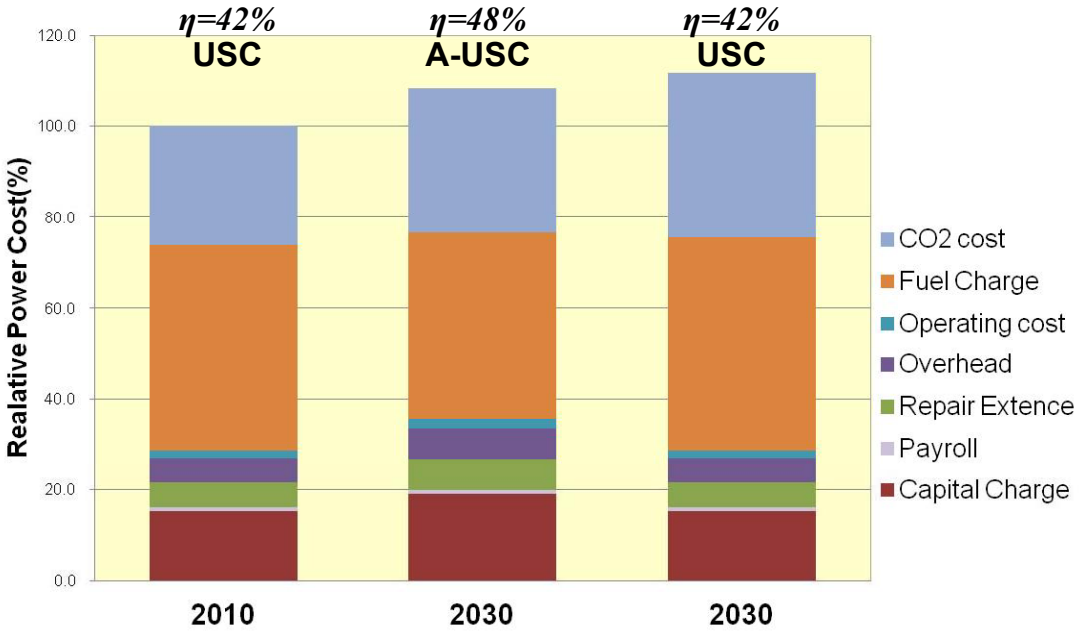
2.4 Power Cost Comparison USC and A-USC

- Even if a construction cost will go up by 25% in 2030, If net efficiency goes up from 42% to 48%, power cost will not increase 10%.
- When USC is adopted in 2030, power cost will be high rather than A-USC.



Source: 'National Policy Unit' in Japan
http://www.npu.go.jp/policy/policy09/pdf/20111221/hokoku.pdf

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2.5 The High Temperature Portion of A-USC System

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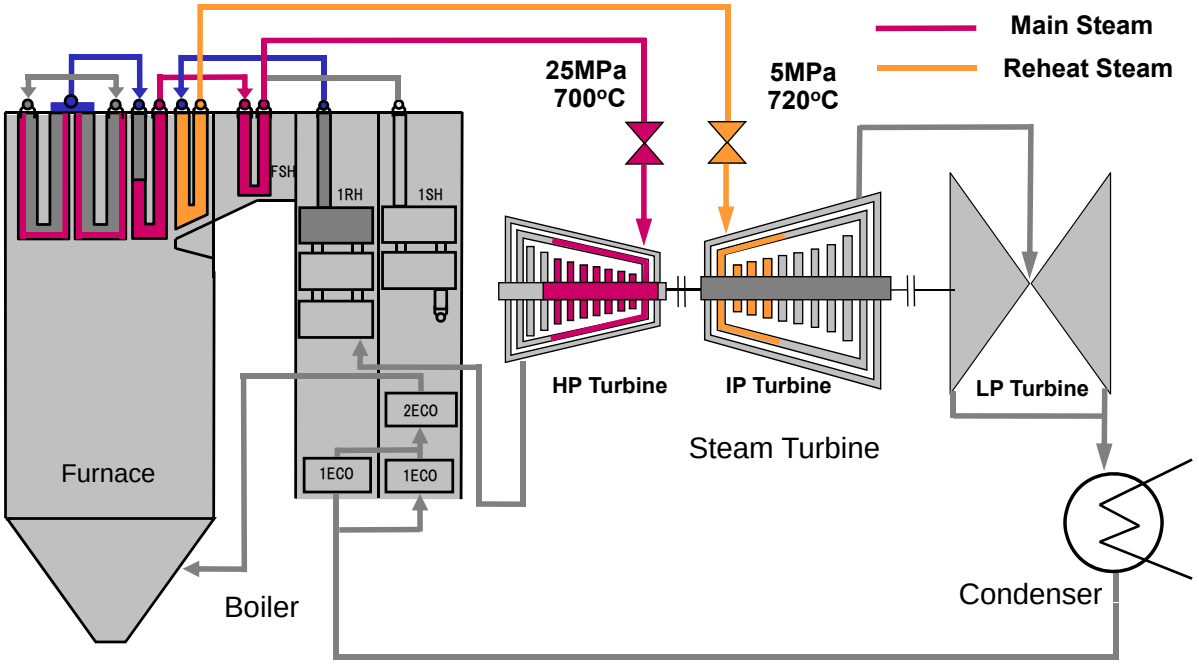
- The portion which raises up power costs are some restricted parts in B&T. Especially a reheat portion has low pressure and there is very little quantity of Ni base alloy.



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2.6 Strategy toward the Realization of A-USC

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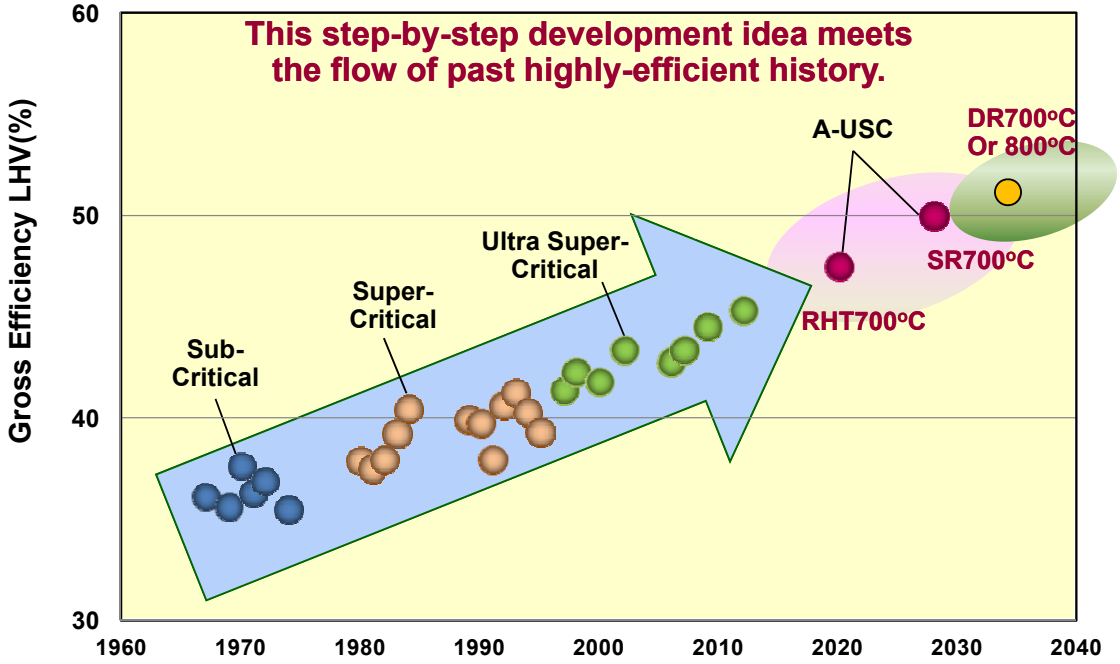
- In order to overcome the subject of reliability and economical efficiency, we provide a market with the system of RHT 700°C with few amounts of application of Ni first.
- Then, if experience of nickel can be gained to some extent in commercial plant, main steam will also perform 700°C application in comfort.



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3.1 700°C class Steam Turbine Material Selection

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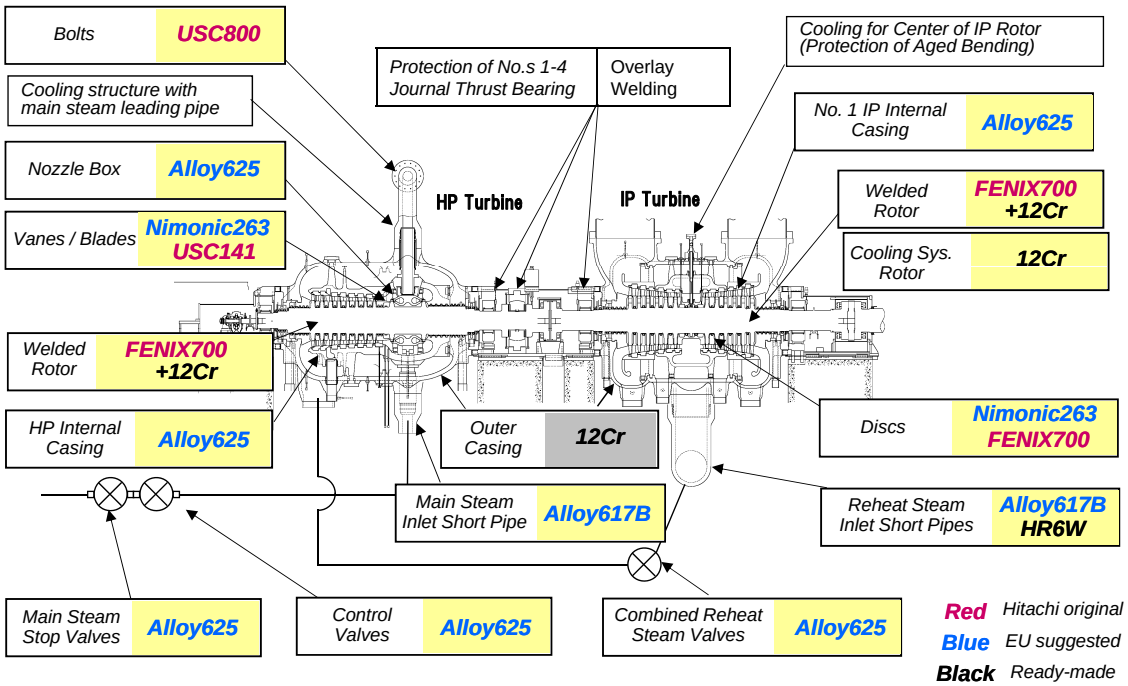
- Selection of the application material of each hot parts of a turbine is already finished.



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3.2 Characteristics of FENIX700 (Rotor material)

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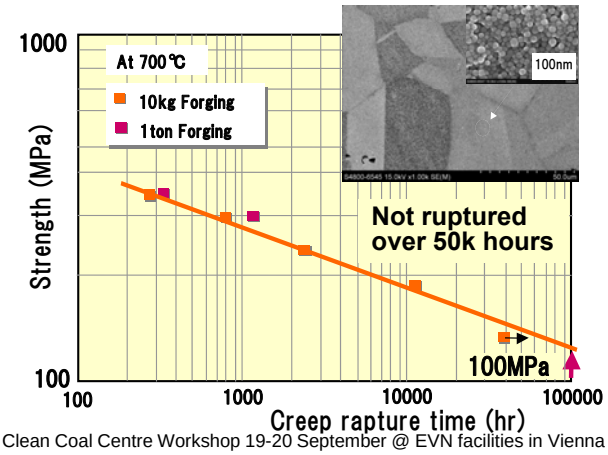
- FENIX700 is a low cost Ni-Fe base super alloy developed for steam turbine rotors.

Large-scale, forged manufacturing; 12.5ton forging

High creep rapture strength; over 100MPa @ 700°C-10^5h

Low cost; 2/3 of typical Ni base super-alloy

The most important strengthening mechanism 'gamma prime' is confirmed.



12.5ton forging for turbine rotor

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3.3 Characteristics of USC141 (Blades, Bolts & Tube)

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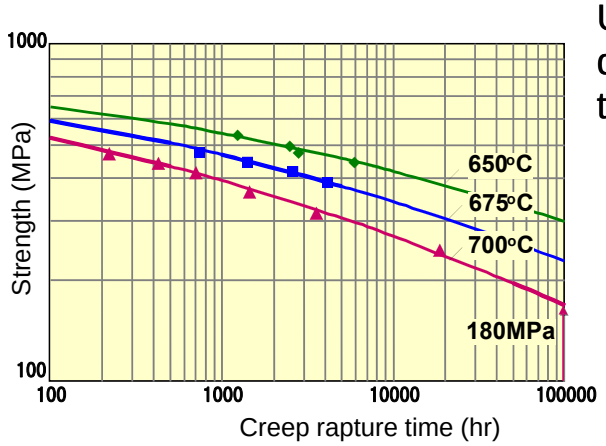
- USC141 is a high strength Ni base super alloy developed for steam turbine blades and bolts.

Low thermal expansion; CTE(RT-700℃)=approx.14 × 10^{-6}/℃

High creep rapture strength; over 180MPa @ 700°C-10^5h

High reduction of area after creep-ruptured : over 30%



USC141 can be applied to boiler tubes due to high creep strength as solution treated condition.

Qualification of USC141 for boiler tubes is ongoing.

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3.4 700°C class Boiler Material Selection

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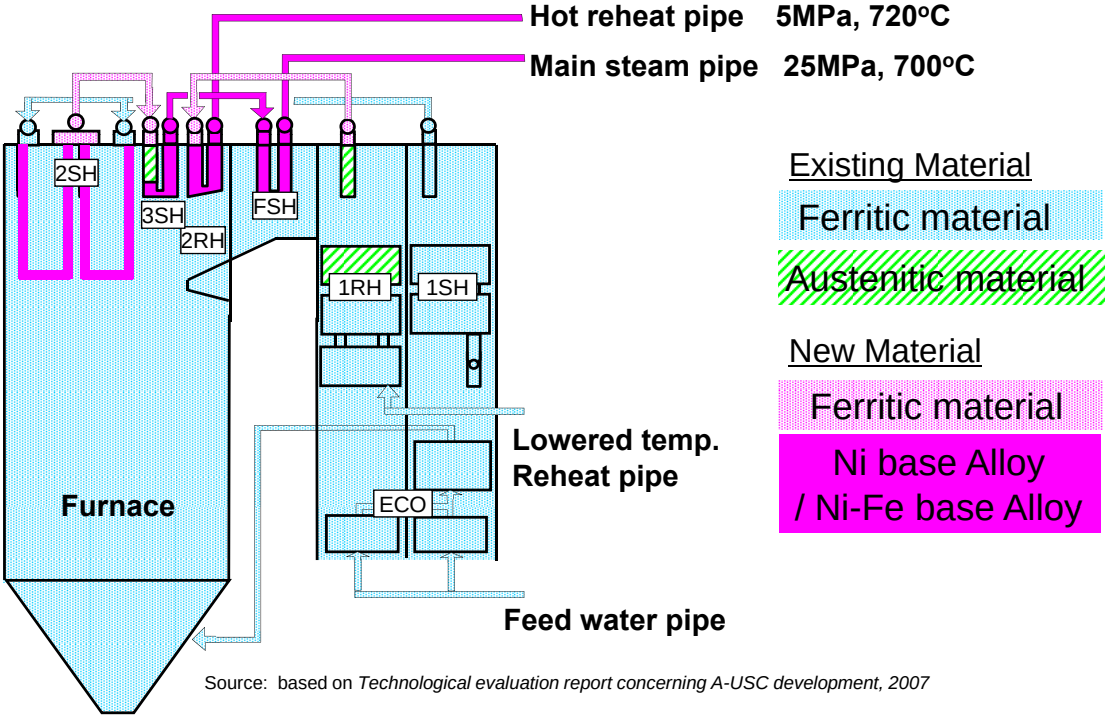
- Application of the Ni base alloy is intended to the high temperature heat exchanger tube and the high-temperature piping.



Source: based on *Technological evaluation report concerning A-USC development, 2007*

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3.5 Boiler development in Japan by BHK

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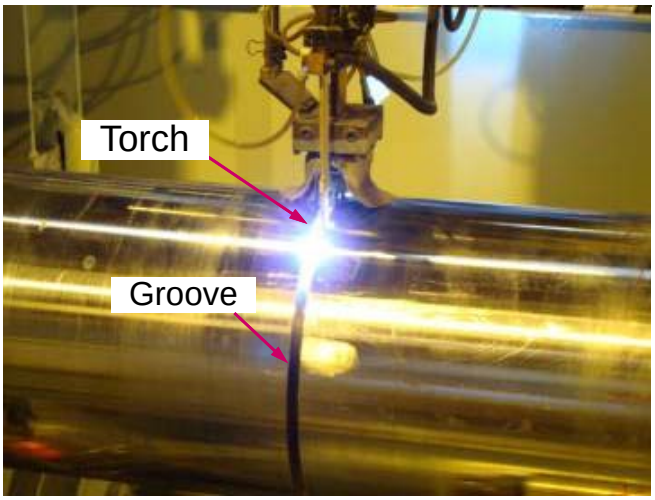
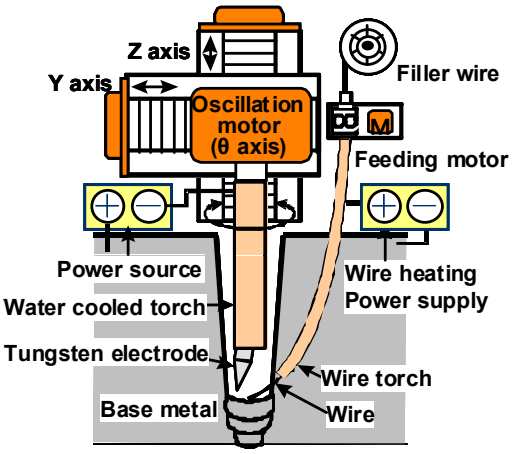
- The welding technique of the pipe made by the Ni base alloy is an essential part of the boiler construction.



Welding examination for candidate materials



Narrow gap welding with HST* method

*** Hot Wire Switching TIG**

Source: based on The156th ISIJ Meeting, 2008

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4 Summary

- **The development of 700°C class USC started in 2008. Practical use is a target as for 2020. However, it makes an effort to moving up development considering carbon dioxide problem.**

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