ULTRA SUPERCRITICAL BOILERS

K.C. RAO
Date 05\textsuperscript{th} Mar, 2013
INTRODUCTION TO L&T- MHI BOILERS
L&T-MHI Boilers (LMB)

L&T 51% 
Larsen & Toubro Ltd., India

MHI 49% 
Mitsubishi Heavy Industries, Japan

L&T-MHI Boilers Pvt. Ltd. Incorporated

More than 2000 Employees

Complete Technology Transfer of Supercritical Boilers to Joint Venture

Apr 18, 2007
Joint Venture Highlights

Product Range: Supercritical Boilers of 500 MW & above (including Pulverizers)

License: Exclusive in India, Non exclusive outside India

Term: 20 years

Technology: Complete Transfer of Technology To JV
Joint Venture Highlights

- Manufacturing Capacity: 4000 MW Equivalent
- Investment: INR 750 Crores
- Training: Extensive Training in Japan
Scope of Business - EPC basis

- Engineering & Designing
- Procurement
- Manufacturing
- Installation
- Commissioning
- After Sales Services
- Renovation & Modernization
- Quality & Safety
- Marketing

Scope of LMB
PROJECT & OFFICE LOCATIONS
Project Sites and Office locations

ENGINEERING & MARKETING OFFICE
FARIDABAD

HEAD OFFICE
VADODARA

FACTORY HAZIRA,
SURAT

PULVERIZER GROUP
POWAI

2 x 700 MW
NPL - RAJPURA

2 x 660 MW
JAYPEE NIGRIE

3 x 660 MW
MAHAGENCO KORADI

ENGINEERING CENTRE,
CHENNAI

BOILER OUTSOURCING
TRICHY

OFFICES
PROJECTS
Projects Under Execution

- Jaypee Nigrie, 2x660 MW
- MahaGenco Koradi, 3x660 MW
- Nabha Power Ltd, Rajpura, 2x700 MW
CONTENTS

1. What is USC Boiler
2. Trends of USC units
3. Supply records of USC
4. Feature of USC Boiler
5. Impact on present SC design
What is USC Boiler?

Subcritical:
Pressure: 16.7 M pa
Temperature: 538/538 Deg-C or 538/560 Deg-C

Supercritical (SC):
Pressure: 24.1 M pa
Temperature: 538/560 Deg-C to 566/593 Deg-C

Ultra Supercritical (USC):
Pressure: 24.1 to 31.0 M pa
Temperature: 593/593 Deg-C to 600/620 deg.c
1. What is USC Boiler
2. Trends of USC units
3. Supply records of USC
4. Feature of USC Boiler
5. Impact on present SC design
Evolution of Steam Pressure & Temperature of Thermal Power Plant in Japan

- **1970**: 24.5 MPag, 566/593°C (Oil)
- **1980**: 24.1 MPag, 538/566°C
- **1990**: 25.0 MPag, 600/610°C (Coal)
- **2000**: 24.1 MPag, 538/538°C (SC)
- **2010**: 25.0 MPag, 600/620°C (USC)
Thermal Efficiency improved by Steam Conditions

Latest Project in India

Note:
The values in diagram are typical HR differences respect to steam pressure and temperature. Actual heat rate may differ and shall be determined based on a given design condition.
### Technoeconomic comparison – Subcritical Vs Supercritical Vs Ultra Supercritical Boilers

**Capacity**: 700 MW  
**Fuel**: Indian coal with 42% ash  
**Fuel GCV**: 3300 kCal/kg

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Subcritical 16.7 M pa 538/538 deg.c</th>
<th>Supercritical 24.1 M pa 566/593 deg.c</th>
<th>Ultra Supercritical 24.1 M pa 600/600 deg.c</th>
<th>Reduction Sub Vs SC</th>
<th>Reduction Sub Vs USC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine Heat rate</td>
<td>kCal / kWh</td>
<td>1918</td>
<td>1838</td>
<td>1814</td>
<td>80(4.2%)</td>
<td>104(5.5%)</td>
</tr>
<tr>
<td>Boiler efficiency</td>
<td>%</td>
<td>87%</td>
<td>87%</td>
<td>87%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Plant heat rate</td>
<td>kCal / kWh</td>
<td>2207</td>
<td>2113</td>
<td>2085</td>
<td>94(4.2%)</td>
<td>121(5.5%)</td>
</tr>
<tr>
<td>Coal consumption</td>
<td>MM T/Annum</td>
<td>3.676</td>
<td>3.524</td>
<td>3.477</td>
<td>0.152(4.2%)</td>
<td>0.199 (5.5%)</td>
</tr>
<tr>
<td>Ash Generation</td>
<td>MM T/Annum</td>
<td>1.544</td>
<td>1.48</td>
<td>1.46</td>
<td>0.064(4.2%)</td>
<td>0.084 (5.5%)</td>
</tr>
<tr>
<td>CO₂</td>
<td>MM T/Annum</td>
<td>7.278</td>
<td>6.981</td>
<td>6.888</td>
<td>0.297(4.2%)</td>
<td>0.39 (5.5%)</td>
</tr>
<tr>
<td>SOx</td>
<td>MM T/Annum</td>
<td>0.0230</td>
<td>0.0221</td>
<td>0.0218</td>
<td>0.0009(4.2%)</td>
<td>0.0012 (5.5%)</td>
</tr>
</tbody>
</table>

* Calculation with 90% PLF
**Technoeconomic comparison – Subcritical Vs Supercritical**

**Fuel**: Indian coal with 42% ash and GCV of 3300kCal/kg

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>700 MW SUBCRITICAL VS SUPERCRITICAL IN CRORES</th>
<th>700 MW SUBCRITICAL VS SUPERCRITICAL IN CRORES</th>
<th>700 MW SUBCRITICAL VS SUPERCRITICAL IN CRORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAL COST</td>
<td>1500 RS/TON</td>
<td>2000 RS/TON</td>
<td>2500 RS/TON</td>
</tr>
<tr>
<td>Reduction in Coal cost per annum</td>
<td>22.8</td>
<td>30.4</td>
<td>38</td>
</tr>
<tr>
<td>Carbon credit benefit per annum @10Euro/MT (1Euro= Rs.60)</td>
<td>17.8</td>
<td>17.8</td>
<td>17.8</td>
</tr>
<tr>
<td>Total cost benefit per annum</td>
<td>40.6</td>
<td>48.2</td>
<td>55.8</td>
</tr>
<tr>
<td>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs SC) COAL COST</td>
<td>301</td>
<td>402</td>
<td>502</td>
</tr>
<tr>
<td>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs SC) COAL COST &amp; CDM BENEFIT</td>
<td>537</td>
<td>637</td>
<td>737</td>
</tr>
</tbody>
</table>
Technoeconomic comparison – Subcritical Vs Ultra Supercritical

**Fuel**: Indian coal with 42% ash and GCV of 3300kCal/kg

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>700 MW SUBCRITICAL VS ULTRA SUPERCritical IN CRORES</th>
<th>700 MW SUBCRITICAL VS ULTRA SUPERCritical IN CRORES</th>
<th>700 MW SUBCRITICAL VS ULTRA SUPERCritical IN CRORES</th>
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<tr>
<td>COAL COST</td>
<td>1500 RS/TON</td>
<td>2000 RS/TON</td>
<td>2500 RS/TON</td>
</tr>
<tr>
<td>Reduction in Coal cost per annum @10Euro/MT (1Euro= Rs.60)</td>
<td>29.8</td>
<td>39.8</td>
<td>49.8</td>
</tr>
<tr>
<td>Carbon credit benefit per annum</td>
<td>23.4</td>
<td>23.4</td>
<td>23.4</td>
</tr>
<tr>
<td>Total cost Benefit per annum</td>
<td>53.2</td>
<td>63.2</td>
<td>73.2</td>
</tr>
<tr>
<td>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs USC) COAL COST</td>
<td>394</td>
<td>526</td>
<td>658</td>
</tr>
<tr>
<td>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs USC) COAL COST &amp; CDM BENEFIT</td>
<td>703</td>
<td>835</td>
<td>967</td>
</tr>
</tbody>
</table>
## Technoeconomic Comparison – Supercritical Vs Ultra Supercritical

**Fuel:** Indian coal with 42% ash and GCV of 3300kCal/kg

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>700 MW SUPERCritical VS ULTRA SUPERCRITICAL IN CRORES</th>
<th>700 MW SUPERCRITICAL VS ULTRA SUPERCRITICAL IN CRORES</th>
<th>700 MW SUPERCRITICAL VS ULTRA SUPERCRITICAL IN CRORES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COAL COST</strong></td>
<td>1500 RS/TON</td>
<td>2000 RS/TON</td>
<td>2500 RS/TON</td>
</tr>
<tr>
<td><strong>Reduction in Coal cost per annum</strong></td>
<td>7.05</td>
<td>9.4</td>
<td>11.75</td>
</tr>
<tr>
<td><strong>Carbon credit benefit per annum @10Euro/MT (1Euro= Rs.60)</strong></td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Total cost benefit per annum</strong></td>
<td>12.55</td>
<td>14.9</td>
<td>17.25</td>
</tr>
<tr>
<td><strong>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs USC) COAL COST</strong></td>
<td>93</td>
<td>124</td>
<td>155</td>
</tr>
<tr>
<td><strong>NPV considering plant life of 30 years with 5% escalation in coal cost (Sub Vs USC) COAL COST &amp; CDM BENEFIT</strong></td>
<td>166</td>
<td>197</td>
<td>228</td>
</tr>
</tbody>
</table>
1. What is USC Boiler
2. Trends of USC units
3. Supply records of USC
4. Feature of USC Boiler
5. Impact on present SC design
MHI Reference List of USC Boilers

- MHI/LMB has adequate experience for over 600/600 boiler.

<table>
<thead>
<tr>
<th>Customer Station</th>
<th>MW</th>
<th>Steam Condition (°C)</th>
<th>Fuel</th>
<th>C/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soma Joint EPCO Shinchi #2</td>
<td>1,000</td>
<td>538/566</td>
<td>Coal</td>
<td>1995</td>
</tr>
<tr>
<td>Tohoku EPCO Haramachi #1</td>
<td>1,000</td>
<td>566/593</td>
<td>Coal</td>
<td>1997</td>
</tr>
<tr>
<td>Chugoku EPCO Misumi #1</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>1998</td>
</tr>
<tr>
<td>Hokuriku EPCO Tsuruga #2</td>
<td>700</td>
<td>593/593</td>
<td>Coal</td>
<td>2000</td>
</tr>
<tr>
<td>Kyusyu EPCO Reihoku #2</td>
<td>700</td>
<td>593/593</td>
<td>Coal</td>
<td>2003</td>
</tr>
<tr>
<td>Kansai EPCO Maizuru #1</td>
<td>900</td>
<td>595/595</td>
<td>Coal</td>
<td>2004</td>
</tr>
<tr>
<td>Tokyo EPCO Hirono #5</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>2004</td>
</tr>
<tr>
<td>China Yuhuan (4 units)</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>2006</td>
</tr>
<tr>
<td>China Taizhou (2 units)</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>2007</td>
</tr>
<tr>
<td>PJ in China (15 units)</td>
<td>600, 660</td>
<td>600/600</td>
<td>Coal</td>
<td>2007~</td>
</tr>
<tr>
<td>China Jinling (1 units)</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>2009</td>
</tr>
<tr>
<td>China Chaozhou (2 units)</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>2010</td>
</tr>
<tr>
<td>Projects in India (11 units)</td>
<td>660, 700</td>
<td>565/593</td>
<td>Coal</td>
<td>(2013~)</td>
</tr>
</tbody>
</table>
MHI Reference List of USC Turbines

- MHI/LMTG has plenty of experience for over 600/600 steam turbines.

<table>
<thead>
<tr>
<th>Customer Station</th>
<th>MW</th>
<th>Steam Condition (°C)</th>
<th>Fuel</th>
<th>C/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chubu EPCO Hekinan #3</td>
<td>700</td>
<td>538/593</td>
<td>Coal</td>
<td>1993</td>
</tr>
<tr>
<td>Hokuriku EPCO Nanao-Ota #1</td>
<td>500</td>
<td>566/593</td>
<td>Coal</td>
<td>1995</td>
</tr>
<tr>
<td>EPDC Matsuura #2</td>
<td>1,000</td>
<td>593/593</td>
<td>Coal</td>
<td>1997</td>
</tr>
<tr>
<td>Chugoku EPCO Misumi #1</td>
<td>1,000</td>
<td>600/600</td>
<td>Coal</td>
<td>1998</td>
</tr>
<tr>
<td>EPDC Tachibanawan #2</td>
<td>1,050</td>
<td>600/610</td>
<td>Coal</td>
<td>2000</td>
</tr>
<tr>
<td>Kansai EPCO Maizuru #1</td>
<td>900</td>
<td>595/595</td>
<td>Coal</td>
<td>2004</td>
</tr>
<tr>
<td>Tokyo EPCO Hirono #5</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>2004</td>
</tr>
<tr>
<td>China Yingkou (2 units)</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>2007</td>
</tr>
<tr>
<td>China Kanshan (2 units)</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>2008</td>
</tr>
<tr>
<td>China Heyuan (2 units)</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>2009</td>
</tr>
<tr>
<td>ENEL Torrevaldaliga Nord (3 units)</td>
<td>678</td>
<td>600/610</td>
<td>Coal</td>
<td>2009</td>
</tr>
<tr>
<td>XCEL Comanche #3</td>
<td>830</td>
<td>566/593</td>
<td>Coal</td>
<td>2010</td>
</tr>
<tr>
<td>Tokyo EPCO Hirono #6</td>
<td>600</td>
<td>600/600</td>
<td>Coal</td>
<td>(2013)</td>
</tr>
<tr>
<td>Korea EWP Danjin (2 units)</td>
<td>1000</td>
<td>600/600</td>
<td>Coal</td>
<td>(2015/6)</td>
</tr>
</tbody>
</table>
Chubu EPCO Misumi #1

Turn Key 1000MW Coal-Fired Supercritical Plant including Major BOPs
Customer: Chugoku Electric Power Company

- MAJOR SPECIFICATIONS
  - CUSTOMER: Chugoku EPCO
  - COMMERCIAL OPERATION: 1998.06.30
  - CAPACITY: 1000MW
  - STEAM CONDITION: 24.5MPa x 600/600degC
  - STEAM TURBINE: Cross Compound
  - BOILER MCR: 2,900t/h
  - FUEL: Coal
  - BOP: FGD, SCR, EP

- SCOPE OF MHI
  BOILER, TURBINE-GENERATOR, DCS, EP, FGD, SCR, COAL HANDLING SYS., ERECTION, COMMISSIONING
Kansai EPCO Maizuru #1

Turn Key 900MW Coal-Fired Supercritical Plant
Customer: Kansai Electric Power Company

MAJOR SPECIFICATIONS
- CUSTOMER : Kansai EPCO.
- COMMERCIAL OPERATION : 2004.08.12
- CAPACITY : 900MW
- STEAM CONDITION : 24.5MPa x 595/595degC
- BOILER MCR : 2,570 t/h
- FUEL : Coal
- STEAM TURBINE : Cross Compound, 4 Exhaust Flows

-SCOPE OF MHI
BOILER, TURBINE-GENERATOR, DCS, SCR, ERECTION, COMMISSIONING
# Tokyo EPCO Hirono #5

## Turn Key 600MW Coal-Fired Supercritical Plant
**Customer: Tokyo Electric Power Company**

<table>
<thead>
<tr>
<th>MAJOR SPECIFICATIONS</th>
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</thead>
<tbody>
<tr>
<td>CUSTOMER</td>
</tr>
<tr>
<td>COMMERCIAL OPERATION</td>
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<tr>
<td>CAPACITY</td>
</tr>
<tr>
<td>STEAM CONDITION</td>
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<tr>
<td></td>
</tr>
<tr>
<td>BOILER MCR</td>
</tr>
<tr>
<td>FUEL</td>
</tr>
<tr>
<td>STEAM TURBINE</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

- **SCOPE OF MHI**
  - BOILER, TURBINE-GENERATOR, DCS, EP, FGD, SCR, ERECTION, COMMISSIONING

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Image: Tokyo EPCO Hirono #5 Power Plant

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**KCR | March 05, 2013**
1. What is USC Boiler
2. Trends of USC units
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4. Feature of USC Boiler
5. Impact on present SC design
Features of MHI USC Coal-Fired Boiler

[1] Water Wall
*Vertical with rifled tubes*

[2] High Steam Temperature
*600 / 600deg-C class*
*High Temp. Resistant Material (18Cr-25Cr Austenitic Steel)*


[4] Low NOx system
*A-PM burner*
*A-MACT*
*Rotary Separator Pulverizer*
Design Feature of Mitsubishi Twin fire-vortices design

- No Final SH out temp. imbalance
  - Controlled by each side SH spray

- No Final RH out temp. imbalance
  - Controlled by each side damper

- No criss-cross arrangement
  - One internal link / header per a fire voltex

- Lower heat input per each burner
  - Heat input is half of single fire-voltex
## History of Tube Material MHI Field Test for Supercritical Boilers

<table>
<thead>
<tr>
<th>Material</th>
<th>'80</th>
<th>'85</th>
<th>'90</th>
<th>'95</th>
<th>'00</th>
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<tbody>
<tr>
<td>SA213T23</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>2.25Cr 0.1Mo 1.6W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCM9M</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>9Cr 2Mo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA213T91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9Cr 1Mo</td>
<td></td>
<td></td>
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<tr>
<td>HCM12</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>12Cr 1Mo 1W</td>
<td></td>
<td></td>
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<tr>
<td>HCM12A (Code Case 2180)</td>
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</tr>
<tr>
<td>11Cr 0.4Mo 1.9W</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Super 304 (code Case 2328)</td>
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</tr>
<tr>
<td>18Cr 10Ni 3Cu</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HR3C (SA213TP310HCBN)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>25Cr 20Ni Nb</td>
<td></td>
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</tr>
</tbody>
</table>

- **Factory Test**
- **Actual Boiler Test**
- **Practical Use**

KCR | March 05, 2013
Ultra Supercritical Sliding Pressure Boiler
High Temperature Resistant Material

- MHI has, in association with the tubes and pipes manufacturers, strived to continuously develop new grades of materials for use in high temperature applications.
- Improved creep and fatigue resistance suitable for cyclic operations.
- High strength in high temperature zone
- Use of advanced materials such as
  - Code Case 2115 25Cr Austenitic
  - Code case 2328 18Cr Austenitic
  - SA-213T92 and SA-335P92 9Cr Ferrite
  - Code Case 2199 (SA-213T23) 2 1/4Cr Ferrite
## Ultra Supercritical Sliding Pressure Boiler High Temperature Resistant Material

<table>
<thead>
<tr>
<th></th>
<th>Superheater</th>
<th>Reheater</th>
<th>Eco.</th>
<th>WW</th>
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<tbody>
<tr>
<td></td>
<td>3rd SH</td>
<td>2nd SH</td>
<td>1ry SH</td>
<td>2nd RH</td>
</tr>
<tr>
<td>25Cr 18Cr</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Code Case 2115 Code Case 2328 SA213TP347H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9Cr</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>SA213T91(unheated zone)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.25Cr</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
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<td>SA213T22</td>
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KCR | March 05, 2013
Ultra Supercritical Sliding Pressure Boiler
High Temperature Resistant Material
History of Mitsubishi Low NOx Combustion Technology

- Continuous Improvement following Japanese Regulation.
CCF: Circular Corner Firing

- High Ignitability and Combustibility
- High Occupation rate of Fire Vortex in Furnace
- Uniform Heat Flux Distribution

Means...
- Low NOx & Unburnt Carbon
- High Efficiency
- Good Operability
- Low Slagging Tendency

Laminar Air Injection

KCR | March 05, 2013
Low NOx PM Burner: Pollutant Minimum

- Coal flame composed by
  Conc: Fuel Rich ⇒ Good Ignition
  Weak: Fuel Lean ⇒ Moderate Combustion

- Divided flame achieves simultaneously;
  - Stable Ignition and Combustion
  - Low NOx Combustion
LMB Firing system
Low NOx Burners (PM burners)

- High ignitiability even under low-O2 condition
- Application for all solid fuel (incl. low combustive fuel)

PM : Pollution Minimum
MACT: Mitsubishi Advanced Combustion Technology (In-furnace NOx Removal System)

[Advantages of MACT]

- No additional cost of Ammonia Injection or Catalyst.
- No emission of Substance Matter
- No change of Boiler Efficiency and Flue Gas Flow
- Stable and Reliable Combustion in Furnace
- Applicable to all fossil fuels, Gas, Oil, Coal, etc.

Concept of NOx Reduction
LMB Firing system
MACT system -in-furnace DeNOx-

Cn''Hm''+O₂ → CO₂+H₂O
Cn'Hm'+O₂ → CO₂+H₂O
CO+H₂+O₂ → CO₂+H₂O
NH₃+O₂ → NO+N₂

Additional Air
CnHₘ+O₂ → H₂+CO₂+Cn’Hm’
Cn’Hm’+NO → NH₃+N₂+Cn''Hm''

Main Burner
CnHₘ+O₂ → CO₂+H₂O
N+O₂ → NO

Furnace Outlet
Combustion Completion Zone
Reductive DeNOx Zone
Main Burner Combustion Zone

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MRS Mill: Mitsubishi Rotary Separator
(High Performance Vertical Mill)

- Effective Classification of Coarse Particles

↓

Good Ignition & Combustion

Recirculation of Coarse Particles

Roller

Hydraulic Loading Device

Grinding Table

Raw Coal → Pulverized Coal → Hot Air → Rotary Separator

Fixed Separator Pulverizer

MRS Pulverizer

Residue on 100Mesh (% [about 149μm]) vs Thru. 200Mesh (% [about 74μm])
1. What is USC Boiler
2. Trends of USC units
3. Supply records of USC
4. Feature of USC Boiler
5. Impact on present SC design
Boiler Design for USC 600/600

➢ To meet with the elevated steam condition from present 566/593 to 600/600, following design change is required. It can be modified based on our existing design.

Modified Point of 600/600 Case

3SH <Tube>
• Increase the No. of tubes
• Tube material is same

3SH <Outlet HDR>
• Increase diameter
• Header material is same

2RH <Tube>
• Increase the No. of tubes
• Tube material is same

2RH <Outlet HDR>
• Increase thickness
• Header diameter is same
• Header material is same
What next to Ultra Super Critical
What Next to Super Critical

**Efficiency improvement**

ADVANCED ULTRA SUPERCRITICAL TECHNOLOGY
- With pressures up to 30 MPa & Temperatures 700 / 700 Deg.C
- Cycle efficiency up to 50% on LHV basis

INTEGRATED GASIFICATION COMBINED CYCLE (IGCC)
- Using super high temperature GTs (1700 deg. c class)
- Cycle efficiency up to 55% on LHV basis
What Next to Super Critical

**Emission improvement**

**ADVANCED ULTRA SUPERCritical TECHNOLOGY**

- Cumulative CO2 emissions reduction by 20-25 %
- By using OXY fuel combustion  CO2 emissions reduction by 90%
- Reduction of Sox, Nox & SPM levels proportional to Eff. Improvement

**INTEGRATED GASIFICATION COMBINED CYCLE (IGCC)**

- Cumulative CO2 emissions reduction by 25-30%
- By using Pre combustion recovery method  CO2 emissions reduction by 90%
- Reduction of Sox, Nox & SPM levels  to 4-5 PPM
# What Next to Super Critical

## CO2 Reduction Roadmap for Coal-fired Power Generation

<table>
<thead>
<tr>
<th>Classification</th>
<th>Item</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
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<tr>
<td>Efficiency improvement</td>
<td>USC (600° C-class)</td>
<td>Material development</td>
<td>Verification test for a boiler</td>
<td>700–1000 MW (600–610° C)</td>
<td>500–650 MW</td>
<td>Commercial 600 MW-class (US/EU)</td>
<td>Commercial 800–1000 MW-class</td>
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<tr>
<td></td>
<td>IGCC</td>
<td>300 MW-class demonstration (US/EU)</td>
<td>Pilot 200 t/d</td>
<td></td>
<td>Commercial 500–650 MW</td>
<td>Commercial 800–1000 MW-class</td>
<td>Commercial</td>
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<tr>
<td></td>
<td>A-USC (700° C-class)</td>
<td>Material development</td>
<td>Verification test for a boiler (Germany)</td>
<td>500 MW</td>
<td>Commercial 500–650 MW</td>
<td>Commercial 800–1000 MW-class</td>
<td>Commercial</td>
</tr>
</tbody>
</table>

**CO₂ Recovery**

- IGCC fuel gas (Pre-combustion)
  - Commercial for chemical plants (2700)
  - Demonstration (Japan)
  - Demonstration (Australia, etc.)
  - Commercial 700 MW (10,000)

- Coal fired - boiler flue gas (Post-combustion)
  - Pilot (100 t/d)
  - Verification test for a boiler
  - Commercial (3,000–5,000)
  - Commercial (Germany) 300 MW (6,000)
  - Commercial (Australia) 30 MW (75)
  - Demonstration (Canada) 180 MW

### Notes:
- Basic R&D, Demonstration, Commercial
- Recovered and stored CO₂ volumes (t-CO₂/d) are in parentheses.
- FEED: Front End Engineering Design
- Solid lines show technology trends outside of Japan
- IGCC could be widely and practically used by 2020.

**Source:** From MHI Technical review
Advantages of A-Ultra Super Critical Technology

Increase in plant Efficiency:

<table>
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<tr>
<th>Type</th>
<th>Parameter</th>
<th>Efficiency LHV BASIS</th>
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<tr>
<td>Sub Critical</td>
<td>16.6MPa /538 /538°C</td>
<td>38-40%</td>
</tr>
<tr>
<td>Super Critical</td>
<td>24 MPa / 566 /593°C</td>
<td>40-42%</td>
</tr>
<tr>
<td>Ultra Super Critical</td>
<td>25~30 MPa /600 /620°C</td>
<td>43-46%</td>
</tr>
<tr>
<td>A-Ultra Super critical</td>
<td>25~30 MPa /700 /700°C</td>
<td>46-50%</td>
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Lesser emissions:
These increases in plant efficiency can reduce CO2 emissions by a ratio of 2 to 1 (i.e. a one percentage point increase in efficiency reduces emissions by around two percent). Improved efficiencies also reduce the level of other pollutants and overall fuel use.