CCT 2009
Fourth International Conference on Clean Coal technologies
18 -21 May 2009

Pre-Engineering Study for a 700 deg C high efficient PC-Power Plant
Pre-Engineering Study NRWPP700

Step by Step Power Plant Development

VGB E_{max} - Initiative
Enhancement of Efficiency
Ecological compatible
Cost effective and Reliable

Long term Option
of CO_{2}-Separation
and -Storage

Reference Power Plant
600/620 °C

Test Facility
COMTES700

700 °C

Component

Demo-Plant
700 °C

R&D Programme:

EU: Thermie, AD 700, FP 6, FP 7
DE: KOMET 650, COORETEC, e. a.

time
Pre-Engineering Study NRWPP700

Steering Committee
E.ON Energie AG (DE), Electricité de France (FR), Electrabel European Generation (BE), EnBW Kraftwerke AG (DE), EVN AG (AS), DONG Energy Generation (DK), RWE Power AG (DE), STEAG AG (DE), Vattenfall Europe Mining & Generation AG & Co. KG (DE), Vattenfall A/S Nordic Generation (DK) & Funds of State North Rhine-Westphalia & EU (ERDF)

Funding

Project Coordination

Overall Plant Layout
Kjaer, DONG

Overall Plant Design and BoP

Concept Master Cycle

Boiler Island
Götte, RWE

Boiler Island

Basic Boiler Design

Membran Wall Arr.

Detailed Boiler Design

Material and Manufacturing Issues

Material Interferences

Boiler Scale

Boiler & Plant Design Transfer to Lignite

Turbine Island
Viennot, EdF

Turbine Island

HP Turbine

IP Turbine

Turbine Scale-up

CO₂ Capture
Tschaffon, RWE

CO₂ Capture

Contractor

Working Groups (60 GEN.-Experts)
Pre-Engineering Study NRWPP700

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DONG Energy
Concept
Master Cycle
Different Boiler Variants - Basic Engineering Phase

- **Alstom Power Boiler**
  High Pressure Cycle (350 /705 /720)

- **Hitachi Power Europe**
  Interm. Pressure Cycle (250 /705 /720)

- **Burmeister & Wain**
  Master Cycle (350 /705 /720)
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- $p = 85 \text{ bar}$
- $t = 443 \text{ C}$
- $t_s = 299 \text{ C}$

- $p = 17 \text{ bar}$
- $t = 234 \text{ C}$
- $t_s = 203 \text{ C}$

- $-31.4\%$
- $-12.04\%$
General Boiler Arrangements

Alstom

High Pressure Cycle
365 bar / 705°C
71 bar / 720°C

Interm. Pressure Cycle
260 bar / 705°C
66 bar / 720°C

Master Cycle
365 bar/702°C
111 bar/720°C
25 bar/720°C

Hitachi

Burmeister & Wain
Furnace Design

Key Figures Furnace Design

- 14m x 14m
  - 34.6 m

- 15m x 15m
  - 42 m

- 13m x 13m
  - 47 m
Cycle Calculation

Efficiency regarding different live steam and reheat pressures

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<th>Live Steam Pressure</th>
<th>RH Steam Pressures</th>
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Net efficiency depending on feed-water temperature and reheating pressure

Boiler Inlet Temperature

RH Pressure

Net efficiency [%]

50,1-50,2
50-50,1
49,9-50
49,8-49,9
49,7-49,8
49,6-49,7
49,5-49,6
49,4-49,5
49,3-49,4
49,2-49,3

Cycle Calculation
Measures for Efficiency Enhancement

- Temperature to 700°C: 2.2
- Starting process 600°C: 0.8
- Increase of live steam pressure: 0.2
- Increase of boiler inlet temperature: 0.7
- Vacuum of condenser: 0.4
- Steam generator: 0.4
- Low temperature heat displacement: 0.4
- High temperature heat displacement: 0.1
- Other: 0.1
Intermediate Pressure Cycle
(260 bar / 705°C / 720°C)

η < 49 %
Master Cycle
(365 bar/ 702°C / 720°C /720°C)

η > 50 %
High Pressure Cycle
(365 bar/ 705°C / 720°C)

η > 50 %
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Call for Tender (HPC)
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Alstom Power Systems
Basic Design 500 MW

Detail Design 500 MW
Pre-Engineering Study NRWPP700

Design 500 MW

Design 1000 MW

Design 1000 MW
Material Concept 700°C Boiler

Heating Surface
- 13 CrMo 45
- 10 CrMo 910 T91
- S 304 B SB
- HR3C Alloy 617 m
- HR3C Sanicro 25
- Alloy 617 m
- Alloy 617 m
- Alloy 617 m
- Alloy 740
- Sanicro 25

Header
- ECO: WB36 (in/out)
- RH1: 13 CrMo 45 Alloy 617 m (in/out)
- SD 3: Alloy 617 m (in/out)
- RH 2: Alloy 617 m (in/out)
- SH 4: Alloy 617 m Alloy 263 (in/out)
- SH 2: P 92 Alloy 617 m (in/out)
Example Temperature Distribution
Example Stress Distribution
Example Insulation

Isolierung bei Dampftemperatur Tm=600°C

**Stützkonstruktion**

AL-Ummantelung 1mm
2 x 100 mm MW RT02
30 mm MW RT02
2 x 25 mm Insulfrax 98

Gewicht: 71 kg/m
Oberflächentemperatur: 53°C
Wärmestromdichte: 146 W/m²
Kosten: ca. 650 €/m

Isolierung bei Dampftemperatur Tm=720°C

**Stützkonstruktion**

AL-Ummantelung 1mm
3 x 80 mm MW RT02
2 x 50 mm Insulfrax 98

Gewicht: 102 kg/m
Oberflächentemperatur: 56°C
Wärmestromdichte: 150 W/m²
Kosten: ca. 750 €/m
Example Insulation
Example Pipe Routing to Turbine
Steam Turbine Technology Development

Alstom Power Generation

Siemens Power Generation
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New WP
Qualification Alloy 740
Q. thick Wall Alloy 617
Q. cent. casted Alloy 617
HP- Turbine Design

- Cooling Steam: ~330 bar / 550°C
- Live Steam: 360 bar / 700°C
- Exhaust Steam: 75 bar
Ongoing Material Qualification Projects

• Manufacturing of test melts of unqualified materials
• Determination of the material characteristics
• Investigation of the manufacturing procedures
• Preparation of green bodies
• Preparation of pilot components
• Testing of pilot components
• Creation of material engineering standards
HP- and IP- Valve Development

Quelle: Siemens
HP- Valve Development (AD 700-2)

Alloy617

Cast weight: 6t
Finished: 3t

Alloy625
Development Alloy 617 Centrifugal Casted Pipe

Schmidt + Clemens GmbH + Co.KG
Edelstahlwerk Kaiserau
51789 Lindlar
Average Worldwide

EU

State-of-the-art Technology

Steam power plant 700°C-Technology

CO2 - Reduction

Efficiency*)

CO2-Emissionens

Fuel Consumption

2005

2010

2020

Time

*) Average data for hard coal fired power plants

VGB PowerTech e.V.

- 21%

- 33%

- 40%

- 90%

But: Efficiency loss 7-12% points

VGB PowerTech e.V.
First 700°C Demonstration Project

Fuel: Hard Coal
Capacity: 550 MW
Efficiency: > 50 %
Start up: 2015
Location: Wilhelmshaven
Source: E.ON