Skoda Supercritical Steam Turbine 660 MW

Jiri Fiala
Head of Engineering Dept.
Skoda Power s.r.o.

27th of October 2010
Vrnjacka Banja - Serbia
Establishment of the company in 1859

Mr. Emil Škoda, founder of Škoda Works
First steam turbine produced by ŠKODA Works in 1904

Eminent personalities in the history of ŠKODA steam turbines

Prof. Auguste Rateau

Prof. Aurel Stodola
• 1904 - First steam turbine 550 HP system Rateau
• 1911 - Turbines or the Rateau system were replaced by turbines of ŠKODA’s own design
• 1932 - Two 23 MW steam turbines with steam reheating
• 1959 - Turboset 110 MW
• 1966 - Turboset 200 MW
• 1976 - Turboset 220 MW for nuclear power plant
• 1978 - Turboset 500 MW
• 1992 - Turboset 1000 MW for nuclear power plant
• 2007 - USC unit 660 MW for Ledvice Power Plant
• 2009 - Company Doosan Heavy Industries & Construction has completed the acquisition ŠKODA POWER s.r.o. and established ŠKODA POWER s.r.o., A Doosan company
ULTRASUPERCritical Units
Comparison of parameters

- Vacuum: 0.045 bar
- 167 bar: 538 °C, 538 °C
- 250 bar: 540 °C, 560 °C
- 250 bar: 566 °C, 566 °C
- 270 bar: 580 °C, 600 °C
- 285 bar: 600 °C, 620 °C
Steam parameters development

- Podkritické parametry: 140b/540°C/540°C
- Nadkritické parametry: 240b/540°C/665°C
- Ultrasuperkritické parametry: 300b/600°C/610°C

Timeline:
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
Power Plant Ledvice, Czech Republic:

**Client:**
CEZ – Czech Republic

**EPC:**
Skoda Praha Invest

**Main Deliveries:**

**Boiler** – Alstom
Coal - lignite – heat content 11 MJ/kg, consumption 460 t/h

**Steam Turbine** – SKODA Power type MTD 70
Live steam 265 bars, temp. 597°C/606°C
Škoda Power scope:
- Condensing turbine MTD 70 - 660 MW
- Generator with excitation system
- Condensers
- LP and HP feed water heating systems
- All interconnecting piping, armatures
- Control system, instrumentations
- Lube oil system
- By-passes
- DWH system
- TG foundation
HBD 660 MW 100% / 18,5°C
Škoda steam turbine design

**Turbine arrangement:**
1xHP, 1x double flow IP, 2x double flow LP

Length of turbine 32170 mm

Weight incl. main valves approx. 1091 t
Concept of USC Steam Turbine ŠKODA Design

- Reliability: new USC turbine 660 MW is derived from successful and proven design of 500 MW – configuration is identical / USC turbine takes over the majority of modules

- High steam temperature is enabled by application of modern heat resisting materials

- Suppliers of basic components – rotor forgings, turbine casings, forgings and castings for turbine valves, material for blades are leading European companies with references from USC units
  - Vallourec-Mannesmann, Saarschmiede, Alstom, Böhler…
Basic Parameters of USC Turbine ŠKODA 660 MW

- Live Steam Pressure / before HP ES valves: 27.3 / 26.5 MPa
- Live Steam Temperature - Boiler / before HP ES valves: 600 / 597 °C
- Steam Flow nominal: 468 kg/s (1685 t/h)
- Reheat Steam Temperature – boiler outlet / before IP valves: 610 / 606.5 °C
- Cooling Water nominal temperature: 18.5 °C
- Electrical Output: 660 MW
- Speed: 3000 rpm
- Thermal Efficiency of Turbine Cycle: 51.5%
- $\eta_{tdi}$ HP / IP / LP: 92.5 / 94.6 / 92%
Materials of Main turbine Components

- **Bolts – parting Plane**: Inconel 718
- **Blades**: Böhler T550 / Böhler T505SC
- **Piping**: P92 / P91
Materials of Main turbine Components

- **Moving blades**
  - HP part Böhler T 550 Extra Re > 600 MPa Rm 800 to 950 MPa
  - IP part Böhler T 505SC Re > 750 MPa Rm 870 to 1020 MPa
  - LP part X12Cr13 mod. Re > 490 MPa Rm 650 to 800 MPa
  - LP part L-0 Böhler T 671 H950 Re > 1103 MPa Rm > 1172 MPa

- **Turbine rotors**
  - HP rotor COST F Re > 700 MPa Rm 800 to 950 MPa
  - IP rotor COST F Re > 700 MPa Rm 800 to 950 MPa
  - LP rotors 27NiCrMoV15-6 Re > 700 MPa Rm 850 to 1000 MPa

- **Main steam valve chambers**
  - HP valves G-X12CrMoVNbN 9 1 Re > 450 MPa Rm 620 to 850 MPa
  - IP valves G-X12CrMoVNbN 9 1 Re > 450 MPa Rm 620 to 850 MPa
Four casing configuration

High pressure casing

1 x HP – single flow (10 stages)
Bearing span 5300 mm
Weight 122 t
Four casing configuration

High pressure casing
Four casing configuration

Intermediate pressure casing

1 x IP – double flow (2 x 8 stages)
Bearing span 5450 mm
Weight 154 t
Four casing configuration

Intermediate pressure casing
Four casing configuration

Low pressure casing

2 x LP – double flow (4 x 5 stages)
Bearings span 8250 mm
Weight 2 x 370 t
Four casing configuration

LP rotor – solid forged
Weight 80 t
Four casing configuration

Last stage moving blade

Material T 671
Length 1085 mm (42”)
Four casing configuration

LP casing – steam inlet
Main steam valves

HP control and stop valve

- two chambers / left and right / alongside HP casing
- Valve body material P91
- Basic material of inner parts P91, P92
- Stop valve balanced type
- Control valves valve unbalanced type
- Graphite spindle sealing
Main steam valves

LP control and intercept valve

- IP Interception and Control Valves - four combined valves - two on each side of IP turbine
- Valve body material P91
- Basic materials of inner parts P91, X22CrMoV
- Intercepting and control valve balanced
- Graphite Chesterton spindle sealing
Main steam valves
## Turbine journal bearings

<table>
<thead>
<tr>
<th></th>
<th>Diameter [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front HP</td>
<td>Ø 300</td>
</tr>
<tr>
<td>Rear HP</td>
<td>Ø 400</td>
</tr>
<tr>
<td>Front IP</td>
<td>Ø 400</td>
</tr>
<tr>
<td>Rear HP</td>
<td>Ø 500</td>
</tr>
<tr>
<td>Front LP1</td>
<td>Ø 560</td>
</tr>
<tr>
<td>Rear LP1</td>
<td>Ø 560</td>
</tr>
<tr>
<td>Front LP2</td>
<td>Ø 560</td>
</tr>
<tr>
<td>Rear LP2</td>
<td>Ø 560</td>
</tr>
</tbody>
</table>
MAIN DATA OF MACHINE HALL:

Whole length of TG: 59.7 m (incl. space for gen. rotor assy)
TG elevation: 15.00 m (TG centr. 16.3 m)
Machine hall dimension: cca 39 x 90 m
Main machine hall elevation:
  + 15.00 m,
  + 6.00 m (heaters),
  ± 0.00 m,
  - 4.50 m

TG foundation: with spring supported upper slab
No. of springs (GERB): 142 pcs
ŠKODA USC 660 MW UNIT

TG foundation
ŠKODA USC 660 MW UNIT

TG foundation
Checking point of foundation
**ŠKODA USC 660 MW UNIT**

**GENERATOR**

<table>
<thead>
<tr>
<th>Rated Data and Outputs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent power</td>
<td>776 MVA</td>
</tr>
<tr>
<td>Active power</td>
<td>659.6 MW</td>
</tr>
<tr>
<td>Current</td>
<td>21.334 kA</td>
</tr>
<tr>
<td>Voltage</td>
<td>21 kV ± 5%</td>
</tr>
<tr>
<td>Speed</td>
<td>50 s⁻¹</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.85</td>
</tr>
<tr>
<td>Inner connection of stator winding / slots</td>
<td>YY</td>
</tr>
<tr>
<td>H₂ pressure</td>
<td>5 bar</td>
</tr>
<tr>
<td>Cont. perm. unbalanced load</td>
<td>8 %</td>
</tr>
<tr>
<td>Rated field current for rated output</td>
<td>5917 A</td>
</tr>
<tr>
<td>Rated field voltage</td>
<td>473 V</td>
</tr>
</tbody>
</table>

The machines are designed in conformity with IEC 34 and should be operated according to these specifications. The field current is no criterion of the load carrying capacity of the turbogenerator.
ŠKODA USC 660 MW UNIT

GENERATOR

Stator weight 316 t
Rotor weight 75 t
Main steam condensers:

No. of pieces for unit: 2
Type of condenser: surface, single path
Heat transfer area: 2 x 19 000 m²
Tubing – number: 20 462 pcs
  - dimensions: Ø 22,0 x 0,70 x 13 520 mm
  - material: ss
Condenser superstructure: LP by pass damp tubes
  - LPH No. 1 (condenser 1)
  - LPH No. 2 (condenser 2)
Cooling water flow: 15 000 kg/s
Evacuation: 3 x 50% - water ring pumps
Ball continuous sponge cleaning system
Main condenser - tubes
ŠKODA USC 660 MW UNIT

Main condenser
LP heater – for placing into condenser neck
LP heater – placed in condenser neck
Feed water tank – dia 4 m length 21.5 m
Weight 120 t
Capacity 250 m$^3$
Feed water tank
ŠKODA USC 660 MW UNIT

TG 660 MW
ŠKODA USC 660 MW UNIT

TG 660 MW
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
ŠKODA USC 660 MW UNIT
Thank you very much for your attention.

Questions, please.