NTPC once again chosen as 'GREAT PLACE TO WORK'
...and it is no surprise

MORE POWER TO EMPOWER.

NTPC elevated to Maharatna status.
SuperCritical Power Generation

Operation: Experience: learning

By:
S Satish Kumar, S S Mistry
B C Shekhar and Siva Prasad
NTPC–Sipat
Some Basics

Boiler Operation

Wet mode Opn

Boiler Protections

Unit Controls

Wet to Dry C/O

Once thru Opn

Dry Mode Opn

Experiences
Critical point is a thermodynamic expression describing the state of a substance (in our case Water-steam) where there is no clear distinction between the liquid and gaseous phase.

Pressure = 22.1 Mpa / 221 bar / 225.35 ksc. Temperature = 374°C / 705.2°F
<table>
<thead>
<tr>
<th><strong>Boiler type</strong></th>
<th>Super Critical Once Through Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Draft System</strong></td>
<td>Balanced Draft</td>
</tr>
<tr>
<td><strong>Firing System</strong></td>
<td>Tilting tangential burner firing</td>
</tr>
<tr>
<td><strong>Evaporator</strong></td>
<td>Spiral / vertical wall</td>
</tr>
<tr>
<td><strong>Pulverizer</strong></td>
<td>10 Bowl mills</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Indian Bituminous Coal</td>
</tr>
<tr>
<td><strong>Operating Mode</strong></td>
<td>Sliding Pressure Operation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pressure</strong>&lt;br&gt;</th>
<th>SH: 256 ksc&lt;br&gt; RH: 50.17 ksc</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong>&lt;br&gt;</td>
<td>SH: 540° C&lt;br&gt; RH: 568° C</td>
</tr>
<tr>
<td><strong>Steam Flow</strong></td>
<td>SH: 2225 T/hr&lt;br&gt; RH: 1743 T/hr</td>
</tr>
<tr>
<td><strong>FW Temp.</strong></td>
<td>291° C</td>
</tr>
</tbody>
</table>
Boiler Protections

1. Economizer Inlet Feed water flow – less than 440 T/h
2. Water wall Temp high (4/54 points above 485 deg C)
3. MS Temp Hi (590 deg C)
4. HRH Temp Hi (590 deg C)
5. Wet Mode: Separator Level hi (17.6m) Lo (1.1m)
6. TG Protection:
   a. MS Temp High/Low (565/470 deg C)
   b. HRH Temp High/Low (593/480 deg C)
Wet Mode

Super Heaters

Storage Tank

SEPARATORS

VERTICAL WW

Spiral water walls

WR

ZR

UG

ECO I/L

Feed Water
Wet Mode

- Separator level control by BFPs and FW flow control by UG with min FW flow 600 T/Hr set point.
- BCP takes suction is common from Separator Storage tank and BFP discharge.
- Feed Water flow varies according to the boiler Heat flux and corresponding steam flow to maintain Separator.
- WR and ZR will act as emergency control for separator level.
Dry Mode

Conditions for Dry Mode

Separator Level less than 3.0m

Difference between feed water temperature and eco inlet temperature < 2 degree C

Separator outlet steam superheated by 20 degree C

Steam flow > 30%
Dry Mode

Super Heaters

To SH spray

WR
ZR

Vertical WW

Eco I/L

Feed Water

Storage Tank

Spiral water walls

UG

Dry Mode Boiler Operation
Dry Mode

- Boiler Operating mode changed to Once Through Operation.
- Feed Water flow From FRS directly goes to Eco Inlet Bypassing the BCP.
- Total Feed Water Flow controlled by total Fuel flow in the Boiler and Degree of Superheat at Separator Outlet
- Any water in the separator goes to SH spray from wet Leg.
Wet to Dry Change Over

1. On 27/03/2011 AT 16:30 hrs First Time Wet to Dry Change Over
2. 24/06/2011 AT 09:45 hrs
3. 24/06/2011 AT 21:20 hrs
4. 25/06/2011 AT 03:36 hrs

Unit tripped on ECO flow low low low
Observations.....

- Both MDBFP were in service
- Both R/C valves are closed
- Suction flow is 800 t/hr each
- But ECO flow was < 300 t/hr
Doubt One

- Doubt In C&I Eco flow Transmitter
- Circulation shutoff valve closed
- BOILER filling started
- MDBFP suction flow & ECO inlet flow MATCHING OBSERVED

C&I flow Transmitter found OK
Doubt Two

- Doubt in NRV before Circulation shut off valve Passing

- Boiler filling started with circulation shutoff valve open
- Rise in separator level observed within few minutes
- Mismatch in BFP suction flow and ECO flow observed

NRV before Circulation shut off valve Passing
First Wet to Dry Change Over

- UG valve was taken into manual & kept at 20% open
- 600T/hr FW flow ensured through FRS manually
- Fuel flow increased gradually to achieve steam flow >600 t/h
- Shut-off valve before mixing piece closed.
- Fuel flow further increased till Separator dried out.
- Wait till Dry conditions Achieved.
- BCP stopped manually.
- FW flow control switched to Flow control and put on auto
FIRST SUCCESSFUL CHANGEOVER

On 26/06/2011 at 15:10 hrs

NRV replaced on 27/07/2011
Wet to Dry C/O – Auto Mode

- Increase unit load up to 200 MW with 3 or 4 elevations of oil guns and one mill
- Keep BRP selection in Auto dry mode and UG Valve in Manual
- Gradually increase fuel firing
- Put FW flow control in Auto (Min FW flow demand in flow control blocked at 30%)
- Ensure Dry mode of operation is achieved by observing the conditions for Dry Mode
Wet to Dry C/O – Auto Mode

- Once dry mode is considered to be achieved, dry mode indication appears in HFC OWS and BRP stops on Auto
- Increase fuel firing further and observe FW flow, furnace vertical WW tube metal temp
- Closely observe Separator outlet temperature and its Set point in FW flow control
- FW flow control should precisely maintain separator outlet temperature. In case of any deviation wait till the control loop bring down the deviation to minimum
Dry Mode–Low Load Operation

Problem Faced: Rise in Water Wall Temperature

Probable Cause: Non Uniform distribution of FW through water wall

Best Practices Developed

✓ FST Heating Charged from PRDS well ahead to increase FW temperature
✓ All LPH heater are charged immediately after rolling to 3000 rpm.
✓ All HP heaters are charged before Wet to Dry Change Over
✓ TDBFP warmed up and rolled from Main steam once Steam Parameters are achieved.
✓ Oil Elev/Mill firing adjusted with the help of Acoustic Pyrometer for uniform Flue gas distribution
✓ Additional Water wall Temp point provided @ 56m and 66m
Dry Mode–Low Load Operation

Problem Faced: Huge Mismatch in Left-Right Steam Temperature

Probable Cause: Non Uniform Left/right Flue gas distribution

Best Practices Developed

- Secondary air flow adjusted to maintain Furnace to WB dp
- SADC corner wise Biasing is provided to adjust the Fire ball position.
- APH outlet damper and ID fan biasing done to reduce the Left-Right Flue gas temperature mismatch.
- Better Mill combination and burner tilt positions are recorded for future references.
- HRSB done once in a day and LRSB done alternated day

Boiler Operating Pressure Increased to improve the Boiler Performance
## Dry Mode–Low Load Operation

**Problem Faced**: Frequent Unit tripping on MS temp high/low

- FW flow not commensurate with Fuel Flow

**Probable Cause**: Sudden change in coal quality
- FW control loop not tuned with the boiler behaviour

### Best Practices Developed

- FW flow Control loop adjusted to the empirical data.
- FW feed forward function generator made more realistic.
- Unit Load Inhibit provided in case of FW and fuel flow deviation.
- Alarm facia provided for Operator for Under fire or Over fire.
- Fuel oil flow included in total Fuel flow summetor
- Separator outlet temperature and Degree of Superheat is closely monitored
## Dry Mode–Full Load Operation

<table>
<thead>
<tr>
<th>Problem Faced</th>
<th>Boiler Second Pass Vibration and Helicopter Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probable Cause</td>
<td>Natural frequency of Boiler Equipments (fans /APH)</td>
</tr>
<tr>
<td></td>
<td>matching with boiler frequency.</td>
</tr>
</tbody>
</table>

### Best Practices Developed

- HRSB operated in every shift.
- All Eco hoppers closed to get them filled.
- First 2 hrs one hopper opened 25%
- Next 2 hrs all hoppers fully closed. Same cycle continued for many days.
UCC–Feed forward structure

Load Demand Computer

Operator Set Limits
- High Limit
- Low Limit
- Ramp Rate

Remote

Local
- Runbacks
- Rundowns
- Block Increase
- Block Decrease

Contingency

Turbine Master
- Turbine controller
- Valve Positioner

Boiler Master
- Feedwater
- Pump (Turbine)
- Pump (Startup)
- Combustion Air to fuel
- Fuel control
- FD Fan
- Sprays

Computer
- High Limit
- Low Limit
- Ramp Rate

Remote

Local
- Runbacks
- Rundowns
- Block Increase
- Block Decrease
UCC–Operating Modes

- TG Load Loop on
- Run Back Run down
- TG Load Loop on
- Blr Load Loop on
- Blr Press Loop on
- TG Press Loop on
- BF2
- BF1
- TF2
- TF1
- Base Mode
- UCC
Unit Control Structure

- Blr Mstr Manual
- Blr Mstr Auto

UCC SP

- Tracks Fuel Flow through Fuel VS load Curve
- Receives Remote SP from Operator

- FW SP
- Air Flow SP
- Sliding Press SP
- Boiler Mstr SP
Unit Control Structure
Learning

Experience

Sharing
Thank you!
Simulation mapping by the software for an ideal furnace

Distorted Fireball simulated by Acoustic Pyrometer
Higher Pressure at Lower Load resulted:

1. Higher Saturation Temp of FW
2. Better FW distribution through WW
4. More uniform Left/right steam flow
And better left/right steam Temperature balance
Dry Mode–Low Load Operation

- Non-Uniform Distribution of FW through Water Wall
- Huge Mismatch in Left-Right Flue Gas temperature
- Exponential Rise of Water Wall temperature with Increasing degree of Superheat at Separator Outlet.
- Maintaining lesser Degree of Superheat to contain Water Wall temperature.
- Less Spray Flow capacity at lower Pressure.
- Low HRH temperature.
Circulation......

Density water and steam changes with pressure as shown.
At higher pressure, density difference reduces.
Flow establishment in down comer, waterwall and drum is due to density difference and height of water column (i.e. waterwall) at lower pressure.