Indian Scenario of Super Critical Power Plants

Issues and Challenges

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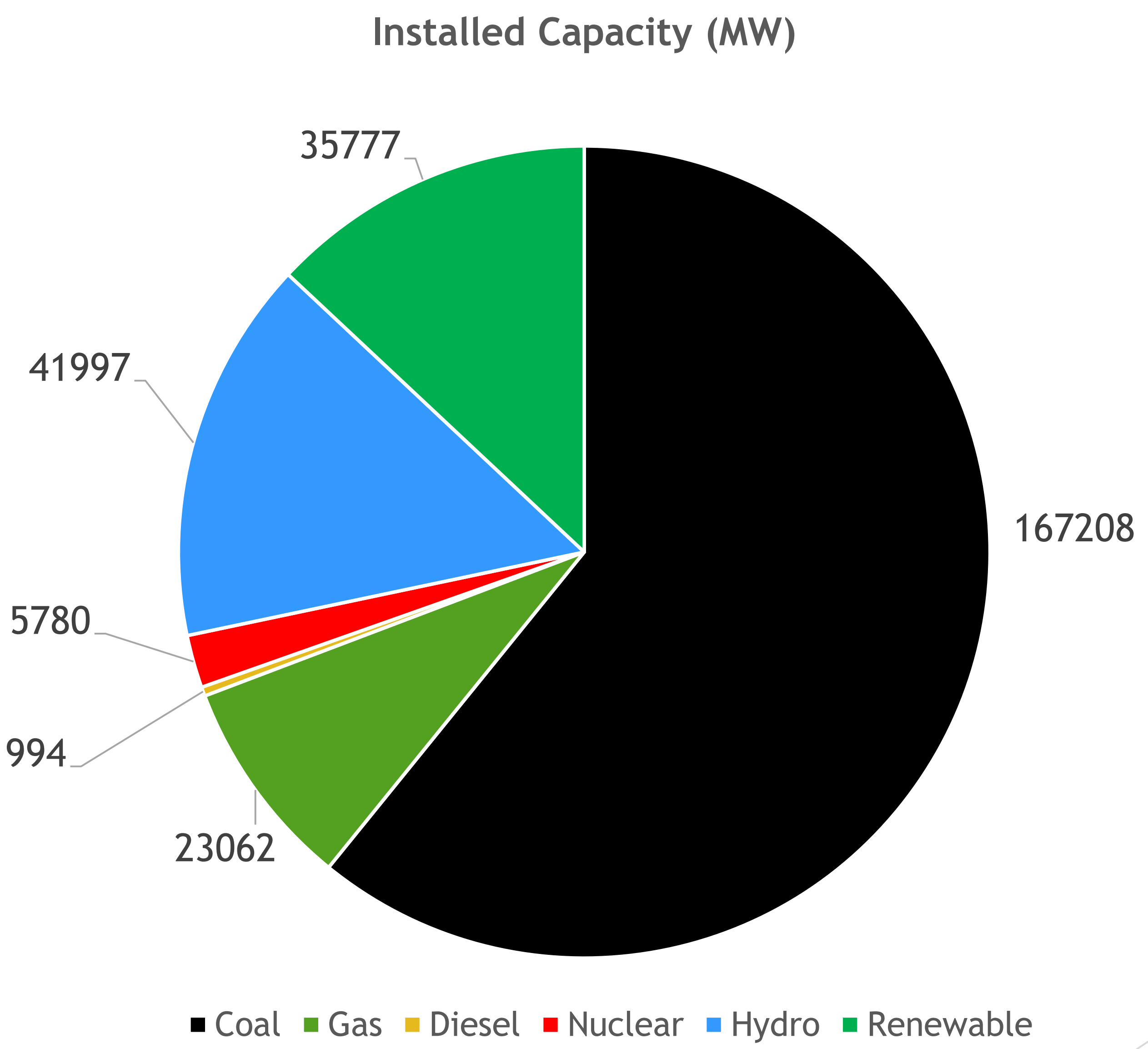
Supercritical Units –Indian scenario

Contents

Indian Power Mix

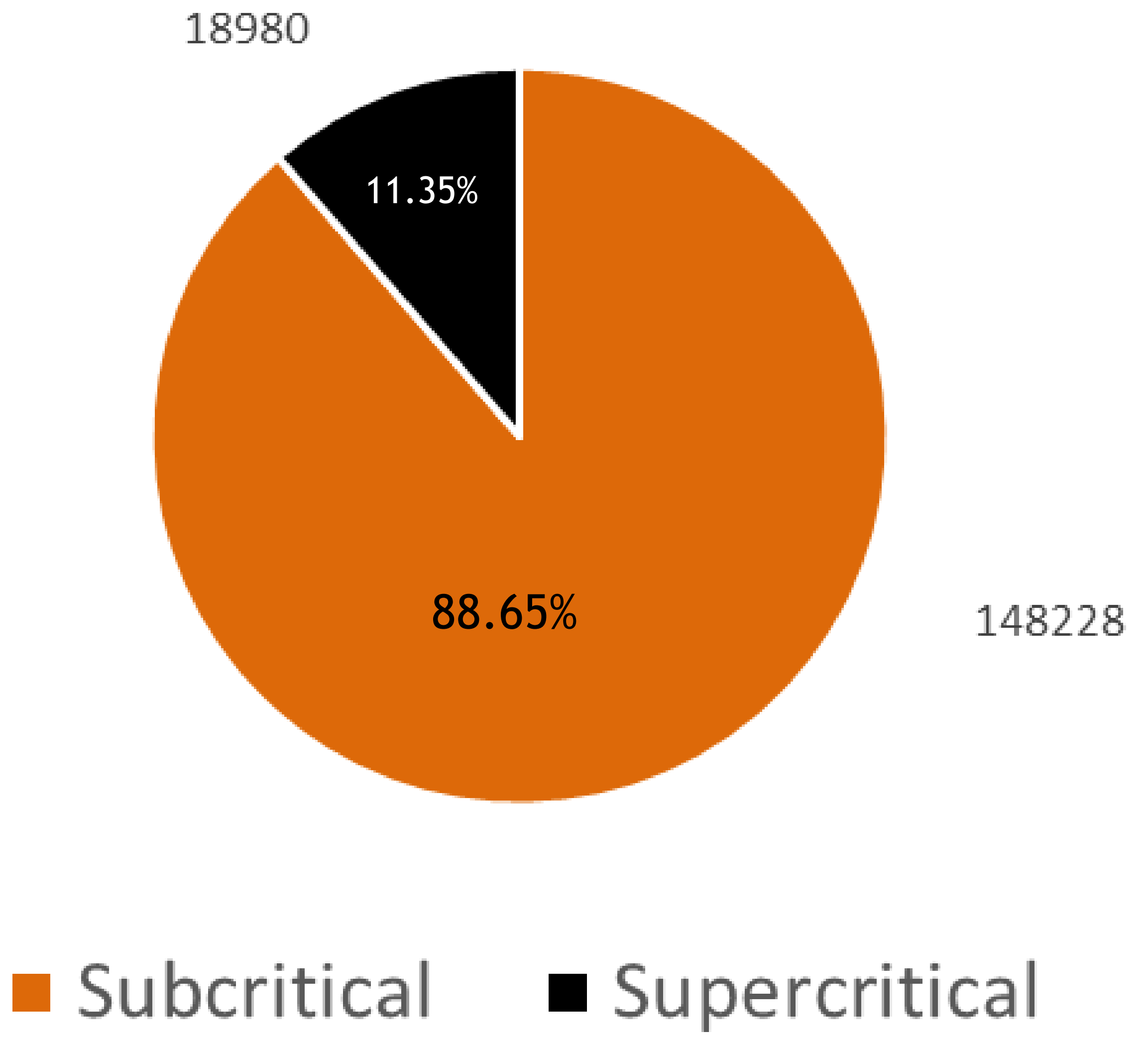
Installed Capacity(MW)*	
Coal	167208
Gas	23062
Diesel	994
Nuclear	5780
Hydro	41997
Renewable	35777
Total	274818

*Excluding captive generation capacity (40726 MW)



Installed Capacity (MW)
35777
41997
5780
994
23062
167208
Coal
Gas
Diesel
Nuclear
Hydro
Renewable

Share of supercritical units (MW)



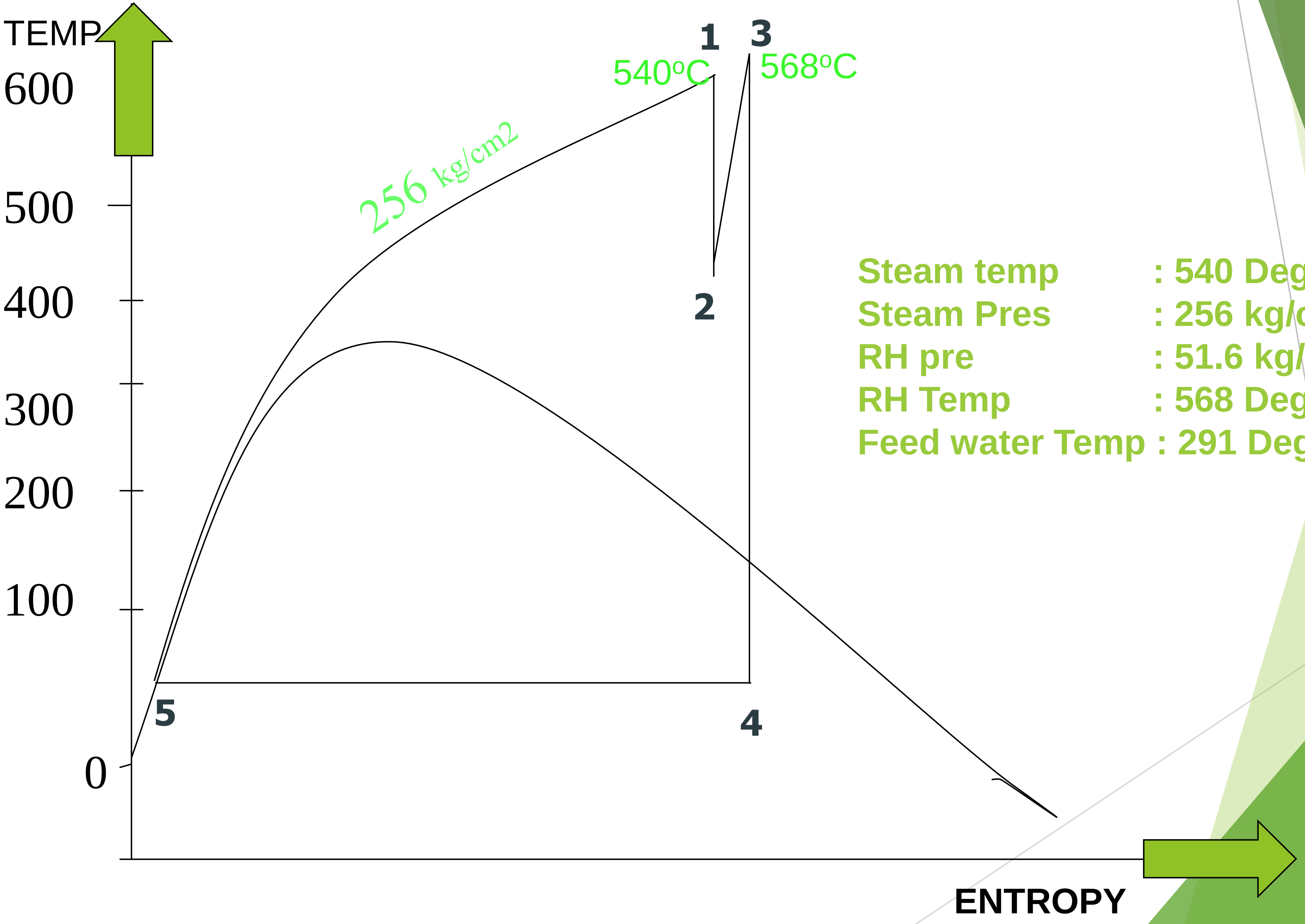
WHY SUPER CRITICAL TECHNOLOGY

- ✓ Reduced emission for each Kwh of electricity generated
- ✓ *1% rise in efficiency reduces the CO2 emission by 2-3%*
- ✓ The Most Economical way to enhance efficiency
- ✓ Fuel cost saving : Economical
- ✓ Operating Flexibility
- ✓ Reduced the Boiler size / MW
- ✓ Reduced Start-Up Time

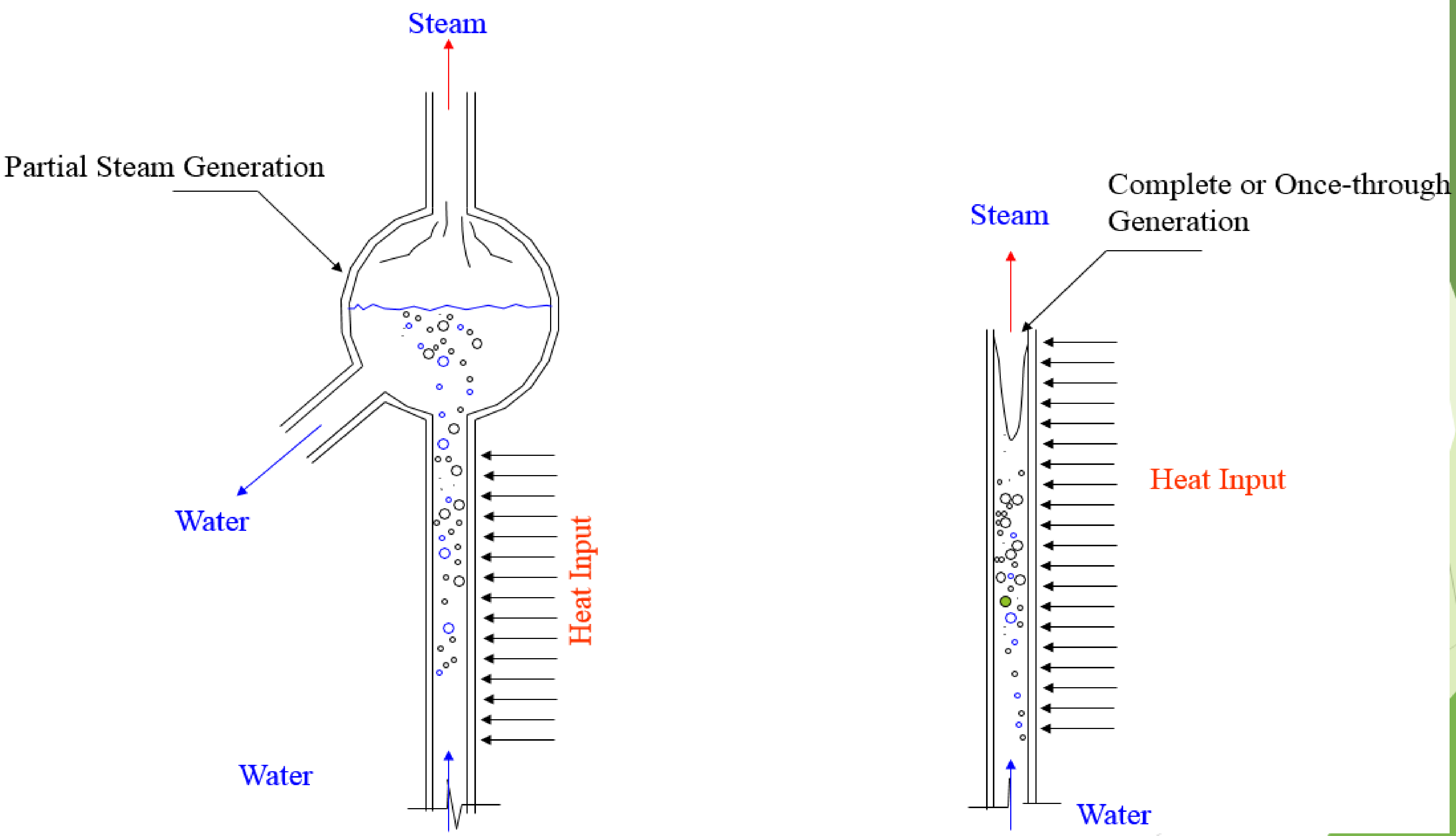
Supercritical

- Critical is a thermodynamic expression describing the sate of a fluid beyond which there is no clear distinction between the liquid and gaseous phase.
- The critical pressure & temperature for water are
- Pressure-225.56 kg/cm^2
- Temperature -374.15^oC
- A boiler operating at a pressure above critical point is called ‘supercritical boiler’
- A point where boiling water and dry saturated line meet so that associated latent heat is zero

SUPER CRITICAL
BOILER CYCLE WITH SH, RH & Regeneration

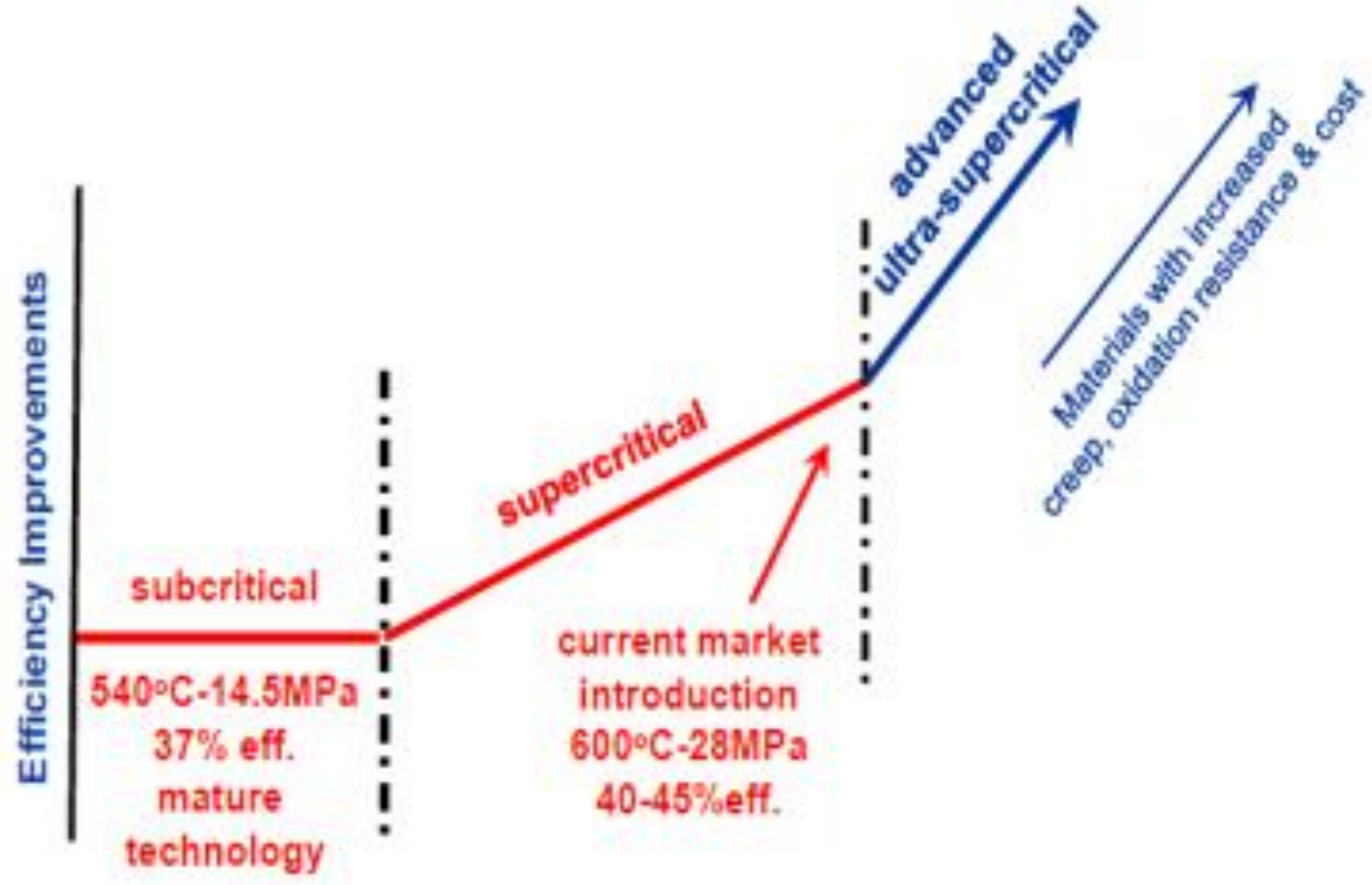


Steam temp : 540 Deg.C
Steam Pres : 256 kg/cm²
RH pre : 51.6 kg/cm²
RH Temp : 568 Deg.C
Feed water Temp : 291 Deg.C



Boiling process in Tubular Geometries

Sub Critical – Ultra Super Critical March Towards Higher Efficiency With Application of Higher Grades of Materials



Efficiency Comparison

CAPACITY	500 MW	660 MW	800 MW
BOILER EFFICIENCY (%)	85.61	86.27	86.33
TURBINE HEAT RATE (kCal/kWh)	1944.4	1904	1826
PLANT HEAT RATE (kCal/kWh)	2271.23	2207.02	2115.13
PLANT EFFICIENCY (%)	33.78	38.96	40.68

<u>Sipat 660 MW</u>

Main steam : 256 ksc, 540^{o}C
Reheat steam : 48.3 ksc, 568^{o}C

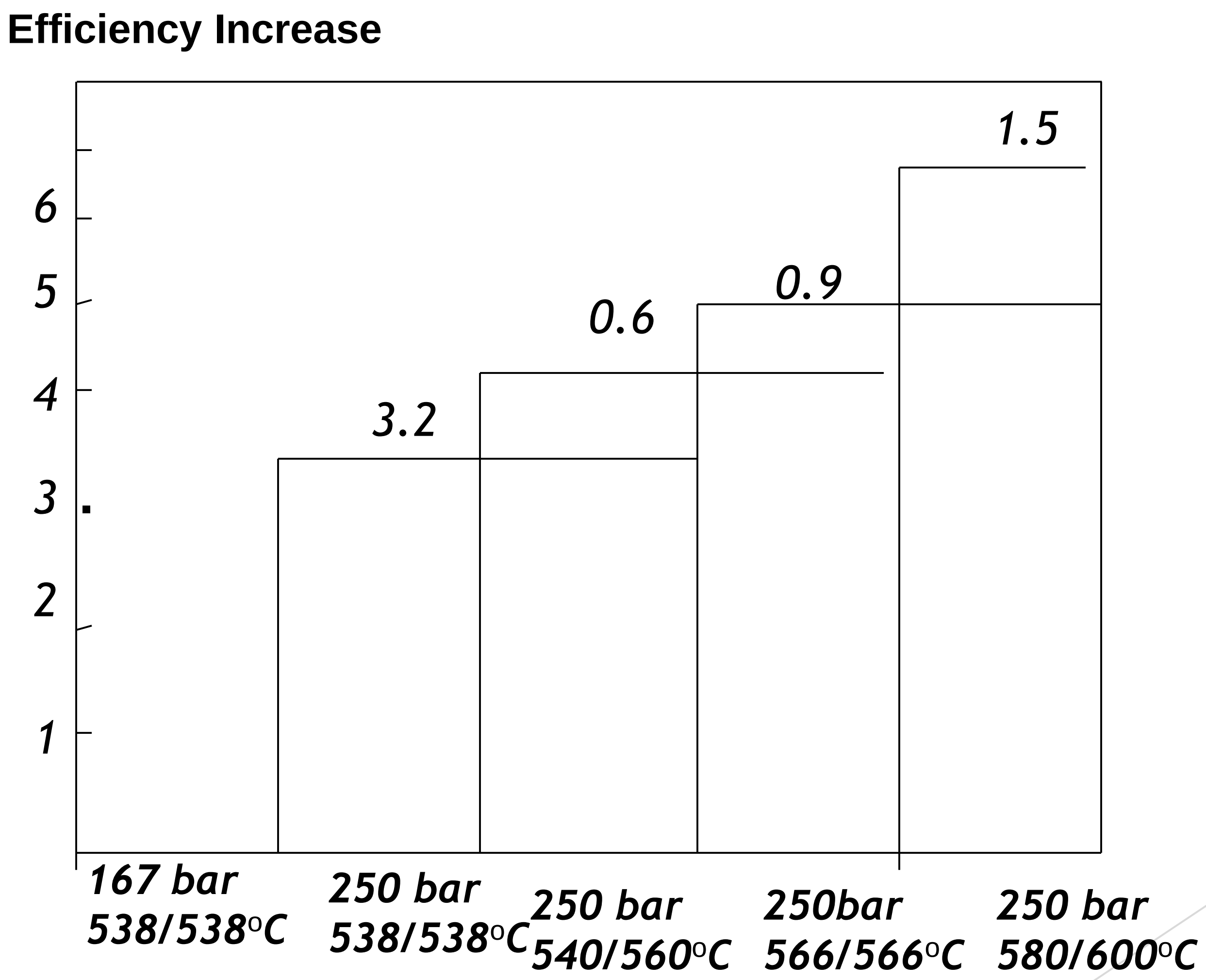
<u>800 MW</u>

Main steam : 258 ksc, 568^{o}C
Reheat steam : 54.23 ksc, 596^{o}C

<u>Barh 660 MW</u>

Main steam : 253.4 ksc, 568^{o}C
Reheat steam : 51.7 ksc, 596^{o}C

INCREASE IN PLANT EFFICIENCY by SUPER CRITICAL PARAMETERS



Existing supercritical units

State	Station	Capacity
Bihar	Barh (NTPC) #4	660
	Barh (NTPC) #5	660
Chattisgarh	Sipat (NTPC) #1	660
	Sipat (NTPC) #2	660
	Sipat (NTPC) #3	660
Maharashtra	Koradi #8	660
	Tirora TPP(Phase 1) #1	660
	Tirora TPP(Phase 1) #2	660
	Tirora TPP(Phase2) #1	660
	Tirora TPP(Phase2) #2	660
	Tirora TPP(Phase2) # 3	660
Andhra Pradesh	Painampuram TPP #1	660
Gujrat	Mundra UMPP #3	800
	Mundra UMPP#4	800
	Mundra UMPP#5	800

Existing supercritical units

State	Station	Capacity	Date of Commissioning
Punjab	Rajpura TPP#1	700	24.01.2014
	Rajpura TPP#2	700	06.07.2014
	Talwandi Sabo TPP #1	660	17.06.2014
Madhya Pradesh	Sasan UMPP #1	660	21.05.2014
	Sasan UMPP #4	660	25.03.2014
	Sasan UMPP #5	660	24.08.2014
	Sasan UMPP #6	660	19.03.2015
	Nigri TPP #1	660	29.08.2014
	Nigri TPP #1	660	17.02.2015
Rajastan	Kawai TPP #1	660	28.05.2013
	Kawai TPP #2	660	24.12.2013
Haryana	Jajjar TPP #1	660	11.04.2012
	Jajjar TPP #2	660	

NTPC - THE LEADER IN POWER SECTOR

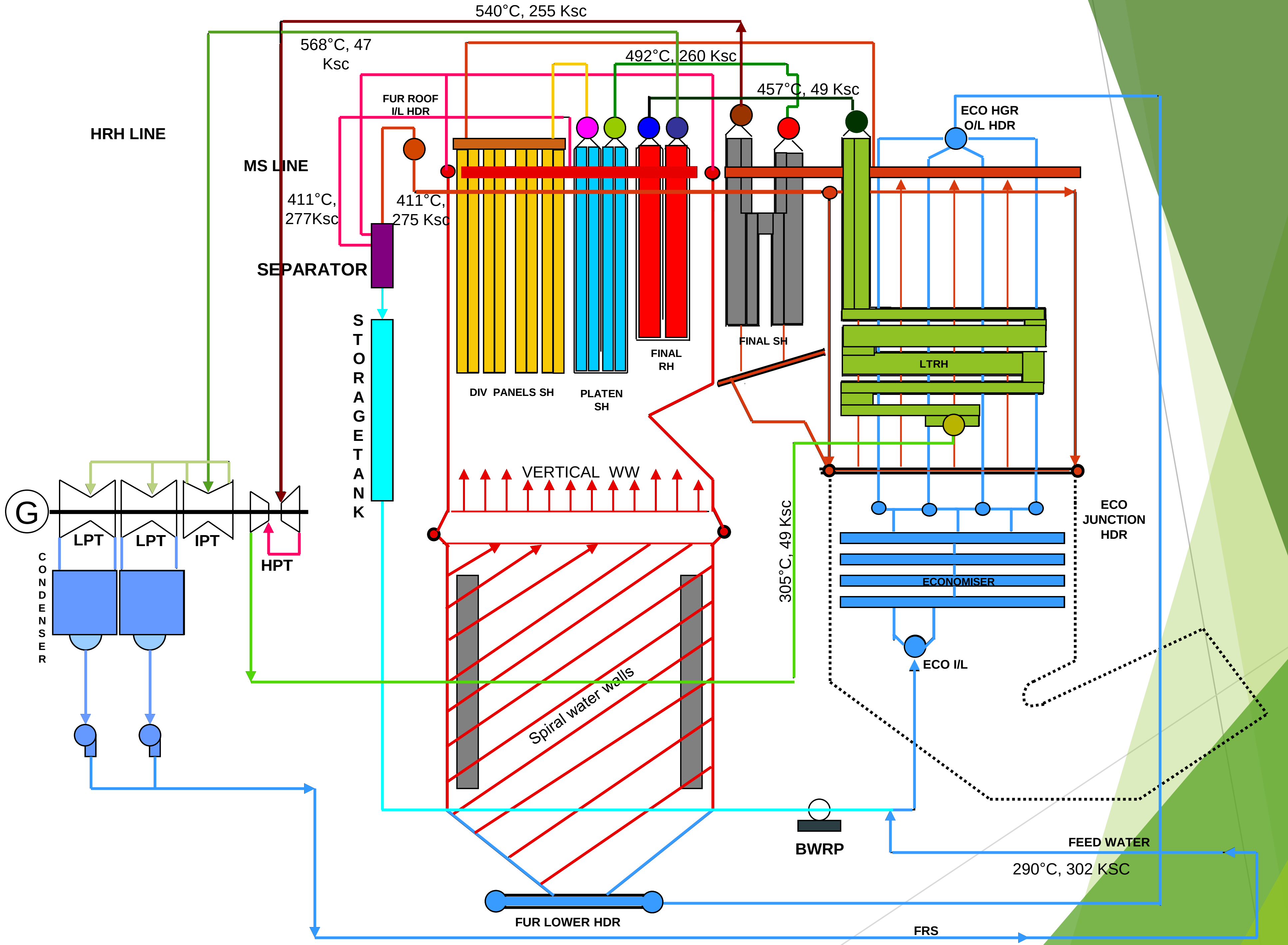
- NTPC's total installed capacity is 45,548 MW in Country's total installed capacity of 274817.94 MW.
- NTPC's share in country's total power generation is 23.81%
- During 11th plan 9,610 MW was added, exceeding the target of 9,220 MW
- Out of 24 (18 NTPC + 6 JV's) nos. coal based plants, 6 stations achieved PLF of more than 85 %
- NTPC plans to add 14,038 MW capacity during 12th plan period (of which 8445 MW has been already added till August 2015) .
- Projects totaling 23004 MW (21 nos) are under construction
- NTPC has made it's presence in Renewable by commissioning 8 nos Solar PV plants with total capacity of 110 MW.
- NTPC has also made forays into hydel generation,(recently 4x200 MW Koldam has started it's commercial operation), coal mining, power distribution & trading, solar energy and entered into JV's with SAIL & other state power utilities

NTPC Projects with Super Critical Boilers

- **Commissioned Units** (3300 MW)
- Sipat (3x660 MW)
- Barh (2x 660 MW)
- **Under Commissioning** (6640 MW)
- Kudgi (3x800 MW)
- Lara (2x800 MW)
- Solapur (2x 660 MW)
- Mouda –II (2X660MW)

NTPC Projects with Super Critical Boilers

- **Upcoming Projects** - under different phase of construction (9520 MW)
- Meja (2x660 MW)
- Khargone (2x 660 MW)
- North Karanpura (3x660 MW)
- Tanda II (2x 660 MW)
- Gadarwara (2x800 MW)
- Barh I (3x 660 MW)


540°C, 255 Ksc
568°C, 47 Ksc
492°C, 260 Ksc
457°C, 49 Ksc
FUR ROOF I/L HDR
ECO HGR O/L HDR
HRH LINE
MS LINE
411°C, 277Ksc
411°C, 275 Ksc
SEPARATOR
STORAGE TANK
DIV PANELS SH
PLATEN SH
FINAL RH
FINAL SH
LTRH
VERTICAL WW
305°C, 49 Ksc
ECO JUNCTION HDR
ECONOMISER
ECO I/L
G
LPT
LPT
IPT
HPT
CONDENSER
Spiral water walls
BWRP
FEED WATER
290°C, 302 KSC
FUR LOWER HDR
FRS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Super critical units –NTPC Experience

Sipat : Boiler package supplier – Doosan Heavy Industries, South Korea

: Turbine package supplier – Power Machines, Russia

Sipat 660 MW Boiler :

- Once through supercritical, Two pass, Balanced draft, Out door
- Furnace width – 18816 mm, depth – 18144 mm, volume – 21462 m^3
- Super Heater: Multi stage with panel, platen, pendant section
- Reheater: Multi stage type (LTRH & FINAL RH)
- Steam output parameters: at BMCR
  - ✓ Main steam : 256 ksc, 540^0C, 2225 T/hr
  - ✓ Reheat steam : 48.3 ksc, 568^0C, 1742 T/hr
- Design coal flow : 438 T/hr

Super critical units –NTPC Experience

BOILER AUXILIARIES :

1. Fans

   ID Fan : Supplier : FlaktWoods, Sweeden
   Type : PFSU – 450 – 300 – 08

   FD Fan : Supplier : FlaktWoods, Sweeden
   Type : PFSU – 280 – 112 – 04

   PA Fan : Supplier : FlaktWoods, Sweeden
   Type : PFTU – 200 – 100 – 02

2. Air Preheaters

   SAPH : Supplier : Doosan
   Type : 31.5 – VI – 1900

   PAPH : Supplier : Doosan
   Type : 26.0 – VI – 1800

3. Mills

   Vertical Bowl Mill 10 nos. – XHPS 1103

4. Coal Feeder

   Gravimetric feeder 10 nos. – 36 inch

5. Boiler Recirculation Pump (BRP)

   Make : Hayward Taylor, England
   Type : Wet stator, Glandless, Single section sing discharge pump

6. Oil elevations : 5 nos. (AB, CD, EF, GH & JK)

Super critical units –NTPC Experience

Sipat 660 MW Turbine :

- Turbine Model: K-660-247 (LMZ, Russia)
- HP Turbine
  - ✓ 1 no. HP turbine, 17 stages
  - ✓ HP turbine has nozzle governing system
  - ✓ 2 nos. HP stop valves, 4 nos. HP control valves
  - ✓ 1 impulse stage + 16 reaction stages
- IP Turbine
  - ✓ 1 no. IP turbine, 11X2 stages
  - ✓ IP turbine has throttle governing system
  - ✓ 2 nos. IP stop valves, 4nos. IP control valves
  - ✓ 22 nos. impulse stages
- LP Turbine
  - ✓ 2 nos. LP turbines, (5X2 + 5X2) stages
  - ✓ 20 nos. impulse stages
- Number of journal bearing for turbine – 8, Number of journal bearings for generator – 4.
- 2 nos. MDBFP (30% each) & 2 nos. TDBFP (50% each)
- Steam turbine parameters
  - ✓ Before HPSV : 247 ksc, 5370C, 2023 T/hr
  - ✓ Before IPSV : 43 ksc, 5650C, 1681 T/hr
- Number of HP heaters : 6
- Number of LP heater : 4

Super critical units –NTPC Experience

SIPAT PROJECT KEY MILE STONES

	UNIT # 1	*UNIT # 2*	*UNIT # 3*
Boiler Hydro Test	06.01.2007	27.07.2007	14.02.2009
Boiler Chemical Cleaning	03.09.2010	08.06.2011	26.01.2012
Boiler Lightup	26.10.2010	23.12.2011	26.08.2011
Steam Blowing	13.01.2011	13.08.2011	19.02.2012
Synchronization	18.02.2011	02.12.2011	01.04.2012
Full Load	28.06.2011	24.12.2011	02.06.2012
Commercial Operation	*01.10.2011*	*25.05.2012*	*01.08.2012*

Super critical units –NTPC Experience

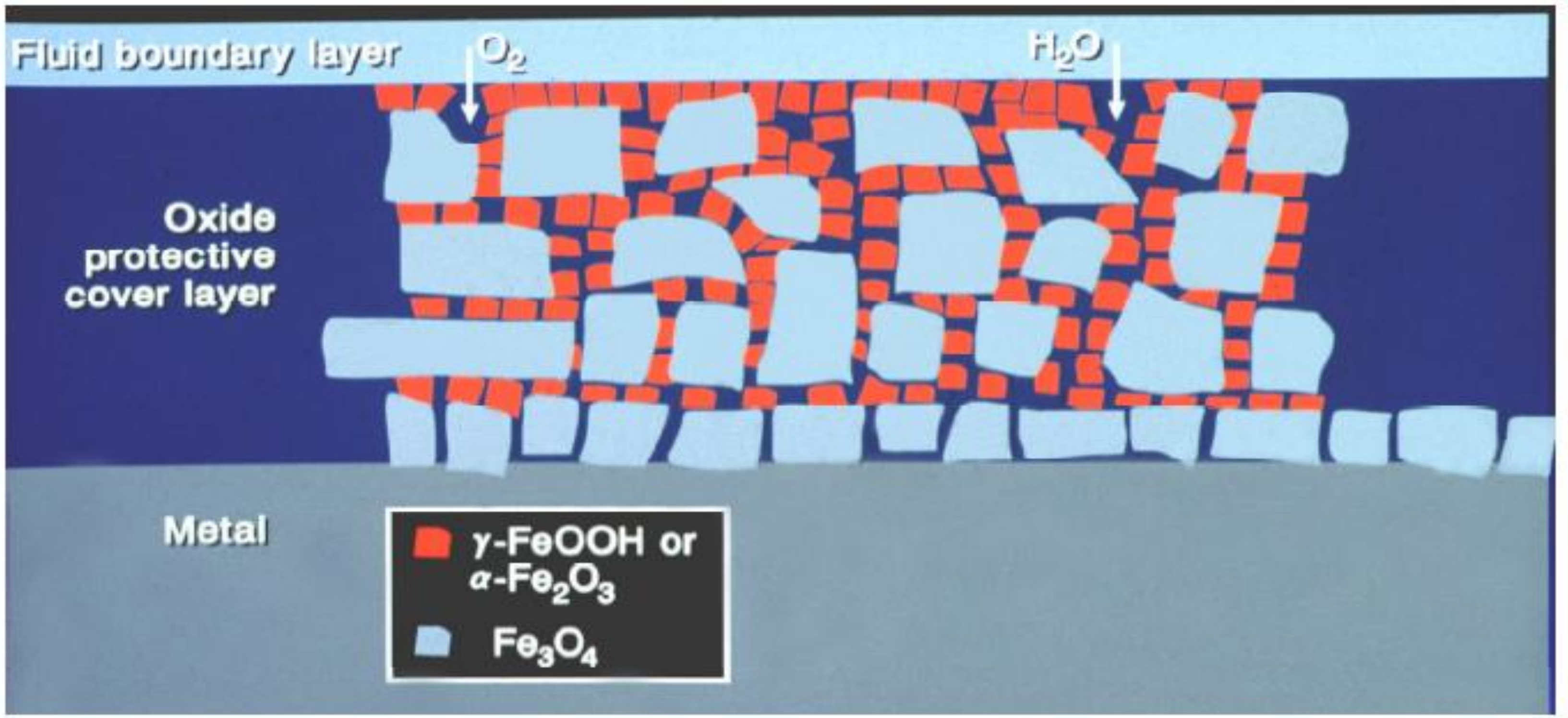
STRINGENT CHEMISTRY REGIME

KEY FEATURE- OXYGENATED TREATMENT

- PROVIDES LONG TERM PROTECTION OF PRE BOILER SYSTEM BY FORMING HAMETITE LAYER.
- CPU OPERATING PERIOD WILL BE MORE DUE TO LOW CONDENSATE AMMONIA CONTENT
- IRON TRANSPORT WILL BE REDUCED BY 90%
- LESS GENERATION OF CRUD
- REDUCTION IN CHEMICAL CLEANING FREQUENCY
- REDUCTION IN OUTAGE TIME AND FASTER START UP
- FAC WILL BE MINIMIZED

ALL THESE LEAD TO VERY LESS BTF

SCHEMATIC OF OXIDE GROWTH AND MORPHOLOGY UNDER 0XIDISING AVT AND OT



2 Fe3O4 + 0.5 02 = 3 Fe2O3

FEED WATER PARAMETERS

S.NO	Parameter	Units	Normal Operation		During Start up
			Alkaline water Treatment	Oxygenated Treatment	
1	PH		Min 9.0	8-8.5	Min 9.0
2	Cation Conductivity, µs/cm	µs/cm	Max 0.2	<0.15	Max 0.5
3	Dissolved Oxygen	ppb	< 5	30-150	Max 100
4	Iron	ppb	< 2	< 2	< 20
5	Sodium	ppb	< 2	< 2	< 10
6	Silica	ppb	<10	< 10	< 30
7	Turbidity	NTU	<2	< 2	<5

OXYGENATED TREATMENT SYSTEM AT SIPAT – OXYGEN DOSING

- Dosing is being carried out in CPU outlet and Deaerator outlet
- The cycle oxygen is controlled by flow control valve having a automatic controller.
- The injection control is automatically adjusted by Feed water flow and residual dissolved oxygen and set point.
- DO should be in the range of < 20 ppb in condensate.

STEAM WATER ANALYSIS SYSTEM (SWAS)

FOLLOWING IS THE PROCESS MONITORING FOR CHEMICAL CONTROL OF STEAM AND WATER

S.NO	SYSTEM	TYPE OF MEASUREMENT
1	MAKE UP DM WATER	SP.COND., CATION CONDUCTIVITY (ACC)
2	CEP DISCHARGE	pH, ACC, Na, DO, SP.COND.,
3	CONDENSATE POLISHER O/L	pH, ACC, Na, SILICA, SP.COND.,
4	DEAERATOR OUTLET	DO
5	FEED WATER AT ECONOMIZER INLET	pH, ACC, COND.,HYDRAZINE,SILICA, TURBIDITY

STEAM WATER ANALYSIS SYSTEM (SWAS)

FOLLOWING IS THE PROCESS MONITORING FOR CHEMICAL CONTROL OF STEAM AND WATER

S.NO	SYSTEM	TYPE OF MEASUREMENT
6	VENT HEADER OF BOILER (SEPARATOR OUTLET STEAM)	ACC, SP.COND., HYDRAZINE, SILICA
7	MAIN STEAM	pH, ACC, Na, SILICA, SP.COND.,
8	WATER SEPARATION STORAGE TANK OF BOILER	CATION CONDUCTIVITY(ACC)
9	REHEATED STEAM	CATION CONDUCTIVITY(ACC)
10	TG ECW COOLING WATER	pH

BOILER CONTROL

BOILER CONTROL

BOILER LOAD CONDITION

Constant Pressure Control

- ✓ Above 90% TMCR The MS Pressure remains constant at rated pressure
- ✓ The Load is controlled by throttling the steam flow
- ✓ Below 30% TMCR the MS Pressure remains constant at minimum Pressure

Sliding Pressure Control

- ✓ Boiler Operate at Sliding pressure between 30% and 90% TMCR
- ✓ The Steam Pressure And Flow rate is controlled by the load directly

Sliding pressure operation

- Variable pressure operation (sliding pressure operation) is desired in all modern power plants because it provides more efficient part load operation.
- The loss due to constant pressure operation at low load is always a concern for the utility.
- The vertical tube supercritical boiler can provide variable turbine pressure operation to gain the thermodynamic advantage of variable pressure.
- Thus the turbine efficiency advantages are obtained by the savings in boiler feed pump power associated with true variable pressure operation.

ADVANTAGES OF SLIDING PRESSURE OPERATION

1. No additional pressure loss between boiler and turbine

2. Low Boiler Pr. at low loads

   - Less fatigue of Pr. part components

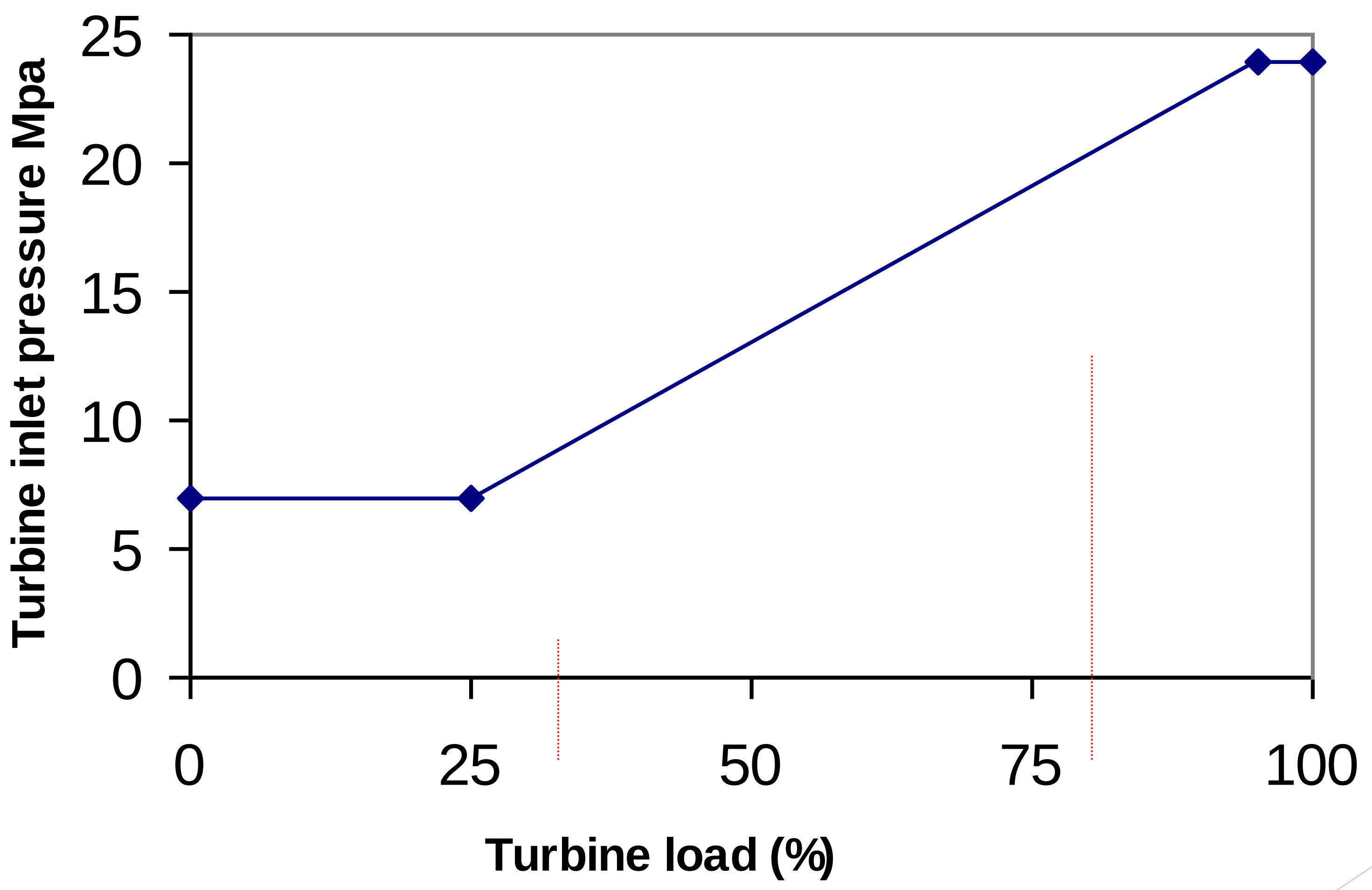
   - Longer life of all components, Less wear of components

   - Less Maintenance

3. Lower thermal stresses in the turbine during load changes

4. Overall reduction in power consumption and improved heat rate

Sliding Pressure



Issues and Challenges

- Erection
- Commissioning
- Operation
- Maintenance Practices

Replacement of Grade 23 Pipes and Fittings

- Issue of absence of appropriate microstructure following normalizing heat treatment in thick walled Grade 23 pipes and fittings .
- In order to avoid inconvenience during operation in future, It was recommended to replace all Grade 23 pipes and fittings with Grade 91 material
- Headers replaced- SH Division panel outlet (2nos), Platen SH outlet, Final SH inlet and their connecting pipes.

Super critical units -NTPC Experience

Issues related to Welding Joints of T 23 Tubes

T23 Joints Details

SN	Pressure Part Area	Material	No of Joints	Type of Pressure part
1	Furnace Rear Hanger Tube +Furnace Upper Rear O/L Hdr	T23+T23	136	Tube
2	Furnace Roof I/L Hdr + Furnace Roof Panel	T22+T23	204	Tube
3	Furnace Roof Panel+ Furnace Roof Panel(Loose Tube)	T23+T23	2	Fin Welded
4	Furnace Roof Panel + Furnace Roof Loose Tube	T23+T23	204	Fin Welded
5	Furnace Roof Loose Tube + Furnace Roof O/L Hdr	T23+T23	204	Fin Welded
6	BP Ext Side I/L Hdr + BP Ext Side Panel	T22+T23	108	Tube
7	BP Ext Side Panel + BP Ext Side Floor Panel	T23+T23	108	Fin Welded
8	BP Ext Side Floor Panel + BP Ext Side O/L Term Tubes	T23+T23	108	Fin Welded
9	LTRH Lower Intermediate Assy + LTRH Upper Intermediate Assy	T12+T23	808	Tube
10	LTRH Upper Intermediate Assy + LTRH Upper Assy	T23+T23	808	Tube
11	LTRH Upper Assy + LTRH Pendant Assy	T23+T91	808	Tube
		Total	**3498**	