

A Review on Power Generation in Thermal Power Plant for Maximum Efficiency

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Abstract

NTPC Limited is the largest thermal power generating company of India, Public Sector Company. It was incorporated in the year 1975 to accelerate power development in the country as a wholly owned company of the Government of India. At present, Government of India holds 89.5% of the total equity shares of the company and the balance 10.5% is held by FIIs, Domestic Banks, Public and others. Within a span of 31 years, NTPC has emerged as a truly national power company, with power generating facilities in all the major regions of the country. NTPC's core business is engineering, construction and operation of power generating plants and providing consultancy to power utilities in India and abroad. The total installed capacity of the company is 41184 MW (including JVs) with 15 coal based and 7 gas based stations, located across the country. In addition under JVs, 3 stations are coal based & another station uses naphtha/LNG as fuel. By 2017, the power generation portfolio is expected to have a diversified fuel mix with coal based capacity of around 53000 MW, 10000 MW through gas, 9000 MW through Hydro generation, about 2000 MW from nuclear sources and around 1000 MW from Renewable Energy Sources (RES). NTPC has adopted a multi-pronged growth strategy which includes capacity addition through green field projects, expansion of existing stations, joint ventures, subsidiaries and takeover of stations.

Keywords: Component; Renewable energy source, boiler, thermal power plant.

1. Introduction

NTPC has been operating its plants at high efficiency levels. Although the company has 18.79% of the total national capacity it contributes 28.60% of total power generation due to its focus on high efficiency. NTPC's share at 31 Mar 2001 of the total installed capacity of the country was 24.51% and it generated 29.68% of the power of the country in 2008-09. Every fourth home in India is lit by NTPC. 170.88BU of electricity was produced by its stations in the financial year 2005-2006. The Net Profit after Tax on March 31, 2006 was INR 58,202 million. Net Profit after Tax for the quarter ended June 30, 2006 was INR 15528 million, which is 18.65% more than for the same quarter in the previous financial year. 2005).

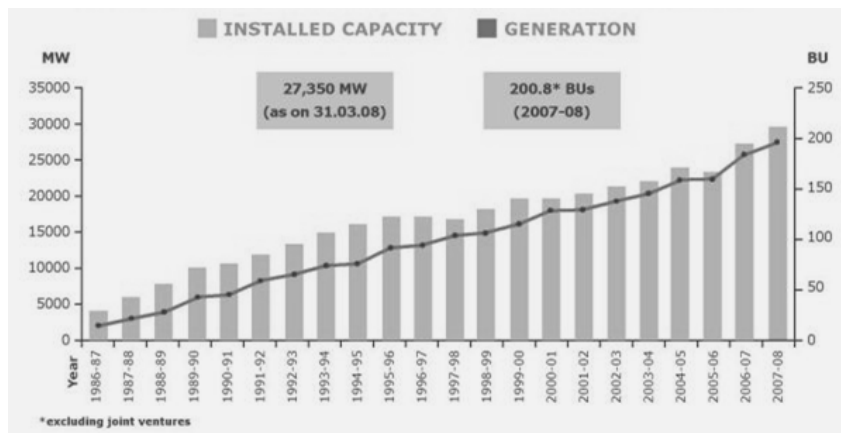


Fig. 1: Growth of NTPC: Installed & Generation capacity.

NTPC has set new benchmarks for the power industry both in the area of power plant construction and operations. Its providing power at the cheapest average tariff in the country. NTPC is committed to the environment, generating power at minimal environmental cost and preserving the ecology in the vicinity of the plants. NTPC has undertaken massive a forestation in the vicinity of its plants. Plantations have increased forest area and reduced barren land. The massive a forestation by NTPC in and around its Ramagundam Power station (2600 MW) have contributed reducing the temperature in the areas by about 3^oc. NTPC has also taken proactive steps for ash utilization. In 1991, it set up Ash Utilization Division.

2. Technological Initiatives

- Introduction of steam generators (boilers) of the size of 800 MW.
- Integrated Gasification Combined Cycle (IGCC) Technology.
- Launch of Energy Technology Centre -A new initiative for development of technologies with focus on fundamental R&D.
- The company sets aside up to 0.5% of the profits for R&D.
- Roadmap developed for adopting 'Clean Development.
- Mechanism' to help get / earn 'Certified Emission Reduction.

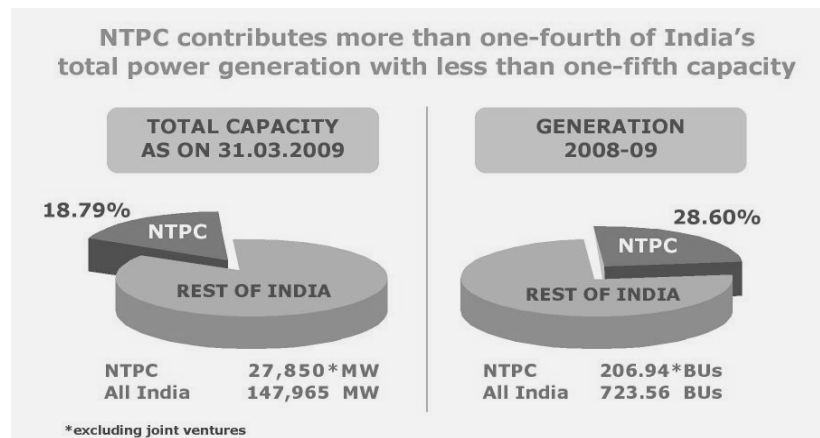


Fig. 2: NTPC contribution in power generation.

3. Environment Management

- All stations of NTPC are ISO 14001 certified.
- Various groups to care of environmental issues.
- The Environment Management Group.
- Ash Utilization Division.
- A forestation Group.
- Centre for Power Efficiency & Environment Protection.
- Group on Clean Development Mechanism.
- NTPC is the second largest owner of trees in the country after the Forest department.

Table 1: Specification of Badarpur NTPC.

Installed Capacity	720 MW
De rated Capacity	705 MW
Location	New Delhi
Coal Source	Jharia Coal Fields
Water Source	Agra Canal
Beneficiary States	Delhi
Unit Sizes	3X95 MW 2X210 MW
Units Commissioned	Unit I- 95 MW - July 1973 Unit II- 95 MW August 1974 Unit III- 95 MW March 1975 Unit IV - 210 MW December 1978 Unit V - 210 MW - December 1981
Transfer of BTPS to NTPC	Ownership of BTPS was transferred to NTPC with effect from 01.06.2006 through GOI's Gazette Notification

4. Basic Steps of Electricity Generation

The basic steps in the generation of coal to electricity are shown below:

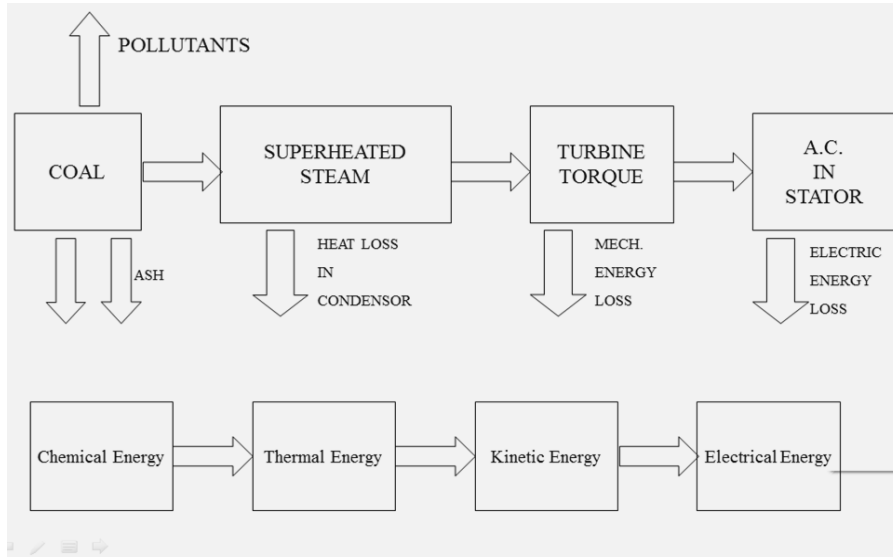


Fig. 3: Flow chart of electricity generation.

4.1 Coal combustion for steam generation

Coal from the coal wagons is unloaded in the coal handling plant. This Coal is transported up to the raw coal bunkers with the help of belt conveyors. Coal is transported to Bowl mills by Coal Feeders. The coal is pulverized in the Bowl Mill, where it is ground to powder form. The mill consists of a round metallic table on which coal particles fall. This table is rotated with the help of a motor. There are three large steel rollers, which are spaced 120° apart. When there is no coal, these rollers do not rotate but when the coal is fed to the table it packs up between roller and the table and the forces the rollers to rotate. Coal is crushed by the crushing action between the rollers and the rotating table. This crushed coal is taken away to the furnace through coal pipes with the help of hot and cold air mixture from P.A. Fan.

P.A. Fan takes atmospheric air, a part of which is sent to Air Pre-heaters for heating while a part goes directly to the mill for temperature control. Atmospheric air from F.D. Fan is heated in the air heaters and sent to the furnace as combustion air.

Water from the boiler feed pump passes through economizer and reaches the boiler drum. Water from the drum passes through down comers and goes to the bottom ring header. Water from the bottom ring header is divided to all the four sides of the furnace. Due to heat and density difference, the water rises up in the water wall tubes. Water is partly converted to steam as it rises up in the furnace. This steam and water mixture is again taken to the boiler drum where the steam is separated from water.

Water follows the same path while the steam is sent to super-heaters for superheating. The super-heaters are located inside the furnace and the steam is superheated (540°C) and finally it goes to the turbine.

Flue gases from the furnace are extracted by induced draft fan, which maintains balance draft in the furnace (-5 to -10 mm of wcl) with forced draft fan. These flue gases emit their heat energy to various super heaters in the pent house and finally pass through air pre-heaters and goes to electrostatic precipitators where the ash particles are extracted. Electrostatic Precipitator consists of metal plates, which are electrically charged. Ash particles are attracted on to these plates, so that they do not pass through the chimney to pollute the atmosphere. Regular mechanical hammer blows cause the accumulation of ash to fall to the bottom of the precipitator where they are collected in a hopper for disposal.

4.2 Application of superheated Steam in steam turbine to produce mechanical power

From the boiler, a steam pipe conveys steam to the turbine through a stop valve (which can be used to shut-off the steam in case of emergency) and through control valves that automatically regulate the supply of steam to the turbine. Stop valve and control valves are located in a steam chest and a governor, driven from the main turbine shaft, operates the control valves to regulate the amount of steam used. (This depends upon the speed of the turbine and the amount of electricity required from the generator).

Steam from the control valves enters the high pressure cylinder of the turbine, where it passes through a ring of stationary blades fixed to the cylinder wall. These act as nozzles and direct the steam into a second ring of moving blades mounted on a disc secured to the turbine shaft. The second ring turns the shafts as a result of the force of steam. The stationary and moving blades together constitute a 'stage' of turbine and in practice many stages are necessary, so that the cylinder contains a number of rings of stationary blades with rings of moving blades arranged between them. The steam passes through each stage in turn until it reaches the end of the high-pressure cylinder and in its passage some of its heat energy is changed into mechanical energy.

The steam leaving the high pressure cylinder goes back to the boiler for reheating and returns by a further pipe to the intermediate pressure cylinder. Here it passes through another series of stationary and moving blades.

Finally, the steam is taken to the low-pressure cylinders, each of which enters at the centre flowing outwards in opposite directions through the rows of turbine blades through an arrangement called the 'double flow'- to the extremities of the cylinder. As the steam gives up its heat energy to drive the turbine, its temperature and pressure fall and it expands. Because of this expansion the blades are much larger and longer towards the low pressure ends of the turbine.

4.3 Conversion of Mechanical power into electrical power by Generator

As the blades of turbine rotate, the shaft of the generator, which is coupled to the turbine, also rotates. It results in rotation of the coil of the generator, which causes induced electricity to be produced.

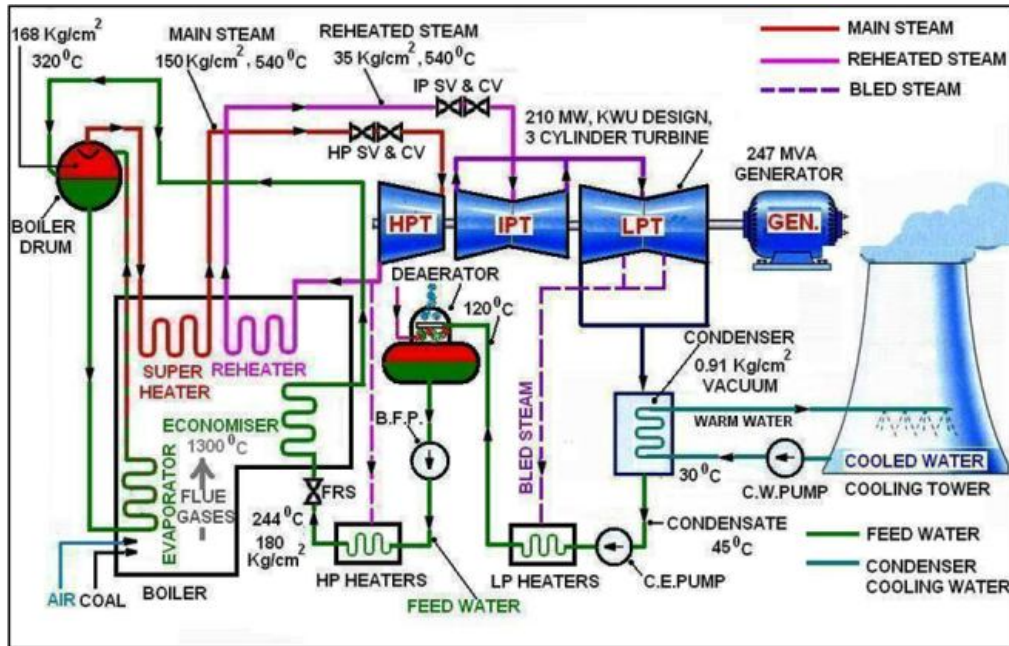


Fig. 4: A Simplified Diagram of a Thermal Power Plant.

The thermal (steam) power plant uses a dual (vapour+ liquid) phase cycle. It is a close cycle to enable the working fluid (water) to be used again and again. The cycle used is Rankine Cycle modified to include superheating of steam, regenerative feed water heating and reheating of steam.

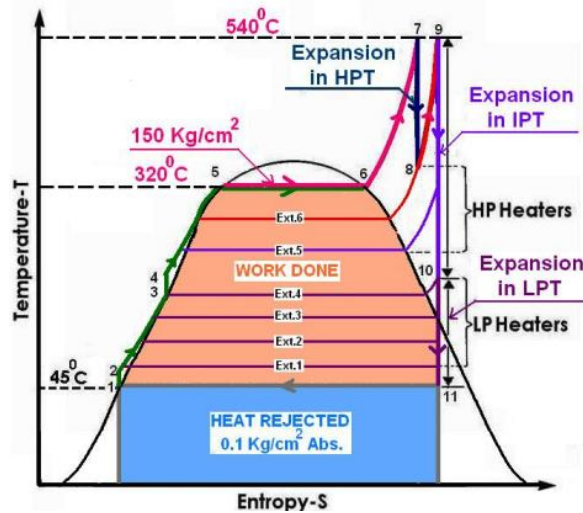


Fig. 5: Modified Rankine cycle used in power plant for steam generation.

On large turbines, it becomes economical to increase the cycle efficiency by using reheat, which is a way of partially overcoming temperature limitations. By returning partially expanded steam, to a reheat, the average temperature at which the heat is added, is increased and, by expanding this reheated steam to the remaining stages of the turbine, the exhaust wetness is considerably less than it would otherwise be conversely, if the maximum tolerable wetness is allowed, the initial pressure of the steam can be appreciably increased.

Bleed Steam Extraction: For regenerative system, nos. of non-regulated extractions is taken from HP, IP turbine.

Regenerative heating of the boiler feed water is widely used in modern power plants; the effect being to increase the average temperature at which heat is added to the cycle, thus improving the cycle efficiency.

5. Factors Affecting Thermal Cycle Efficiency

Thermal cycle efficiency is affected by following:

- Initial Steam Pressure.
- Initial Steam Temperature.
- Whether reheat is used or not, and if used reheat pressure and temperature.
- Condenser pressure.
- Regenerative feed water heating.

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