

Control of CO₂ emission through enhancing energy efficiency of auxiliary power equipment in thermal power plant



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ABSTRACT

This paper describes the results of energy efficiency enhancement in 23 numbers of 210 MW coal fired power plants spread over India. Energy efficiency improvement of major auxiliary equipment with different plant load factors are summarized here with improved performance. The effect of plant load factor on all major auxiliary equipment and improvement in performance of auxiliary equipment are discussed in this paper. Operation of the plant at improved plant load factor reduced the specific auxiliary power from 11.23% at 70% PLF to 8.74% at 100% PLF that reduced the net auxiliary power by 9.1 MU/year that is an equivalent reduction of CO₂ emission by 9500 t/year. Optimizing the excess air, controlling the furnace ingress, enhanced energy efficiency of individual equipment by proper maintenance, etc., improves the plant capacity and reduces the overall auxiliary power by about 1.5–2.1% of gross energy generation i.e., equivalent CO₂ reduction of 23,000–32,400 t/year and release an additional power of about 3.5 MW (for a typical one 210 MW power plant) into grid.

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Introduction

The present total installed power generation capacity in India is 228.72 GW, out of which 134.39 GW is from coal based thermal power plant that forms 58.75% of total installed capacity by 30th September 2013 [1]. The major concern of power generation through thermal route is CO₂ emission, global warming and disposal of ash. The approximate CO₂ emission in India due to thermal power generation is about 13 million t/h. The auxiliary power used for coal fired power plants is varied for different plant size from 30 MW plant to 500 MW plants, varied between 5.2% and 12.3% at Maximum Continuous Rating (MCR) condition. The estimated auxiliary power used for running the coal fired thermal power plants in India is about 11,340 MW that forms average of about 8.4% of coal based power plants and 4.9% of total installed capacity [2]. The estimated CO₂ emission due to auxiliary power is 11,900 t/h. The thermal power plant availability depends largely upon the operational reliability of the auxiliary equipment and the capability of the auxiliary system [3]. The auxiliary power consumption is on higher side as compared to other developed countries [4] due to poor plant load factor, the use of poor coal quality, excessive steam flow, excessive water flow, internal leakage in

equipment, inefficient drives, lack of operational optimization of equipment, ageing of equipment, hesitation in technology upgradation, obsolete equipment, design deficiencies, oversizing of equipment, use of inefficient controls, etc. By reducing the auxiliary power of coal fired stations in India by 1%, about 1350 MW of power can be pumped into grid that will reduce the CO₂ emission by 10 million t/year.

The progressive changes in the unit size and technological advancement in new power plants, have improved the average plant load factor of Indian coal fired power plants from 55.3% (1991–1992) to 73.3% (2011–2012) (refer Fig. 1) and the specific auxiliary power had reduced from 9.46% to 8.47% [5]. At higher PLF the specific auxiliary power is reduced (Fig. 2).

The auxiliary power consumption can be reduced, by improving the plant load factor of the plants, by operational optimization, adoption of advanced control techniques and implementation of energy conservation measures. By reducing the auxiliary power additional power will be available at grid. This paper presents the results of performance test conducted on 23 units of 210 MW sub-bituminous coal fired power plants with tangentially corner fired and balanced draft system.

Auxiliary power

The auxiliary power is the essential power used by the auxiliary equipment. The auxiliary power is tapped at Unit Auxiliary

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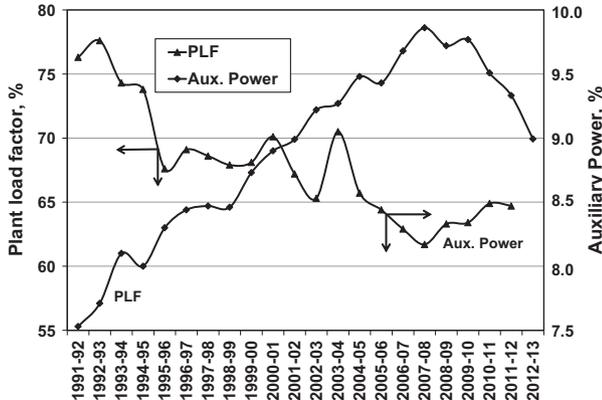


Fig. 1. Variation of average PLF and specific auxiliary power.

Transformers (UAT) during normal running of the plant and from Station Transformers (ST) during starting of the plant. The auxiliary power can be broadly classified into in-house auxiliary power whose loading vary with change in plant load of particular unit and out-lying or common auxiliary power. The typical in-house auxiliary equipment are: Boiler feed pumps (BFP), Condensate extraction pumps (CEP), Induced draft fans (ID), Forced draft fans (FD), Primary air fans (PA), Mills, etc. [6]. The out-lying or common auxiliary power is the power used by the common auxiliary equipment i.e., they cater the power to more than one particular units and out-lying auxiliary equipment are: Circulating water pumps (CWP), Ash slurry pumps, HP & LP water pumps, DM pumps, Crushers, Conveyors, Wagon tippers, etc. Fig. 3 gives the schematic of the in-house High Tension (HT i.e., operating at 6.6 kV voltage) auxiliary equipment in a typical coal fired power plants. Table 1 shows the HT in-house auxiliary equipment details.

The HT in-house auxiliary power equipment is:

1. Boiler feed pumps increase the feed water (FW) pressure from deaerator (0.5–0.6 MPa) to drum pressure (16.0–17.5 MPa) and also to overcome the hydraulic pressure drop across HP regenerative feed heaters, economizer, feed regulating station, water walls, superheaters and reheaters. The specific auxiliary power used by BFP accounts for 2.45% of gross energy generation at MCR or designed plant load as against to the design value of 2.28% i.e., an equivalent CO₂ emission of 4.8–5.2 t/h.
2. Condensate extraction pumps increase the condensate pressure from condenser (i.e., vacuum 10–15 kPa) to deaerator pressure and to overcome the hydraulic pressure drop across LP regenerative feed heaters. The specific auxiliary power used by CEP accounts for 0.22% of gross energy generation at MCR as against

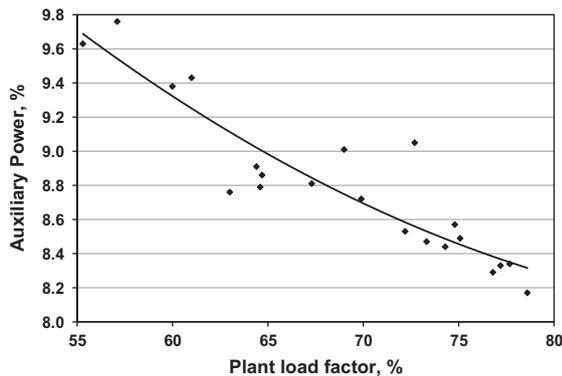


Fig. 2. Variation of specific AP with PLF.

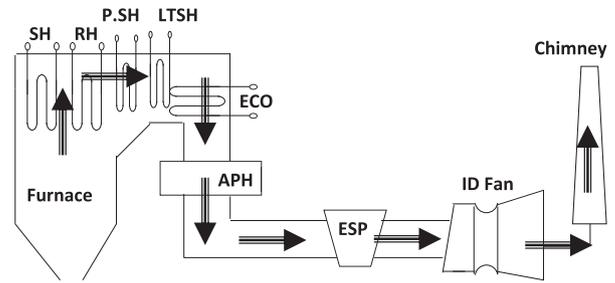


Fig. 3. Scheme of flue gas circuit (ID fan).

to the design value of 0.22% i.e., an equivalent CO₂ emission of 0.46–0.48 t/h.

3. Induced draft fans' main aim is to suck the flue gas from the furnace and throw to the atmosphere through chimney. These fans have to maintain the pressure always on negative side in the range of –49 to –98 Pa. The specific auxiliary power used by ID fans account for 1.11% of gross energy generation at MCR as against to the design value of 0.90% i.e., an equivalent CO₂ emission of 1.9–2.3 t/h.
4. Forced draft fans provide the secondary air for combustion at windbox and to maintain the windbox differential pressure to about 0.98 kPa. The specific auxiliary power used by FD fans account for 0.21% of gross energy generation at MCR that is lower compared to the design value of 0.25% i.e., an equivalent CO₂ emission of 0.48–0.52 t/h.
5. Primary air fans provide the primary air at about 6.86–7.85 kPa at mill inlet to lift the pulverized coal from mills to burners. The specific auxiliary power used by PA fans account for 0.93% of gross energy generation at MCR as against to the design value of 0.65% i.e., an equivalent CO₂ emission of 1.9–2.1 t/h.
6. Six numbers of XRP 863 Bowl mills are installed to provide the pulverized coal for combustion. The specific auxiliary power used by Mills accounts for 0.66% of gross energy generation at MCR as against to the design value of 0.50% i.e., an equivalent CO₂ emission of 1.3–1.5 t/h.
7. The total CO₂ emission due to auxiliary power for a typical 210 MW plant is about 17.9–23.5 t/h.

Fig. 4 is the share of specific auxiliary power for in-house HT equipment. The auxiliary power is greatly influenced by the Plant Load Factor (PLF) of units. As the PLF increases, the percentage of auxiliary power (specific auxiliary power) decreases. The variation of total specific auxiliary power is curve fitted in second order polynomial (standard deviation $R^2 = 0.99$) with PLF to:

$$AP = 8.9 \times 10^{-5} * PLF^2 - 0.098162 * PLF + 17.66993 \quad \% \quad (1)$$

where AP is the total specific auxiliary power in percentage of gross power generation and PLF is plant load factor of unit in percentage and is computed as:

$$PLF = \frac{P_{Gen}}{P_{Rating}} * 100 \quad \% \quad (2)$$

where P_{Gen} is the average power generation by the individual generator in MW, P_{Rating} is the Maximum Continuous Rating (MCR) of particular generator in MW.

The standard of deviation (R^2 value) for the second order polynomial curve fit is 0.9959. This shows that the confidence level of curve fit for the measurement data is more than 99% which seems to be good and the scatter of data of auxiliary power of different units is within 1%.

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