The Journal of CPRI,
Vol. 10, No. 1, March 2014 pp. 65-74

Reducing Auxiliary Power of Induced Draft Fans in Coal Fired Thermal Power Plants by Energy Audit

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This paper describes the various opportunities for reducing the auxiliary power of induced draft fans in coal fired thermal power plants. The auxiliary power used by induced draft fans forms about 0.9 to 1.18 % of the total gross energy generation for 210 MW to 800 MW power plants. ID fans are the second largest (in rating) motor in a thermal power plant after Boiler Feed Pump (BFP). The detailed energy audit of auxiliary equipment in various thermal power stations, operational optimization and appropriate control system had shown ample scope for improving the energy efficiency of induced draft fans. The implementation of energy conservation measures reduce the average auxiliary power used by ID fans for 210 MW plant from average value of 1.18 % to 0.90 % of gross energy generation and the energy conservation schemes are economically attractive with a payback period of 1 to 5 years.

Keywords : *Thermal power plant, Auxiliary power, HT motors, Fans, Pumps, Mills.*

1.0 INTRODUCTION

The total installed power generation capacity in India is about 245 GW, out of which 148 GW is from coal based thermal power plant that forms 58.75 % of total installed capacity by 30th Sept. 2013 [1]. For coal fired thermal power plants, auxiliary power is essential to run the auxiliary equipment. The auxiliary power varies depending on the type of auxiliary equipment used. 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 & 4.9 % of total installed capacity [2]. The thermal power plant availability largely depends upon the operational reliability of the auxiliary equipment and the capability of the auxiliary system [3]. The net overall efficiency of the coal fired thermal power plants are in the range of 19.23 % (30 MW plant) and 30.69 % (500 MW plant). The auxiliary power consumption is varying between 5.2 % (500 MW plant) and 12.3 % (30 MW plant).

The boilers used for power generation generally work on the principle of balanced draft system i.e., both Forced Draft (FD) & Primary Air (PA) fans for pushing air into the furnace and Induced Draft (ID)

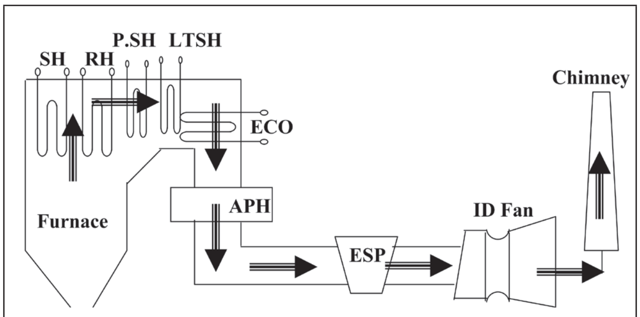

FIG. 1 SCHEME OF FLUE GAS CIRCUIT (ID FAN)

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fans to suck the flue gas from the furnace & throw out the flue gas to atmosphere through chimney. Figure 1 gives the schematic of flue gas circuit in thermal power plant.

In each power boiler, generally there will be two ID fans for plant size of 210 MW & below and four ID fans for 500 MW, 660 MW & 800 MW plants. ID fans have to handle large quantity of flue gas at higher temperature. The flue gas flow will be controlled either by inlet guide vane or scoop (hydraulic coupling).

2.0 AUXILIARY POWER

The auxiliary power used by ID fan varies widely may be due to use of different grade coals and use of different controls like, IGV, Scoop (hydraulic) and VFD control. Figure 2 gives the variation of average specific auxiliary power for ID fans for different unit size. The variation of specific power is curve fitted with unit size:

a) For scoop and IGV controlled fans

$$AP_{ID} = 3.493 \ x \ PCAP^{-0.203} \quad \% \qquad ....(1)$$

b) For VFD controlled fans

$$AP_{ID} = 42.492 \ x \ PCAP^{-0.739} \quad \% \qquad ....(2)$$

Where PCAP is the plant capacity in MW

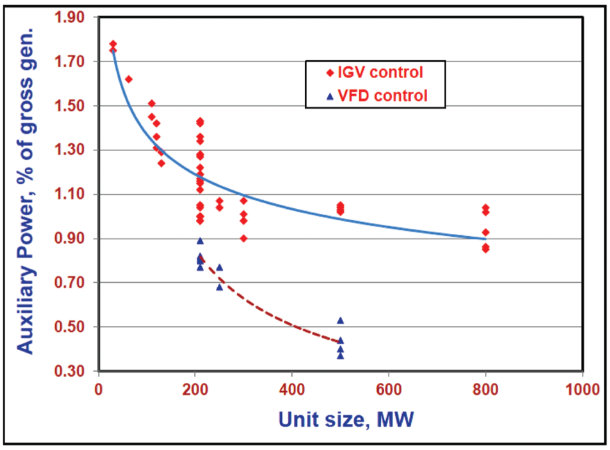

FIG. 2 AUXILIARY POWER WITH UNIT SIZE

The average auxiliary power used by ID fans for different power plants (at 100 % PLF) is 0.90 % of gross energy generation for 800 MW plant; 0.99 % for 500 MW plant; 1.10 % for 300 MW plant; 1.14 % for 250 MW plant; and 1.18 % for 210 MW plant for normal scoop & IGV control [4]. For VFD control the average specific auxiliary power measured during performance tests is 0.43 % of gross energy generation for 500 MW plant; 0.72 % for 250 MW plant; and 0.82 % for 210 MW plant.

The power used by ID fans is greatly influenced by the plant load factor (PLF) and is presented in Figure 3. The auxiliary power variation can be curve fitted for 210 MW power plant [5]:

$$AP_{ID} = A_0 + A_1 \ x \ PLF + A_2 \ x \ PLF^2 \quad \% \qquad ....(3)$$

Where PLF is plant load factor in percentage, A_0, A_2, and A_3 are constants ($A_0 = +2.340381$, $A_1 = -0.019394$ & $A_2 = +7.0x10^{-5}$).

The specific auxiliary power of ID fan reduces with the increase in plant load. It can be seen from the Figure that the actual measured auxiliary power of ID fans is higher than the design value due to use of poor coal quality, sub-optimal operation of ID fans, etc. The auxiliary of ID fans is higher by 0.20 % at MCR condition and 0.24 % at 70 % PLF.

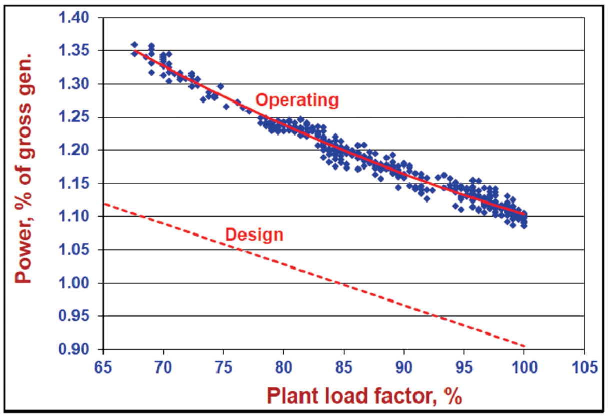

FIG. 3 AUXILIARY POWER OF ID FANS WITH PLF

3.0 PERFORMANCE EVALUATION OF ID FANS

3.1 Motor losses

The efficiency and power loss in motor can be computed by any one of the eight methods specified by IEEE standard 112. i.e., nameplate method; slip method; current method; statistical method; equivalent circuit method; segregated loss method; air-gap torque method; and shaft torque method [6, 7].

Among all the above methods, segregated loss method gives the more realistic estimation of motor loss and efficiency. In this method as per IEEE standard 112 Method E1, the magnitudes of five losses like stator copper loss, rotor copper loss, core loss, stray load loss and friction & windage losses are computed.

To compute the core loss, the no load test is carried out on the motor by disconnecting the fan from the motor during annual overhaul time.

a) Core loss at no load is computed as:

$$L_{NL\,core} = P_0 - L_{NL\,stator} - L_{F\&W}\ kW \quad ....(4)$$

Where P_0 is no load power in kW, $L_{NL\,stator}$ is no load stator copper loss in kW, $L_{F\&W}$ is friction and windage loss and is given by the manufacturer and vary between 1 – 1.5 % of input power.

b) Power input ($P_{motor\,in}$) is measured during the performance test by using power analyzer

c) The stator copper loss during performance test is computed by

$$L_{FL\,stator} = \frac{\left(I_R^{\,2} + I_Y^{\,2} + I_B^{\,2}\right) x\ R_{S2}}{1000}\ kW \quad ....(5)$$

Where I_R, I_Y, & I_B are full load (phase) current during performance test in A, R_{S2} is stator resistance at stator winding temperature.

d) Rotor input power is computed by [8, 9]:

$$P_{rotor\,input} = P_{motor\,in} - L_{FL\,stator} - L_{FL\,core}\ kW \quad ....(6)$$

Where $L_{FL\,core}$ is the core loss during performance test. The core loss is proportional to square of applied voltage and the full load core loss is computed by

$$L_{FL\,core} = \left(\frac{V_{FL}}{V_{NL}}\right)^2 x\ L_{NL\,core}\ kW \quad ....(7)$$

e) Rotor copper loss is computed by

$$L_{rotor} = P_{rotor\,input}\ x\ s \quad kW \quad ....(8)$$

Where *s* is slip in fraction

f) Total motor losses will be computed by

$$L_{motor\,total} = L_{FL\,stator} + L_{FL\,core} + L_{rotor} + L_{F\&W} + L_{stray}\ kW \quad ....(9)$$

Where L_{stray} is stray load loss and is difficult to measure during the performance test and is assumed to be 1.2 % of motor input power as per NEEMA MG1

g) The power output of motor is computed as

$$P_{motor\,output} = P_{motor\,in} - L_{motor\,total}\ kW \quad ....(10)$$

3.2 Fan losses

The ID fan must provide the power to overcome the hydrodynamic resistances offered by different elements. The power supplied by ID fans is computed by:

$$P_{motor\,input} = P_F + P_{ECO} + P_{APH} + P_{ESP} + P_{CH} + L_{duct\,APH-ESP} + L_{duct\,ESP-IDF} + L_{fan} + L_{motor\,total}\ \ kW \quad ....(11)$$

Where P_F power to overcome the resistance in furnace (SH, RH, Platen SH, LTSH) in kW, P_{ECO} is power to overcome the resistance in Economizer in kW, P_{APH} is power to overcome the resistance in Air preheater in kW, P_{ESP} is power to overcome the resistance in ESP in kW, P_{CH} is power to exit the flue gas to atmosphere through Chimney in kW, $L_{duct\,APH\text{-}ESP}$ is power loss in flue gas duct between APH and ESP in kW, $L_{duct\,ESP\text{-}IDF}$ is power loss in flue gas duct between ESP and ID fan suction in kW, L_{fan} is power loss in fan in kW and $L_{motor\,total}$ is power loss in motor to drive the fan in kW.

$$P_{motor\,input} = P_{fan\,output} + L_{fan} + L_{motor\,total}\ kW \quad ....(12)$$

a) ID fan output power is computed by [10]:

$$P_{fan\,output} = \sum_{i=1}^{i=5} \frac{PRDP_i\ x\ \overset{o}{m}_{fl_i}\ x\ 9.81}{1000} + \sum_{f=1}^{f=2} \frac{PRDP_f\ x\ \overset{o}{m}_{fl_f}\ x\ 9.81}{1000}\ kW \quad ....(13)$$

Where $PRDP_i$ is pressure drop in flue gas across each element i.e., i=1 for furnace, i=2 for Economizer, i=3 for APH, i=4 for ESP & i=5 for chimney in mmWC, $PRDP_f$ is pressure drop in flue gas ducts i.e., f=1 between APH output to ESP input; & f=2 between ESP output to ID fan inlet in mmWC, $\overset{o}{m}_{fl_i}$ and $\overset{o}{m}_{fl_f}$ are flue gas flows in corresponding elements, flue gas flow for i=1 for furnace and i=2 for economizer is computed as:

$$\overset{o}{m}_{fl} = \frac{\overset{o}{m}_{cl}\ x\ (1 - ASH_{bottom})}{\rho_{cl}} + \overset{o}{m}_{PA} + \overset{o}{m}_{SA}\ m^3/s \quad ....(14)$$

Where $\overset{o}{m}_{cl}$ is coal flow in m^3/s, $\overset{o}{m}_{PA}$ is primary air flow supplied by PA fans in m^3/s, $\overset{o}{m}_{SA}$ is secondary air flow supplied by FD fans in m^3/s, ρ_{cl} is density of coal in kg/m^3; and ASH_{bottom} is bottom ash collected at furnace bottom in fraction and is computed as

$$ASH_{bottom} = 0.20\ x\ ASH \quad ....(15)$$

where ASH is ash content (in fraction) in coal measured by proximate analysis. The ash in coal will be generally bifurcated into 80 % fly ash and 20 % bottom ash.

for i=3 for APH, flue gas flow is computed as

$$\overset{o}{m}_{fl_i} = \left(\frac{\overset{o}{m}_{fl} + \overset{o}{m}_{fl-APH\ out}}{2} \right) m^3/s \quad ....(16)$$

Where

$$\overset{o}{m}_{fl-APH\ out} = \overset{o}{m}_{fl}\ x \left\{ 1 + \left[\frac{(O_{2-APH\ out} - O_{2-APH\ in})}{100} \right] \right\} m^3/s \quad ....(17)$$

$O_{2-APHout}$ is oxygen content in flue gas after APH in %; and $O_{2-APHin}$ is oxygen content in flue gas before APH in %.

for i=4 for ESP, flue gas flow is computed as

$$\overset{o}{m}_{fl_i} = \left(\frac{\overset{o}{m}_{fl-ESPin} + \overset{o}{m}_{fl-ESPout}}{2} \right) m^3/s \quad ....(18)$$

Where

$$\overset{o}{m}_{fl-ESPin} = \overset{o}{m}_{fl}\ x \left\{ 1 + \left[\frac{(O_{2-ESPin} - O_{2-APHin})}{100} \right] \right\} m^3/s \quad ....(19)$$

$O_{2-ESP\ in}$ is oxygen content in flue gas before ESP in %

$$\overset{o}{m}_{fl-ESPout} = \overset{o}{m}_{fl-ESPin} - \left(\overset{o}{m}_{cl}\ x\ ASH_{fly} x \eta_{ESP} \right) m^3/s \quad ....(20)$$

ASH_{fly} is fly ash collected at in flue gas fraction and is computed as

$$ASH_{fly} = 0.80\ x\ ASH \quad ....(21)$$

And η_{ESP} is fly ash collection efficiency of ESP in fraction for i=5 for Chimney, flue gas is computed as

$$\overset{o}{m}_{fl} = \left(\frac{\overset{o}{m}_{fl-APH\ out} + \overset{o}{m}_{fl-ESP\ in}}{2} \right) m^3/s \quad ....(22)$$

b) Power loss to overcome the hydrodynamic resistance in flue gas duct between APH & ESP is computed by:

$$L_{duct\ APH-ESP} = \frac{PRDP_{duct\ APH-ESP}\ x \left(\frac{\overset{o}{m}_{fl-APH\ out} + \overset{o}{m}_{fl-ESP\ in}}{2} \right) x\ 9.81}{1000} kW \quad ....(23)$$

Where $PRDP_{duct\ APH-ESP}$ is pressure drop in flue gas duct in mmWC between APH & ESP and is computed as

$$PRDP_{duct\ APH-ESP} = PR_{APH-out} - PR_{ESP-in}\ mmWC \quad ....(24)$$

c) Power loss to overcome the hydrodynamic resistance in flue gas duct in mmWC between ESP & ID fan inlet is computed by:

$$L_{duct\ ESP-IDF} = \frac{PRDP_{duct\ ESP-IDF}\ x \left(\frac{\overset{o}{m}_{fl-ESP\ out} + \overset{o}{m}_{fl-IDF\ in}}{2} \right) x\ 9.81}{1000} kW \quad ....(25)$$

Where $PRDP_{duct\ ESP-IDF}$ is pressure drop in flue gas duct in mmWC between ESP & ID inlet is computed as

$$PRDP_{duct\ EPS-IDF} = PR_{ESP-out} - PR_{IDF-in}\ mmWC \quad ....(26)$$

$$\overset{o}{m}_{fl-IDF\ in} = \overset{o}{m}_{fl-ESP\ out}\ x\left\{1+\left[\frac{O_{2-IDF\ in}-O_{2-ESP\ in}}{100}\right]\right\} m^3/s \quad ....(27)$$

Where $O_{2\text{-}ESPin}$ is oxygen content in flue gas before ID fan in %

d) ID fan output is computed by:

$$P_{fan\ output} = P_F + P_{ECO} + P_{APH} + P_{ESP} + P_{CH} + L_{duct\ APH-ESP} + L_{duct\ ESP-IDF}\ kW \quad ....(28)$$

e) ID fan input is computed by:

$$P_{fan\ input} = P_{motor\ output}\ kW \quad ....(29)$$

f) Loss in ID fan is computed by:

$$L_{fan} = P_{fan\ input} - P_{fan\ output}\ kW \quad ....(30)$$

4.0 RESULTS AND DISCUSSION

As the plant load increases, the flue gas flow also increases thereby the auxiliary power at ID fan input also increases. Figure 4 gives the variation of flue gas flow with PLF for 210 MW plant. It can be seen from the Figure that the actual measured flue gas flow is higher than the design value may be due to use of poor coal quality. The variation of flue gas flow with PLF is curve fitted to:

$$Flow = B_0 + B_1\ x\ PLF + B_2\ x\ PLF^2 \quad t/h \quad ....(31)$$

Where B_0, B_2, and B_3 are constants (B_0 = -326.4299, B_1 = +20.888 & B_2= -0.73171).

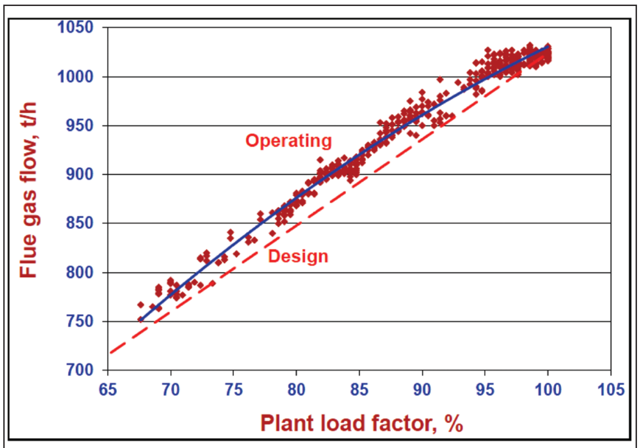

FIG. 4 FLUE GAS FLOW WITH PLF

The FG flow is higher by 0.65 % than the design value at MCR condition and is higher by 2.26 % at 70 % PLF. This causes an additional auxiliary power of ID fans by 0.01 to 0.03 % of gross energy generation.

The specific energy consumption (SEC) of ID fans vary with plant load (Figure 5) and is varying between 2.22 – 2.54 kWh/t of flue gas flow at 210 MW plant and is higher than the design value of 1.85 – 2.11 kWh/t of flue gas flow. The variation of SEC with plant load factor is curve fitted to:

$$SEC = C_0 + C_1\ x\ PLF + C_2\ x\ PLF^2 \quad kWh/t \quad ....(32)$$

Where C_0, C_1 and C_2 are constants (C_0 = 4.6819, C_1 = -0.0468 & C_2 = 0.00022).

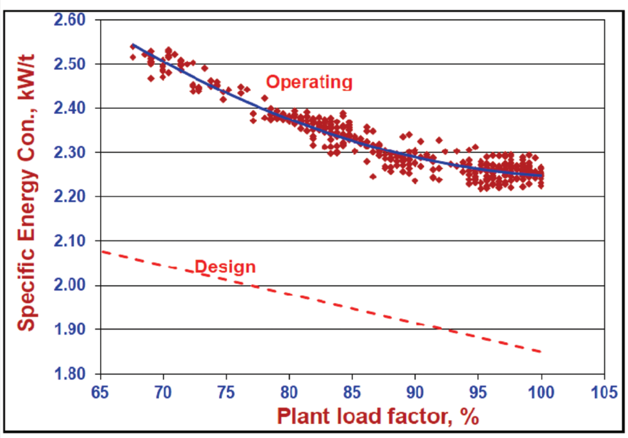

FIG. 5 SEC OF ID FANS WITH PLF

The flue gas pressure at ID fan inlet also increases with plant load factor and is given in Figure 6. The pressure variation with plant load factor is curve fitted to:

$$PR = D_0 + D_1\ x\ PLF + D_2\ x\ PLF^2 \quad mmWC \quad ....(33)$$

Where D_0, D_1 and D_2 are constants (D_0 = +357.1589, D_1 = -10.2034 & D_2 = +0.0354).

The flue gas pressure at inlet is higher due to hydrodynamic resistance across APH, ESP & Economizer and flue gas ducts. The increased suction pressure is higher by 12.43 % at MCR and 14.05 % at 70 % PLF compared to design value. The increased power due to higher ID fan suction pressure compared to design value is 0.13 – 0.16 % of gross energy generation.

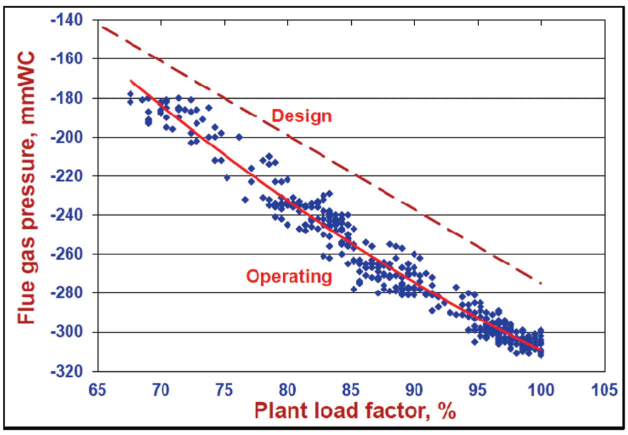

FIG. 6 FLUE GAS PRESSURE WITH PLF

5.0 FACTORS INFLUENCING HIGHER AUXILIARY POWER

The factors responsible for high auxiliary power for induced draft fans are:

- Oversizing of equipment
- Use of age old technologies and hesitation in adopting new energy efficient technologies
- *Poor or sub-optimal performance of equipment*: implementation of energy conservation measures will improve the performance of equipment and reduce the auxiliary power considerably.
- *Instrumentation & control:* lack of knowledge and resources in upgrading control & instrumentation to operate the plant efficiently.
- *Forced outages:* occurring due to unforeseen circumstances or breakdown of equipment
- *Operational practices and constraints:* lack of operational capabilities of operators

5.1 Oversizing of fans

Generally to keep the safety margins and to operate the plant more than 60 % of its capacity by operating with even single air-flue gas cycle, the induced draft fans are designed with high reserve capacities. Table 1 gives the design and operating capacities of ID fans for 500 MW and 210 MW plants [11, 12]. Operating the equipment at partial load will reduce the efficiency of ID fans and will increase the auxiliary power.

ID fans are oversized by 20.0 – 23.2 % in flue gas flow, by 23.2 – 28.5 % in pressure (total head developed by fans), by 35.2 – 42.8 % in output power for 210 & 500 MW plants. The ID fan efficiency at their 100 % rated capacity is 84.5 % for 500 MW plant and 76.5 % for 210 MW plant. The ID fan efficiencies at 100 % maximum continuous rating (MCR) of plant are reduced to 72.9 % for 500 MW plant and 63.91 % for 210 MW plants (efficiencies are taken from the fan curves supplied by manufacturer). Therefore, the oversizing of ID fans have reduced the overall efficiency in the range of 11.45 – 12.27 % that leads to the increased auxiliary power of about 0.11 – 0.15 % of gross energy generation (2.72 – 4.75 MU/year).

TABLE 1

CAPACITY UTILIZATION OF ID FANS

Sl No.	Particulars	500 MW plant		210 MW plant	
		Design value (fan 100 % cap.)	100 % MCR	Design value (fan 100 % cap.)	100 % MCR
01	Motor rating , kW (Nos.)	1800 (4)		1400 (2)	
02	Flue gas flow, m^3/s	255	204	228	192.2
03	Total head developed, mmWC	480	343	384	295
04	Fan efficiency, %	84.50	72.90	76.50	63.91
05	Fan output power, kW	1200	686.43	858.89	556.22
06	Fan input power, kW	1420.12	941.60	1122.73	870.31
07	Motor efficiency, %	95.06	94.48	94.96	94.46
08	Motor input power, kW	1493.92	996.62	1182.31	921.36
09	Motor load factor, %	79.00	52.31	80.20	62.17
10	Overall efficiency, %	80.33	68.88	72.64	60.37
11	Reduction in overall efficiency, %	11.45		12.27	

5.2 New technology adoption

Many of the 210 MW and 500 MW plants are provided with either IGV control or hydraulic scoop coupling for ID fans with conventional power frequency drives and the energy efficiency of these fans is on lower side. The load on ID fans will be continuously varying between 60 – 75 %. It is beneficial to install the variable frequency drives (VFD). These fans can be controlled by using variable frequency drives. Table 2 gives the performance results of ID fans with and without VFD for 500 MW and 210 MW plants [11, 12].

The installation of VFD will reduce the energy consumption by 4.51 MU/year per fan at 500 MW plant and 2.12 MU/year per fan at 210 MW plant. The average SEC has decreased from 3.03 to 1.69 kWh/t of flue gas at 500 MW plant and from 2.02 to 1.45 kWh/t of flue gas at 210 MW plant. The techno-economic evaluations were carried out by Central Power Research (CPRI) energy audit team and the simple payback period is about 3 – 4 years. The other advantages of VFD over the prevailing technology of hydraulic and fixed speed motor drives are [13]:

- smooth control of flue gas
- absence of limitation of number of starts
- no voltage dips in the system from direct-on-line starting of large size motors
- increased efficiency over wide operating speed range

But these VFD drives inject harmonic currents in the system (Figure 7). 5th and 7th individual current harmonics ($6n \pm 1$ harmonics) are on higher side. This shows that the drives use 6-pulse rectifier bridges. The current total harmonic distortions (THD) are in the range of 25.3 – 26.6 %). These harmonics can be suppressed by either passive or active harmonic filters.

TABLE 2

PERFORMANCE RESULTS OF ID FANS WITH AND WITHOUT VFD

Sl. No.	Particulars	500 MW plant		210 MW plant	
		Without VFD	VFD	Without VFD	VFD
01	Suction Pr., mmWC	-256.6	-246. 0	-265.0	-266.0
02	Discharge Pr., mmWC	4.20	-47.88	8.00	4.50
03	Flue gas flow, t/h	474.16	511.77	439.41	427.47
04	Electrical power input, kW	1436.9	867.15	889.35	621.96
05	Mechanical power output, kW	406.98	333.69	439.37	423.52
06	Operating overall efficiency, %	28.32	38.48	49.40	68.09
07	SEC, kWh/t	3.03	1.69	2.02	1.45
08	Energy saving per fan, MU/year	4.51		2.12	

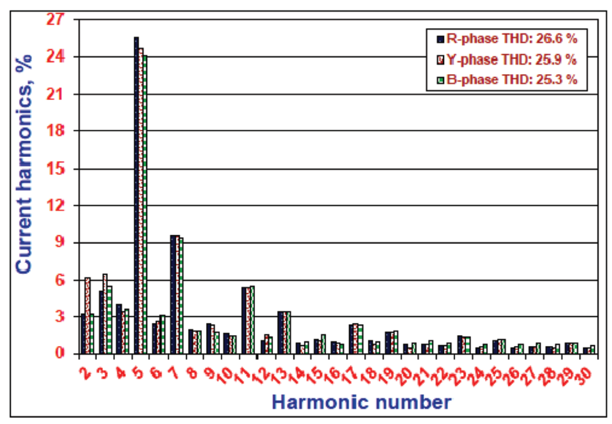

FIG. 7 CURRENT HARMONICS AT ID FANS WITH VFD

5.3 Reducing the hydrodynamic pressure

Figure 8 gives the variation of flue gas pressure profile inside the furnace in the ID fan circuit. Figure 9 gives the pressure drop across each element in ID fan circuit. Figure 10 gives the pie chart for power and loss in different elements in ID fan circuit for a typical 210 MW plant. The observations and suggestions for energy conservation measures are as follow

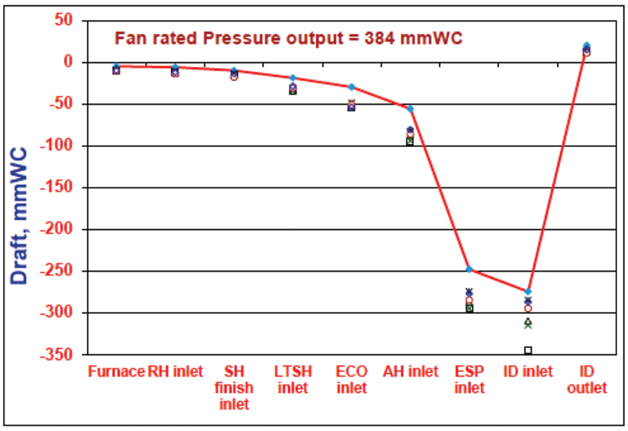

FIG. 8 PRESSURE PROFILE IN FLUE GAS DUCT

i) The actual operating flue gas pressure drop across furnace is varying between 49 – 55 mmWC as against to the design value of 30 mmWC. The increased energy consumption due to higher pressure drop is 60.6 MWh/month. Clearing the debris in SH, RH, Platen SH and LTSH zones reduced the ID fan power by 0.04 % of gross generation.

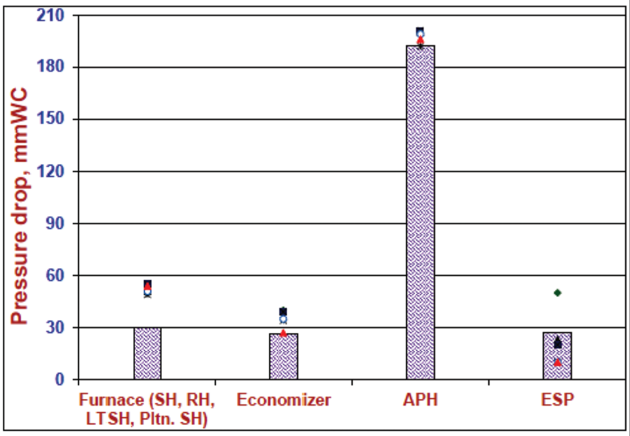

FIG. 9 PRESSURE DROP IN FLUE GAS DUCT

ii) The pressure drop in Economizer coils (flue gas side) is varying between 27 – 40 mmWC and is on higher side as compared to the design value of 26 mmWC. Reducing the pressure drop by clearing the debris in the economizer section help in reducing the ID fan power by 0.022 % of gross generation.

iii) The pressure drop in flue gas side across APH is varying between 192 – 201 mmWC as compared to the design value of 192 mmWC. The higher pressure drop may be due to blockage in APH baskets. Cleaning the APH baskets during overhaul reduced the ID fan power by 0.014 % of gross generation.

iv) The pressure drop across ESP is varying between 10 – 50 mmWC as against to the design value of 27 mmWC. The reduction of pressure drop in ESP on flue gas side reduced the energy consumption by 55.8 MWh/month. This helps in reducing the ID fan power by 0.037 % of gross generation.

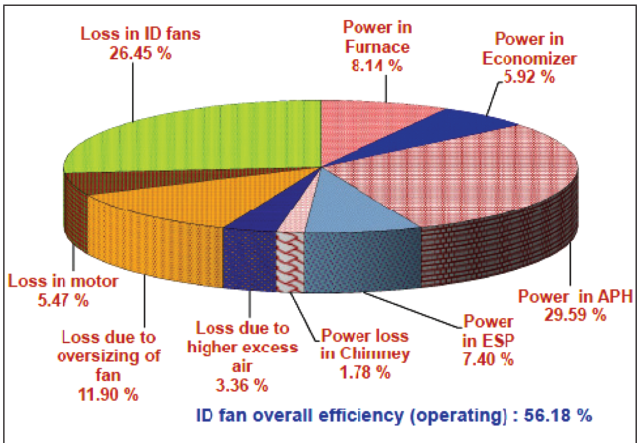

FIG. 10 POWER AND LOSS IN ID FAN CIRCUIT

5.4 Excess air and furnace ingress

The smaller plants (less than 210 MW plant capacity) are provided with refractory type of water walls where the more furnace air ingress is observed. Table 3 gives the furnace ingress and air leakages in APH measured in a 110 MW power plant [14]. The furnace ingress is measured to 47.4 % of total air and air leakage through APH is 21.3 %. This increases the auxiliary power of ID fans by 0.34 % of PLF [15].

In many of the power plants, the oxygen content before ID fans is measured in the range of 6.2 – 9.9 % and is on higher side. The increased oxygen content at ID fan inlet is mainly due to air leakages in APH, furnace air ingress and air ingress in ESP & flue gas duct. The reduction in oxygen content at ID fan inlet to below 4.5 % by arresting air ingress & reduction of air leakage in APH reduced the energy consumption by 65.7 MWh/month. This helps in reducing the ID fan power by 0.043 % of PLF.

TABLE 3

AIR FLOW THROUGH THE SYSTEM IN M^3/S AT 110 MW POWER PLANT

Sl. No.	Particulars	Design (100 % MCR)	Operating (99.5 MW)
01	Primary air along with coal	31.44	18.37
02	Secondary air to wind box	58.39	64.29
03	Illegal furnace ingress	0.00	74.47 (47.4 %)
04	APH in-leakage from air side to flue gas	0.00	33.51 (21.3 %)
05	Total air flow through fans	89.83	82.66
06	Total air flow in flue gas before APH	89.83	157.13
07	Total air flow in flue gas after APH	89.83	190.64

6.0 CONCLUSION

The appropriate sizing and matching of fan-motor improve the energy efficiency of ID fans and will reduce the auxiliary power of ID fans by 0.32 % of gross energy generation. Use of VFD for ID fans reduces the auxiliary power of ID fans by 0.23 % of gross output. The reduction in hydrodynamic resistance in ID fan circuit reduced the auxiliary power of ID fans by 0.11 % of gross generation. Control of excess air, reduction of air ingress in furnace & flue gas duct will reduce the auxiliary power of ID fans considerably. Improving the dust collection efficiency of ESP also improves the performance of ID fans.

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