ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Improvement Strategy of Energy Efficiency in Water Tube Boilers

Mrs. K.Lavanya, M.Tech
Assistant Professor,
Department of Mechanical Engineering,
Sanketika Vidya Parishad Engineering College,
P.M.Palem, Visakhapatnam.

M. Venkatesh
B.E
Department of Mechanical Engineering,
Sanketika Vidya Parishad Engineering College,
P.M.Palem, Visakhapatnam.

M.R.L.V. Sai Kumar
B.E
Department of Mechanical Engineering,
Sanketika Vidya Parishad Engineering College,
P.M.Palem, Visakhapatnam.

M.Vijay Kumar
B.E
Department of Mechanical Engineering,
Sanketika Vidya Parishad Engineering College,
P.M.Palem, Visakhapatnam.

M.Naveen
B.E
Department of Mechanical Engineering,
Sanketika Vidya Parishad Engineering College,
P.M.Palem, Visakhapatnam.

Abstract:

Boiler in thermal power plant are to be operated efficiently to achieve higher plant efficiency in the present day market economy coal fired water tube boiler is one of the most important component for any thermal power plant. But now a days no boiler is giving efficiency not more than 65%. Boiler efficiency effects the overall performance of the electricity generation process and as well as plant economy it reduces with time, due to various heat losses such as loss due to unburnt carbon in waste, loss due to formation of water from H_2 in fuel, loss due to dry flue gas, loss due to moisture in fuel, loss due to moisture content in air, loss due to radiation and convection, loss due to unburnt in bottom ash. The boiler efficiency can be estimated by considering Air affecting on boiler, Grass calorified value of coal fines (unburnt air), Relative humidity between air efficiency.

1. LITERATURE SURVEY:

Verma et al. [1] compared nine wood pellets boilers in terms of the combustion efficiency, with accuracy presented as absolute error. Most boilers met permissible efficiency standards and ecolabelling, some units, however, required additional testing in order to upgrade their parameters.

Carvalho et al. [2] suggested that the 15 kW pellet boiler was in operation with different pelletized biomass to evaluate its efficiency, where the accuracy met the requirements of mean SEMs standard error. The authors proposed several modifications in boilers technology to improve its combustion. It was concluded that the efficiency was progressively decreasing due to ash. accumulation on the heat exchangers. Conditions achieved from four biomass types combusted in a grate-fire unit (nominal output 250 kWth) were described as average values of thermal efficiency, with an accuracy of the given standard deviations.

DiazRamirez et al. [3] says that, Different operating conditions had to be implemented among tested fuels to achieve the highest thermal efficiency. It is common that most studies of small-scale boilers performance demonstrate results directly, neglecting any kind of information on results accuracy. Another activity is the use of fuel additives to improve combustion efficiency, but this issue raises controversy, and the results obtained this way are doubtful. The report of the European Commission shows the effectiveness of seventeen commercial and non-commercial coal additives in reducing ash fouling and slagging, and gaseous emissions in fluidised bed combustion (FBC),

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

stoker fired (SF) and pulverised fuel fired boilers (PF), in both laboratory and industrial scale. Regarding the efficiency, it was only mentioned that the combustion enhancers can potentially increase plant efficiency by up to 2.5%. More details on boilers effi- ciency can be found in studies on oil-fired boilers.

Prelec et al. [4] conducted a research on 320 MW steam boiler reveals that using additives prolongs time lapses between boilers cleanings, which corresponds to the steam boiler efficiency improvement between 0.3% and 0.5%.

Rahman et al. [5] states that, it was concluded that chemical additive dosing to oil-fired boilers gives some positive effects in SO3 reductions and the acid dew point. Moreover, boilers.efficiency is not affected. As in the above case, the accuracy of boilers efficiency was not appointed.

Avadheshetal. [6] explained in detail about performance modeling and behavior analysis of coal handling system of a thermal power plant. This paper describes the behavior analysis of coal handling system of a thermal power plant. The detailed study was done on various handling systems. On the basis of various factors analysis of coal handling system was done. The performance modeling is explained in detail.

Bhattachrya, etal. [7] Written a paper about Impact of Coal Beneficiation on Rail transport in India Thermal Coal, which is the mainstay of India's power generation, contains as high as 50%ash, to meet the rapidly growing demand for thermal power the transportation facilities need to be significantly expanded. The present work examines the impact of beneficiation on thermal coal transportation by railways and finds that it would considerably improve the loading capacity of wagons, there life and also release carrying capacity on the saturated rail network.

Everett [8] stated that Steam is a critical recourse in today's industrial world. It is essential for cooling and heating of large buildings, driving equipment such as pump and compressors and for powering ships. However, its most importance priority remains as source of power for the production of electricity. Steam is extremely valuable because it can be produced anywhere in this world by using the heat that comes from the fuels that are available in this area.

2. INTRODUCTION

2.1 HISTORY OF BOILERS:

The history of boilers has based on it's the industrial age. However, the foundation of what makes a boiler successful still stays true to a few basic components. While the boiler industry benefits from constant innovation, there is no difference of the basic structure and function of the historical boiler from the equipment we use today.

2.2 THE FIRST BOILERS:

The steam boilers are the first historical boilers used for power transportation, and those are commonly seen in trains and ships. Early models like the "Scotch Marine" and similar early fire tube boilers which are made from a steel shell with rounded tube sheets that were welded at both ends. A door on the vessel would swing outward, so that the interior of the boiler could be accessed for inspections and cleaning. These early boilers were fueled by coal or wood and the tubes had to be placed to prevent soot accumulation.

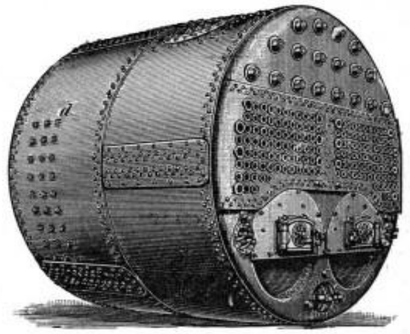

Fig1.1.: The first boilers

2.3 BENT TUBE AND CAST IRON BOILERS:

In the next stage i.e., in 1946 bent tubes are used in boilers instead of straight tubes. The resulting bent

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

tube boilers were more compact and could better handle the cold water feeds that were interlock during that period. Cast iron boilers were the next type of boilers used for producing high pressure steam, there is no system in today good at producing low pressure steam used for applications of heating buildings. Cast iron is heavy and difficult to repair, but it was an effective because it could be made in a variety of shapes and was tough enough for low pressure steam.

2.4 WORLD WAR II AND BEYOND

World War-II was a big turning point in the history of the boiler Because, from here after, Tube boilers were developed, along the seminal Rite water tube boiler, which marked a great improvement in the efficiency of boilers and the speed with conversion of water to steam. Copper tube boilers arised after Rite boilers, but they are very problematic and required frequent and need replacements. It wouldn't until approximately fifteen years ago in the history of boilers that the new condensing boiler came into use.

3.INDUSTRIAL INVESTIGATION

3.1 WORK ESTABLISHMENT:

- In HETERO Industry we are using Atomic fludised bed combustion AFBC boiler.
- AFDC boiler gives the efficiency up to 83 to 88%
- This type of boiler is mainly depending on 4 systems. They are:
- Feed water system 2) steam system 3) Flue gas 4) air system

3.2 FEED WATER SYSTEM:

- Feed water is supplied to the boiler through the feed pump
- Theb quality of water supplied to be atleast equal to that evaporated and supplied to the engine.this feed water is demineralized in the deaceator by injecting the N_2H_4.
- It is again passes through B.F.P to economizer and then to Drum.

3.3 STEAMSYSTEM:

- When steam is generated from secondary super heater to primary we connect steam pump to turbine.
- Here we get 66 kg/cm^2 pressure to import the turbine to exhaust.

3.4 FLUE GAS SYSTEM:

- In flue gas system, we are giving input to the bed i.e. 400^{o}C to 450^{o}C after that steam is Passed through secondary super heater to primary super heater at a temperature of 500^{o}C to 550^{o}C
- In this process temperature will gradually decreased and it passes through Bank zone at 380^{o}C to 400^{o}C and then again it passes through Economizer by maintaining temperature 200^{o}C to 280^{o}C
- To reduce the flue gas temperature we place Air Pre Heater (APH).
- By using APH we can decrease flue gas temperature up to 140^{o}C
- Again this flue gas can passes through ESP to maintain constant temperature by the help of ID forms.

3.5AIR SYSTEM:

- It can be divided into FD fan and PA fan.
- When this air is passes through FD fan until it reaches to APH and it goes through the PA fan to wind box.
- By using this PA fan we can increase the efficiency of boiler.

Fig3.1: Overall view of water tube vertical boiler

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

3.6 WORKING PROCESS:

In this type of boiler, we are pumping natural coal (Indonesia coal) as fuel. In a pulverized fuel system, the coal is first reduced to a fine powder (say6.5mm) with the help of grinding mill and send it to coal bunkers and then projected into combustion chamber. Now, air can be passed through the wind box and push the air by using primary air fan(PA) fan so that ,air and coal combustion takes place. In this combustion chamber, we place primary super heater and secondary super heater.by using secondary super heater we can increase the temperature upto 500°C-550°C.In this process, water can be feed into water tubes along with Demineralized (DM) water from the tank.it is passing through detector with low pressure (LP) doping(N_2H_4).after that it passing through Boiler Feed water Pump(BFP) and then through economizer. water can be controlled by feed wall system (30°,90°) and again it is passed through primary drum(steam drum) to secondary drum(mud drum).there, we kept the water bed coil to increase the heat of water. Primary drum is the major drum to produce the steam of overall efficiency.it is based on input components.it is also known as steam drum because here, steam is collected by 50% and water is 50% inside the drum. so, we get the moisture less steam. when it is pumping into main steam then, outlet pressure of 66 kg/cm^2 can be formed. here waste can be formed from two drums, and those drums can be connected to down commers and ash containers.

4. DATA COLLECTION:

For theoretical process:

Table 3.1: Data recorded for theoretical process:

Coal	As per the Value	Based on the Coal consumption	Petcoke	As per the Value	Based on the Coal consumption
TM	42	25.2	TM	4.5	2.7
GCV	5433	3259.8	GCV	8469	5081.4
ASH	9.1	5.46	ASH	0.78	0.468
CA	48.9	29.34	CA	94.72	56.832
CARBON	36.4061	21.844	CARBON	82.975	49.785
HYDROGEN	3.14427	1.8866	HYDROGEN	3.5046	2.1028
NITROGEN	0.57702	0.3462	NITROGEN	1.4208	0.8525
OXYGEN	8.23476	4.9409	OXYGEN	1.6102	0.9661
SULPHUR	0.5379	0.3227	SULPHUR	5.2096	3.1258
Max CO_2	18.31	10.983	Max CO_2	19.03	11.419
CO_2 in FG	12.9882	7.7929	CO_2 in FG	13.503	8.1019
O_2 in Flue gas	6.1	6.1	O_2 in Flue gas	6.1	6.1

SPECIFICATIONS:

Fuel firing rate = 5900 kg/hr
Steam generation rate = 56000 kg/hr
Steam pressure = 66 kg/cm^2 (g)
Steam temperature = 481° C
Feed water temperature = 164° C
%CO_2 in Flue gas = 12.98
%CO in flue gas = 0.55
Average flue gas temperature = 145° C
Ambient temperature = 31 ° C
Humidity in ambient air = 0.0204 kg / kg
dry air Surface temperature of boiler = 70 ° C
Wind velocity around the boiler = 3.5 m/s
Total surface area of boiler = 90 m^2
GCV of Bottom ash = 800 kCal/kg
GCV of fly ash = 3800kCal/kg
Ratio of bottom ash to fly ash = 90:10

FUEL ANALYSIS (in %):

Ash content in fuel = 4.94
Moisture in coal = 23.25
Carbon content = 71.81
Hydrogen content = 3.32
Nitrogen content = 0.99
Oxygen content = 4.92
GCV of Coal = 6951kCal/kg

For industrial process:

HEAT OUTPUT DATA:

Quantity of steam generated (Q) = 90TPH
Steam pressure (P) = 89 kg/cm^2
Steam temperature (T_s) = 515°C
Enthalpy of steam at 10 kg/cm^{2}pressure (H) = 815 kcal/kg
Feed water temperature (T_f) = 205 °C
Enthalpy of feed water (h) = 205 kcal/kg

HEAT INPUT DATA:

Quantity of coal consumed (Q) =20 TPH
GCV of coal (GCV) = 3200 kcal/kg

HEAT LOSSES IN DRY FLUE GAS:

$$L_1 = \frac{m \times C_p \times (T_f - T_a)}{GCV of fuel} \times 100$$

$$L_1 = \frac{8.723 \times 0.24 \times (145 - 31)}{6951} \times 100$$
$= 3.433\%$

HEAT LOSS DUE TO FORMATION OF WATER FROM H2 IN FUEL:

$$L_2 = \frac{9 \times H_2 \times \{584 + C_p(T_f - T_a)\}}{GCV of fuel} \times 100$$

$$L_2 = \frac{9 \times 0.03 \times \{584 + 0.24(145 - 31)\}}{6951} \times 100$$
$= 2.723$

% OF HEAT LOSS DUE TO MOISTURE IN FUEL:

$$L_3 = \frac{M \times \{584 + C_p(T_f - T_a)\}}{GCV of fuel} \times 100$$

$$L_3 = \frac{8.723 \times \{584 + 0.24(145 - 31)\}}{6951} \times 100$$
$= 2.125\%$

% OF HEAT LOSS DUE TO MOISTURE IN AIR:

$$L_4 = \frac{AAS \times humidity factor \times C_p \times (T_f - T_a)}{GCV of fuel} \times 100$$

$$L_4 = \frac{16.18 \times 0.0204 \times 0.24 \times (145 - 31)}{6951} \times 100$$
$= 0.13\%$

% OF HEAT LOSS DUE TO PARTIAL CONVERSTION OF C TO CO :

$$L_5 = \frac{\%CO \times C}{\%CO + \%CO_2} \times \frac{5744}{GCV of fuel} \times 100$$

$$L_5 = \frac{0.55 \times 0.72}{0.55 + 12.98} \times \frac{5744}{6951} \times 100$$
$= 2.411\%$

HEAT LOSS DUE TO RADIATION AND CONVENTION:

$$L_6 = 0.548 \times \left[\left(\frac{T_s}{55.55}\right)^4 - \left(\frac{T_a}{55.55}\right)^4\right] + 1.957 \times (T_s - T_a)^{1.25} \times \sqrt{\left[\frac{(196.85V_m + 68.9)}{68.9}\right]}$$

$$L_6 = 0.548 \times \left[\left(\frac{70}{55.55}\right)^4 - \left(\frac{31}{55.55}\right)^4\right] + 1.957 \times (70 - 31)^{1.25} \times \sqrt{\left[\frac{(196.85(3.5) + 68.9)}{68.9}\right]}$$
$= 0.206\%$

% OF HEAT LOSS DUE UNBURNT IN FLYASH:

$$L_7 = \frac{(0.00493) \times 3800}{6951} \times 100$$
$= 0.27\%$

%OF HEAT LOSS DUE UNBURNT IN BOTTOM ASH:

$$L_8 = \frac{(0.044) \times 800}{6951} \times 100$$
$= 0.512\%$

Boiler $\boldsymbol{Efficiency} = 100 - (L_1 + L_2 + L_3 + L_4 + L5 + L6 + L7 + L8$

Boiler Efficiency =

$$100 - (3.443 + 2.735 + 2.125 + 0.13 + 2.411 + 0.206 + 0.27 + 0.512)$$

Boiler $\boldsymbol{Efficiency} = \mathbf{88.169}\%$

5. RESULTS AND DISCUSSIONS

TABLE 5.1: HEAT LOSSES FOR THEORETICAL PROCESS (FORL$_1$, L$_2$, L$_3$, L$_4$):

Cp (kcal/kg)	Tf °C	Ta °C	GCV	L1 (%)	L2 (%)	M	L3 (%)	AAS	Humidity	L4 (%)
0.24	145	31	6400	3.056	2.620	0.239	2.319	16.18	0.0204	0.143
0.24	145	31	6500	3.111	2.579	0.239	2.283	16.18	0.0204	0.141
0.24	145	31	6600	3.254	2.539	0.239	2.247	16.18	0.0204	0.138
0.24	145	31	6700	3.357	2.463	0.239	2.180	16.18	0.0204	0.134
0.24	145	31	6800	3.402	2.427	0.239	2.148	16.18	0.0204	0.132
0.24	145	31	6900	3.458	2.392	0.239	2.117	16.18	0.0204	0.130

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

TABLE 5.2: HEAT LOSSES FOR THEORETICAL PROCESS (L_5, L_6):

%CO	%C	%CO_2	GCV	L_5 (%)	Ts (K)	Vm (K)	HRT	TSA	Fuel firing rate	L_6 (%)
0.55	0.72	12.98	6400	2.626	70	3.5	1061.751	90	5900	0.253
0.55	0.72	12.98	6500	2.586	70	3.5	1061.751	90	5900	0.249
0.55	0.72	12.98	6600	2.547	70	3.5	1061.751	90	5900	0.245
0.55	0.72	12.98	6700	2.5202	70	3.5	1061.751	90	5900	0.241
0.55	0.72	12.98	6800	2.472	70	3.5	1061.751	90	5900	0.238
0.55	0.72	12.98	6900	2.436	70	3.5	1061.751	90	5900	0.234

TABLE 5.3: HEAT LOSSES FOR THEORETICAL PROCESS: (L_7, L_8):

Total ash collected/Fuel of air burnt	GCV of fly ash	L_7 (%)	Total ash collected/Fuel of air burnt	GCV of bottom ash	L_8
0.00493	3800	0.292	0.004	800	0.55
0.00493	3800	0.288	0.004	800	0.41
0.00493	3800	0.283	0.004	800	0.533
0.00493	3800	0.279	0.004	800	0.525
0.00493	3800	0.275	0.004	800	0.517
0.00493	3800	0.271	0.004	800	0.5101

TABLE 5.4: HEAT LOSSES FOR INDUSTRIAL PROCESS:

L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Total efficiency
3.056	2.62	2.319	0.1433	2.6262	0.253	0.2927	0.55	88.1392
3.111	2.579	2.283	0.1411	2.5864	0.2491	0.5415	0.5415	88.2207
3.254	2.529	2.247	0.1389	2.5472	0.2453	0.5333	0.5333	88.2215
3.357	2.463	2.18	0.1347	2.5092	0.2417	0.5253	0.5253	88.3095
3.402	2.427	2.148	0.1328	2.4723	0.2381	0.5176	0.5176	88.3867
3.458	2.392	2.117	0.1308	2.4364	0.2347	0.5106	0.5101	88.4495

6 GRAPHICAL REPRESENTATION

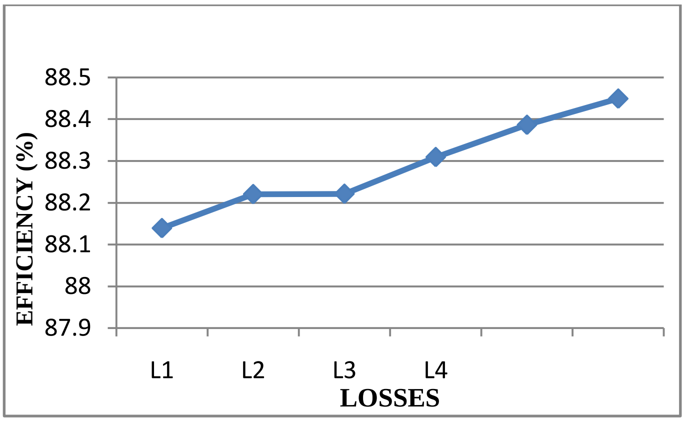

Fig. 6.1 GRAPH BETWEEN LOSSES(L1,L2,L3,L4) AND EFFICIENCY

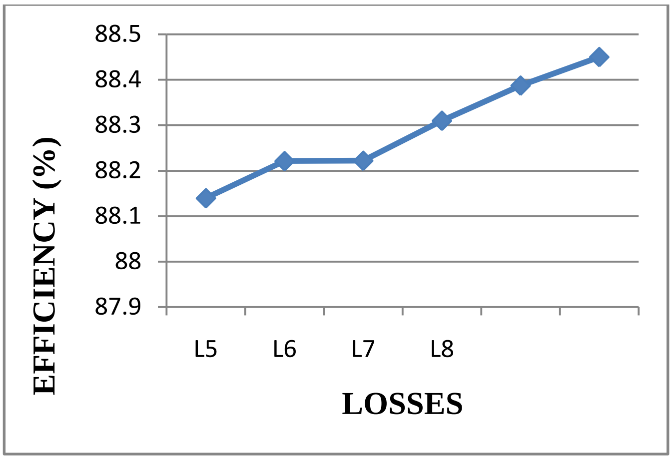

Fig 6.2: GRAPH BETWEEN LOSSES (L_5, L_6, L_7, L_8) AND EFFICIENCY

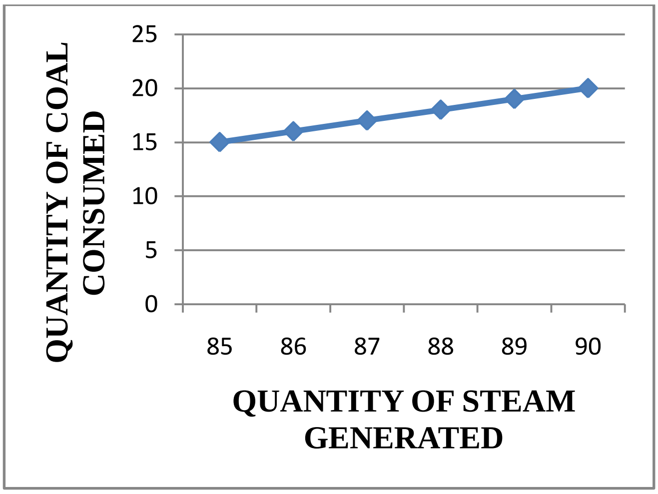

Fig 6.3: GRAPH BETWEEN QUANTITY OF STEAM GENERATED AND QUANTITY OF COAL CONSUMED

7 CONCLUSIONS AND RESULT:

Hence in the overall project we worked on the improvement of the efficiency of the Boiler by considering various aspects involving in it such as, The fuel used for combustion, Type of Boiler, Various load, Power plant age, Heat exchanger fouling they lose efficiency. Much of these losses in efficiency due to the mechanical wear on variety of components resulting heat losses. The periodic vision on the boiler is very important. The operation of the boiler also plays a key role. In coming years industries all over the world are increasing powerful competition and increased automation of plants. We have to use advanced technologies in order to perform effective role in the turnover of the company.

REFERENCES

[01] V.K. Verma, S. Bram, I. Vandendael, P. Laha, A. Hubin, J. De Ruyck, Residential pellet boilers in belgium: Standard laboratory and real life performance with respect to European standard and quality labels, Appl. Energy 88 (2011) 2628-2634, http://dx.doi.org/10.1016/j.apenergy.2011.02.004

[02] L.Carvalho, E.Wopienka, C.Pointner, J.Lundgren, V.K.Verma, W.Haslinger, C.Schmidl, Performance of a pellet boiler fired with agricultural fuels, Appl.Energy 104 (2013) 286–296, http://dx.doi.org/10.1016/j.apenergy.2012.10.058.

[03] M. Diaz-Ramirez, F. Sebastian, J. Royo, A. Rezeau, Influencing factors on NOx emission level during grate conversion of three pelletized energy crops, Appl.Energy 115 (2014) 360–373, http://dx.doi.org/10.1016/j.apenergy.2013.11.011.

[04] Z. Prelec, T. Mrakovcic, V. Dragicevic, Performance study of fuel oil additives in real power plant operating conditions, Fuel Process. Technol. 110 (2013) 176-183, http://dx.doi.org/10.1016/j.fuproc.2012.12.010

[05] M.M. Rahman, A.G. Dalvi, K.A. Rabbani, S. Al-Sulami, F. Mandili, H.M. Khaledi, B. Al-Jowdi, Evaluation of fuel chemical additives to reduce corrosion and stack emission in SWCC power plants, in: 4th SWCC Acquired Experience Symposium, Jeddah, Saudi Arabia, (2005).

[06] Avadhesh et al. (2008)Applied Thermal Engineering, Volume 119, 5 June 2017, Pages 553-559

[07] Bhattachrya, Sreya Roy Chowdhury, Parthasarathi Mukherjee, International Journal of hydrogen energy Volume 41, Issue 38, 15 October 2016, Pages17072-17083.

[08] Avadheshetal. (2008), explained in detail about performance modeling and behavior analysis of coal handling system of a thermal power plant.