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Comparative Analysis of Coal Blends on Captive Thermal Power Plant: Concentrate Different Parameters Effect on Its Efficiency

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ABSTRACT

Coal is the prime fuel for electricity generation in India and its utilization is continuously growing to meet the energy requirements of the country. The basic function of power plant is to convert energy in coal to electricity. Therefore, the first thing we should know is how much energy there is in coal. Energy content of coal is given in terms of kilojoules per kilogram (kJ/kg) of coal as the Gross calorific value (GCV) or High Heating Value (HHV) of coal. This value can be varies from 10500 kJ/kg to 25000 kJ/kg depending on the quality and type of coal. Indian coals are of poor quality and often contain 30-50% ash when shipped to power stations. In addition, over time the Calorific Value and the ash content of thermal coals have deteriorated as the better quality coal reserves are depleted and surface mining and mechanization expand. This poses significant challenges. Significant research has been done to determine the beneficial results of using high Calorific Value coals in thermal power plants. [5, 6, 15]

Keywords: consumptions, efficiency, coal blend and cost, gross calorific value

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INTRODUCTION

The main objectives is to find the performance of coal based on the properties of coal and also the reasons of poor efficiency levels of coal blend have been identified, basic ideas have been developed for improving the performance of these coal blend. It is a practical work which is performed in the RSWM coal testing laboratory. In this practical work measure GCV (gross calorific value) of coal and coal blend, identify presently uses coal property, prepare new efficient coal blend and calculate energy efficient parameters and proximate analysis of fuel (coal blend) with cost analysis. This is the initial stage of increasing boiler efficiency. The Main object of coal analysis in the Power Station is to monitor the quality of coal. Therefore performance evaluation of coal is necessary [1, 2, 4].

Rajasthan Spinning and weaving Mills Ltd. (RSWM) Mordi is a coal based captive power plant. Here steam generated by Atmospheric Fluidized Bed Combustion (AFBC) Boiler. Generation capacity of this plant is 46 MW and coal consumption per day is approximately 1100 tons which is not only depends on generation but also it depends on GCV of fuel (coal). It is use under bed fuel feeding system and it use coal blend. There are different types of coal available in market but this captive power plant use C grade, F grade, imported coal and pet coke and crushed coal particle size is 1 – 6 mm. Coal supply in RSWM plant through truck and per truck coal weight is 25 tons or it varies 20–55 tons. Coal price and GCV show in Table 1.

Table 1. *Coal GCV and actual price.*

Coal type	GCV (kcal/kg)	Purchased from	Cost (Rs./Ton)
C grade	4940–5600	Niyati	4719
F grade	2400–3360	Shambhupura	2450
Imported coal	~4500	Bhatiya	3965
Pet Coke	~5600	Agrawal	4986

**Coal price in September 2010.*

ANALYSIS OF COAL SAMPLE

The main object of collecting and preparing a sample of coal is to obtain a quantity of coal representative of the full quantity of coal under consideration. Sampling is the first stage in the evaluation of coal and unless this is not correctly done all the subsequent calculation will suffer. Related to the Power Station supplies, sample of coal may be collected from conveyor, during loading and unloading of wagons and from the stationary wagons. The number of sample to be collected from one lot depends on the quantity of coal in it and samples are collected as per the Indian Standard guideline.

Fig 1. *Bomb calorimeter.*

The calorific value of a coal is a measure of its total heat energy. It is expressed as kilo calories/kg. The determination of calorific value is carried out using a bomb calorimeter. This gives the gross calorific value. Highly efficient and very complicate structure of the bomb calorimeter. [7]

Table 2. *Actual coal blend analyses.*

S. No.		ARB				ADB		
	T.M.	Ash	GCV	I.M.	Ash	V.M.	F.C.	GCV
	%	%	Kcal/kg	%	%	%	%	Kcal/kg
1	24.12	29.24	3701	6.10	35.94	28.60	28.96	4580
2	24.82	28.67	3697	6.54	35.56	28.34	29.86	4595
3	24.82	28.52	3694	6.32	35.42	28.64	29.64	4590
4	19.35	29.92	3706	5.14	35.28	29.02	30.36	4370
5	20.85	31.60	3704	6.82	37.20	26.90	28.88	4360
Avg.	22.744	29.59	3700	6.19	35.88	28.30	29.54	4499

DIFFERENT COAL BLEND RATIO AND COST ANALYSIS

For the analysis of coal blending performance here assumed that consumption of coal is constant at fix power generation. Suppose that at 46 MW power generations, the consumption of coal is 1067 tons/day with the help of this assumption, able for find optimum condition of coal blend.

It is very long process because prepare different coal blend according to fix weight and different ratio and after that one by one of all coal blend samples performs proximate analysis with individual gross calorific value calculation. Finally reach at the result with cost analysis and achieve optimum coal blending ratio which is highly efficient to presently running coal blend. [10]

Table 3. *Recommended coal blend reading.*

Coal type	Imp		C	F		Total
Coal Ratio %	51		18	31		100
Coal consumption variation (tons/day)	544.17		192.06	330.77		1067
Cost (Rs./Day)	2157634.05		906331.14	810386.50		3874351.69
ARB			ADB			
TM %	Ash %	GCV kcal/kg	IM %	Ash %	VM %	FC %	GCV kcal/kg
22.05	29.66	**3766**	6.48	35.16	28.19	30.08	4519

Test Result: Optimum condition coal blend.

MODIFIED COAL BLEND READING:

Table 4. *Recommended coal blend reading.*

		ARB				**ADB**		
S. no.	**T.M.**	**Ash**	**GCV**	**I.M.**	**Ash**	**V.M.**	**F.C.**	**GCV**
	%	**%**	**kcal/kg**	**%**	**%**	**%**	**%**	**kcal/kg**
1	21.45	29.58	3758	6.45	35.05	27.85	31.03	4476
2	21.86	29.94	3772	6.76	35.27	28.33	29.59	4501
3	22.85	29.46	3768	6.23	35.17	28.39	29.63	4580
Avg.	22.05	29.66	3766	6.48	35.16	28.19	30.08	4519

Table 5. *Readings of proximate analysis of coal blend.*

Proximate analysis	**Units**	**Present running**	**Recommended**
		Coal blend	**Coal blend**
	As receive based		
Total moisture	%	22.74	22.05
Ash	%	29.59	29.66
GCV	Kcal/kg	3700	3766
	As dried based		
Inherent moisture	%	6.19	6.48
Ash	%	35.88	35.16
Volatile moisture	%	28.30	28.19
Fixed carbon	%	29.54	30.08
GCV	Kcal/kg	4493	4519

COMPARISON OF ANALYSIS OF COAL BLEND

Two type of analysis is generally carried out. [6]

(i) Proximate Analysis

(ii) Ultimate Analysis

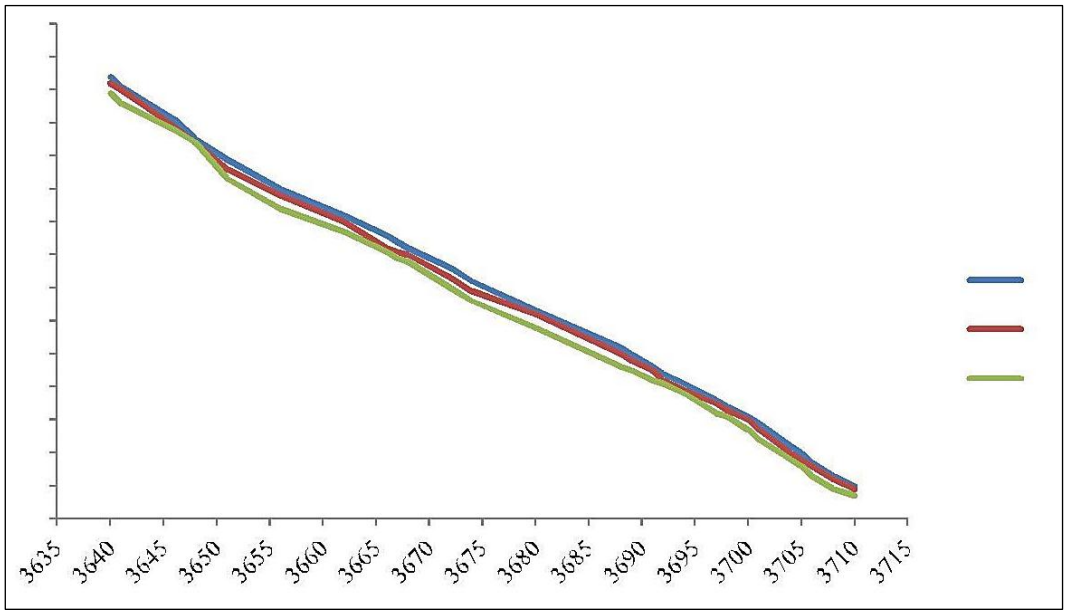
Proximate analysis indicates the percentage by weight of the Fixed Carbon, Volatiles, Ash, and Moisture Content in coal. The ultimate analysis indicates the various elemental chemical constituents such as Carbon, Hydrogen, Oxygen, Sulphur, etc.

Table 6. *Typical ultimate analyses of various coal blends*.

Ultimate Analysis	Units	Present Running Coal Blend	Recommended Coal Blend
Ash AD	%	35.88	35.16
Moisture AD	%	22.74	22.05
Carbon	%	42.6214	42.9813
Hydrogen	%	3.0603	3.070
Nitrogen	%	1.534	1.536
Oxygen	%	12.845	12.640
Sulphur	%	0.33	0.33
GCV_{ARB}	Kcal/ kg	3700	3766
Ash	%	29.54	29.66
Inherent Moisture	%	6.19	6.48

COAL CONSUMPTION ANALYSIS ON THE BASIS OF GCV AND POWER

Generation		
	1180	
	1170	
Day)	1160	
	1150	
	1140	
(Tons/	1130	
	1120	
	1110	
	1100	46MW
	1090	44MW
Consumption	1080	
	1070	42MW
	1060	
Coal	1050	
	1040	
	1030	



GCV of Coal (kcal/ kg)

Figure 1: Coal Consumption Analysis on the Basis of GCV and Power Generation [8, 11]. Finally, concluded for the recommended coal blend, the recommended coal blend GCV is higher the present coal blend around 66 kcal/ kg (3700 kcal/ kg to 3766 kcal/ kg). Therefore here assume that when apply recommended coal blend for power generation in RSWM Mordi, it will be save coal consumption around 70 – 80 Tons/ Day. [13]

ENERGY SAVING ANALYSIS OF BOILER:

Boiler efficiency plays an important role for power plant. There are different types of losses occurs in boiler which is already discussed and calculated in previous chapters. In the complete analysis of coal blend, recommended coal blend GCV is greater than presently used coal blend therefore boiler efficiency will be increases up to 3.96% (Through Direct Method). [9, 11]

Boiler Efficiency (Direct Method)

Parameters to be monitored for the calculation of boiler efficiency by direct method are:

Boiler Eficiency =	Heat Output	
	Heat Input	
Presently Running Coal	**Recommended Coal**	**% of increase η**
76.85	80.81	3.96

Boiler Efficiency (Indirect Method)

In order to calculate the boiler efficiency by indirect method, all the losses that occur in the boiler must be established. These losses are conveniently related to the amount of fuel burnt. Ultimate analysis of fuel has calculated in previous chapter. Results of ultimate analysis of fuel and flue gas analysis are directly used here for calculate theoretical air, excess air and actual mass of air and dry flue gas.

Boiler η	Unit #1	Unit #2
Presently Running Coal	78.8119	79.3197
Recommended Coal	79.4023	79.8764
% of increase η	0.5904	0.5567

RESULTS AND DISCUSSIONS

The energy efficiency measures implemented in Rajasthan Spinning and Weaving Mills limited Banswara (Textile Industry) Rajasthan. RSWM Mordi is captive thermal power plant. GCV (Gross Calorific Value) of coal has increased 3700kcal/kg to 3766kcal/kg means

66kcal/kg. By the analysis of previous data of TPP, coal consumption of recommended coal blend is 997tons/ day (assumption with analysis). In the complete analysis of coal blend, recommended coal blend GCV is greater than presently used coal blend therefore boiler efficiency will be increases up to 3.96% (Through Direct Method).

Overall Thermal Power plant Efficiency		
Presently Running Coal Blend	%	24.05
Recommended Coal Blend	%	25.29
Efficiency Increase	%	1.24

After the efficiency increment, second aim is monetary saving. Actually cost is not a secondary thing because cost and efficiency are directly proportional to each other therefore need an optimum condition which gives highest efficiency and maximum saving of money as soon as possible. Cost is variable factor which is also depends on consumption of fuel (coal). Saving through recommended coal blend -

If coal consumption is not changing than saving is 11.61×10^6 Rs/yr.
If coal consumption is changing than saving is 103.15×10^6 Rs/yr.

CONCLUSION

This complete study is survey specific scenario calculations for the possible implementation works and the related impacts on the power plant efficiency. The study found that the implementation in coal blend system would increase the overall plant efficiency. This higher GCV value of recommended coal blend is improved boiler efficiency 3.96% and overall power plant efficiency 1.24%. The boiler losses will be reduced if gross calorific value of coal is high.

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