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Reduction of Coal usage and Improving Boiler Efficiency in Thermal Power Stations

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***Abstract*— India is one of the more producer of the electricity in the world. Major source of generation of electricity in India is due to coal. As per National Electricity plan, the government has approved to install 50,025 MW coal based thermal power plants. But, It was observed that more amount of coal is using to generate the electric power than reference level. This was because of presence of magnetic elements in the bed material which was used in boiler to maintain desired temperature at the bottom of the boiler. The efficiency of the boiler is decreasing due to damage caused by the magnetic elements in the bed material. These magnetic elements decrease the reference temperature in the boiler and consequently the boiler operator is allowing excess amount of coal to maintain the reference temperature in the boiler. Because of this, excess amount of coal is used to generate electric power and there by producing excess amount of ash. This can be reduced by constructing a magnetic separator near the bed material stack point and verifying the magnetic elements in the bed material thoroughly. Due to this separator, the boiler efficiency can be maintained nearer to the designed value, usage of excess amount of coal can be reduced. The investment cost for erecting the magnetic separator can be obtained in a couple of years. As a case study, the SKS Power Generation CG Ltd, Raigarh is considered. The proposed theme is applied in MATLAB and the cost of thermal power plant is calculated and existing making data. The obtained results showed that the proposed structure gives a feasible system and best experience and is proved that it is essential for solving such type of assignments.**

***Index Terms*— Electrical Energy Situation, fluidized bed, efficiently removes iron particles from material, limit, Payback time, MATALB.**

I. INTRODUCTION

India is one of the more producer of the electricity in the world. Major source of generation of electricity in India is due to coal. As per National Electricity plan, the government has approved to install 50,025 MW coal based thermal power plants. India's electricity sector is dominated by fossil fuels, in particular coal, which produced about three-quarters of the country's electricity. The government is making efforts to increase investment in renewable energy. It is expected that non-fossil fuels generation contribution is likely to be around 44.7% of the total gross electricity generation by 2029–30. The installed capacity in India as on July 2023 is shown in fig 1. The Circulating Fluidized Bed Combustion (CFBC) boiler is the most advanced steam generator technology.
Among many distinguishable advantages of CFBC boilers, it achieves very low NOx and Sox emission by capturing sulfur contents of the fuel during the burning process. CFBC boilers are said to achieve better calcium

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to sulphur utilization – 1.5 to 1 vs. 3.2 to 1 for the AFBC boilers, although the furnace temperatures are almost the same. CFBC boilers are generally claimed to be more economical than AFBC boilers for industrial application.

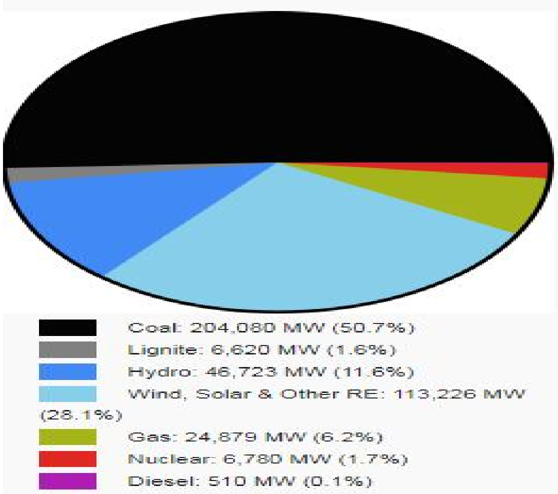

TABLE 1: GROWTH OF INSTALLED CAPACITY OF THERMAL POWER STATIONS

Installed Capacity as on	Installed Capacity (MW)
31.12.1947	854
31.12.1950	1153
31.03.1956	1825
31.03.1961	2736
31.03.1966	4903
31.03.1974	9058
31.03.1979	15207
31.03.1985	27030
31.03.1990	43764
31.03.1997	61010
31.03.2002	74429
31.03.2007	86015
31.03.2012	131603
31.03.2014	168255
31.03.2017	218330
31.03.2018	222906
31.03.2019	226279
31.03.2020	230600
31.03.2021	234728
31.03.2022	236109

Coal is the major source of fuel for generation of electricity in India. In the entire world, coal is used as a major source for generation of electricity.

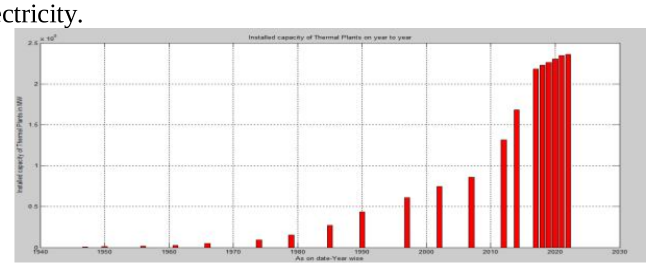

Fig 2: Growth of installed capacity of Thermal Plants from year to year

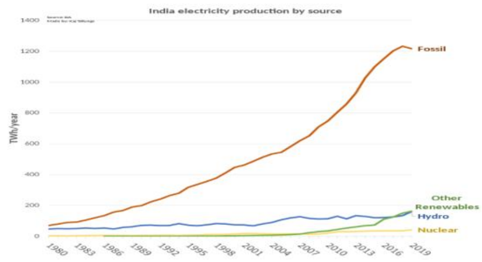

Fig 3: Electricity Production in India

Growth of Installed Capacity of Thermal Power Stations is shown in table 1 and fig 2 for statistical analysis. Electricity Production in India is growing year to year very rapidly and the same is shown in fig 3. Gross Calorific Value of the coal is the key factor in deciding the plant heat rate. Heat rate is expressed in BTU/KWH. Heat rate is the amount of fuel is required to generate one unit of electricity. The lesser the plant heat rate then more is the efficiency of the plant. The nations like Malaysia, Chile, South Korea and Japan rely on coal for few reasons.

To get more GCV of the coal, the Indian coal is blended with imported coal. For example, Indonesian coal is blended with Indian coal. Table 2 shows the cost of coal is required to generate one unit of electricity and cost of one unit of electricity generated.

TABLE II: UNIT & COST OF ENERGY

Particulars	Unit	Value
Electricity	Rs/KWh	4.00
Coal	Rs/MT	3900

TABLE III: THEORETICAL AND PRACTICAL VALUES OF A BOILER

Description	Theoretical Values	Practical Values
Unit-1,BoilerEfficiency	86.26%	83.50%
Unit-2,BoilerEfficiency	86.26%	83.01%
Unit-1,UnitRate	2585.64	3109
Unit-2,UnitRate	2588.77	3207

To get more efficiency in the boiler, the bed material should consists of less magnetic components as low as possible. As the bed material consists of fewer amounts of magnetic materials, it is possible to maintain the reference level of temperature in the boiler. Because of this, the stoppages of the boiler also decrease. Thus maintenance of the boiler also decreases. Because of the presence of magnetic materials the efficiency of the two boilers are reduced to 83.50% and 83.01% from reference efficiency of 86.26% respectively.

II. PROBLEM FORMULATION

For the SKS Power Generation CG Ltd, Raigarh. The highest and lowest generating capacity of the generator is 300 MW and 150 MW respectively. In general, the bed material should not contain greater than 2.5% for maintaining of better efficiency of boiler. Boiler efficiency test was driven for boiler-1 and boiler-2 independently. During testing, load on the Unit-1and Unit-2 was 144.96 MW and 146.18 MW respectively. From the table 3, it was observed that the boiler efficiencies and heat rates are deviated from the reference levels. The amount of coal is required, the amount coal is blended and the number of units of electricity is generated is shown in table 4. On examining the bed material, it was observed that more than 2.5% of the magnetic components present in the bed material. In bed materials, the presence of magnetic elements lies in the range from 1% to 10%. Because of these magnetic components in bed material, the boiler efficiency was not in the reference level.

To improve boiler efficiency and thus to reduce frequent stoppages in the boiler, a magnetic separator unit was proposed to install the bed material stock point. With the help of this magnetic separator unit, the entire load of bed material is tested before sending to boiler.

III. Results And Discussions

The cost of the bed material per ton is Rs. 5,000/-. First boiler uses 8000 Tons per its operation. The cost of the bed material is 400 Lakh rupees. Because of the construction of Magnetic separator, one can reduce the usage of coal to maintain the temperature in the boiler. The payback time because of construction of magnetic separator is 5.4 years if the magnetic elements available in the bed material are 1%. The following fig 1 shows the payback times for different amounts of magnetic elements in the bed material i.e. for 1% to 10% of magnetic elements in the bed material.

TABLE IV: LOAD ON THE PLANT, GENERATED UNITS, USAGE OF COAL AND ITS BLENDING RATIO

Month & Year	Unit#1							
	Load (MW)	Gen. M.Units	Coal Feeding MTS		Blending Ratio		Overal GCV	Total coal Consumption MTS
			Aus	Indo	Aus	Indo		
01.10.2016	143.96	3.455	1000	729	57.84	42.16	**5084**	1729
02.10.2016	130.38	3.129	980	599	62.06	37.94	**5075**	1579
03.10.2016	145.42	3.490	1100	660	62.50	37.50	**5099**	1760
04.10.2016	139.42	3.346	850	831	50.57	49.43	**5110**	1681
05.10.2016	136.25	3.270	900	748	54.61	45.39	**5088**	1648
06.10.2016	129.63	3.111	800	779	50.66	49.34	**5055**	1579
07.10.2016	124.58	2.990	750	764	49.54	50.46	**5048**	1514
08.10.2016	127.96	3.071	800	751	51.58	48.42	**5042**	1551
09.10.2016	106.54	2.557	650	649	50.04	49.96	**5024**	1299
10.10.2016	137.42	3.298	817	850	49.01	50.99	**5038**	1667

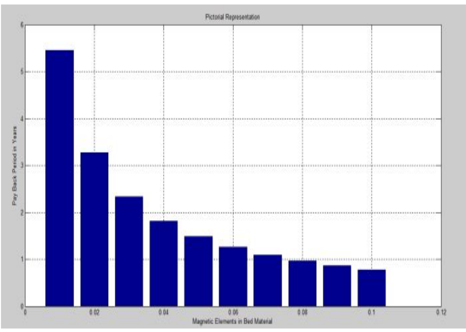

Fig 4: Percentage of Magnetic elements Vs. Payback Time

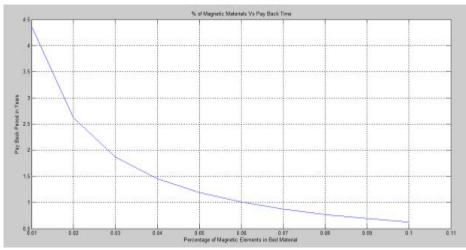

Fig 5: payback times for different amounts of magnetic elements in the bed material i.e. for 1% to 10% of magnetic elements in the bed material

TABLE V: PAYBACK TIMES FOR DIFFERENT AMOUNTS OF MAGNETIC ELEMENTS IN THE BED MATERIAL I.E. FOR 1% TO 10% OF MAGNETIC ELEMENTS IN THE BED MATERIAL FOR THE 8000 TONS OF BED MATERIAL.

S. No	Cost of Bed Material per Ton (Rs)	Number of Tons of Bed Material required (Tons)	Total Cost of the Bed Material (Lakhs)	Magnetic Elements in the Bed Material	Pay Back Period (Years)
1.	5,000	8000	400	1%	5.4
2.				2%	3.2
3.				3%	2.3
4.				4%	1.8
5.				5%	1.4
6.				6%	1.25
7.				7%	1.1
8.				8%	0.9
9.				9%	0.8
10.				10%	0.7

The cost of the bed material per ton is Rs. 5,000/-. First boiler uses 6000 Tons per its operation. The cost of the bed material is 300 Lakh rupees. Because of the construction of Magnetic separator, one can reduce the usage of coal to maintain the temperature in the boiler. The payback time because of construction of magnetic separator is 0.7 years if the magnetic elements available in the bed material are 10%. The following fig 2 shows the payback times for different amounts of magnetic elements in the bed material i.e. for 1% to 10% of magnetic elements in the bed material.

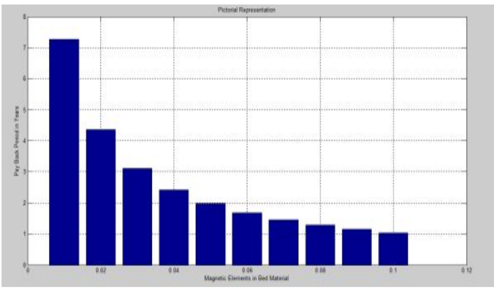

Fig 6: Percentage of Magnetic elements Vs. Payback Time

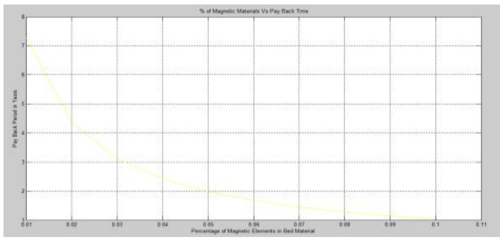

Fig 7: payback times for different amounts of magnetic elements in the bed material ie., for 1% to 10 % of magnetic elements in the bed material

TABLE VI: PAYBACK TIMES FOR DIFFERENT AMOUNTS OF MAGNETIC ELEMENTS IN THE BED MATERIAL I.E. FOR 1% TO 10% OF MAGNETIC ELEMENTS IN THE BED MATERIAL FOR THE 6000 TONS OF BED MATERIAL.

S. No	Cost of Bed Material per Ton (Rs)	Number of Tons of Bed Material required (Tons)	Total Cost of the Bed Material (Lakhs)	Magnetic Elements in the Bed Material	Pay Back Period (Years)
1.	5,000	6000	300	1	7.2
2.				2	4.4
3.				3	3.1
4.				4	2.4
5.				5	2.0
6.				6	1.7
7.				7	1.5
8.				8	1.3
9.				9	1.1
10.				10	1.0

The cost of the bed material per ton is Rs. 5,000/-. First boiler uses 9000 Tons per its operation. The cost of the bed material is 450 Lakh rupees. Because of the construction of Magnetic separator, one can reduce the usage of coal to maintain the temperature in the boiler. The payback time because of construction of magnetic separator is 0.7 years if the magnetic elements available in the bed material are 10%. The following fig 8 shows the payback times for different amounts of magnetic elements in the bed material i.e. for 1% to 10% of magnetic elements in the bed material.

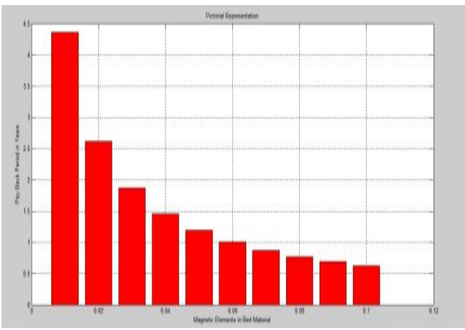

Fig 10:Percentage of Magnetic elements Vs. Payback Time

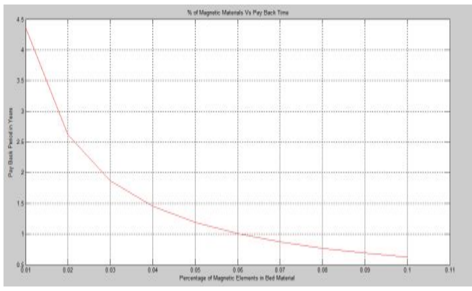

Fig 11: payback times for different amounts of magnetic elements in the bed material

TABLE VII: PAYBACK TIMES FOR DIFFERENT AMOUNTS OF MAGNETIC ELEMENTS IN THE BED MATERIAL I.E. FOR 1% TO 10% OF MAGNETIC ELEMENTS IN THE BED MATERIAL FOR THE 10000 TONS OF BED MATERIAL.

S. No	Cost of Bed Material per Ton (Rs)	Number of Tons of Bed Material required (Tons)	Total Cost of the Bed Material (Lakhs)	Magnetic Elements in the Bed Material	Pay Back Period (Years)
1.	5,000	10000	500	1%	4.3
2.				2%	2.6
3.				3%	1.8
4.				4%	1.4
5.				5%	1.1
6.				6%	1.0
7.				7%	0.8
8.				8%	0.7
9.				9%	0.6
10.				10%	0.5

TABLE VIII: PAYBACK TIMES FOR DIFFERENT AMOUNTS OF MAGNETIC ELEMENTS IN THE BED MATERIAL I.E. FOR 1% TO 10% OF MAGNETIC ELEMENTS IN THE BED MATERIAL FOR THE VARIOUS TONS OF BED MATERIAL.

S. No	Cost of Bed Materi al per Ton (Rs)	Number of Tons of Bed Material required (Tons)	Total Cost of the Bed Material (Lakhs)	Design ed boiler (%ή)	Actual boiler (%ή)	Cost of the Magnetic Separator (Lakhs)	Pay Back Period (Years)
1.	5,000	8000	400	85.60	83.50	23.8110	5.4
2.	5,000	6000	300	85.60	83.50	23.8110	7.2
3.	5,000	9000	450	85.60	83.50	23.8110	4.9
4.	5,000	10000	500	85.60	83.50	23.8110	4.4

The efficiency can be improved from 83.50% to 85.60% for the first generator and 83.01% to 85.21% for the second generator. This has possible because of maintaining desired temperature in the boiler.

IV CONCLUSIONS

With the construction of magnetic separator, the temperature in the boiler maintained as per the reference temperature without using excess amount of coal. The cost spent for the construction of magnetic separator can be obtained in a couple of years. As the percentage of magnetic elements is more and more, the payback period is smaller and smaller. Payback times for different amounts of magnetic elements in the bed material i.e. for 1% to 10% of magnetic elements in the bed material are from 4.3 years to 0.5 years if the bed material is 10000 Tons.

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