Performance Evaluation of Co-Firing MSW with Coal in A 600 Mw Coal-Fired Power Plant

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***Abstract* - In this work, it has been shown that the involvement of composite fuels in thermal power engineering will enable to recycle both industrial and municipal combustible wastes while saving fossil fuels. This study investigated performance of 600 MW coal fired power plant along with boiler efficiency, net plant efficiency for co-firing using the example of several fuel compositions with wood, food waste, plastic, and cardboard, each added separately along with coal currently using in power plant through process simulation based on an existing 600 MWe coal fired power plant using an educational process simulator. A model validation has been carried out for the validity of the results. Different blend of coal (90%) and each selected waste (10%) based on thermal share are investigate for power generation of each blended fuel with a more rigorous simulation.**

***Index Terms* - Municipal Solid Waste, Coal Fired Power Plant, Calorific Value, Plant Efficiency, Power Generation**

I.INTRODUCTION

A power plant is assembly of systems or subsystems to generate electricity, i.e., power with economy and requirements. The power plant itself must be useful economically and environmentally friendly to the society.

The history of power development in India dates back to 1897 when a 200-kW hydro-station was first commissioned at Darjeeling. The first steam station was set up in Calcutta in 1899. By the end of 1920, the total capacity was 130 MW, comprising. Hydro 74 MW, thermal 5 goes to 1208 MW. There was very slo0 MW and diesel 6 MW. In 1940, the total capacity w development during 1935-1945 due to Second World War. The total generation capacity was 1710 MW by the end of 1951. The development really started only after 1951 with the launching of the first five-year plan.

II- LITERATURE REVIEW

1.“Thermodynamic analysis on the transient cycling of coal-fired power plants: Simulation study of a 660 MW supercritical unit”
Chaoyang Wang, Ming Liu, Bingxin Li, Yiwen Liu, Junjie Yan
The flexibility of coal-fired power plants must be improved to satisfy load fluctuations in power grids caused by the rapid spread of power generation capacity from unpredictable renewable energy sources. Startups, shutdowns, and large amplitude load cycling have become normal operational states for coal fired power plants in recent years. The extremely high thermal inertia of a power plant influences the energy consumption of the power plant in load fluctuation processes. To obtain the energy consumption characteristics of power units during transient cycling processes, dynamic models of a 660 MW supercritical unit were established with the GSE software. The heat storage and control systems of the unit were considered.

2.“Performance evaluation of co-firing various kinds of biomass with low rank coals in a 500 MWe coal-fired power plant.”
Tae-Young Mun, Tefera Zelalem Tumsa, Uendo Lee, Won Yang
Recently in Korea, the co-firing of biomass in existing pulverized coal power plants has become an important mean to comply with the nation's renewable portfolio standard (RPS). This study investigated boiler efficiency, net plant efficiency, and combustion characteristics from co-firing various biomasses along with two coal blends and the combustion of low rank coals through process simulation based on an existing 500 MWe coal fired power plant using a commercial process simulator (gCCS). Five sources of biomass -

wood pellet, empty fruit bunch pellet, palm kernel shell, walnut shell, and torrefied biomass were selected as renewable fuels for co-firing.

III-RESEARCH METHODOLOGY

Materials and methods

1.Process description

The thermal power plant produces power by converting thermal energy to mechanical energy and from mechanical energy to electrical energy. Thermal energy is generated in the boiler section which consists of furnace, economizer, drum, superheater and reheater. Correct proportion of the coal and air are given to the furnace for the complete combustion of the coal to produce flue gas. The obtained hot flue gas from this unit transfers heat to all the other units of boiler. Meanwhile, feed water enters the economizer unit for the preheating purpose. The preheated liquid enters drum unit for the conversion of liquid to steam. Drum unit in turn comprises of down comer, riser and a drum. Downcomer transfers hot water from economizer and riser, where the conversion of water to unsaturated steam takes place.

2.Simulation

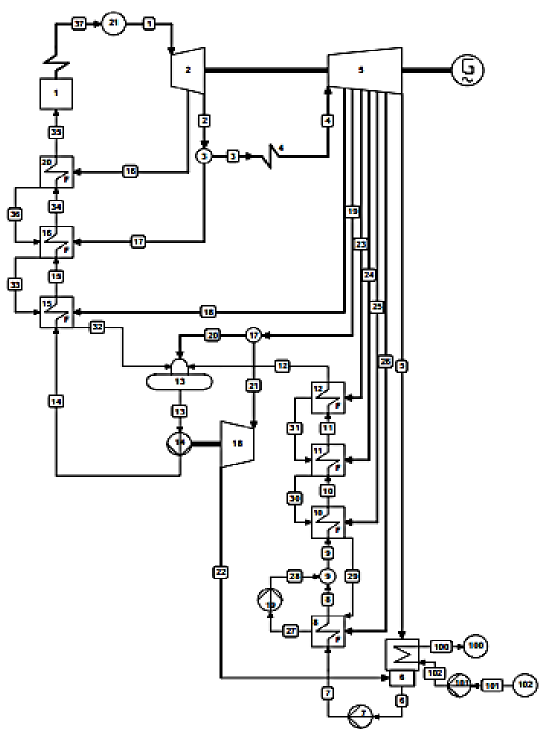

Figure 3.1 Power Plant Layout considered for the Simulation

IV- RESULTS

A simulation study has been carried out for the assessment of Fuel percentage based on the different composition mixing of MSW with coal. This chapter divided in two-part first part consists the modal validation along with the actual data obtained from the plant and second part consist the simulating of the same model with different fuels for power plant performance.

Model Validation

The model validation has been performed using the data when only coal is used as fuel as the current running condition of fuel. The initial data input is same as given in Table 3.2.

The following results have been obtained after simulation and direct visual inspection from SCADA system applied in plant.

Table 4.1 Validation of model

Sr.No.	Apparatus	Simulation Results				Actual Results			
		Pressure (bar)		Temperature (°C)		Pressure (bar)		Temperature (°C)	
		inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet
1	Boiler	189.9	146.9	272.6	502.6	178.50	140	257	498
2	HP Turbine	141.7	30.29	500	287.1	136	27.5	496	280.4
3	LP Turbine	27.54	0.0261	530	89.53	25.65	0.024	496	84.24
4	Condenser	0.0261	0.0261	89.62	21.75	0.024	0.024	84.2	20.4

For the validation of model, the output results for primary concerned apparatus have been considered i.e., Boiler-, High- and low-pressure turbines and condenser. Table 4.1 shows the output and input value of pressure and temperature for each of the apparatus as stated above. Table 4.2 shows the difference in the parameters value for the same.

It is observed from the table 4.2 that the percentage difference between both the readings i.e., simulated, and actual readings are not more than 10%, thus it is in acceptable condition. On the conclusion it can be stated that the model is validated and can be applied for further research.

Figure 4.1 shows the values obtained during simulation at each and every stage.

Table 4.2 Difference between Simulated and Actual results.

Sr. No.	Apparatus	Percentage Difference			
		Pressure (bar)		Temperature (°C)	
		inlet	outlet	inlet	outlet
1	Boiler	6.0	4.7	5.7	0.9
2	HP Turbine	4.0	9.2	0.8	2.4
3	LP Turbine	6.9	6.3	6.4	5.9
4	Condenser	8.0	8.0	6.0	6.2

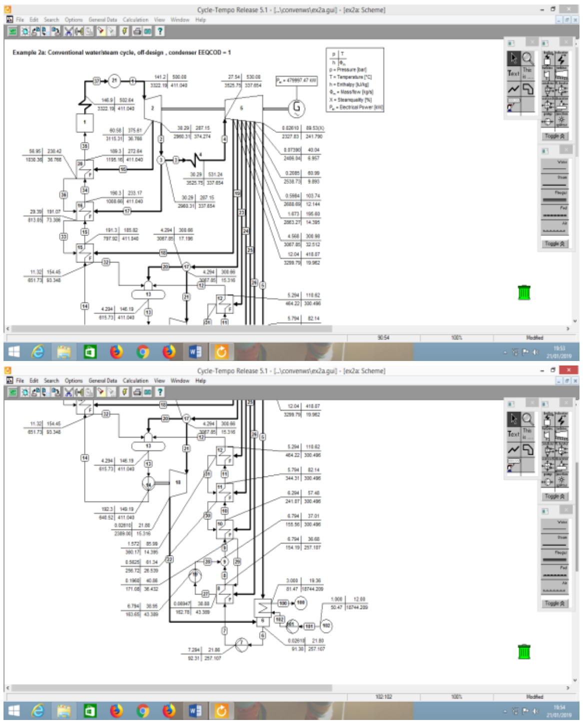

Figure 4.1 Energy balance sheet for the power production operation when coal is used as working fuel

Discussion

By the example of a typical thermal power plant, calculation has been carried out for the possibility of replacing the main fuel (coal) by composite fuel obtained from Munciple Solid Waste

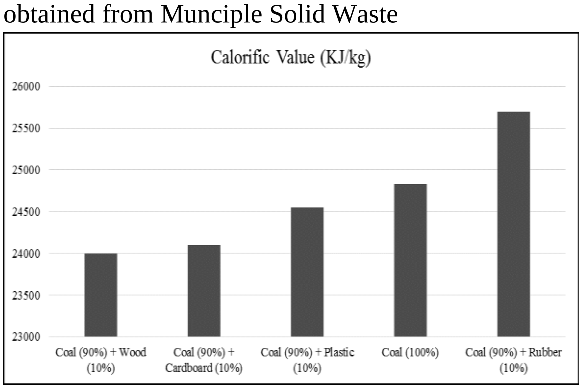

Figure 4.2 Comparative analysis for different calorific values for each fuel

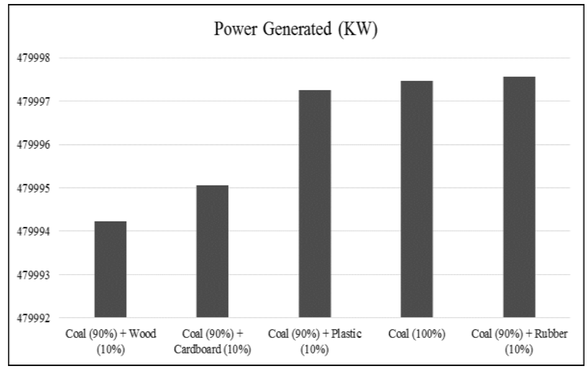

Figure 4.3 Comparison of Power Generated from each fuel

Figure 4.6 and 4.7 shows the calorific value and power generation capacity for different composite fuel. The maximum power more than 100% coal can be generated by 90% coal composition with 10% rubber which is also little bit more than the 100% coal power generation. It can be observed that almost same power with the little difference can be generated when various constituents of MSW added with coal for combustion in boiler house.

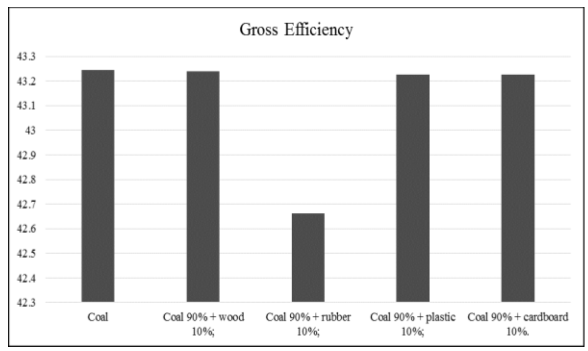

Figure 4.4 Comparison of Gross Efficiency from each fuel

In all the cases the gross efficiency values are in the range of 42.5-43.5% as shown in figure 4.8. The gross efficiency is almost same about 43.2 % for all the materials but it is about 42.6 % in case of rubber which is due to the fact that the rubber having high moisture content and high carbon content, which results wet loss as a main cause of the efficiency penalty in addition to heat loss due to unburnt carbon in ash.

V- CONCLUSION

The facts for the energy potential of MSW are as

1. About 50 billion tons of municipal solid waste have already been accumulated in the world by 2018 and are now stored in landfills; and about

24.60-hectare landfill area is utilized as landfill in Jabalpur available for next 10 years only.

2. The annual amount of the world production of MSW is about 1.5 billion tons (nomenclature GMSW); and about 421 mt/day in 2009 and about 1500 mt/day in 2018 MSW are generated in Jabalpur city which is near the power plant and facing problem for MSW management.
3. About 60% of MSW is not recycled and is stockpiled at landfill sites.
4. About 80% of non-processed MSW is combustible

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