Effect of Blending ratio on Co-Combustion of Coal and Biomass through Emission Analysis

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Abstract

The environmental problems caused by industrial pollutants and global warming are on the rise. There is a need to develop a technology for reducing harmful pollutants. The co-combustion is getting serious attention by the scientists regarding its key facets to reduce the environmental pollutants. Its function is based on utilization of biomass with coal. In this work different types of biomass were used with coal samples to identify the suitable methodology. The biomass resource fulfills the requirement with reducing environmental pollutants and overcome energy crises. The ratios of biomass with coal samples were analyzed using stack gas analyzer. The banana tree waste (BTW) was found to be effective for reducing CO2 and CO emission. While, Cow dung manure (CDM) was found to be efficacious to decrease NOx. LC 80%+BTW 20% for SO2 and CDM for NO. To conclude, CDM and BTW decreases the emissions keeping blending ratio 80:20 with lignite coal to biomass in co-combustion respectively.

Keywords—Blending ratio, Co-combustion, Biomass, Coal and Emission analysis.

1 Introduction

In the recent past, there have been increased complications concerning energy issues and global warming. It is due to emissions of sulfur oxides, carbon oxides and nitrogen oxides, abbreviated as SOx, COX and NOx respectively. There are existing various technology to decrease these harmful pollutants [1]. The co-firing of coal and biomass deploys best options for decreasing emissions and consumption of biomass. The biomass contents Rice husk and bamboo give less emissions by blending its high percentage with lignite coal (LC) to ratio of 80:20 respectively [2-3]. The biomass-coal co-combustion has proven to be an inexpensive, safe process, environmental affable and sustainable renewable energy option that fulfills reductions of sulfur oxides, carbon oxides and nitrogen oxides [4]. The biomass consumption is based to generate low amount of CO2 during combustion. Further, it has tendency to decrease the CO2 emissions at coal-fired power generation system, for example, in a situation where coal is co-fired alone in power generation system. It is also known to decrease system efficiency [5]. The biomass insertion in coal combustion system proves to reduce NOx and Nitrogen dioxide (N2O) in flue gas. The fuel to nitrogen ratio was examined as a key factor for determining these emissions [6]. It is confirmed from research works that addition of biomass increases NOx reduction under inert and air-staged conditions [7-9]. The main purpose of this research work is to investigate the effects of biomass and coal blends on emissions generation. In addition, it has many advantages regarding environmental pollution control and global warming reduction. There has manifested a fact about replacement of coal to biomass for reducing emissions will be beneficial perspective for environment.

Recently, scientists recognize the efficacy of co-combustion of coal and biomass due to its immense potential to reduce environmental pollution. There is a minimized SO2 emission because of blending of coal with biomass. It is helpful to solve environmental complications like global warming and disease. The co-combustion of coal and biomass is effective in cement industry, as it helps to overcome the problems related to emissions. Co-burning is a potential solution to consume the biomass as waste material into useful

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Fig. 1: Illustration of co-combustion steps of the methodology

product. We can attain viable energy from biomass waste through the co-combustion technology.

2 Materials & Methods

The materials and methods of this research are discussed in the following sections.

2.1 Materials

The materials were collected from Tandojam, Jamshoro and Kotri areas of Sindh province, Pakistan. Three types of biomass banana tree waste (BTW), cow dung manure (CDM) and tree leaves (TL) were obtained to conduct this research. The Lignite coal (LC) was brought from Lakhra plant. The research was conducted using equipment such as stack gas electrical muffle furnace, grinder, crusher and sieves. The stack gas analyzer is used to characterize emissions, and 0.75 nm samples sizes are obtained from sieve analysis.

2.2 Methodology

The experimental methodology comprises the following steps. Firstly, the collection of samples is carried out. Afterwards, it is crushed and grinded. The third step implements blending of LC. At Muffle furnace, there co-combustion of samples take place to desired product as emission gases. This research work was completed in particle technology lab in department of chemical engineering at MUET, Jamshoro, Pakistan. The whole research work has five steps, as shown in Figure 1[10-11].

The coal and biomass samples were blended with different ratios described as 10:90, 20:80, 30:70 and 40:60 respectively. Muffle furnace works for co-combustion and stack gas emission. Thereafter, gases emission is scrutinized to find the degree of co-combustion.

3 Results & Discussion

The prime purpose of this research work is to investigate the effect of biomass and coal blends on emissions generation to devise effective solutions to environmental pollution and global warming. The current investigation deploys a scientific evidence regarding replacement of coal with biomass for reducing harmful emissions.

Coal, biomass and their blends in co-combustion process were investigated to deplete the emissions. However, different tests are performed which displays the particle size, emissions, carbon, hydrogen, nitrogen, sulfur and calorific values. At co-combustion of coal and biomass, emissions are analyzed using stack gas analyzer, as this process results in the generation of different gases. Table 1 shows the gases that were generated during co-combustion.

Blending ratio is referred to as a ratio of coal to biomass. In this study, biomass to coal ratio is varied for observing its effectiveness. The obtained gases after co-combustion process were CO, CO2, O2, H2, NO2, NOX and SO2. The fluctuating blending ratios explore maximum concentration of the combustible gases. Due to this, we used different concentration of coal and biomass to see the behavior on co-combustion. It is a preliminary investigation to look precisely on obtained gases concentration through blending ratios [12-13].

Table 1 displays the highest percentage of obtained O2 from burning of cow dung manure (CDM) around 17.63%. It also displays that the highest value of CO in flue gases concentration is about 1644.16 ppm after the burning of 60% LC+40% BTW blend. The maximum percentage of produced CO2 was found to be around 4.37% for 90% LC+10% TL blend and the maximum NO percentage was about 68 ppm for pristine BTW sample.

It is worth pointing out that the maximum obtained NO2 concentration was noted to be around -0.98ppm for pristine TL. In case of NOx, the highest concentration value of about 66.16 ppm was observed by tilizing 60% LC+40% TL blend. For SO2, the maximum amount obtained was 345.3 ppm using 90% LC+10%TL blend. From the results reported in Table 1, it can be concluded that under blending ratios the maximum CO concentration is found to be 1510.5 ppm with pristine BTW blend. In addition, minimum CO concentration was noted to be around 684.667 ppm with LC70%+CDM30% blend in feed. It is evident that on account of incomplete combustion, minimum CO amount from LC70%+CDM30% blend was observed as shown in Figure 2. This blending ratio has several industrial applications due to its efficiency.

Figure 3 demonstrates NO concentration under different blends. It reveals a sample which is affected by NO. A maximum amount of 68 ppm of NO was generated under pristine BTW. It shows that using CDM, the NO concentration in co-combustion can be reduced. For this reason, biomass concentration

SNO	Material	O2%	CO (ppm)	CO2	NO (ppm)	NO2 (ppm)	FT©	NOx (ppm)	SO2 (ppm)	Hs (ppm)
1	LC	16.89	901.83	2.19	30.66	-3.01	76.63	30.63	325	-248.9
2	TL	15.33	925	3.03	40.66	-0.986	76.7	40.66	-23.5	269.33
3	BTW	16.75	1510.5	1.63	68	-2.267	73.56	64.66	66.66	140.33
4	CDM	17.79	1322.1	1.79	32.16	-1.683	94.66	30.83	-70.16	221
5	LC90% + TL 10%	13.2	1083.8	4.37	43.33	-7.61	65.18	51.16	345.3	704
6	LC80% + TL 20%	15.74	1103.6	2.87	45.33	-4.41	75.63	45.5	138.1	179.33
7	LC70% + TL 30%	15.74	1220	2.86	52.83	-5.75	79.1	53.16	21.83	333.66
8	LC60% + TL 40%	15.45	928.83	3.02	65.83	-5.25	83.41	66.16	32.83	526.16
9	LC90%+BTW10%	15.525	1136.1	3.10	45.66	-2.98	84.71	45.83	9.83	223.83
10	LC80%+BTW20%	16.49	1247.5	2.50	45.83	-2.13	87.2	42.66	-305	129
11	LC70%+BTW30%	15.34	1449.1	3.20	54.5	-3.08	87.43	44	-18	104.16
12	LC60%+BTW40%	15.65	1644.1	2.97	55.33	-2.216	82.31	55.5	-47.66	54.5
13	LC90%+CDM10%	16.31	1263.3	2.47	40.66	-3.383	85.68	43.33	50.83	197.66
14	LC80%+CDM20%	16.55	839.5	2.49	48.16	-4.35	96	48.33	1.166	240.5
15	LC70%+CDM30%	14.04	684.66	3.92	38.5	-2.4	55.95	39.33	-2.5	-103.667
16	LC60%+CDM40%	14.66	1073.8	3.50	40.16	-2.366	68.03	41.33	-18.66	-77

TABLE 1: Emissions analysis from coal and biomass blends.

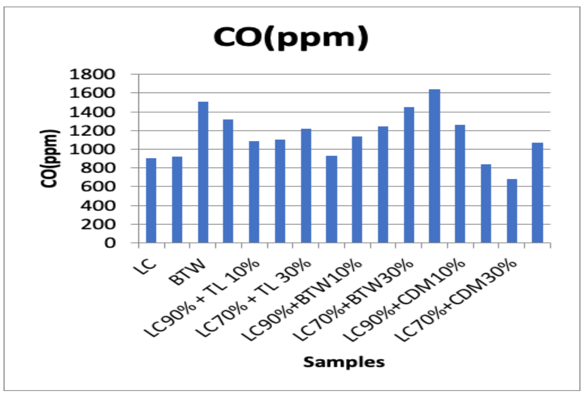

Fig. 2: Illustration on effect of blending ratios on CO production

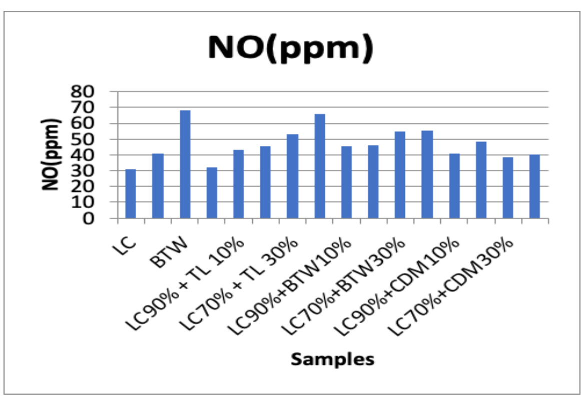

Fig. 3: Illustration on effect of blending ratios on NO production

is vitally-important. Hence, this blending ratio is efficacious to decrease the emission of NO [14].

On the flip side, Figure 4 shows that the maximum amount of NOx is obtained at 66.16 ppm under

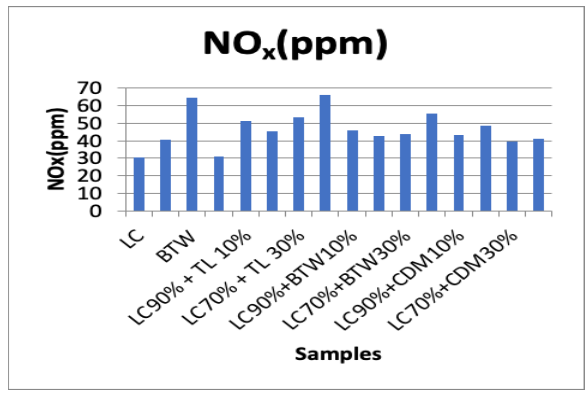

Fig. 4: Illustration on effect of blending ratios on NOx production

blending ratio of LC60% + TL 40%. The minimum NOX content of about 30.83 ppm is produced using pristine CDM blend [14].

Figure 5 shows CO2 emission during the co-combustion process. The maximum amount of 43700ppm of CO2 is produced using LC90%+TL10% blend. While the minimum concentration of 16330 ppm of CO2 is procured using pristine BTW [15].

Figure shows the O2 concentration in product gases. The maximum concentration of O2 is 17790 ppm using pristine CDM. While, the minimum concentration is 1320 ppm by using LC 90%+TL 10% blending ratio in feed. The different biomass blends affect the emission. The presented results show that these blends significantly contribute to optimize the emission of pollutant gases.

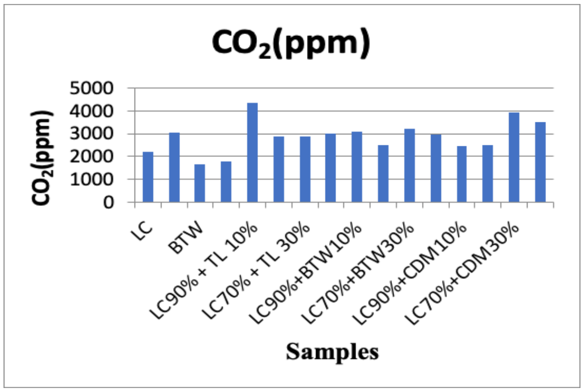

Fig. 5: Illustration on effect of blending ratio on CO2 production

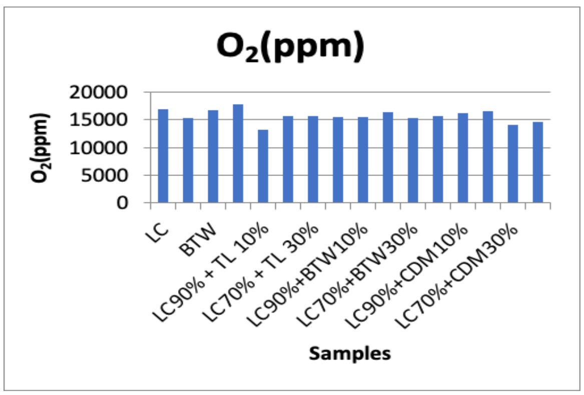

Fig. 6: Illustration on effect of O2 production on blending ratios.

4 Limitations & Future Work

1) Biomass co-combustion is the outcome of technological and economic factors. This co-combustion process of biomass and coal has certain limitations. The technical limitation of this process is that combustion process design is based on a specific fuel ratio. Whereas, their burners are designed with respect of volatile components such as ash, water, samples size distribution and dust values. Co-firing of biomass is essential to work for building news system with discussed specifications. A high risk of generation of corrosion caused by HCl formation and higher chlorine values exists. The corrosion rate of these components is elevated at super-heater high temperature.
2) One of the limitations is high operating cost of bio-mass and coal blends in co-combustion process. Other economical crucial factor is high fuel cost incurred from transport preparation till the delivery of materials at plant. Consequently, the blending ratio handling at a site increases the expenses per unit energy. The ash quantity at biogenic fuel should not increase more than 10% of its original value. The produced ash from co-combustion can be fed to cement and concrete industries if there are optimum values of P2O5, SO3 and Cl and unburned carbon at ash. According to Environmental Protection Agency (EPA) ash should fulfills physical and chemical demands with the defined standards.

5 Conclusion

1) Co-combustion of coal and biomass has many advantages regarding reduction of environmental problem. It also enables to resolve the energy crisis. Various concentration of biomass, coal and coal-biomass blends were investiaged in this paper.Different tests including particle size analysis, thermo gravimetric analysis, emis-sions analysis, carbon content, hydrogen content, nitrogen, sulfur analysis and calorific value were conducted. It is concluded that gas emissions decrease by utilizing biomass with coal. Additionally, BTW and CDM were found to be best fit for decreasing emissions during the process.
2) The minimum CO2 emissions was observed using BTW. The minimum NOx emission is observed by utilizing CDM. The BTW sample usage results in minimum SO2 emissions with lignite coal to BTW ratio of 80:20. These alarming environmental concerns are readily diminished using biomass and lignite coal sample in a combustor. Hence, this study concludes that coal with biomass blends enable to reduce the gases pollutants up to a desirable level.

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