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A Study on Gasification of Chicken Litter with Saw Dust in A Laboratory Scale Fluidized Bed Gasifier

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Abstract: In India, the poultry industry is growing at a faster rate. The increase in the demand for chicken meat and eggs has led to the faster growth of the poultry industry. Poultry farms are largely located in rural areas which face scarcity of power. The energy requirements of poultry farms or the poultry industry can be met by utilizing the energy content of the chicken litter through energy conversion technologies. The fluidized bed gasification technique is right choice to utilize chicken litter as energy source. In this paper, a discussion on gasification of chicken litter for different proportions of saw dust is made and was found that the blend of 30% SD and 70% CL was found to yield best quality producer gas.

Keywords: Chicken litter, Saw Dust, Gasifier, Fluidized bed Gasification.

Abbreviations: CL – Chicken Litter, SD – Saw Dust

I.INTRODUCTION

In India, the poultry industry is growing at a faster rate. The increase in the demand for chicken meat and eggs has led to the faster growth of the poultry industry [1]. India occupies the third position in the world in chicken meat production and the ninth position in egg production [2]. These industries produce a large amount of waste. It has been estimated that 10,000 birds can produce around 137 tons of dried litter per year [3]. Currently saw dust and rice husk are being widely used in the gasifiers. Among the biomasses that are utilizing useful bio-resource , the forestry residues and woody resources (sawdust, barks, tree limbs) account for 12 percent of the world's total bio-resources available [4]. In India, out of the total land area available, viz., 328 million hectares (mha), 75 mha is woody or forestry land which is presently exploited. Firewood consumption is 150 m tons per year, of which 20 percent is sawdust thrown out as waste [5]. It can cater to smoother capacity of 5,000 MW. But presently there are plants working with 1 – 5 MW capacities [6]. In the poultry farms, the waste is usually available in the form of a mixture of chicken litter, rice husk, saw dust, etc. This waste has to be disposed of in proper manner. Composting is one way of disposal of chicken litter. If the composted litter is scattered across the fields and as a result, mixes with water, nitrate contamination of water results. The consumption of such water by human beings leads to cancer, lung diseases, etc [7]. Hence chicken litter cannot be utilized as a fertilizer. Poultry farms are largely located in rural areas which face scarcity of power. The energy requirements of poultry farms or the poultry industry can be met by utilizing the energy content of the chicken litter through energy conversion technologies. The energetic value of chicken litter ie., 10,256 kJ/kg indicates that the chicken litter can be utilized as an energy source. [8]. Anaerobic digestion is one method of converting chicken litter into energy. The high Ph value of chicken litter decreases the rate of producer gas production from the digester. Hence it is not advisable to utilize chicken litter as an energy source in the anaerobic digestion process [9]. The high moisture content, the high ash content and the low ash fusion temperature renders the fluidized bed gasification technique the right choice to utilize chicken litter as energy source [10]. In this regard an experimental study on gasification of chicken litter with saw dust is made in a fluidized bed gasifier.

II.METHODOLOGY

100 Kg of chicken litter was collected and dried in an open field to achieve the required dryness. Then it was ground and sieved to 850 μ m. The gasifier chamber was filled up to a height of 30 mm with 850 μ m of sand. The dried and sieved litter is mixed with the powdered saw dust at different proportions and then feed into the gasifier. The gasifier was initially heated to a temperature of 700 – 800^0 C using a Kandal A1 coil. When the coil reached a temperature of

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800^0 C, the air required for fluidization of sand particles was supplied by using an air compressor and then the chicken litter-saw dust mixture sample prepared for the purpose was added through a manual feeder. The producer gas inside the gasifier chamber was at a slightly higher temperature; hence its temperature had to be reduced to the required level. The gases obtained were passed through a heat exchanger, to be cooled down. The gases consisted of a certain amount of moisture; they had to be reduced before they are utilisation as an energy source. Hence it was made to flow through a calcium chloride chamber. Then, through the vacuum pump, the producer gas generated was made to pass to the four-gas analyzer. The gasifier was operated continuously for 3-4 hours and the compositions of producer gas obtained for different equivalence ratios are measured using four gas analyzer ie., CO, CO_2, H_2 and $CH_4$and the average value of the results was tabulated in the Table 1, 2, 3 and 4. Figure-.1 is a schematic representation of the experimental process undergone during the gasification of chicken litter.

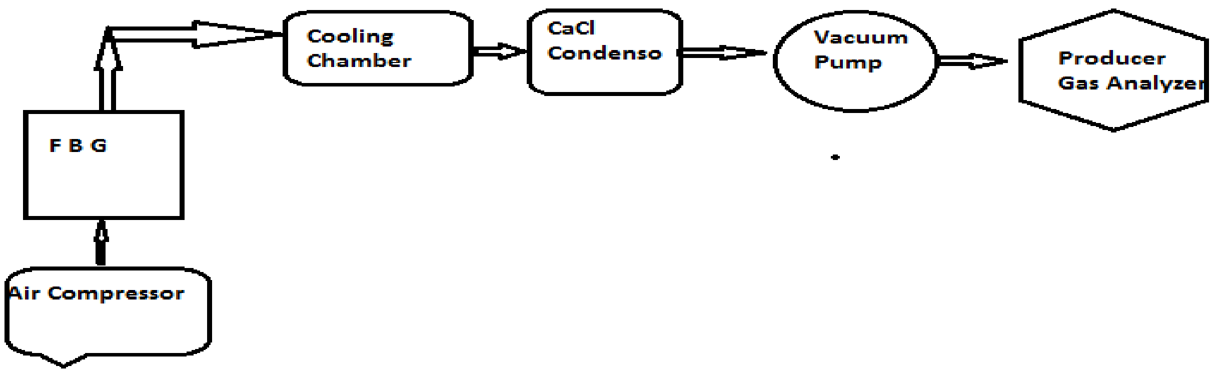

Figure-1: Schematic representation of production of producer gas

Table 1: Variations in CO for blends of CL and SD

Equivalence Ratio	100% CL	10% SD 90% CL	20% SD 80% CL	30% SD 70% CL	40% SD 60% CL	50% SD 50% CL	100% SD
0.12	22.3	26	16.2	23.1	19.2	17.1	21
0.16	16.8	24	15.7	22.8	18.6	16.5	19
0.21	13.5	23	15.2	22.4	16.8	15.1	17
0.26	12.6	21	14.9	21.8	15.9	14.5	15
0.3	12	20	14.2	21.2	15.2	13.6	14

Table 2: Variations in CO_2 for blends of CL and SD.

Equivalence Ratio	100% CL	10% SD 90% CL	20% SD 80% CL	30% SD 70% CL	40% SD 60% CL	50% SD 50% CL	100% SD
0.12	5.7	5.8	6.1	8.4	9.3	8	5
0.16	6.1	6.3	7.2	11	10.7	8.5	7.8
0.21	6.8	6.8	8.2	12.1	12.6	9.1	8.3
0.26	7.4	7.2	9.4	12.9	13.8	9.6	9.5
0.3	8.2	7.8	9.6	14.2	14.1	10.1	9.9

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Table 3: Variations in H_2 for blends of CL and SD

Equivalence Ratio	100% CL	10% SD 90% CL	20% SD 80% CL	30% SD 70% CL	40% SD 60% CL	50% SD 50% CL	100% SD
0.12	8	13.8	14.2	14.9	16.2	10	8.6
0.16	6.5	8.2	8.1	13.7	14.8	9.1	8
0.21	4.8	4.8	6.1	11.8	12.1	7.5	7.8
0.26	4.2	3.6	4.2	8.5	9.1	4.3	7.1
0.3	3.5	2.7	1.4	5.2	5.4	2.6	6.2

Table 4: Variations in CH_4 for blends of CL and SD

Equivalence Ratio	100% CL	10% SD 90% CL	20% SD 80% CL	30% SD 70% CL	40% SD 60% CL	50% SD 50% CL	100% SD
0.12	8	4.1	4	5.4	5.8	4.4	2.8
0.16	6.5	3.8	3.5	4.5	5	3.8	2.6
0.21	4.8	3.2	3.2	3.9	4.1	3.1	1.7
0.26	4.2	2.5	2.5	2.8	3.2	2.4	1.3
0.3	3.5	1.5	1.6	1.1	1.2	0.9	0.8

III. RESULTS AND DISCUSSION

The different blends of chicken litter with saw dust for different equivalence ratios is tested at the bed temperature of 800^0C in a fluidized bed gasifier and the results obtained are as follows.

The heating values of the producer gas determine the quality of the fuel. The lower heating value of the producer gas for various equivalence ratios was estimated. The details of calculations are shown in equation 1.

$$\mathbf{LHV_g = 0.1263(\%CO) + 0.358(\%CH_4) + 0.1079(\%H_2)} \quad (1)$$

The lower heating values of the producer gas obtained from the gasification of CL and SD blends are shown in Figure-2. It indicates that with an increase in the equivalence ratio, there is a decrease in the heating values of the producer gas. It was found that for 30% SD and 70% CL, the heating value was the highest in comparison with other blends, namely, 6453 to 3626.6 KJ/ N m^3 , with an increase in equivalence ratio from 0.16 to 0.3.

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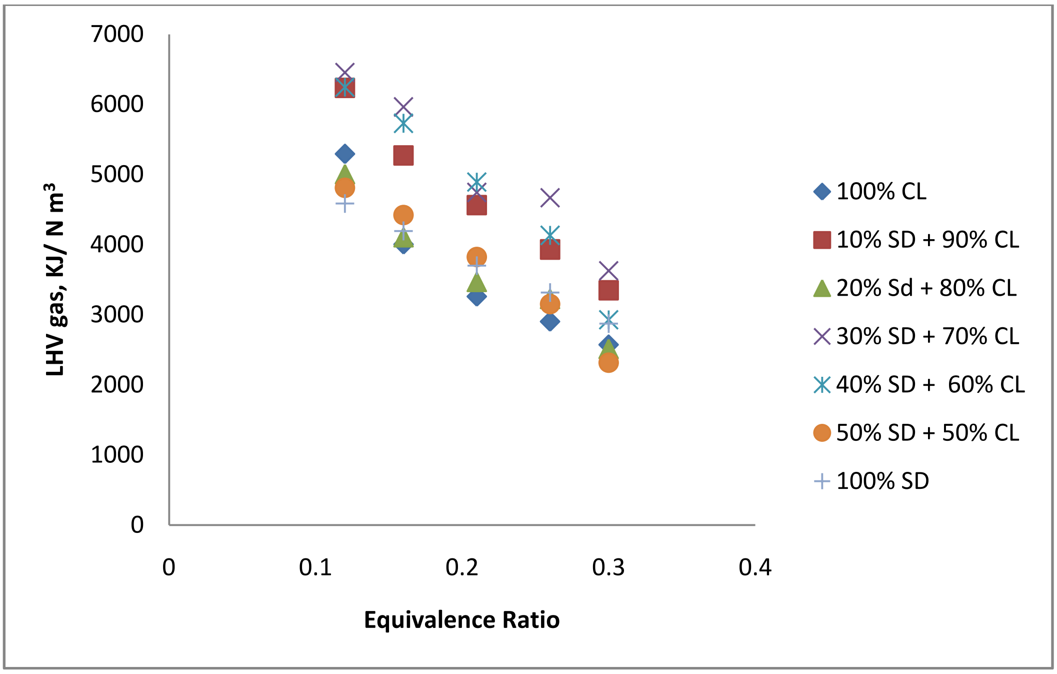

Figure-2: Variations in the lower heating value of the producer gas for blends of SD and CL.

The producer gas obtained from the gasification of CL and SD was meant for utilisation as an energy source at the poultry farm itself. Hence the cold gas efficiency of the gasifier was calculated using the equation 2.

$$\eta_{\text{cold gasifier}} = \frac{\text{Volume flow rate}_{\text{gas}}\text{Higher Heating value}_{\text{gas}}}{\text{Mass flow}_{\text{chicken litter}}\text{Heating value}_{\text{chicken litter}}} \quad (2)$$

The cold gas efficiency of fluidized bed gasifier for different blends of SD and CL are shown in Figure-3. It indicates that with an increase in the equivalence ratio, there was a decrease in the efficiencies of the gasifier. It was found that with a 40% SD and 60% CL, the efficiency was found to be better in comparison with that of other blends.

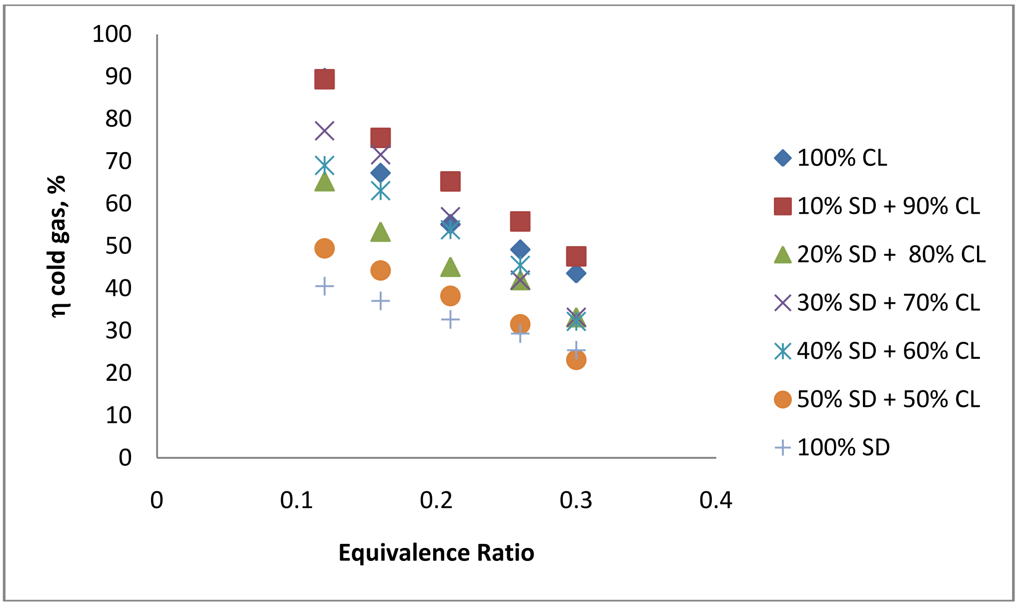

Figure-3: Variations in the efficiencies of the gasifier for blends of SD and CL

The percentage of CO produced in the producer gas with blends of CL and SD was plotted as shown in Figure-4. It was observed that with an increase in the equivalence ratio from 0.16 to 0.3, there was a decrease in the production of CO from 26% to 13.6% , with an increase in the percentage of blend. The results obtained for 30% SD and 70% CL were found to be comparable with that of other blends, indicating the better heating capacity of the fuel.

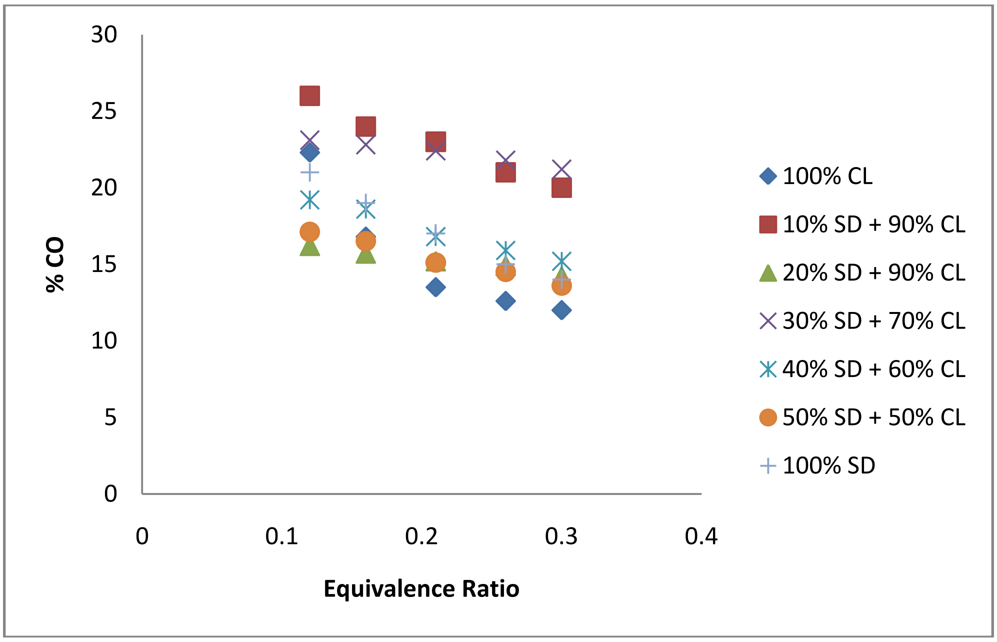

Figure-4: Variation of CO % for various blends of CL and SD

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The amount of CO_2 produced in the producer gas for different blends of SD and CL was found to increase with an increase in equivalence ratio as shown in Figure-5. It was observed that the values obtained for 40% SD and 60% CL were higher for equivalence ratios of 0.16 and 0.3 in comparison with that of other blends.

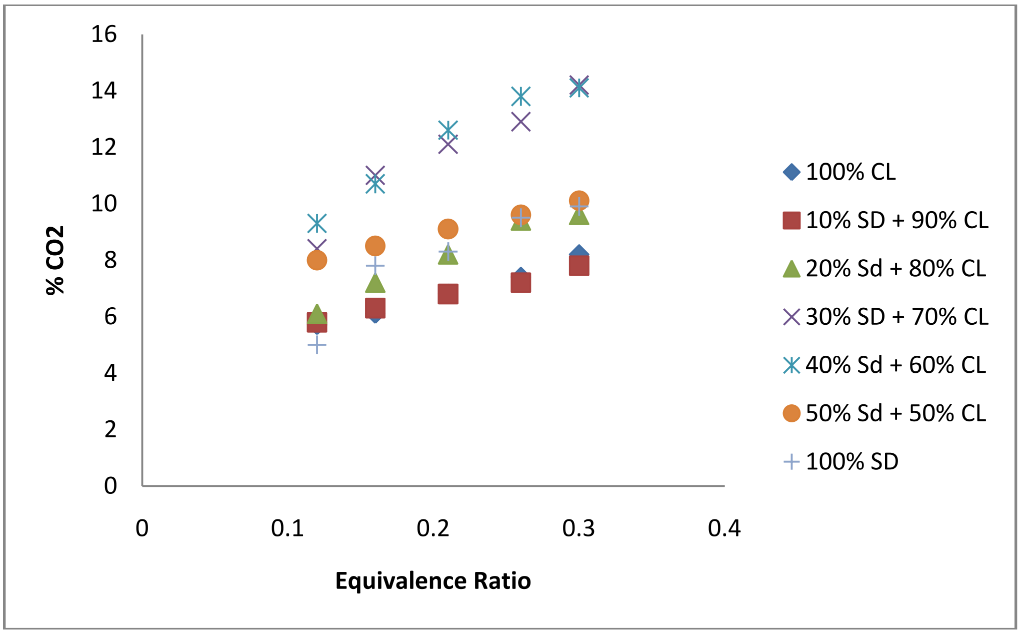

Figure- 5: Variation of CO_2 for blends of SD and CL.

The percentage variation in H_2 produced in the producer gas for various blends of SD and CL is indicated in Figure-6. It indicates that with an increase in equivalence ratio from 0.16 to 0.3 for different blends, the amount of H_2 decreased from 6% to 1.9%. The amount of H_2 produced for 40% SD and 60% CL was found to be significantly higher than that of other blends, pointing to better heating value capacity.

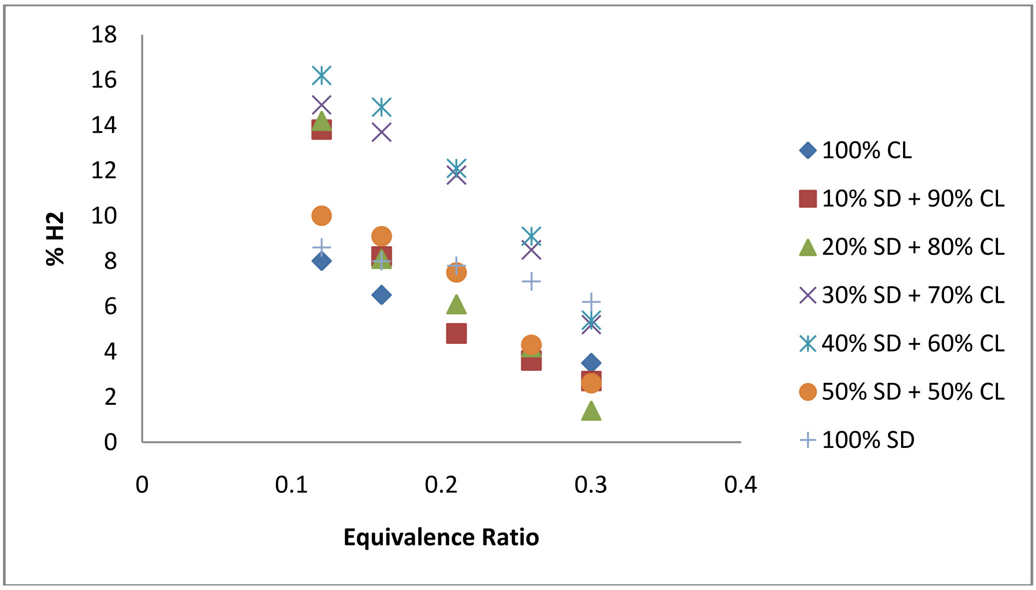

Figure 5.6: Variation of H_2 for blends of SD and CL

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The amount of CH_4 obtained in the producer gas by gasifying different blends of SD and CL is indicated in Figure-7. It indicates that with an increase in equivalence ratio, the amount of CH_4 produced decreased from 5.8% to 0.9%. For a blend of 40% SD and 60% CL, it was found to have the highest CH_4 from 5.8 to 4.1% for equivalence ratios in the range 0.16 to 0.21 compared with the results generated by other blends and equivalence ratios.

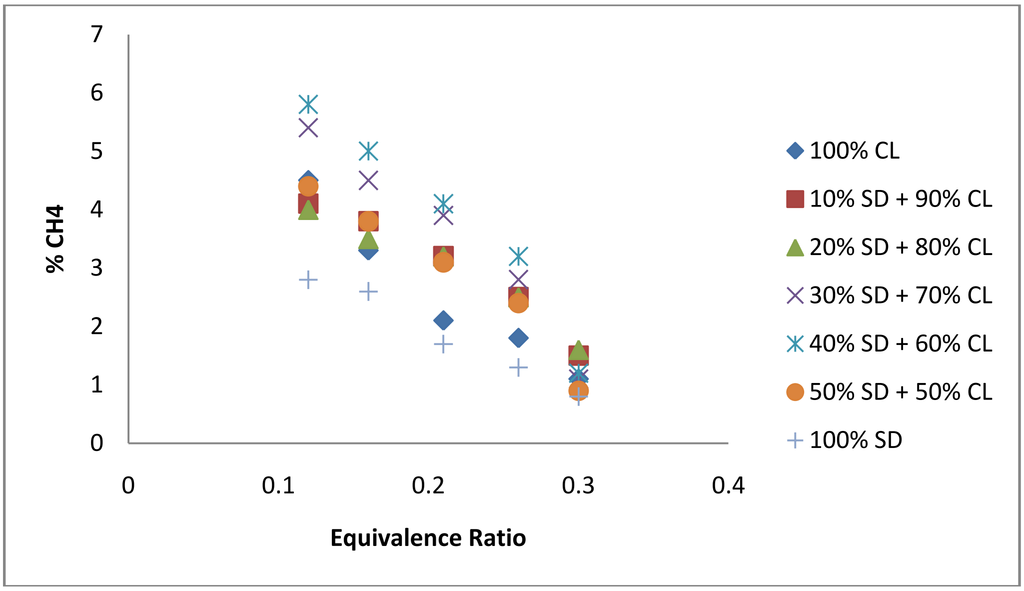

Figure-7: Variation of CH_4 for blends of SD and CL.

IV CONCLUSION

The chicken litter is available in the poultry farms in the mixture form, hence it was planned to test the composition of producer gas for different blends of CL and SD. The test was done for various blends of CL and SD ie, 10% RH and 90% CL, 20% SD and 80% CL, 30% SD and 70% CL and 40% SD and 60% CL, 50% SD and 50% CL.

The percentage of CO, CH_4 and H_2 were found to decrease with an increase in equivalence ratio. It indicates that the heating value of producer gas (for 30% SD and 70% CL), the percentage of CO obtained was higher in comparison with the other; the percentage of CO_2, CH_4 and H_2 obtained from the gasification of 40% SD and 60% CL was found to be the highest in comparison with that of the others. It indicates that a 40% SD and 60% CL blend was a better option for the gasification of the mixture.

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