Comparative Study of Dual Fuel Downdraft Gasifier by using Agriculture Wastes as a Fuel for Power

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Abstract— It is a well-known fact that known sources of fossil fuels in world are depleting very fast. As result of projection of energy shortage in the years to come, the effort has to be made to develop an alternative fuel sources which cater the demand of human beings. Biomass as a source of energy has several advantages over fossil fuels. It is renewable, environment clean and easily adaptable. In present study the experimental investigations have conducted on biomass fuels like rice husk, rice straw, cotton stalk, wheat straw and sugarcane bagasse. Proximate analyses of Cotton Stalk, Sugarcane Bagasse, Rice husk, Rice straw, and wheat straw were conducted. Result revealed that in case of sugarcane bagasse, volatile matter was found maximum (73.8%) and ash content were recorded minimum (4.27%). Result of ultimate analysis concludes that sugarcane bagasse shows maximum higher heating value 18.6 kJ/g. The performance of downdraft gasifier operated on duel fuel mode using Diesel as primary fuel and different biomass Cotton Stalk, Sugarcane Bagasse, Rice husk, Rice Straw, and Wheat Straw as secondary fuel were compared at same load conditions at six rotation of control valve of producer gas. It has been found that maximum diesel consumption is 16.65 ml/min on 2.5 kW load at six revolution of producer gas control valve in case of rice husk and minimum diesel consumption is 9.7 ml/min under same loading condition and at six revolution of producer gas control valve in case of sugarcane bagasse. Average diesel substitution varied from 40% to 66.92% at six revolution of producer gas control valve.

Index Terms— Biomass, Producer gas, proximate analysis, ultimate analysis, % saving diesel.

I. Materials and Equipment

A downdraft biomass gasifier equipped with generator, has been installed in the lab of Mechanical Engineering Department, SLIET, Longowal.

A. *Biomass Gasifier*

Technical specifications of biomass gasifier are given in table-1.

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Table-1 Technical specifications of biomass gasifier

Model	AG-5
Gasifier type	Downdraft
Rated gas flow	$15 Nm^3/hr$
Average gas calorific value	1,000 $kcal/Nm^3$
Gasification temperature	1050-1100°C
Fuel storage capacity	40 kg
Start-up	Through engine suction/blower
Fuel type & size	Wood waste with maximum dimension not exceeding 30 mm.
Permissible moisture content in biomass	5 to 20%
Biomass charging	Batch mode, by topping up once every four hours
Rated hourly consumption	4 to 5 kg
Typical gas composition	CO-19±3% H_2-18±2% CO_2-10±3% CH_4- Up to 3% N_2-50%

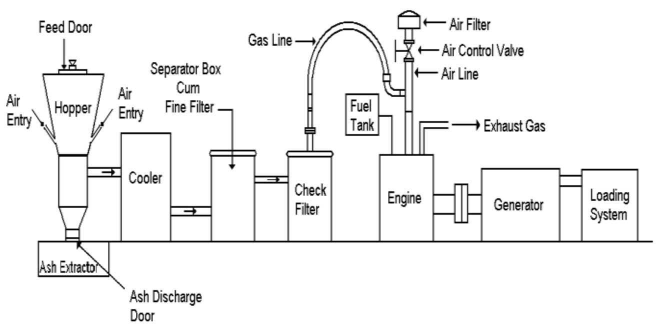

Fig 1: Schematic diagram of biomass gasifier experimental set up

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B. Materials

The following biomass fuels have been tested for loaded condition in single and dual fuel mode of operation: - Cotton Stalk, Sugarcane Bagasse, Rice husk, Rice Straw and Wheat Straw.

C. Source of Material

Rice husk collected from the rice mill of Sangrur. Cotton stalk collected from the villages, Longowal. Rice straw and wheat straw collected from seller. Sugarcane bagasse collected from Longowal. The collected biomass was sun dried for 15 days.

D. Analysis of Different Biomass

Ultimate analysis was conducted to find out the composition of the biomass in wt% of carbon, hydrogen and oxygen (the major components) as well as Sulphur and Nitrogen.

Table-2 Ultimate analysis of biomass fuels

Biomass Fuels	C wt% dry	H wt% dry	O wt% dry	N wt% dry	S wt% dry	HHV kJ/g
Cotton Stalk	42.10	6.30	43.67	1.51	0.00	17.44
Sugarcane Bagasse	44.8	6.2	44.4	0.3	0.01	18.16
Rice husk	37.85	4.79	35.49	0.78	0.04	14.80
Rice Straw	45.38	4.93	40.5	1.31	0.02	17.35
Wheat Straw	43.35	5.20	40.40	1.03	0.11	17.89

HHV = Higher Heating Value

Weight Percentage of fixed carbon, volatile matter, ash content and moisture in different biomass were measured by performing the proximate analysis.

Table-3 Proximate analysis of biomass fuels

Biomass Fuels	Fixed carbon	Volatile matter	Ash content	Moisture
	wt%	wt%	wt%	wt%
Cotton Stalk	22.4	70.89	6.68	< 15
Sugarcane Bagasse	20.1	73.8	4.27	< 15
Rice husk	16.0	63.6	20.6	< 15
Rice Straw	18.5	69.4	5.7	< 15
Wheat Straw	19.8	71.3	8.90	< 15

II. RESULTS AND DISCUSSION

The experiments were conducted on down draft gasifier by using primary fuel and various biomass fuels like rice straw, rice husk, cotton stalk, sugarcane bagasse and wheat straw. The results of different experimental investigations carried out under the present study are presented in the form of table and graphs. The results were analyzed and discussed under the following headings:

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- Effects of applied load on diesel consumption by using primary fuel (Diesel).
- Effects of applied load on diesel consumption at six revolutions of producer gas control valve using biomass fuels as secondary fuel.

A. Effects of Applied Load on Diesel Consumption by Using Primary Fuel (Diesel).

The diesel consumption recorded for diesel as primary fuel at different loads as presented in Table-4. The graph plotted between applied load and diesel consumption in single mode is shown in Fig 2.

Table-4 Diesel consumption for diesel as primary fuel at different loads.

Sr. no	Revolution of producer gas control valve	Applied load (kW)	Diesel consumption In (ml/min)
1	6	0.5	13
2	6	1	16.60
3	6	1.5	20
4	6	2	24
5	6	2.5	27.75

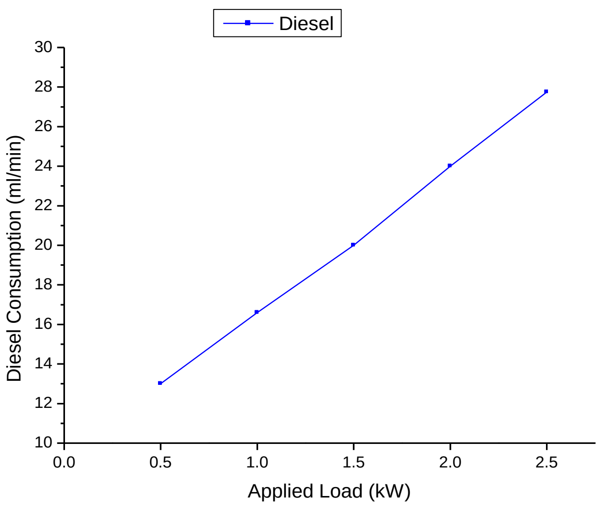

Fig. 2: Diesel consumption vs applied load at single mode

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The graph indicates that the linear trend between diesel consumption and applied load is observed. It has also observed that maximum diesel consumption is 27.75 ml/min at 2.5 kW load and minimum diesel consumption is 13 ml/min at 0.5 kW load. Effects of Applied Load on Diesel Consumption at Six Revolutions of Producer Gas Control Valve for Different Biomass Fuels

The results of diesel consumption at varying load from 0.5 kW to 2.5 kW at six revolutions of producer gas control valve are presented in Table 5. The graphs plotted between diesel consumption and applied load for different biomass fuels at Six revolutions of producer gas control valve are shown in Fig 3. The rate of increase in diesel consumption at 0.5 kW, 1.5 kW and 2.5 kW for different biomass fuels like rice husk, rice straw, cotton stalk, wheat straw and sugarcane bagasse at six revolutions of producer gas control valve observed as 7.7, 11.87 and16.65, 5.92, 9.1and 12.8, 5.32, 8.3and11.6, 4.75, 7.35 and10.35, 4.3, 6.92 and 9.7 ml/min respectively. It has been also observed that the rate of increase in diesel consumption is less for sugarcane bagasse and high in case of rice husk biomass fuel.

The histogram is also plotted between %age saving in diesel of diesel and applied loads for different biomass fuels shown in Fig.3. It has been observed that maximum percentage saving in diesel at 2.5 kW load at six revolutions of producer gas control valve for the biomass rice husk, rice straw, cotton stalk, wheat straw and sugarcane bagasse is 40%, 53.87%, 58.19%, 62.70% and 65.04 % respectively.

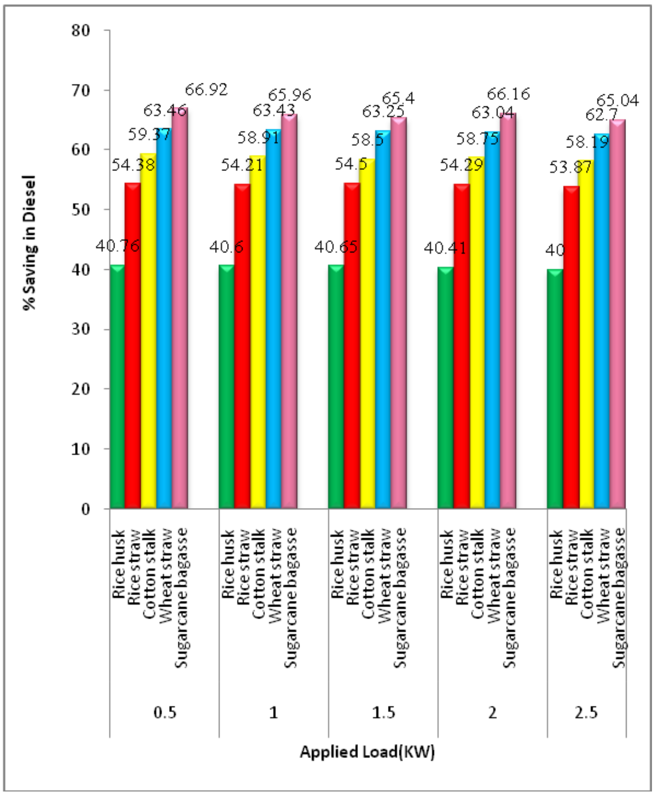

Fig 3: Percentage saving in diesel in dual fuel mode at six revolutions for various biomass fuels

Table-5 Diesel consumption and %age saving in diesel for different biomass fuels at Six revolutions of producer gas control valve

Types of biomass	Revolution of Producer gas control valve	Load (kW)	Diesel Consumption (ml/min)	%age saving in diesel
Rice husk	Six	0.5	7.7	40.76
		1	9.85	40.60
		1.5	11.87	40.65
		2	14.3	40.41
		2.5	16.65	40.00
Rice straw	Six	0.5	5.92	54.38
		1	7.6	54.21
		1.5	9.1	54.50
		2	10.97	54.29
		2.5	12.8	53.87
Cotton stalk	Six	0.5	5.32	59.07
		1	6.82	58.91
		1.5	8.3	58.5
		2	9.9	58.75
		2.5	11.6	58.19
Wheat straw	Six	0.5	4.75	63.46
		1	6.07	63.43
		1.5	7.35	63.25
		2	8.87	63.04
		2.5	10.35	62.70
Sugarcane bagasse	Six	0.5	4.3	66.92
		1	5.65	65.96
		1.5	6.92	65.4
		2	8.12	66.16
		2.5	9.7	65.04

III. Conclusion

Rice husk

- The consumption of diesel is maximum about 16.65 ml/min on 2.5 kW load and minimum about 7.7 ml/min on 0.5 kW load at six revolution of producer gas control valve.
- The maximum percentage of saving is observed about 40.76% on 0.5 kW load at six revolution of producer gas control valve.

Rice straw

- The consumption of diesel is maximum about 12.8 ml/min on 2.5 kW load and minimum about 5.92 ml/min on 0.5 kW load at six revolution of producer gas control valve.
- The maximum percentage of saving is observed about 54.50% on 1.5 kW loads at six revolution of producer gas control valve.

Cotton stalk

- The consumption of diesel is maximum about 11.6 ml/min on 2.5 kW load and minimum about 5.32 ml/min on 0.5 kW load at six revolution of producer gas control valve.
- The maximum percentage of saving is observed about 59.07% on 0.5 kW load at six revolution of producer gas control valve.

Wheat straw

- The consumption of diesel is maximum about 10.35 ml/min on 2.5 kW load and minimum about 4.75 ml/min on 0.5 kW load at six revolution of producer gas control valve.
- The maximum percentage of saving is observed about 63.46% on 0.5 kW load at six revolution of producer gas control valve.

Sugarcane bagasse

- The consumption of diesel is maximum about 9.7 ml/min on 2.5 kW load at one revolution of producer gas control valve and minimum about 4.3 ml/min on 0.5 kW load at six revolution of producer gas control valve.
- The maximum percentage of saving is observed about 66.92% on 0.5 kW loads at six revolution of producer gas control valve.

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