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Utilization of biomass as engine fuel

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In this study, performance of gasifier engine system is analyzed by running 5kW engine at different load conditions to check maximum diesel savings in dual fuel mode operation. Cotton stalks replaces diesel by 80% while sugarcane bagasse replaces it by 82%. By using appropriate agricultural residue, gasifier system integrated with CI engine is economically better than diesel system alone.

Keywords: Biomass, Dual fuel engine, Gasification, Gasifier

Introduction

India continues to experience an energy supply shortfall[1] since 1985 (Table 1). India produces about 600 million tonnes of agricultural residues (mainly rice husks, paddy straw, sugarcane waste, wheat residues and cotton stalks), of which 300 million tonnes are unutilized and are disposed of by burning in open fields thus creating environmental hazards[2].

Biomass gasification produces producer gas[3,4] (CO_2, 18-22; H_2, 15-19; CH_4, 1-5; N_2, 45-55; hydrocarbons, 0.2-0.4; and water vapour, 4%). Sridhar *et al*[3] used producer gas as a reciprocating engine fuel at a high compression ratio (17:1) and observed that operating engines in SI mode is technically feasible. Ramadhas *et al*[4] proved that producer gas dual fuel engine could run only at a maximum of 50-60% load condition and higher diesel saving is achieved in wood chips as compared to coir pith. Jorapur & Rajvanshi[5] developed a low density biomass gasification system at commercial scale (1080 MJ/h) for thermal application and demonstrated that gasifier run on sugarcane leaves or bagasse can be successfully retrofitted to existing oil fired furnace / boilers in metallurgical and other industries.

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Table 1 —Energy planning as per 5 Years Plans[1]

5 Years Plan	Demand MW	Installed capacity MW	Shortage MW
6th (1980-85)	52,000	47,000	5000
7th (1985-90)	75,000	65,000	10,000
8th (1990-92,92-97)	1,05,000	85,000	20,000
9th (1997-2002)	1,32,000	1,05,045	26,955
10th (2002-007)	1,46,000	1,32,329	13,671

This study presents engine performance using rice husk, rice straw, cotton stalks and bagasse as biomass fuel in downdraft gasifier in dual fuel mode.

Methodology

Important properties of rice husk, rice straw, cotton stalks and bagasse (sugar cane) are compared with that of wood (Table 2).

Experimental Work on Engine

In biomass gasifier (5 kW, Kirloskar, single cylinder, four stroke engine with 1500 rpm), biomass was fed through feed door and stored in hopper (Fig. 1). Throat (or hearth) ensures relatively clean and good quality gas production. Grate holds charcoal for reduction of partial combustion products while gas outlet is connected with

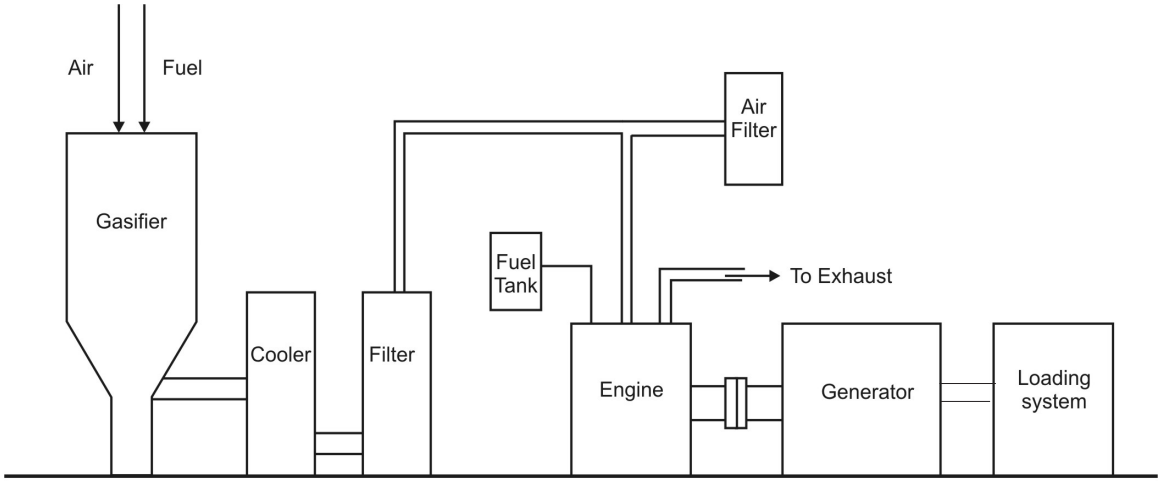

Fig. 1— Schematic arrangement of experimental set up

Table 2 —Characterization of fuels

Biomass	Ash %	C %	H %	N %	O %	S %	Calorific value, MJ/kg
Cotton stalks	6.68	43.64	5.81	0	43.87	0	17.4
Bagasse	4.27	44.80	6.20	0.20	44.40	0.01	18.11
Rice husk	17.60	38.30	4.80	0.34	35.45	0.03	14.4
Rice straw	10.70	42.30	5.60	0.90	40.50	0.02	11.7
Wood chips	3.20	48.60	5.56	0.60	41.46	0.03	17.4

engine via venturi scrubber, separator box cum fine filter and check filter with an air control valve to facilitate running of engine in dual-fuel mode. Dust particle in gas were removed by passing through gas filter. Valves were provided in passage of gas and airflow to control gas. A single cylinder naturally aspirated direct injection four-stroke diesel engine coupled with generator was used for power generation. Dual fuel mode of operation was carried out by supplying gas to combustion chamber of engine through inlet manifold. Gas control valve is opened gradually to feed gas into engine. Also, engine governor control knob is closes to dual fuel position, to decrease amount of diesel when sound becomes normal. With rotation of gas valve, optimum adjustment of gas and diesel is made.

Results and Discussion

As producer gas is increased, there is a decrease in diesel consumption (Fig. 2). Hence, higher diesel substitution in dual fuel mode of operation is achieved opening producer gas valve fully so that higher amount of producer gas flow will replace higher amount of diesel. Sugarcane bagasse fuel replaced maximum diesel (82%) at 3 kW load followed by cotton stalks fuel (80%).

As gas flow is increased in cotton stalks fuel, diesel substitution varies from 60.58% to 79.79%; maximum diesel substitution is obtained at full opening of gas flow valve. Wood also replaces a little more diesel (80-85%) as both fuels have same characterization properties. Sugarcane bagasse for producer gas generation in gasifier showed maximum diesel substitution (82.1%) in dual fuel mode. As compared to cotton stalks and sugarcane bagasse, diesel displacement in case of rice husk as fuel is very less (33.36-59.74%), because presence of small quantities of C (38.3%) and H (4.5%) and also very high ash content, which creates hindrance in producer gas generation. Rice straw gave minimum diesel replacement (47%), due to nitrogen present in rice straw that dilutes

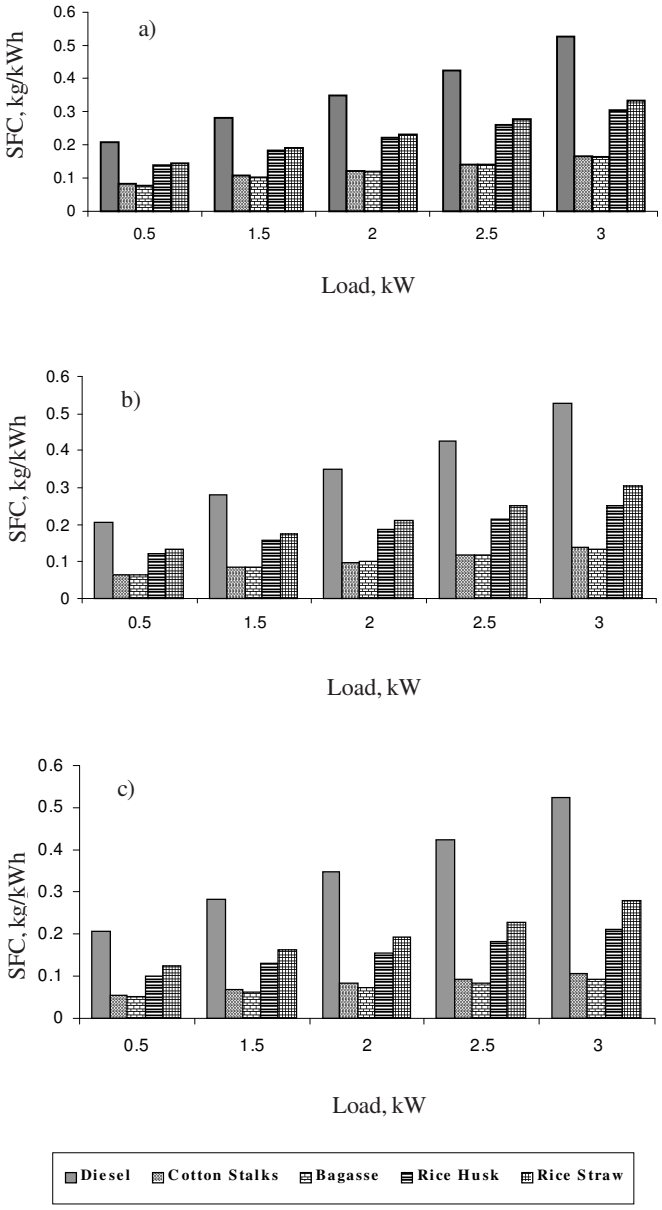

Fig. 2 — Specific fuel consumption at producer gas flow ratios of: a) 2 revolutions; b) 4 revolutions; and c) 6 revolutions

producer gas quality and also ash content being very high createing hindrance in production of producer gas. Energy costs (Fig. 3) to produce 1 kWh energy (at 3 kW load), considering cost associated with drying, collection, storage and transportation of biomass fuels[7], is given as

Energy cost (Rs/kWh) = cost of diesel x diesel consumption +cost of biomass x producer gas consumption

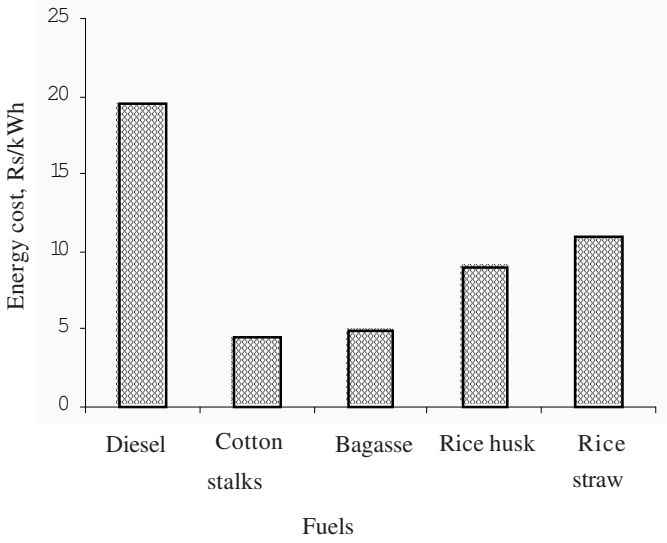

Fig. 3 — Energy cost of fuels

Looking into energy costs, sugarcane bagasse is higher than cotton stalks but its diesel replacement is more than cotton stalks, because cost of bagasse is higher than cotton stalks.

Conclusions

Diesel engine is capable of successful running in dual fuel mode of operation with suitable biomass in gasifier. To produce 1 kWh of energy, 630 ml diesel was used at Rs 19.55. Maximum diesel replacement in dual fuel mode of operation using cotton stalks in gasifier was 80%. To produce 1 kWh of power energy, cost associated was Rs 4.46. Maximum diesel replacement in dual fuel mode of operation using sugarcane bagasse in gasifier was 82%. To produce 1 kWh of power energy, cost associated was Rs 4.82. Maximum diesel substitution in case of rice husk was 60% and to produce 1 kWh of power energy, cost associated was Rs 9.00. Maximum diesel replacement in case of rice straw was 47% while to produce 1 kWh of power energy, cost associated was Rs 10.97. Hence, power generation cost while using biomass is cheaper than conventional power generation cost.

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