ABSTRACT

Because of the current energy shortage. there has been much interest in developing new fuels as alternatives to petroleum fuels. Biogas appears to be a feasible nontraditional fuel for internal combustion engines because it can be derived from agricultural roughages and residues which provide the raw material for biogas production. Biogas technology is a sustainable source of energy especially for the rural people

The present research work was carried out in the biogas laboratory of the Agricultural Engineering Department, Faculty of Agriculture, Mansoura University in order to study the possibility of producing biogas compressed in cylinders to be utilized as unconventional source of fuel for operating small engines.

The main objectives of the present study were to modify a small kerosene engine to operate on biogas as fuel and investigate its effect on the performance and efficiency of the engine-generator set using six different nozzle diameters 4, 5, 6, 7, 8, and 9 mm with seven different electric loads 0, 0.29, 0.58, 0.87, 1.16, 1.43 and 1.62 kW.

For the duration of the experimental work the biogas used had the following properties of (77.29% methane (CH_4), 18.83 carbon dioxide (CO_2), 3.88 % nitrogen (N_2) and NIL hydrogen sulphide (H_2S)). The gross and net calorific values were 31.572 and 28.427 MJ/kg (29.08 and 26.181 MJ/m^3). The gas

density was 0.921 kg/m^3. The biogas was compressed in gas cylinders reaching a maximum pressure of 15 bar. The gas volume inside the cylinder was 894.9 liter with total energy of 6.508 kWh. The energy consumed for compression was 0.213 kWh and consequently providing net energy of 6.295 kWh.

The obtained results showed that the nozzle diameters of 4 and 5 mm were the best options for operating the engine-generator unit. With these nozzles and at the maximum power output of generator (1.62 kW), the main results were recorded:

1- The operating biogas pressure was 20 and 21 mbar, and biogas consumption rate was 1.028 and 1.033 m^3/h. The specific biogas consumption was: 0.488 and 0.491 m^3/kWh for 4 and 5 mm diameter, respectively.

2- The brake power was constant for all experiments (2.106 kW).

3- The brake thermal efficiency was lower than with kerosene fuel, the reduction was 2.36 and 2.84% respectively.

4- The mechanical efficiency was also lower with reduction of 2.6 and 3.19% respectively.

5- The CO value in exhaust gasses was 594 and 571 ppm with a reduction of 70.8 and 71.94% while the exhaust gas temperature was higher compared with kerosene fuel

6-The combustion efficiency was 79.7 and 81.3% increasing by 5.7 and 7.8% using the selected nozzles, however, the theoretical and actual air to fuel ratios were lower

¯- The maximum electric generation efficiency was 76.9 % for all treatments. While the generator thermal efficiency was lower by about 2.25 and 2.7% respectively.

8- The cost of mechanical and electrical energy unit was lower compared with kerosene as fuel. The reduction was 45.52%. for the mechanical energy unit and 46.23 and 45.89% for the electrical energy unit for both nozzles respectively.

CONTENTS

Nomenclature

N_d	Nozzle diameter
Bc	Biogas consumption
T	Torque
E_L	Electric load
P_b	Brake power
SBC	Specific biogas consumption
SKC	Specific kerosene consumption
SBC_g	Specific biogas consumption for generator
SKC_g	Specific kerosene consumption for generator
Q_B	Energy provided from biogas
Q_K	Energy provided from kerosene
η_b	Brake thermal efficiency
η_i	Indicated thermal efficiency
η_m	Mechanical efficiency
η_{gth}	Generator thermal efficiency
η_{elg}	Electric generation efficiency
η_{com}	Combustion efficiency
P_g	Generator electric output
P_i	Indicated power
P_f	Friction power
$\overline{P}_b$	Brake mean effective pressure
$\overline{P}_f$	Friction mean effective pressure
C_M	Mechanical energy unit cost
C_E	Electrical energy unit cost
BDC	Bottom dead center