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PARAMETERS AFFECTING PERFORMANCE OF BIOMASS GASIFIER-DIESEL ENGINE SETUP USING WOODY BIOMASS (SUBABOOL) FOR INDUSTRIAL USE (AN LITERATURE REVIEW, EXPERIMENTAL STUDY & ANALYSIS)

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ABSTRACT

The gasification technology is now considered to be in an advanced stage of development. Hence there is huge expectation from the user industry for its application. Gasification is a process that converts carbonaceous materials, such as coal, petroleum, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel. Gasification is a very efficient method for extracting energy from many different types of organic materials, and also has applications as a clean waste disposal technique. The biomass gasifier, using wood chips as fuel, has a dry producer gas consisting of H_2 (up to 45 vol%), CO (up to 30 vol%), CO_2 (up to 20 vol%), CH_4 (8–12 vol%) and N_2 (1–2 vol%). This gas composition makes the producer gas highly suitable as fuel for Solid Oxide Fuel Cell (SOFC). However, the gas has a relatively high particle loading (up to 60 g/Nm^3) and a tar content of up to 2 g/Nm^3. In addition, it has been reported that the dry producer gas contains 100–200 ppmv H_2S and 500–1000 ppmv NH_3. Due to otherwise expected diesel engine performance degradation, theparticles have to be removed before entering the Biomass Gasifier-Diesel engine setup.

The advantage of gasification is that using the syngas is more efficient than direct combustion of the original fuel; more of the energy contained in the fuel is extracted. Syngas may be burned directly in internal combustion engines, used to produce methanol and hydrogen, or converted via the Fischer-Tropsch process into synthetic fuel. Gasification can also begin with materials that are not otherwise useful fuels, such as biomass or organic waste. In addition, the high-temperature combustion refines out corrosive ash elements such as chloride and potassium, allowing clean gas production from otherwise problematic fuels.The objective of the present work was to estimate saving in energy by reducing the moisture content in biomass. The *reduction in moisture content increases the fuel value ofbiomass.*

This work relates to the analysis and the evaluation of the performance of Biomass Gasifier-Diesel engine setup with focus on moisture content in biomass and its effects on various parameters under typical operating conditions. The aim of this paper is focused on evaluation of performance parameters for biomass gasifier-diesel engine setup using woody biomass (Subabool). For the purpose,downdraft gasifier of %KW capacity was used that was coupled to 10 hp single cylinder diesel engine

Keywords*: Biomass, Gasification*

1. INTRODUCTION

Gasification is a high temperature chemical process in which solid fuel is reacted with a limited supply of air or oxygen to completely convert all the carbonaceous material into a fuel gas. Thus thermo chemical characteristics of biomass play a major role in the selection of the gasification system design and performance.

The efficiency of the biomass gasifier depends on the design of choke plate, flow of air and combustion process. This work concentrates on the analysis of performance of gasifier engine system on different loads and speeds with reference to study the effect of feed material (subabool) on the performance of the gasifier engine system. To study the brake specific fuel consumption and brake specific energy consumption and the brake thermalefficiency.

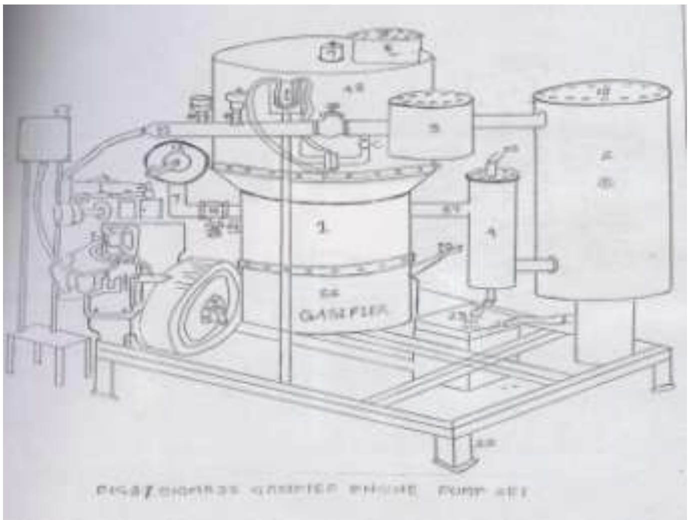
Down draught biomass gasifier with following specifcation wasused

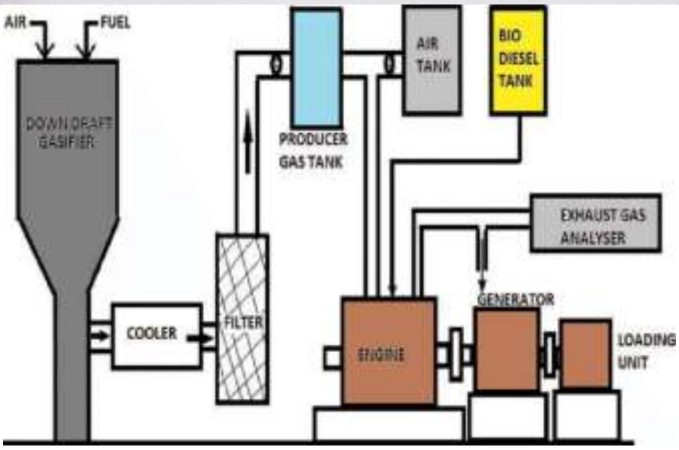
Make :-Punjab Agricultural University (PAU) downdraft gasifier of 10 KW capacity manufactured by Pumped Engineering and Consultants, Ludhiana,India,

2. DESIGN OF DOWN DRAFT BIOMASS GASIFIER

In downdraft gasifier, (Co-current) the biomass feed and the gas stream moves in the same direction. The downdraft gasifier can be of two types. Those having, throat type design (including choke plate) and those with open core design. Throat type gasifier are used for biomass fuels with low ash and uniform size, while open core gasifier can tolerate more variation in fuel properties like fuel moisture, size and ash content. Also smaller throat diameter means higher gas velocities at the oxidative and reduction zones. This reduces tars but increases dust loading. Large throat diameter causes an increase of tar in the gas stream due to bypassing of the hot zone. Fuels with high ash content (e.g. rice husk -21.3%) create, problems by ash clogging and slogging at the combustion zone in downdraft gasifier. The choke plates and throat type combustion regions used in downdraft gasifier work well with lower coking tendency fuels (e.g. wood), but when high coking fuels (e.g. cotton stalk) are used they cause bridging in and above the pyrolysiszone.

A down draft gasifier is designed forhauling a 10 HP diesel engine. The engine is coupled to A.C. alternator having an output of 8 kW as shown infigure





The main performance parameters of interest in dual fuel engine are asfollows:

1. The power capacity of theengine.
2. Range of diesel substitution by the supplementary fuel at full loads as well as partloads.
3. Thermal efficiency of theengine.
4. Smoothness of operation and load following capability.
5. Engine durability and maintenance requirements.
6. Exhaust emissions i.e., environmental implications.

Each of the above parameters are influenced by the number of factors suchas:

1. Properties of supplementary fuel (calorific value, stoichiometric air fuel ratio, moisture content, flame velocities, flammability limits, ignition energy requirements,etc.)
2. Engine design parameters (Excess air capacity, L/D ratio, type of the combustion chamber, type of cooling, injector nozzle parameters.)
3. Operating parameters (load and speed variations under which the engine has to operate.

: Powercapacity:

Power capacity of the dual fuel engine is compared with its power capacity under straight diesel

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operation. In some published work, increase, decrease or no change have been expressed equally strongly. Such contradictions are rather conditional and can be explained based upon the analysis of influence of various factors described below:

: Fuelproperties:

Power capacity of a given engine provided with a certain stroke volume (litre capacity) depends upon the maximum possible heat input per cycle and the number of cycles per unit time. In case of diesel engines, since the stroke volume contains only air and the volume of the fuel is negligible, the power capacity becomes a function of the amount fuel that can be burnt per unit air volume contained in the cylinder. When all the air available is utilised and all the fuel injected is completely burnt, the combustion is referred to as the stoichio metric combustion.

In case of engines of higher speed ranges, limitations on power capacity are imposed due to the need of reducing the engine operating speed to accommodate lower flame velocity of fuels like producer gas. Derating due to speed reduction is a very prominent factor while considering high speed spark ignition engines. The powercapacity of the engine reduces in proportion to the speedreduction.

: Engine DesignParameters:

The main engine parameters which influence the power capacity of engine under dual fuel operation are the designed excess air provision type of cooling and the L/D ratio.

Charge efficiency is also influenced by the L/D ratio of the engine. Larger diameter engine provides scope of using larger values and thus improves charge efficiency. On the other hand, large cylinder diameter implies lesser surface to volume ratio and therefore poorer cooling and adverse effect on the charge efficiency. One has therefore to properly choose the engine from point of view of theseaspects.

: OperatingParameters:

As discussed earlier, very high speed of operation do not quite suit dual fuelling by the producer gas. The engine may require de-speeding and consequentderating.

: Range Of Diesel Substitution:

The amount of diesel fuel which can be replaced by supplementary fuel is of great interest, being the main purpose of dual fuelling. The factors which govern the amount of diesel which can be substituted are different at the full load and part load conditions.

: Diesel Substitution At FullLoad:

Under full load conditions, it is the maximum amount of diesel that can be substituted by the supplementary fuel, which is of great interest. Maximum diesel substitution refers to the condition of no power-loss under dual fuel operation. The ultimate maximum limit of substitution is decided by the ignition requirements, i.e, by the minimum quantity of diesel required to be injected for sure ignition, followed by combustion of premixed mixture by turbulent flame propagation.

: Diesel Replacement at PartLoads:

Certain minimum quantity of diesel rate has to be maintained to ensure ignition and hence steady operation of engine. As engine load decreases, the usual procedure is to keep the diesel rate unchanged and tokeep

decreasing the supplementary fuel supply rate with decreasing load. Under these circumstances, therefore, the diesel substitution expressed as a percentage of quantity consumed at that load under diesel operation will keep on reducing.

From the point of view of power capacity and the range of diesel substitution, power performance prediction charts (PPP charts) have been developed which are applicable to the complete range of diesel engines manufactured currently. The PPP charts can indicate the probable power loss for spark ignition engines when the fuel is changed from gasoline to producer gas, speed remaining unchanged. Most of the calculations have been assuming a speed of 1500 rpm, considering the two most important applications i.e., electric power generation and irrigation water pumping. It may be mentioned that except for the assumption made, these are not just the theoretical work -outs, but are near to realistic presentations based upon the actual experimental results obtained in the laboratory with regard to specific fuel consumption (SFC) variations and the specifications of the engine.

: Thermal Efficiency Of The Dual-Fuel Engine:

Thermodynamic efficiency of a cycle improves with increase in the compression ratio, and that, for a given compression ratio, efficiency improves with the increase in expansion ratio, the combustion duration being the sole responsible factor the difference between compression ratio and expansion ratios. Combustion in dual fuel engines take place in a mode which can be called hybrid in the sense that it starts as a multipoint ignition as in diesel engines but progresses as rapid turbulent flame propogation as in Otto - engines. Theoretically, therefore, the efficiency of this mode should be any time better than diesel operation. The actual efficiency however depends on many other practical considerations, one of the main being the timely and complete combustion of premixed mixture higher level of turbulence in IDI engines helps in reducing the magnitude of the problem. Larger diameter engines are likely to give higher amounts of unburnt fuel. The various methods suggested for improving part load performance include increase compression pressure, supercharging, preheating the mixture, increase in pilot quantity of diesel, increasing air motion,etc.

: Smoothness Of Operation And Load FollowingCapacity:

Smoothness of operation underdual fuelling is an important aspect which influence not only the thermal efficiency of the engine but also the engine durability. The normal phenomenon like knocking and misfiring are known to adversely affect the maintenance requirement. Referring to particular case of producer gas, misfiring can be anticipated under part load conditions due to premixed mixture becoming leaner thanleaner flammable. Such over lean mixtures burn at very low rates which may result in accumulation of unburnt mixtures in the exhaust system in certain cycles and its combustion in subsequent cycles, giving rise to high exhaust temperature, noisy operation and even a flame to the exhaust pipe. In case when the flame continues to exist in the cylinder, even when suction begins, the possibility of back firing through suction passages is an obvious possibility. In either case, a considerable cycles variation in engine power and therefore speed is the result, which also implies inefficient and unsteadyoperation.

: Exhaust Emissions And Environmental Aspects:

It has already been stated in earlier article that there are always certain pockets in diesel engine combustion space in which the flame may not be able to reach due to various reasons, one of them being their higher surface to volume ratio. Dual fuel engines therefore are likely to have certain amount of unburnt premixed mixture in the exhaust. It is therefore expected that the concentrations of the hydrocarbons and carbon mono-oxide in producer gas dual fuel engines will be higher compared to diesel operation. There are many experimental evidences available in the literature to this effect. The problem of unburnt fuel being exhausted is more serious at part load conditions where comparatively leaner premixed mixture is to be burned. On the other hand, dual fuelling gives a comparatively smoke free operation. The research in the area of diesel engines explained this on the basis of replacement of diffusion combustion by premixed combustion and the fact that most gaseous fuels used for dual fuelling are cleaner burning fuels compared todiesel.

3. RESULTS AND CONCLUSION

Results obtained from investigation on the trial on gasifier - IC engine system on diesel and dual fuel (diesel and producer gas)mode.

: Physical Properties Of The Wood:

Before conducting the trial on the gasifier - I C engine system, the physical properties of the fuel wood such as lump size, moisture content and the bulk density were measured and are presented below:

: LumpSize:

The lump size is very critical for the production of uniform quality of the producer gas. As the size of the lump increases, the retention time as well as exposed area decreases. Both these factors adversely affect the carbon mono-oxide percentage, thereby, the quality of the producer gas produced. The use of small size of lump improves the mobility of the fuel in the fuel bed and quality of gas due to increased retention time as well as exposed surface area. The lump size selected was 50 mm length and 50 mm diameter, which was well within the prescribed limit (12 to 50 mmsize).

: MoistureContent:

The moisture content value was found to be 13.33%.The gas production from downdraft gasifier is more susceptible to the moisture content. To ensure free flow and good quality gas production, low moisture content is desirable. On the contrary, the moisture content lowers the efficiency of combustion by using the heat in evaporating the moisture. The acceptable limit of the moisture content in the fuel for gasification is below 15 percent(Parikh et al, 1984). It is sound that value of moisture content obtained is well within the acceptable limit.

: BulkDensity:

The bulk density of Subabool with bark was found to be 0.69 gm/cc. The high density of fuel is advantageous because it represents high-energy value for unit volume.

: Performance Of I C Engine On Diesel Fuel:

The performance test of engine was conducted on diesel fuel at 1500 rpm and 1400 rpm. Observations were taken at different loads at above speeds.

: FuelConsumption:

The fuel consumption at corresponding speed was maximum as 1.95816 Kg/Hr (@ 1500 rpm) and 1.71339 Kg/Hr (@ 1400 rpm
) respectively. From this it is observed that as the speed decreases, the fuel consumption also decreases. Also it was observed that for the same speed as the load increases, fuel consumption also increases.

: Brake Specific Fuel Consumption(BSFC):

It is observed that at maximum load the brake specific fuel consumption (BSFC) was found to be minimum and these values were 0.2693267 Kg/kWh and 0.2525 Kg/kWh for 1500 rpm and 1400 rpm respectively. From these values it is observed that as the speed decreases from 1500 rpm to 1400 rpm; BSFC decreases. Also it is observed that for the same speed, as the load increases, BSFC decreases.

: Brake Specific Energy Consumption (BSEC):

It is observed that at maximum load the BSEC was found to be minimum and these values were 11.83998 Mj/ kWh and 11.100254 Mj/kWh for 1500 rpm and 1400 rpm respectively. Thus as the speed decreases from 1500 rpm to 1400 rpm; BSEC decreases. Also it is observed that for the same speed as the load increases, BSEC decreases.

: Brake Thermal Efficiency (BTE)%:

It is observed that at maximum load the brake thermal efficiency was found to be maximum and these values were 30.40546 % and 32.43249 % for 1500 rpm and 1400 rpm respectively. From these values it is observed that as the speed decreases from 1500 rpm to 1400 rpm, brake thermal efficiency increases. Also it is observed that for the same speed as the load increases, brake thermal efficiency also increases.

: Exhaust GasTemperature:

It is clear that at maximum load the exhaust gas temperature was found to be maximum and these values were 3280 C and 3890 C for 1500 rpm and 1400 rpmrespectively. From these values it is observed that as the speed decreases the exhaust gas temperature increases. However for the same speed, the exhaust gas temperature increases.

: Carbon Mono-oxide In ExhaustGas:

It is observed that at maximum load the emission of carbon mono-oxide in exhaust was found to be maximum and these values were 0.165 % and 0.138 % for 1500 rpm and 1400 rpm respectively. Thus as the speed decreases from 1500 rpm to 1400 rpm the emission of carbon mono-oxide in exhaust gas increases. However, for the same speed the CO % increases with load.

;Performanc Of Gasifier-IC Engine System Using Woody Biomass (Subabool): The performance test of engine was conducted on dual fuel (i.e., diesel and producer gas generated by gasification of biomass) at1500 rpm and 1400 rpm.

Observations were taken at different loads at above speeds.

: FuelConsumption:

The values of diesel consumption on dual fuel at maximum load and at 1500 rpm and 1400 rpm of engine speed were 0.8164424 Kg/Hr and 0.9043156 Kg/Hr respectively with the size of Subabool biomass as 60 x 60 mm length. Fuel consumption was found to increase with increase in engine load at same speed.

: Brake Specific Fuel Consumption (BSFC):

Among both the speeds BSFCat maximum load was found to be0.112294 minimum BSFC is observed nearly at full load.

: Brake Specific Energy Consumption(BSEC):

The variation of the BSEC with load on engine at 1500 rpm and 1400 rpm can be seen. It is observed that

BSEC is minimum at maximum load and the values were 22.902 Mj/kWh and 25.42Mj/kWh for 1500 rpm and 1400 rpm respectively. Thus as the speed decreases, BSEC increases. However at a constant engine speed BSEC decreases with the increase inload.

: Brake Thermal Efficiency (BTE)%:

It is observed that BTE % is maximum at maximum load condition and the values were 62.38% and 61.54% for 1500 rpm and 1400 rpm respectively. Thus as the speed decreases, brake thermal efficiency also decreases. However, at a constant engine speed BTE% increases with the increase in engine load.

: Exhaust GasTemperature:

It is observed that for both the speeds of 1500 rpm and 1400 rpm, the values of exhaust gas temperature were increasing with the increase in engineload.

: Carbon Mono-Oxide In ExhaustGas:

It is observed that for both the speeds of 1500 rpm and 1400 rpm, the values of emission of carbon mono-oxide in exhaust gas were decreasing with the increase in engineload.

: FuelReplacement:

It is observed that the maximum fuel replacement corresponding to maximum load was 58.30 % and 57.22 % respectively. At a constant speed operation it was found to increase initially with increase in load and then decreased slightly.

: Specific GasConsumption:

It is observed that the values of specific gas consumption were found to decrease initially and then increase slightly with the increase in engineload.

The percentage volumetric Kg/ kWh and 0.13326 Kg/kWh respectively. composition of CH 4 and CO2 are very well It is seen that BSFC goes on decreasing as the load on the engine increases and agree with the theoretical prediction for all the cases. The percentage volume tric composition of N2 is higher than the 13. Parikh P P, Arkkat P: "Scope and limitations of utilisations of biomass based producer gasindual theoretical prediction. This may be due to the poor gasification of biomass in the reduction chamber.

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