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DEVELOPMENT OF WOOD GASIFIER (PROTOTYPE) USING TIMBER WOOD AS FUEL

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ABSTRACT

The energy is the major concern in every engine which made it affordable and fit for commercial exploitation but every engine has difficulties in attaining efficiency level due to many reasons includes input cost, output power in comparison to input cost, etc. A wood gasifier is a gasification unit which converts timber or charcoal into wood gas, a syngas consisting of carbon monoxide, hydrogen, traces of methane, and other gases, which after cooling and filtering can then be used to power an internal combustion engine or for other purposes.

Objective

After the double fuel crises of 1973 and 1979, the harmful effect of high and rising oil prices on the economies and development efforts of oil-importing developing countries have become apparent. There has, as a result been increased interest in indigenous, renewable energy sources, of which biomass in the form of wood or agricultural residues are the most readily available in many developing countries. Experience from the Second World War shows, however, that properly designed wood gasifiers, operated within their design range and using fuels within the fuel specifications (which may differ between designs), can provide a sufficiently tar free gas for trouble-free operation. One of the objectives of this project is to make decision makers more aware of the possibilities of using wood gasification as a substitute for gasoline and diesel oil, without unreasonable increase of the demand on the natural resource.

KEYWORDS: Timber Wood, Gasifier

INTRODUCTION

A wood gasifier is a gasification unit which converts timber or charcoal into wood gas, a syngas consisting of carbon monoxide, hydrogen, traces of methane, and other gases, which after cooling and filtering can then be used to power an internal combustion engine or for other purposes Historically wood gas generators were often mounted on vehicles, but present studies and developments concentrate mostly on stationary plants. Gasification had been an Important and common technology which was widely used to generate Town gas from coal mainly for lighting purposes during the 19th and early 20th century.When the first stationary internal combustion engines based on the Otto cycle became available in the 1870s, they began displacing steam engines as prime movers in many works requiring stationary motive power Adoption accelerated after the Otto engine's patent expired.The potential and practical applicability of gasification to internal combustion engines were well-understood from the earliest days of their development.

THOERY

GASSIFICATION

The substance of a solid fuel is usually composed of the elements carbon, hydrogen and oxygen. In addition there may be nitrogen and sulphur, but since these are present only in small quantities they will be disregarded in the following discussion. In the types of gasifiers considered here, the solid fuel is heated by combustion of a part of the fuel. The combustion gases are then reduced by being passed through a bed of fuel at high temperature. In complete combustion, carbon dioxide is obtained from the carbon and water from the hydrogen. Oxygen from the fuel will of course be incorporated in the combustion products, thereby decreasing the amount of combustion air needed. Oxidation, or combustion, is described by the following chemical reaction formulae:

$$C + O_2 \Leftrightarrow CO_2 \text{ -401.9kJ/mol}$$

$$H + 1/2O_2 \Leftrightarrow H_2O \text{ - 241.1kJ/mol}$$

These formulae mean that burning 1 gram atom, i.e. 12.00 g of carbon, to dioxide, a heat quantity of 401.9 kJ is released, and that a heat quantity of 241.1 kJ results from the oxidation of 1 gram molecule, i.e. 2.016 g of hydrogen to water vapour.

In all types of gasifiers, the carbon dioxide (CO_2) and water vapour (H_2O) are converted (reduced) as much as possible to carbon monoxide, hydrogen and methane, which are the main combustible components of producer gas. The most important reactions that take place in the reduction zone of a gasifier between the different gaseous and solid reactants are given below. A minus sign indicates that heat is generated in the reaction, a positive sign that the reaction requires heat.

a)	$C + CO_2 \Leftrightarrow 2CO$	+ 164.9 kJ/kmol
b)	$C + H_2O \Leftrightarrow CO + H_2$	+ 122.6 kJ/kmol
c)	$CO + H_2 \Leftrightarrow CO + H_2O$	+ 42.3 kJ/kmol
d)	$C + 2H_2 \Leftrightarrow CH_4$	0
e)	$CO + 3H_2 \Leftrightarrow CH_4 + H_2O$	- 205.9 kJ/kmol

Table 1: Composition of Gas from-Commercial Wood and Charcoal Gasifies

Component	Wood Gas (Vol. %)	Charcoal Gas (Vol. %)
Nitrogen	50 – 54	55 – 65
Carbon monoxide	17 – 22	28 – 32
Carbon dioxide	9 – 15	1 – 3
Hydrogen	12 – 20	4 – 10
Methane	2 – 3	0 – 2
Gas heating value kJ/m³	5000 – 5900	4500 - 5600

Equations (a) and (b), which are the main reactions of reduction, show that reduction requires heat. Therefore the gas temperature will decrease during reduction. Reaction (c) describes the so-called water-gas equilibrium. For each temperature, in theory, the ratio between the product of the concentration of carbon monoxide (CO) and water vapour (H_2O) and the product of the concentrations of carbon dioxide (CO_2) and hydrogen (H_2) is fixed by the value of the water gas equilibrium constant (K_{WE}).In practice, the equilibrium composition of the gas will only be reached in cases where the reaction rate and the time for reaction are sufficient.

Prediction of the gas composition Introduction of the water-gas equilibrium concept provides the opportunity to calculate the gas composition theoretically from a gasifier which has reached equilibrium at a given temperature, as was shown by Tobler and Schlaepfer. The procedure is to derive from mass balances of the four main ingoing elements (carbon, hydrogen, oxygen and nitrogen), an energy balance over the system and the relation given by the water-gas equilibrium. By further assuming that the amounts of methane in the producer gas per kg of dry fuel are constant (as is more or less the case of gasifiers under normal operating conditions) a set of relations becomes available permitting the calculation of gas compositions for a wide range of input parameters (fuel moisture content) and system characteristics (heat losses through convection, radiation and sensible heat in the gas).

Generally a reasonably good agreement with experimental results is found.Table-1 gives typical gas compositions as obtained from commercial wood and charcoal downdraught gasifiers operated on low to medium moisture content fuels (wood 20 percent, charcoal 7 percent).

Ash Content and Ash Chemical Composition

Ashes can cause a variety of problems particularly in up or downdraught gasifiers. Slagging or clinker formation in the reactor, caused by melting and agglomeration of ashes, at the best will greatly add to the amount of labor required to operate the gasifier If no special measures are taken, slagging can lead to excessive tar formation and/or complete blocking of the reactor. A worst case is the possibility of air-channeling which can lead to a risk of explosion, especially in updraught gasifiers. Whether or not slagging occurs depends on the ash content of the fuel, the melting characteristics of the ash, and the temperature pattern in the gasifier. Local high temperatures in voids in the fuel bed in the oxidation zone, caused by bridging in the bed, may cause slagging even using fuels with a high ash melting temperature. In general, no slagging is observed with fuels having ash contents below 5-6 percent. Severe slagging can be expected for fuels having ash contents of 12 percent and above. For fuels with ash contents between 6 and 12 percent, the slagging behavior depends to a large extent on the ash melting temperature, which is influenced by the presence of trace elements giving rise to the formation of low melting point eutectic mixtures. For gasification purposes the melting behavior of the fuel ash should be determined in both oxidating and reducing atmospheres. As far as ash content is concerned, raw wood and wood charcoals seldom present problems, the ash content being normally from 0.75 to 2.5 percent. However, in a number of tropical woods charcoal ash contents may be much higher and those charcoal types are unsuitable for gasification purposes.Table-2 lists agricultural residues which have been tested with respect to their slagging properties in a small downdraught laboratory gas producer. Up and downdraught gasifiers are able to operate with slagging fuels if specially modified (continuously moving grates and/or external pyrolysis gas combustion) Cross draught gasifiers, which work at very high temperatures of 1500° C and above, need special safeguards with respect to the ash content of the fuel. Fluidized bed reactors, because of their inherent capacity to control the operating temperature, suffer less from ash melting and fusion problems.

Table 2: Slagging of Agricultural Residues in a Small Laboratory

Slagging Fuels	Ash Content Percent	Degree of Slagging
Barley straw mix	10.3	Severe
Bean straw	10.2	"
Corn stalks	6.4	Moderate
Cotton gin trash	17.6	Severe
Cubed cotton stalks	17.2	"
RDF pellets 1/	10.4	"
Pelleted rice hulls	14.9	"
Safflower straw	6.0	Minor

CONSTRUCTION

Main Cylinder

This is the main part where the major processes take place. In the main cylinder destructive distillation of wood takes place. In this process various gases like hydrogen, carbon monoxide, nitrogen, methane and carbon dioxide are produced. The total volume of the cylinder is 24 liters. It further contains two parts. First is upper cylinder and other is lower cylinder.Figure1 shows the main cylinder.

Figure 1: Main Cylinder Figure2: Lower Cylinder

LOWER CYLINDER

This is the cylinder which is subjected to heat. The heat is supplied by the external source i.e. either by using a heater or by using a grate. Figure2 shows the lower cylinder. Some technical specifications about the lower cylinder are

SPECIFICATIONS

- Volume of the cylinder: - 20 liters.
- Material of the cylinder:- Galvanized iron

Figure3: Upper Cylinder

UPPER CYLINDER

This is simply a paint can. This cylinder is soldered on the lower cylinder by using a hard solder wire. This cylinder is fully air tight. The main purpose of this cylinder is to air tight the whole main cylinder. Fig3 shows the main cylinder.

SPECIFICATION

- Volume of the cylinder: - 4 liters
- Material of the cylinder: - Tin

U-SHAPED PIPE

This pipe is used as a outlet for the gas. The pipe is given the u shape to provide the necessary cooling effect to the gas. The can be further connected to any appliance where gas is needed. The pipe is brazed to the main cylinder.Figure4 shows the u-shaped pipe.

SPECIFICATION

- Material of the pipe: - Mild Steel Length of the pipe:- 2m
- Diameter of the pipe: - 16mm

Figure 4: U-Shaped Pipe **Figure 5: Hose Pipe**

HOSE PIPE

The hose pipe is used to connect the outlet of the U shaped pipe to the burner. It is made up of a heat resisting rubber. Fig5 shows the hose pipe.

SPECIFICATION

- Length of the pipe: - 1.5m
- Material of the pipe: - Reinforced Rubber

BURNER OR EXTERNAL SOURCE

The burner is used for the demonstration of the wood gas. It is the component where the wood gas burns. The wood gas burns without any emissions. An external power source is required to heat the main cylinder. The external heat source can be a heater or a grate. Heat is supplied at the bottom of the main cylinder. In the grate coal is burner as a source of heat.Figure6 shows the burner or external source. Figure6 shows the burner or external source.

Figure 6(a): Burner

Figure 6(b): Heater

ADVANTAGES

- Wood gas generators have a number of advantages over use of petroleum fuels
- They can be used to run internal-combustion engines (or even gas turbines, for maximal efficiency) using wood, a renewable resource, and in the absence of petroleum or natural gas, for example, during a fuel shortage.
- They have a closed carbon cycle, contribute less to global warming, and are sustainable in nature.
- They can be relatively easily fabricated in a crisis using materials on hand.
- They are far cleaner burning than, say, a wood fire or even a gasoline-powered engine is (without emissions controls), producing little if any soot.
- When used in a stationary design, they reach their true potential, as they are feasible to use in small combined heat

and power scenarios (with heat recovery from the wood gas producer, and possibly the engine/generator, for example, to heat water for hydronic heating), even in industrialized countries, even during good economic times, provided that a sufficient supply of wood is attainable. Larger-scale installations can reap even better efficiencies, and are useful for district heating as well.

APPLICATIONS

- Wood gas can be used to run automobiles as an alternative of petrol and diesel.
- It can be used for cooking food as an alternative of L.P.G.
- It can be used to heat water in gas geezers
- It can be used to produce electricity with the help of a turbine or generator.
- It can be converted into liquid fuel known as ethanol which can used in automobile engines.

CONCLUSIONS

The use of wood gasifier can help to convert the wood or other biomass into gas which can be used for many domestic and industrial purposes which will otherwise goes waste. Wood gas can also help to control air pollution as the whole process has a closed carbon cycle.

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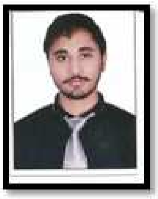

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