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PERFORMANCE OF DOWN DRAFT GASIFIER

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## INTRODUCTION

1.1 History:

Manufactured gas was discovered in the laboratory at the end of the 18th century, and it comes into commercial and domestic use in 1830. The gas industry grew rapidly from that time. By the time of world war II it was estimated that there were about 1200 plants in the United States producing & selling gas. Then since the 1930's natural gas gradually replaced manufactured gas. Now with increased cost of natural gas, producer gas is being considered again.

The beginning of world war II and scarcity of liquid fuel in Europe resulted in a great search in designing and installing gas generators. After end of the war, new supplies of liquid fossil fuels were discovered, since then a few generators have been in operation.

With the increase in oil prices following the formation of OPEC, there has been a renewed interest in all forms of gasification. A number of research projects are underway.

1.2 Types of Gasification process & gasifiers

## 1.2.1 Gasification process

- a. Pyrolysis: Decomposition of biomass using mainly heat to produce char, pyrolysis oil, and medium Btu gas.
- b. Pyrolysis Gasification: The process is operated to yield char, and oil products with the gas burned to operate the process
- c. Air Gasification: To burn biomass with limited supply of air to produce a low energy gas containing primarily  $H_2$ , and  $C_2$ , but diluted with nitrogen. (150-200 Btu V/SCF)
- d. Oxygen Gasification: Burn biomass with limited supply of oxygen to yield medium energy gas (300 Btu V/SCF).

e. Hydrogen Gasification: To convert biomass to gaseous or liquid fuels under pressure with hydrogen

### 1.2.2 Types of Gasifiers

There is a number of types of gasifiers we will briefly define some of them here

- a. Fixed Bed Gasifiers: used for bulky fuels include:
  - updraft gasifiers, air or oxygen is passed up through reacting bed, while fuel passes down.
  - Down draft gasifier: Both fuel and air pass downward through the heat bed. This type is tested in this project (see Fig. 1 for detailed parts)
- b. Fluidized Bed Gasifiers, use wide range of fuel size
- c. Suspended Flow Gasifiers; used finely divided particles

### 1.3 State of Commercialization

The only available commercial shaft power gasifiers at present are in Brazil.

Siquirali Company, produce gasifiers suitable for engines with output 75 KW. The cost is \$750 Escplo. Co. produce charcoal gasifiers for tractors, 45 Kw of output, cost \$3100, and 80 Kw output cost \$3500.

Termoquip producing direct heat systems gasifiers output ranging from 0.25 - 2.5 GJ/h cost between \$7500 - 30,000 (\$75/Kw).

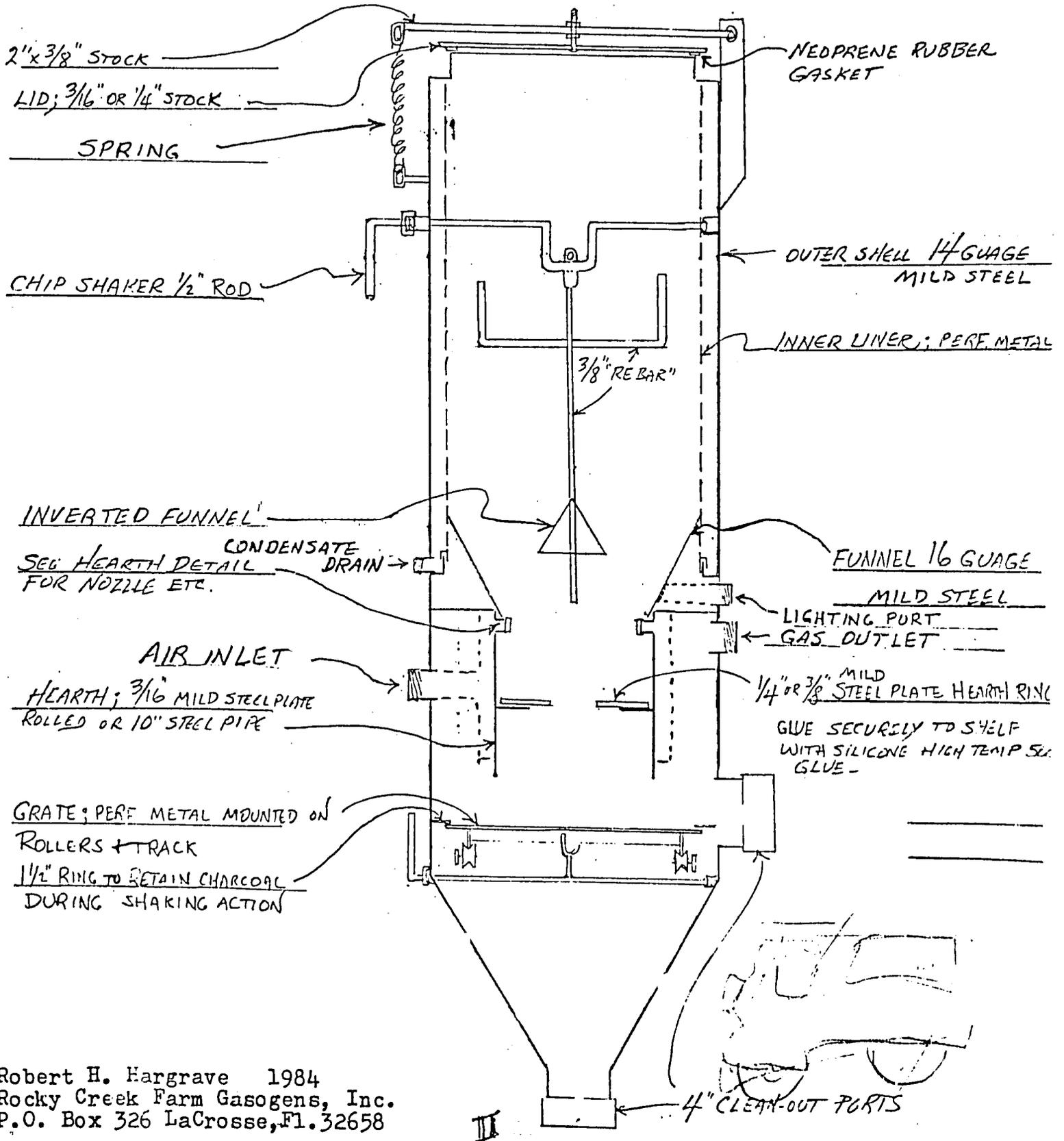
### 1.4 Objective of this report

This report is intended to investigate on:

- 1 Operation of down draft gasifiers and the problems associated its operation
- 2 Efficiency and amount of fuel consumed
- 3 Quality and contents of gas produces

# PARTS OF A WOOD GAS GENERATOR: WOODCHIP M

SCALE: 1/8" = 1"



Robert H. Hargrave 1984  
 Rocky Creek Farm Gasogens, Inc.  
 P.O. Box 326 LaCrosse, Fl. 32658

## 2. GASIFIER OPERATION

A good description of gasifiers operation was given by Robert H. Hargrave in his hand out as follows:

### 1. Daily servicing

a. Shake grate and empty ashes from generator

b. Empty ash from Cyclone

c. Check fiberglass filters, and replace if they appear clogged

(A manometer measure is more accurate for checking filter clogging)

d. Empty condensate, be sure the drain valve is not clogged with tar

e. Use the poker rod and dislodge chips which have stuck to sides and funnel above air nozzles. Cave in any burned out air line left above hearth as fuel burned out following last shut down.

Do not rake charcoal bed from between nozzles and top of hearth ring as it protects metal. Do not push uncharred chips through hearth ring.

f. Add dry sifted fuel to top of fuel hopper

### 2. Starting Procedure

a. Leave the filtering lid partially open. Be sure condensate valve closed, valve to filters closed. Open lighting part and open Flare off valve.

b. Observe wind direction, move vehicle to a position from which smoke will not reach people or animals. Start starting blower

d. Remove cap from primary air inlet and divert blower into it.

Blower is through primary air inlet for two or three minutes and try lighting smoke at flare off outlet.

- e While waiting for engine quality gas to be produced, the engine controls and valves are adjusted for wood gas (Producer gas) use
- f. When the smoke from the flare off port will stay lit, let it burn and observe it for an inner cone of water vapor. If the off gas (smoke) will not stay lit, continue blowing and shake chip shaker. If the hearth has become clogged, very little smoke will be blown through the flare off pot
- g Fanning as blowing require 2 - 5 minutes if charcoal and wood fuel were dry and generator was run recently
- h. Flame at the flare off will be red with blue tinges
- i Shake the chip shaker once or twice during fanning
- j. After engine quality producer gas is secured, open the valve to the filters and engine and blow some producer gas into the filters and gas lines to run the engine. Remove the fan and close the flare off part.
- The gasifier was fired to burn all amount of wood inside the gasifier and to be familiar with method of operation
  - Later the gasifier was cleaned and all residues of charcoal & ashes were removed, filters were renewed
  - Wood Chips were fed into gasifier record of time was kept to observe performance of gasifier when operating for the first time. Performance was recorded as follows with respect to time:
    - 9:50 AM = Start firing
    - 10:10 = Some smoke start coming out, smoke coming at flare off point was checked every two minutes, smoke mainly is white smoke water vapor
    - 10:30 = Gasifier start producing gas
    - 11:15 = Gasifier gas closed and let to cool down
    - 2:00 = Start firing gasifier again
    - 2:15 = Gas produced

- From this results and running gasifier several times introducing new wood it was noticed that two factors affect the gas being produced quickly, these are formation of charcoal at the bed, and the degree of dryness of wood.

Once gasifier is in operation after the first time there will be no problem with regard to charcoal formation. Concerning drying of wood is necessary through air and sun drying before introducing the wood into gasifier.

### 3. EFFICIENCY AND AMOUNT OF WOOD CONSUMED

Biomass includes many different materials each of which has somewhat different requirement for collection, preparation and gasification. The main feedstocks for gasifier are:

1. Wood - This is the most common Biomass. It involves wood specifically harnested for fuel
  2. Forest residues - This comes from forest industries engaged in logging and lumbering. The bale is the primary objective of logging industries - therefore the branches, deformed trunk, and buttresses are uses as fuel
  3. Mill waste - Consists of sawdust, bark, coarse residues, and shavings
  4. Agricultural crop waste and residues - Most food crops have residues after processing which can be used as fuel e.g: corn cobs, peanut cobs, rice husks, and many others
  5. Municipal solid waste (MSW) - In location which waste is abundant It can be used in gasifiers as fuel
  6. Animal manure (kung) - have also been applied in gasification
- During our experiment, we used oak wood chips. A 22 lbs of chips was introduced into the gasifier and ignited. After burning for about 7 minutes, produce gas began to form, we closed the valve of the gasoline and opened the valve of the producer gas. Engine was left running under producer gas until the 22 lbs wood was completely burned and the engine came to a complete stop.

Time taken to do this was recorded as 30 minutes.

Dividing  $22 \div 30$ , we got 0.73 lbs/min.

- Engine was then run in gasoline, amount of gasoline consumed per minute was calculated to be 150 C C /minute

- The engine was kept at 2500 R.P.M in both cases.

- Efficiency then was calculated

$$= \frac{\text{Energy output}}{\text{Energy input}}$$

$$= \frac{150 \text{ c.c} \times 7665 \times 2.2}{1000 \times 0.73 \times 4400} = \frac{2529450}{3212000}$$

$$= 0.787$$

So efficiency of gasification process is almost about 79%. This figure is different and efficiency is higher than the one which was calculated in a previous group project.

#### 4. GAS ANALYSIS

##### 4.1 Method used in gas analysis:

The Fisher-Orsat gas analyser was used to analyse the gas sample. This apparatus consists of a glass burette, graduated from 0 to 100 ml. This burette is immersed in a water jacket & connected at the top to a stopcock manifold made of capillary tubing. Absorption pipets (connected to the manifold at each stopcock position) contain liquid absorpents that remove one or more constituents from a gas sample. It also contains a slow combustion pipet for determining those hydrocarbons for which no absorpents exist. In operation the volume of gas is measured before & after each absorption, under constant pressure & temperature. Any decrease in gas volume then represents the amount of constituent that was present, with results reported on volume percentage basis.

The manifold stopcocks are arranged so that the buret may be connected to or bypass any or all of the pipets. Gas expansion bags are normally fitted over absorption pipets expansion chambers to prevent exhaustion of the absorbent through air contact, and also to protect a long standing sample from being slowly diffused with air. The bottom of the burette is connected to a movable reservoir for levelling bottle containing a confining liquid; by adjusting the reservoir height, gases in the burette can be brought to any desired volume, relative to the pressure of the continuing liquid. All components are assembled in a wooden case with front & rear sliding access doors and a carrying handle.

For our experiment, the first pipet was filled with potassium hydroxide (caustic potash-Fisher no So-P-226) for the absorption of carbon dioxide. The second pipet was supposed to be filled with alkaline pyrogallate for determination of oxygen but we did not use it because usually oxygen is present only in insignificant amount in producer gas. The third pipet also was supposed to be filled with fuming sulfuric acid for the determination of unsaturated hydrocarbons, but again we did not use it because of the insignificance of these in producer gas. The fourth pipet was filled with acid cuprous chloride (Fisher No So-C-166). This is used to determine carbon monoxide.

#### Procedure:

The gas sample was collected using a blow bottle in the following manner: The blow bottle which consists of two bottles connected by flexible plastic tubing & valves & one bottle filled with water & the other filled with air, is used to draw a sample of the gas from the outlet of the gasifiers filter. One end of the blow bottle tube was inserted into the gas outlet & someone would suck on the other end of one tube of the blow bottle. This would cause the gas to be drawn into the bottle filled with & the water is transferred to the other bottle as the gas displaced it. The tube which was inserted

into the gas outlet was capped & the sample was ready.

The sample was then taken to the gas analyser & transferred to the Burette as follows:

The cap was removed from the plastic tubing of the blow bottle & it was directly connected to the intake tube of the apparatus manifold.

The inlet 3-way stopcock was used to vent a small amount of the gas to the atmosphere to flush that connection. Ideally the manifold should have been filled with nitrogen which being inert would not interfere with the sample. But that could not be done & so we tolerated a certain error which should be small because we were using a large sample. At that time the burette was filled with the confining liquid to the top mark (0) & all stopcocks to the pipets were closed.

The absorption procedure was carried out as follows:

a. The levelling bottle was raised to place the sample gas under slight pressure. This was done to avoid draining absorption solution into the manifold.

b. The stopcock over the first pipet was opened & the levelling bottle was raised thus forcing the gas sample into the pipet until the confining liquid reached the top mark on the burette.

\* The first pipet was used to determine volume of  $\text{CO}_2$ .

c. The levelling bottle was lowered to draw the gas back into the burette.

d. The previous steps were repeated 5 or six times.

e. The absorption solution was finally drawn back into the pipet by lowering the levelling bottle until the solution reached the point just below the pipet stopcock body. The pipet stopcock was closed.

f. The levelling bottle was adjusted until the level of the liquid inside the bottle & the level of it inside the burette were in the same horizontal level\*. The burette was allowed to drain for about one minute before it was read. It was read to 0.05 ml. from bottom of meniscus.

g. The percentage of absorbed component was calculated as follows:

$$\% \text{ component} = \frac{\text{decrease in volume} \times 100}{\text{volume of sample}}$$

This absorption procedure was repeated with the fourth pipet to determine the volume of carbon monoxide.

Slow Combustion Procedures:

The slow combustion procedure is used to determine hydrogen & saturated hydrocarbons (mainly methane). In this procedure, oxygen needed to be added. Air could have been used but it dilutes the sample with nitrogen thus increase the margin of error. If air was used, a volume as great as five times as the volume of oxygen is needed.

For our experiment we filled the slow combustion pipet to the mark with oxygen & closed it & then took a new sample & repeated the analysis for carbon dioxide and carbon monoxide. This helped to confirm the previous results.

The transformer was turned on and the retrostat was adjusted for maximum current. Then the heating coil inside the slow combustion pipet was glowing bright yellow.

By slowly opening the stopcock over the slow combustion burette & raising the levelling bottle of the burette slowly, the gas was introduced into the pipet at a slow rate. This was important to avoid explosion of the gas and shattering of the glass.

Several passes were made over the hot coil (subsequent passes were made at faster rate).

With the final pass still inside the pipet, the current was turned off and the pipet was cooled using compressed air.

The gas was then returned to the burette and measured.

The volume of hydrogen was determined according to the principle that:

$$\text{Volume of hydrogen} = 2/3 \text{ contraction}$$

for the determination of methane, it is stated that the volume of methane equals the volume of carbon dioxide so the sample was run once more through the first pipet which contains the caustic potash to absorb  $\text{CO}_2$  and its

\* This was done to compensate for any change in atmospheric pressure

volume was determined which should be equal to the volume of burned methane.

#### 4.2 Results

Table 1 give results obtained of gas analysis

Table 1.1. Percent of different components of producer gas analyzed.

Component	% Volume
CO <sub>2</sub>	11
CO	21
H <sub>2</sub>	14
CH <sub>4</sub>	4
N <sub>2</sub>	50

The results seems to be satisfactory when compared to what is indicated in the literature. Table 2 gives expected percentage of each of producer gas components.

Table 2. Expected percentages of different components of producer gas.

Component	% Volume
CO <sub>2</sub>	3-12
O <sub>2</sub>	Trace
CO	15-30
H <sub>2</sub>	8-18
CH <sub>4</sub>	0.5-3
N <sub>2</sub>	40-70

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