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BIOMASS GASIFIER COOKSTOVE: MANUEFACTURING AND PERFOMANCE TEST
AND
CARBON NANOTUBES FROM BANANA PEELS

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An Undergraduate thesis submitted to the department of Mechanical & Chemical engineering of Islamic University of Technology, Board Bazar, Gazipur in partial fulfilment of the requirements for the degree

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(Mechanical and Chemical Engineering)

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CANDIDATES DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma

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ABSTRACT

VOLUME ONE

Up to now, efforts to replace solid biomass fuels have largely failed as vast numbers of people still use them. The absolute figures are even set to increase in the next decades being that solid biomass is the most abundant source of vital and renewable cooking energy worldwide.

The most effective way – as measured by cost, health benefits and adaptation rates – to address the current situation is to re-engineer the devices themselves as well as the practices used in converting solid fuel into useable cooking heat. Gasifiers offer just this opportunity: they are devices that produce their own gas from solid biomass in a controlled manner. Gas generation occurs separately from subsequent gas-combustion, and both stages of combustion can be controlled and optimized separately. Gasification is not a new concept but micro-gasification is a relatively new development; it was long a challenge to create gasifiers small enough to fit under a cooking pot.

The volume one of these theses is aimed to portrait our achievement on this regard.

ABSTRACT

VOLUME TWO

Carbon nanotubes showed excellent mechanical and electronic properties with can be metallic or semiconducting, field effect. transistors, single electron transistor, rectifying diodes and have high-capacity hydrogen storage. The long conducting fibers may have many applications in biosensors; ion activated molecular switches, and microelectrodes for medical uses. The irregular outer surface of the carbon nanotubes are expected to give a very large surface area for catalytic applications.

Any bio-product rich in carbohydrate are suitable for carbon Nano tube production. Our aim is to produce activated carbon from banana peels and test it as well as make samples for carbon Nano tube production and test with suitable procedures to find the existence of Nano tubes.

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VOLUME ONE

BIOMASS GASIFIER COOKSTOVE: MANUEFACTURING AND PERFOMANCE TEST

CHAPTER ONE

INTRODUCTION TO BIOMASS STOVE

1.1 INTRODUCTION

Throughout the world, people use a variety of cook stoves and fuels to meet their daily cooking needs. Over 40% of the world's population still burns various forms of biomass – such as wood, dung, charcoal, or crop residues – or coal as a cooking fuel. They cook over open fires or on rudimentary cook stoves. This way of cooking emits a harmful smoke that causes range of deadly chronic and acute health effects such as child pneumonia, lung cancer, chronic obstructive pulmonary disease, heart disease, and low birth-weight.

Clean, efficient, durable, safe, and affordable stoves are – along with clean fuels and other products like chimneys and heat retention cookers –central to most solutions to the health, environmental, and other risks inherent in cooking with fire. Cooking with clean fuels is the most common way to achieve the dramatic health and climate benefits that is the main objectives of this thesis. Where solid biomass must be used, advanced clean cook stoves are most likely to achieve significant health and climate benefits. Processing the biomass into pellets or briquettes often facilitates advanced performance.

Moreover, the thermal efficiency of the fuel must be higher and also the fuel consumption rate should be lower to keep the fuel cost lower as well. The energy output of the stoves has to be higher than our conventional cooker. Also the size of the cooker should be limited as for to be used for domestic purposes.

To meet the above constraints, (micro) gasifier stoves are perfect fit. “You do not need to switch to costly fuel or stoves, switch to gasifier stoves”. Micro-gasifiers: much more than ‘just another improved cook stove’. They are portable, cleaner, healthier, cheaper and more efficient than other cooking stoves.

1.2 BIOMASS COOKSTOVE

A Stove is that is heated by burning wood, charcoal, animal dung or crop residue. Cook stoves are the most common way of cooking and heating food in developing countries.

In cooking, a cook stove is heated by burning wood, charcoal, animal dung or crop residue. Cook stoves are commonly used for cooking and heating food in developing countries. Developing countries consume little energy compared to developed nations; however, over 50% of the energy that they do use goes into cooking food. The average rural family spends 20% or more of its income purchasing wood or charcoal for cooking. Living in the city provides no refuge either as the urban poor frequently spend a significant portion of their income on the purchase of wood or charcoal. Besides the high expense, another problem of cooking over an open fire is the increased health problems brought on from the smoke, particularly lung and eye ailments, but also birth defects. Replacing the traditional 3-rock cook stove with an improved one and venting the smoke out of the house through a chimney can dramatically improve a family's health. Deforestation and erosion are often the end result of harvesting wood for cooking fuel. The main goal of most improved cooking stoves is to reduce the pressure placed on local forests by reducing the amount of wood the stoves consume. Additionally, the money a family spends on wood or charcoal translates into less money being available to be spent on food, education, and medical care; so an improved cooking stove is seen as a way of boosting a family's income.

1.2.1 BIOMASS GASIFIER vs. TRADITIONAL COOKSTOVES

Traditional wood-fires are commonly associated with negative impacts such as

- Lack of convenience: ‘not modern’ like LPG, electricity, or biogas burners
- Emissions of smoke, carbon monoxide and soot (black carbon): ‘not healthy’
- Forest degradation: ‘non-sustainable’ fuel-supply from abused renewable resources

So-called ‘’improved stoves’’ rarely meet standards expected for clean stoves.

In past decades countless efforts have been deployed to improve cooking performance over conventional wood-fires‘. Some successes were achieved to develop wood-fuel technologies that consume less fuel, are convenient to use and also partially burn cleaner. With the recent increased focus on negative health impacts associated with emissions from solid biomass cooking fuels, better results on emissions reductions are needed if biomass is to remain a viable acceptable fuel for the billions of people relying on it to satisfy their daily cooking energy needs.

‘Reinventing the fire’ instead of continuing with conventional wood-fire

Micro-gasifiers or wood-gas-stoves approach the concept of generating heat from wood and biomass in a completely different way. Gasifiers separate the generation of combustible gases from their subsequent combustion to create cooking heat. The combustion step is essentially a ―gas burner‖ that gives a ‘quantum leap’ in emission reductions while allowing achievement of convenience, efficiency and emission objectives! These are “gas-burning stoves” that make their own supply of gas. When needed from dry biomass that can be safely stored and transported. Gasification advantages have been known for nearly two hundred years, but only recently could they be reliably accomplished at sufficiently small (micro) scales appropriate for household stoves.

1.2.2 WOOD-GAS STOVES’ CERTAIN ADVANTAGES OVER OTHER IMPROVED COOK-STOVES

- Cleaner burning of biomass (much less soot, black carbon and indoor/outdoor air pollution).
- More efficient due to more complete combustion (less total biomass consumption).
- Uses a wide variety of small-size biomass residues (no need for stick-wood or charcoal).
- Biomass fuels are often within the immediate area of the users (affordable access at own convenience), easy to transport and easy to store after gathering.
- Creation of gas from dry biomass can be achieved with very simple inexpensive technology directly in the burner unit (portable, no piping or special burner-head needed).

- Performance similar to biogas (but not dependent on water and bio-digester) and approaching the convenience of fossil gases.
- Gas available on demand (unlike electricity or LPG that are dependent on local providers and imports, and unlike solar energy that is dependent on clear weather and daylight hours).
- Pyrolytic micro-gasifiers can create charcoal which may be used for energy purposes or to improve soil productivity as biochar.
- Easy lighting permits cooking to start within minutes (contrasted with charcoal slowness).

1.3 BIOMASS STOVES: SOLUTION FOR ALL

The above discussion clearly indicates that biomass stove is going to be the solution for next generation cooking problem. Most importantly it uses biomass which is available in everywhere. So people all around the world should be more conscious about this type of energy to face the upcoming challenge of energy scarcity.

CHAPTER TWO

MICRO-GASIFIER AND DESIGN

2.1 MICRO-GASIFICATION IN PRACTICE

Micro-gasification refers to gasifiers' small enough in size to fit under a cooking pot at a convenient height. When burning any biomass, various gases and vapours called "smoke" must be driven from the solid fuel and then the smoke is burned. For over a hundred years scientists and engineers have known that combustion of biomass is cleaner when the air is well mixed with only combustible gases, instead of having the combustion occur in zones where solid fuel is still present. The creation of combustible gases that are separate from the combustion of those gases is a clearly distinguishing characteristic of a true "gasifier."

Practical gasification in small devices (i.e., micro-gasification) was not achieved until 1985 when Dr. Thomas B. Reed conceptualized and accomplished what is now called "Top-Lit Updraft" (TLUD) gasification with batches of biomass fuel. In 2004 Dr. Paul S. Anderson created a variation of traditional updraft micro-gasification with continuous-operation, being called AVUD for "Another Variation UpDraft" to distinguish it from conventional updraft gasifiers.

Both TLUD and AVUD micro-gasifiers can be constructed in several different ways. Figure 1 shows one diagram for each type. The distinguishing characteristic of these and any other true gasifiers is that the creation of the gases ("smoke") is separate from where the gases are combusted.

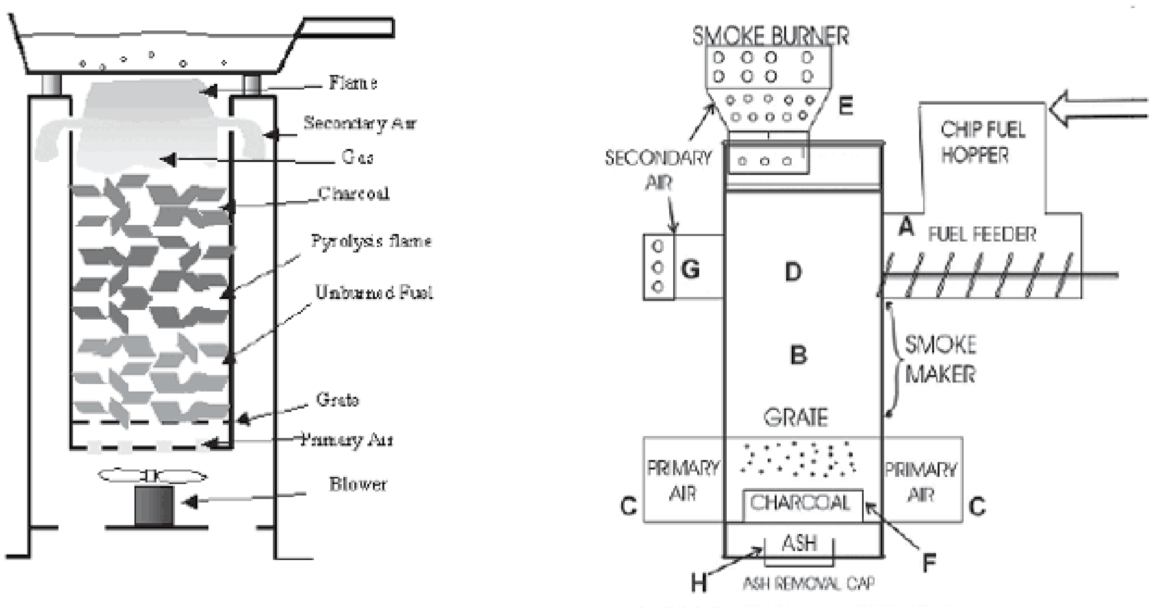


Figure V1.1: ***Diagrams of a forced-air TLUD, left, and an AVUD micro-gasifier,***

2.2 TLUD GASIFIER STOVES:

TLUD stands for Top Lift UpDraft which self-explains its construction of the stoves. The simplest TLUD can be a single tin-can with separate entry holes for primary and secondary air as combustion unit. Thorough mixing of the gaseous fuel with the oxygen provided by the secondary air to ensure optimal combustion can be enhanced with a concentrator disk or forced air. A riser above the combustion zone can increase draft and further enhance thorough mixing of gas and oxygen.

In TLUD gasifiers, the fuel does not move except by shrinkage in volume when pyrolysis occurs. Two things move:

1) A hot— flaming pyrolysis front‖ moves downward through the mass of solid raw fuel, converting the biomass to char.

2) The created gases travel upward towards the combustion zone, while the char remains behind above the pyrolysis front.

The name— Top-Lit Up-Draft denotes two key characteristics of these types of micro-gasifiers: The fire is ignited at the top of the column of biomass fuel and the primary combustion air is coming upward from the bottom through the column of fuel. The limited amount of primary combustion air allows only a partial combustion of the created wood-gas, just enough to provide the heat required to keep the pyrolysis reactions going. Since the rate of heat generation is determined by the amount of available oxygen, the progression of the pyrolysis front is controllable by regulating the primary airflow. Additionally, increased air-flow (with a fan or sufficient riser/chimney) will result not only in faster progression of the flaming pyrolysis front down the column of biomass, but also in higher temperatures in the pyrolysis zone. This will impact the characteristics of the created char, which is important if it is intended to be used as bio char.

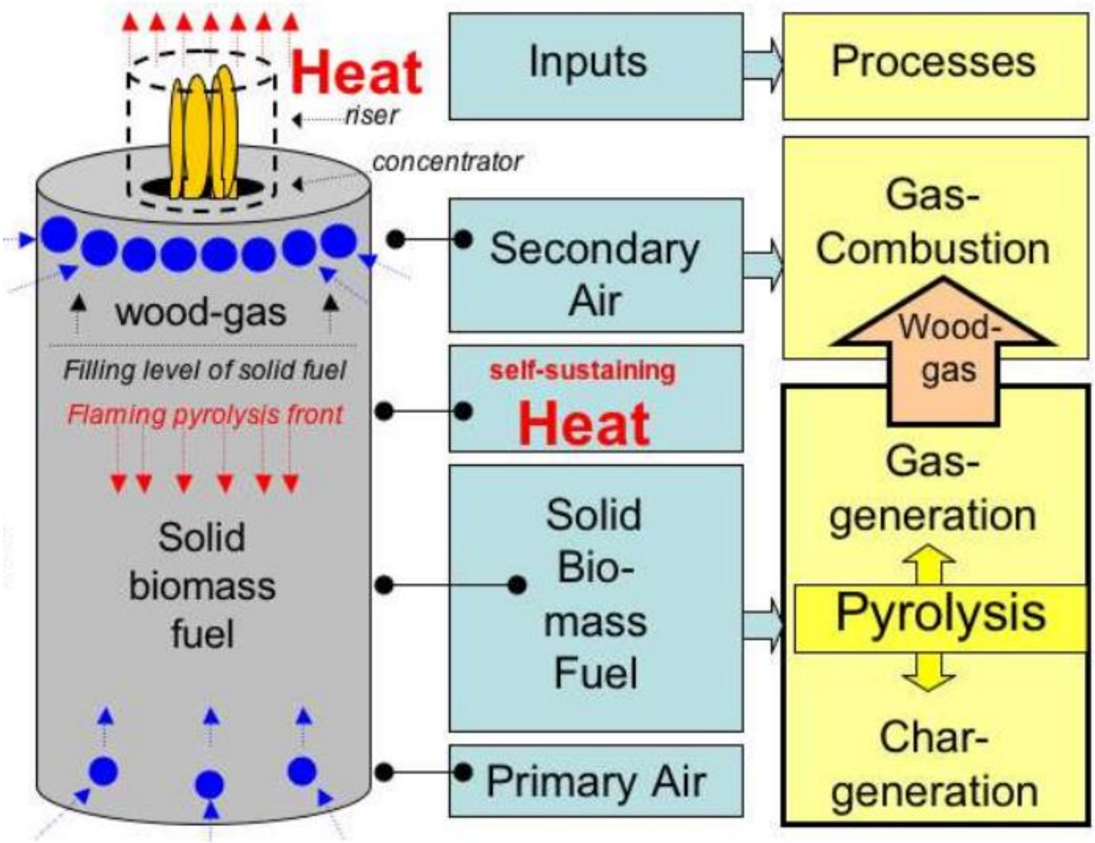


Figure V1.2: **TLUD Micro Gasifiers and Processes.**

The TLUD gasifier stoves fall into two main categories based on having forced air or natural draft.

1. Forced Draft: Air is forced into the combustion chamber using a fan or small blower of little power.
2. Natural Draft: Air is flowed through the camber due to natural convection process.

2.3 COMPARATIVE ADVANTAGES OF MICRO-GASFIERS FOR COOKING

Small-scale micro-gasifiers offer good opportunities for the use in cook-stove applications and/or for domestic heating, because they can

- Cleanly burn the wood gas in mainly smoke-free combustion (unlike conventional burning of solid fuel)
- Provide a steady hot flame shortly after ignition (no waiting, as with charcoal)
- Have high fuel-efficiency due to complete combustion of the fuel (little smoke)
- Be operated batch-fed over extended periods without attention (no tending of fire)
- Utilise a wide variety of solid biomass fuels, even inexpensive often discarded small biomass residues, that other stoves cannot easily handle (no stick-wood)
- Give the user the freedom to decide individually when to use the device, as biomass fuel is often locally available, within reach of most people. It can be collected or bought directly by the stove user. Hence it makes biomass-gasifiers ‗ready-to-use' options, independent from external factors beyond the control of the user that determine the availability of other energy sources like electricity, fossil fuel supply, or sunlight for solar cooking.

2.4 DESIGN FEATURES MAKING MICRO-GASIFIERS SUITABLE FOR COOKING

To make micro-gasifiers widely usable for practical and cost reasons they need to

- Operate at atmospheric pressure (no pressurized storage of fuel or air needed, but could include very small, economical fans or blowers in some situations.)
- Use ambient air as the gasifying agent (available at no cost)
- Use solid, dry biomass as a fuel, if possible inexpensive biomass residues
- Use a fixed fuel bed (the fuel basically does not need to be moved during operation)

- Produce a ‘dry‘ residue, either char or ash, to facilitate removal (not slagging and clogging the stove)

Common properties of micro-gasifiers suitable to heat a cooking pot placed on top:

- Close-coupled combustion of the produced gases: they are combusted directly above the gas generating zone and the fuel-bed while still hot. The heat can directly reach a cooking pot. No cooling, scrubbing and piping of the gases needed.
- Top-lit: Most micro-gasifiers for cooking use are lit at the top of the fuel-bed. This is an easy way to keep the heat close under the cooking pot. Many micro-gasifiers work with a batch-load of fuel, meaning the fuel container is filled once and then lit at the top.
- Up-draft: One main differentiating feature of micro-gasifiers is the flow of the gases in relation to the progression of the pyrolysis front. The air and the combustible gases flow upwards, while the flaming pyrolysis front moves down-ward. Up-draft design is one easy option for cooking purposes, because hot gases naturally rise if they are lighter than cold ambient air. This creates a natural draft through the fuel-bed, facilitating the oxygen supply to the pyrolysis zone. Depending on the fuel type and the density of the fuel bed, fans can be added to force air through the fuel-bed for an appropriate flow of oxygen. The use of fans or small blowers augments the natural draft, and is often called ―forced convection‖.
- Most micro-gasifiers are autothermal, meaning the fuel is directly pyrolysed with a flaming pyrolysis. Yet there are hybrid forms specifically designed for biochar-production with two separated fuel chambers: the fuel in the inner combustion chamber features flaming pyrolysis or conventional open fire, and the heat generated in this process heats up the fuel in the surrounding outer container until it starts the allothermal pyrolysis without having been in touch with a flame.

2.5 PERFORMANCE FACTORS INFLUENCED BY DESIGN OR USER

2.5.1 GASIFIER POWER AND HEAT-OUTPUT

The power output of a gasifier unit is mostly determined by the amount of gaseous fuel or pyrolytic vapours produced at any one time from the solid fuel.

The burn rate, at which solid fuel is pyrolysed to create the combustible vapours, largely depends on

- The peak temperature in the fuel container,
- The available primary air,
- The diameter of the fuel container,
- The type and the density of the fuel.

2.5.2 REGULATING FIREPOWER BY DESIGN FEATURES

Elevating the temperature at the combustion zone: The combustion reactions can be enhanced at higher temperatures. This can be achieved by protecting the gasifier from cooling especially by wind, by **insulating the combustion** Micro-gasification: Cooking with gas from dry biomass chamber and/or by **preheating the secondary air** before entering the combustion zone.

2.5.3 DRAFT SPEED AND AIRFLOW

Natural draft (ND) vs. forced convection (FA = Forced Air or Fan Assisted): All options for providing adequate primary air depend on fuel size. Some gasifiers with the provision of forced air can regulate the fan speed and thus the air supply. Some stoves use natural draft with lower manual or no control over the flow.

Note: ND system is cheaper than the FA system stoves as the later one need higher producing and maintenance costs and a means of constant power supply during operation.

2.5.4 DIAMETER OF THE FUEL CONTAINER

If constant high power is needed, a fuel container with a greater surface area is advisable. For simmering where less power is needed, a smaller diameter has advantages. One way to regulate power output is to have different sizes of fuel containers for different tasks.

With constant fuel and air supply, the AREA of the fuel container determines the heat output of the gasifier. More experience and data needs to be gathered on how to regulate fire-power or achieve a good turn-down ratio between high-power and low-power operation of a micro-gasifier.

2.5.5 REGULATING THE FIREPOWER BY THE USER DURING OPERATION

Primary air control: Primary air is probably the easiest parameter for the user to control to regulate the power output during operation, especially if its movement through the fuel is facilitated by a fan. Even with natural draft systems, the primary air supply can be regulated by opening or restricting primary air entry holes.

Duration of cooking time: In a batch-operated pyrolytic TLUD gasifier, fuel is usually not added during operation. The duration of the cooking time depends on the mass of fuel that can be placed in the fuel container. Mass is a function of density and volume of a substance. This means a low-density fuel in the same volume of the fuel container will have less mass to burn and will provide less total heat during the burning of the fuel stack.

2.5.6 REGULATION BY DESIGN FEATURES

With constant fuel and air supply, the **HEIGHT** of the fuel container determines the **duration of burn-time** of a batch-fed TLUD micro-gasifier. The cooking time can be extended, when a sequence of fuel containers is used, with minor disruption of the cooking cycle as the container with the spent fuel gets exchanged and replaced by a container with fresh fuel, already lit at the top before inserting it in the stove.

2.5.7 REGULATION THROUGH THE USER

Fuel properties: High-density fuels have a higher energy value than low-density fuels. For the same rate of primary air, the high-mass fuel will burn longer and give more energy, as more solid fuel can be converted to wood gas.

CHAPTER THREE

FUEL-SAVING STOVE OPERATION TECHNIQUES

The key to fuel economy in cooking is:

- minimizing cooking times, and
- maximizing the efficiency of combustion.

This section brings together techniques used in conjunction with the use of an improved stove to further enhance efficiency and smoke reduction.

3.1 AIR VENTS

Ventilation is the key to efficient combustion. Ventilation is required in two parts of a stove.

It is required at the fuel level as well as above the fuel, at the hot volatiles. Sufficient air for the fuel facilitates the first stage of combustion, the pyrolysis and the conversion of carbon and CO to CO2. This can be provided from under a grate, and is referred to as *primary air*.

Air at the second stage facilitates the combustion of the flammable volatiles, and should be introduced above the grate. It is referred to as *secondary air*.

3.2 FUEL USE

3.2.1 MOISTURE CONTENT

A common problem in areas with resource shortages is that people resort to using freshly cut wood. To burn efficiently, wood must be very dry or combustion does not take place at such high temperatures, and is therefore less complete.

- Freshly cut wood can liberate a total energy of just 8MJ/Kg, whereas oven-dried wood (i.e., moisture content approaching 0%) up to 18.8MJ/Kg.
- In terms of efficiency, the optimum water content has been found to be around 5%, and it is possible to reach this by sun drying wood.
- It has been found that drying wood instead of using it freshly cut can lead to fuel savings of more than 20%. Such practice requires small-scaling stockpiling of wood to allow for drying.

3.2.2 SIZE

In addition to speeding up the speeding of the drying process, chopping wood small has been shown to be beneficial to the combustion of the wood. This is to do with surface area to volume ratios, and is a result of increased air flow to burning wood. In order to fully convert carbon to CO_2 and not just partially to CO, much oxygen is required at the surface where it is liberated. Small pieces of wood have larger surface area to volume ratios.

This measure has its disadvantages. It requires more work to split or chop wood into small pieces.

3.2.3 RE-CHARGING

During cooking, ideally, small charges of fuel should be made. Small amounts of fuel burn more efficiently than larger amounts as air is more easily able to reach all the wood. When wood is added to a burning fire to top-up the firebox, the new wood cools the existing fire, and can serve to smother it, and reduce oxygen flow. The larger volume of wood added, the more this happens, so it is preferable to just add small amounts. This is one of the reasons that a small firebox is preferable in the design of an improved stove - it forces the user to build a small fire at the outset, and to make small recharges.

3.2.4 EXTINGUISHING

After cooking has finished, it is normal to simply leave the fire burning until it naturally dies.

This means that fuel is burning without the heat being harnessed usefully (assuming it is not just heating a room or area), and it is therefore beneficial to extinguish fires immediately at the end of cooking. This need not be done with water (which would create a mess and again negate one of the benefits of improved stoves – i.e. their cleanliness) but with sand, which smothers the fire, saving up to 15% fuel. The sand is shaken off the wood and charcoal when cool, and both are re-used.

3.2.5 ASH

The ash box should be cleared out regularly in order to keep air vents clear, and in order to allow free flow of air under the grate.

3.3 SAFETY ISSUES

Most safety education relating to general stove use relates to hot components, and the care that should be exercised (particularly with regard to children) to avoid burns. However, the issue of carbon monoxide poisoning is worthy of explanation, and worthy of being a part of an improved stove programme.

If used in an unventilated area, combustion is less efficient and likely to result in the release of Carbon Monoxide (CO). This is a highly toxic gas that can kill and which must be known about by users. It is important that kitchen areas (if indoors) are well-ventilated and that exhaust gasses can escape through holes in the wall or roof.

CHAPTER FOUR

BIOMASS GASIFIER STOVE AND MANUEFACTURING

4.1 KEY OBJECTIVES OF THE CHAPTER

- To build a T-LUD (Top lid up draft) biomass stove.
- To improve efficiency.
- To make it more economic, more clean and eco-friendly.
- To make the combustion as complete as possible.
- To produce less harmful gas (CO_2, CO etc.)
- To optimize the stove for domestic use.

4.2 DESIGN FACTORS CONSIDERED

- Small bore reactor.
- Optimum height (for domestic use)
- Less weight to carry easily.
- Ambient air as gasifying agent at atmospheric pressure.
- Maintain proper ratio of primary and secondary air.
- Air control chamber(for controlling primary air and a portion of secondary air)
- Flexible combustion chamber.
- Fixed fuel bed.
- Scope for recharging of fuel while operating.
- Efficiently designed seat for various pot sizes (small, large, oval shape, flat surface etc.)

4.3 OUR BIOMASS STOVE

Most of the people of Bangladesh especially people of rural areas still now use different type of stove using biomass (wood, wood chips, dry leaves etc.) to cook. Even in city area now a days lots of people are using different stoves for cooking by using biomass as the scarcity of supply gas. And within next 10-15 years people will not have gas for cooking. So there is no option but using biomass stove. But this stove must be fuel efficient and less harmful to the user and to environment.

The stoves that now a days people use are not that much fuel efficient and in most of the cases these stoves produces harmful gases co_2, co etc. as in most of the cases incomplete combustion occurs. These are very harmful for the users.

Normally wood produces wood gas which burns but most of the cookers uses only primary air system as a result about 40 to 50% wood gas remains unused. The main target of our biomass stove is how we can use most of the wood gases to ensure complete combustion and emission of less harmful gas.

With a view to doing that we have kept primary air, secondary air and even tertiary air supply system that will ensure most possible use of wood gas.

4.4 DIFFERENT PARTS OF OUR BIOMASS STOVE:

Three chambers-

- Outer chamber
- Air chamber
- Inner chamber or Combustion chamber

4.4.1 OUTER CHAMBER

Dimensions:

- Height 43 cm
- Diameter 24.5 cm

The outer chamber has three stands to fit on the surface and it holds the air chamber which is welded to the outer chamber by three joint (by welding)

4.4.2 AIR CHAMBER

Dimensions:

- Height 40 cm
- Diameter 19.5 cm

It is the passage for the primary air. The air chamber is welded to the outer chamber by welding at three points.

Figure V1.3: Outer and air chamber

4.4.3 COMBUSTION CHAMBER

It is the chamber where combustion takes place. Fuels are kept here for gasification.

It has three sections

- ➢ Fuel Chamber
  Dimension
  - Height 26 cm
  - Diameter 14.5 cm

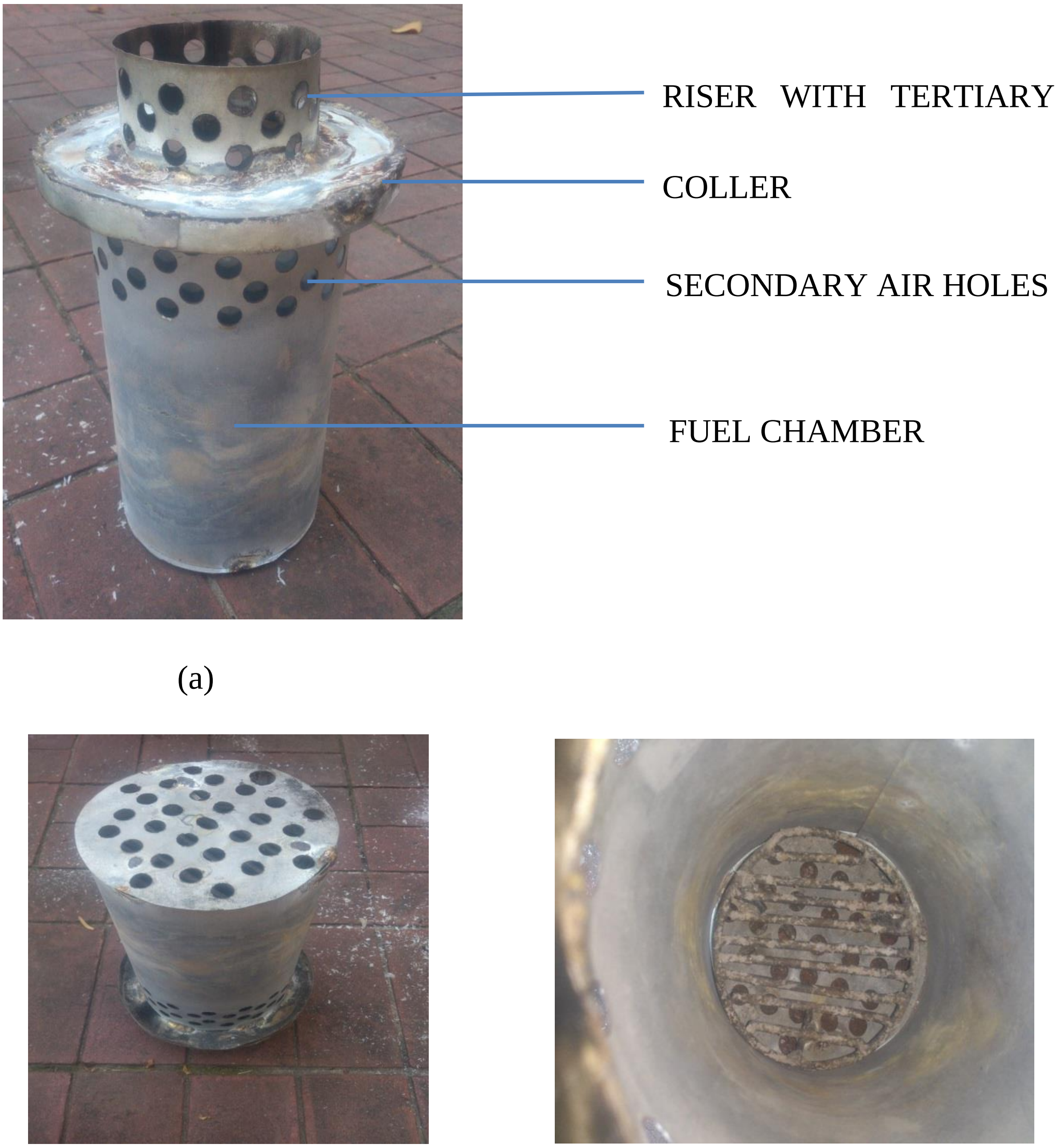
It has holes in the base for primary air and also in the upper portion for secondary air. The fuel bed is attached with it. It can be easily removed from the stove for cleaning and loading purposes.

- ➢ Collar
  Dimension
  - Diameter 19.5 cm

Collar fits onto the air chamber. It sits over the air chamber and airlocks it. It work as a partition between the air chamber and the outer chamber.

- ➢ Riser
  Dimension
  - Height 5 cm
  - Diameter 10 cm

It has also small diameter holes which are used for tertiary air. This amount of air is always available in the neck of the stove whether the air controller is fully open or fully closed giving proper burning of the wood gas produced.



(a)

(b)

(c)

Figure V1.4:

(a) Combustion chamber and its components, (b) Primary holes and (c) Fuel bed.

4.4.4 AIR CONTROLLER

To control the primary air supply and a portion of secondary air supply. Area of fully open condition =90 square cm

Figure V1.5: **Air controller**

4.4.5 UTENSIL SEAT

It is designed in such a way that different types and sizes of utensils can be used without any difficulty.

- It has provision for fuel recharging during operation.
- 15 nos. holes for emission of gases.

Figure V1.6: **Utensil seat**

4.5 STOVE SPECIFICATION

Weight of the Stove
The weight of the biomass stove =4370 gm. which is suitable for easy carry.
Flame temperature
The flame temperature is around 1100ºC -1200ºC.
Emission:

CARBON-DI-OXIDE, CO_2 – more than 10,000 ppm
CARBON MONOXIDE, CO - While operating about 140 ppm.

Figure V1.7: **Flame snapshots of the stove while operating.**

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CHAPTER FIVE

IMPROVED COOKING STOVES (ICS), FUEL PREFERENCES AND EQUIPMENT

5.1 COMPARING EFFICIENCIES

In summary, it is difficult to generalize about consumption levels or fuel and equipment choices for cooking. Cooking is an end-use in which one finds

- Strong culture related preferences of food and cooking habits
- Strong and often highly specific fuel preferences. The reasons for choosing particular fuels and cooking appliances ease of handling and lighting, flame quality and temperature, ability to secure fire from young children, smoking ness and taste imparted to food, as well as relative prices and availability of fuels.

These factors may lead households to reject “improvements” such as more efficient stoves which do not satisfy their customs and preferences. Protection against shortages of modern fuels is another key factor, often expressed by the ownership of more than one type of fuel/cooking device.

It is critical that stoves be designed and disseminated around social preferences as well as technical factors. Stove users, producers, disseminators, developers and evaluators should all be involved in any stove development and dissemination project, since each group has its own set of objectives, priorities and measures of success. The active participation of women, extension groups and stove producers has proved to be essential to the success of stove programs.

Other factors and how they affect energy efficiencies and fuel savings are listed in table below:

Table 5.1.1: Factors Affecting Cooking Efficiencies

Giving Higher Efficiencies	Giving Lower Efficiencies
Fuel	
- dry wood, dry climate	- wet wood, moist climate
- small pieces(even air fuel ratio)	- large wood pieces, dung and crop residues(usually higher moisture content)
Fuel Use and Cooking Site	
-Careful fire tending(burning rat to match required power output for cooking task; fire alight for minimum periods before and after cooking)	- poor fire tending (e.g. attention to other domestic tasks)
- indoor cooking(protection from drafts)	- exposed outdoor site(but smoke and health effects)
Stoves and Equipment	
-aluminium pots(good heat transfer)	- clay pots
- use of pot lids(reduced heat losses)	- no pot lids
-large pot. small fire/stove	- small pot, large fire/stove
-pot embedded into stove opening(large heat transfer area)	- non-embedded pot
-well-fitted pot, with small gap between pot and stove body(increased heat transfer)	- poorly fitted pot
-new stove, good condition(e.g. educed heat loss through cracks)	- old stove, poor condition
-metal ceramic-lined stove	- clay or mud stove, open fire
Cooking Methods	
-stove well adapted to or allows improvements methods	- stove ill-adapted to customary methods
-food preparation to reduce cooking items (e.g. pre-soaking of cereals, beans) use of ancillary equipment(e.g. hay box for extended, slow cooking, thus reducing need for stove)	

Table .5.1.2: Average Cooking Efficiencies (%) for Various Stoves and Fuels1)

Fuel/Stove Type	Lab2)	Field3)	Acceptable Value4)
Wood:			
Open fire(clay pots)	18-24	5-10	7
Open fire(“3 stone”; aluminium pot)		13-15	15
Mud/clay	11-23	8-14	10
Brick	15-25	13- 16	15
Portable Metal Stove	25-35	20-30	25
Charcoal			
Clay/mud	20-36	15-25	15
Metal(lined)	18-30	20-35	25
Kerosene			
Multiple wick	28-32	25-45	3
Wick Single wick	20-40	20-35	30
Pressurized	23-65	25-55	40
Gas(LPG)			
Butane	38-65	40-60	45
Electricity			
Single element	55-80	55-75	65
Rice cooker		85	
“Electric jug/pot”		80-90+	85

1) Assuming aluminium cooking pots unless otherwise indicated.
2) Mostly from water boiling tests.
3) Generally reflects cooking cycle tests.
4) Acceptable: assuming that the dominant stove types are higher quality examples of the type; i.e. excluding stoves demonstrated as having inferior efficiencies.

Stoves with high efficiencies in laboratory tests have failed to produce the expected fuel saving under practical conditions. This is usually because cooks prefer (or are “forced”) to operate the stove in ways that are sub-optimal for maximum efficiency in order to make up for various technical deficiencies. On the other hand, improved stoves which have been designed taking into consideration users habits have been shown to save substantial amounts of fuel under real life conditions.

It is essential to compare like with like when assessing stove performance and not comparing “apples and pears” like:

1. comparing different products, e.g. a one-pot and two-pot stove;
2. using different cooking utensils, e.g. aluminium versus clay pots;
3. using different test procedures; and
4. poor definitions of test procedures

To clear up this confusion, standard efficiency tests have been devised. These tests do not measure efficiency in the narrow technical sense (i.e. utilized output/fuel energy input) but also the specific fuel consumption (SFC) for defined cooking cycles, such as preparing a standard meal.

5.2 OTHER NON-TECHNICAL ASPECTS

Smoking ness and its relationship to eye irritations, eye disease, chest complaints and other afflictions among women (or other family members) has often been neglected by stove designers and analysts. Nevertheless it is an important criterion in stove acceptance. Smoke from cooking fires can be highly carcinogen levels greatly exceed acceptable exposure rates in developed countries. On the other hand, smoking is sometimes is seen as a benefit since it repels insect, and the smoke has creosotes which preserve thatch and timber roofs from premature deterioration.

Furthermore, costs to the stove user may be estimated but costs for other essential groups in the design, production and dissemination chain are frequently neglected. To the producer the important economic factors are profits or return to the labour; to the stove developer, the development and testing costs; and to the disseminating agency, the margins after accounting for the costs of marketing, distribution, tainting, monitoring and possibly subsidizing the improved stove. All these costs and margins should be considered, since an improved stove program can fail if the economics are poor for any one link in the chain.

5.3 DISSEMINATION AND IMPACT

In addition to stove costs and payback periods, any stove program must also allow for regional fuel constraints, user preferences, and institutional requirements. There are six essential conditions for getting operational stoves into widespread use:

- active participation of women(stove users),artisans, and the marketing or disseminating (extension) workers in developing or adapting a stove design;
- proof that long-run market, production, delivery, and maintenance systems exist or can be established.
- establishment of training programs for local artisans or extension workers;

- development of and strong financial support for a strategy to market the chosen stoves and appliances based on comprehensive acceptance surveys;
- continued support for research and monitoring of stove development ;
- market conditions which allow competitive models to be developed and reach the market.

CHAPTER SIX

STOVE TESTING

6.1 EFFICIENCY TEST

6.1.1 WATER BOILING TEST

This test is useful for design and comparing the impact of technical changes of a stove construction. The test procedure is carried out in two phases:

- the ***High Power Phase*** from starting point to boiling point of water and
- the ***Low-Power Phase*** from boiling point to end point. Efficiency and power is measured separately for the two phases.

6.1.2 STANDARD MEAL TEST

This test uses a certain weight of a typical meal of a selected region. The consumption of wood is measured for preparing this typical meal – so this test is more useful under social and cultural aspects, but comparing the fuel consumptive between regions or countries is not possible.

6.1.3 KITCHEN PERFORMANCE TEST

In this test the stove user is participating: the consumption of fuel of traditional and improved stove is compared under “kitchen conditions” including a typical meal, cooking habits and fire management. This test is the most realistic test but needs also most time.

6.2 EXAMPLE OF WATER BOILING TEST

The energy efficiency of a stove is given by:

“Energy utilised” E_{out} divided by “Energy delivered” E_{in}

a) ***High-Power Phase*** (up to boiling point with closed pot)

E_{out} is the heat energy which is transferred into the water

$E_{out} = m_{water} * c_{water} * (T_2 – T_1)$ (in kJ)

m_{water} = mass of water (in kg)

c_{water} = specific heat (4.19 kJ/[kg*K])

$T_2 – T_1$ = difference of temperature (in K) between beginning (T_1) and end (T_2) of test

E_{in} is the heat energy generated by burning the fuel.

$E_{in} = (m_{fuel\,1} – m_{fuel\,2}) * NHV$ (in kJ)

$m_{fuel\,1}$ = mass of fuel at the beginning of the test (in kg)

$m_{fuel\,2}$ = mass of fuel at the end of the test (in kg)

NHV = net heating value (in kJ/kg)

(for wood: NHV is depending on moisture content, for charcoal: 29000 kJ/kg)

Using fuel wood special care must be taken as by the combustion process charcoal is produced. The mass (weight) of the fuel then must be separated in wood and charcoal because of different NHV:

$E_{in} = (m_{wood\,1} – m_{wood\,2}) * NHV_{wood} + (m_{charcoal\,1} – m_{charcoal\,2}) * NHV_{charcoal}$

$PHU_{HPP} = E_{out} / E_{in}$

b) ***Low-Power Phase***

In this phase the water is simmering to evaporate (open pot).

The delivered energy (E_{out}) therefore is:

$E_{out} = (m_{water\,1} – m_{water\,2}) * L$

$m_{water\ 1}$ = mass of water at the beginning of LPP (in kg)

$m_{water\ 2}$ = mass of water at the end of LPP (in kg)

L = latent heat of water 2260 kJ/kg

E_{in} follows the same principle like shown in HPP

$PHU_{HPP} = E_{out} / E_{in}$

Besides PHU the power P is important:

$P = E_{out} / t$ (in W)

t = time of testing in seconds

6.3 TEST CARRIED OUT IN OUR STOVES

6.3.1 EFFICIENCY TEST

6.3.1.2 TEST 1

- Open fire
- Using oval shape pot
- Air chamber –fully open
- Fuel used –wood chips

Mass of fuel, m_f=231g=0.231kg
Initial temperature of water t_i=27.5°C
Final temperature of water t_f=100°C
Mass of water $m_{w=}$ 2kg
HHV of fuel =15.209Mj/kg=15209Kj/kg
Heat energy absorbed by water, $E_{out}=m_w\, cp_w\, (t_f-t_i)$
=2kg* 4.2kj/kg.k*(100-27.5)k
=606.97kj
Heat energy supplied by fuel, $E_{in} = m_f$ HHV
=0.231kg*15209kj/kg
=3513.279kj
Efficiency= (Energy utilized, E_{out}/Energy supplied, E_{in})*100%
= (606.97kj/3513.279kj)*100%
= 17.27%

Figure V1.8: Oval shape pot is used for TEST 1.

6.3.1.2 TEST 2

- Open fire
- Using flat surface pot
- Air chamber-fully open
- Fuel used-wood chips

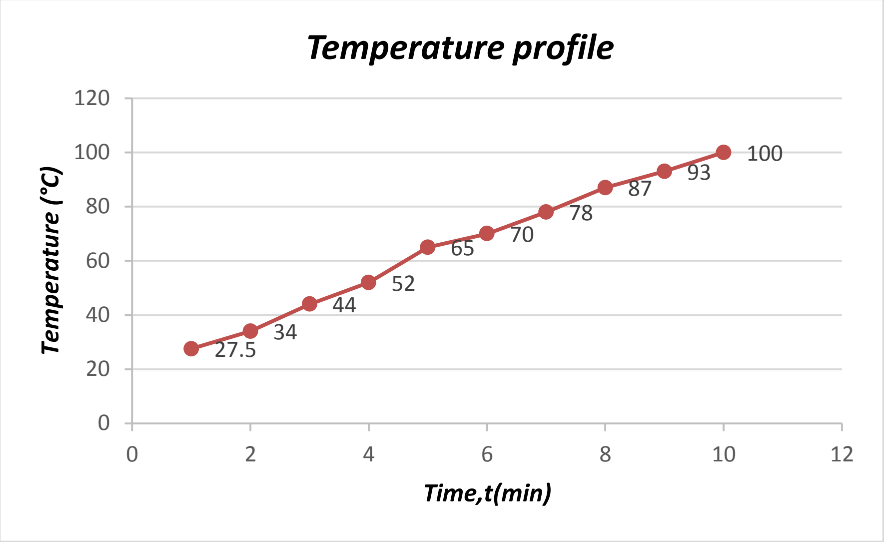
Mass of fuel m_f=185g=.185kg
Mass of water m_w=2kg
Initial temperature of water t_i=28°C
Final temperature of water t_f=100°C
HHV of fuel=15.209Mj/kg=15209Kj/kg
Heat energy absorbed by water, $E_{out}=m_w\, cp_w\, (t_f-t_i)$
$=2kg*4.2kj/kg.k*(100-28)k$
$=604.8Kj$
Heat energy supplied by fuel, $E_{in}=m_f$ HHV
$=.185kg*15209Kj/kg$
$=2813.6Kj$

Efficiency, η = (Energy utilized, E_{out} /Energy supplied, E_{in})*100%
= (604.8kj/2813.6Kj)*100%
= 21.5%

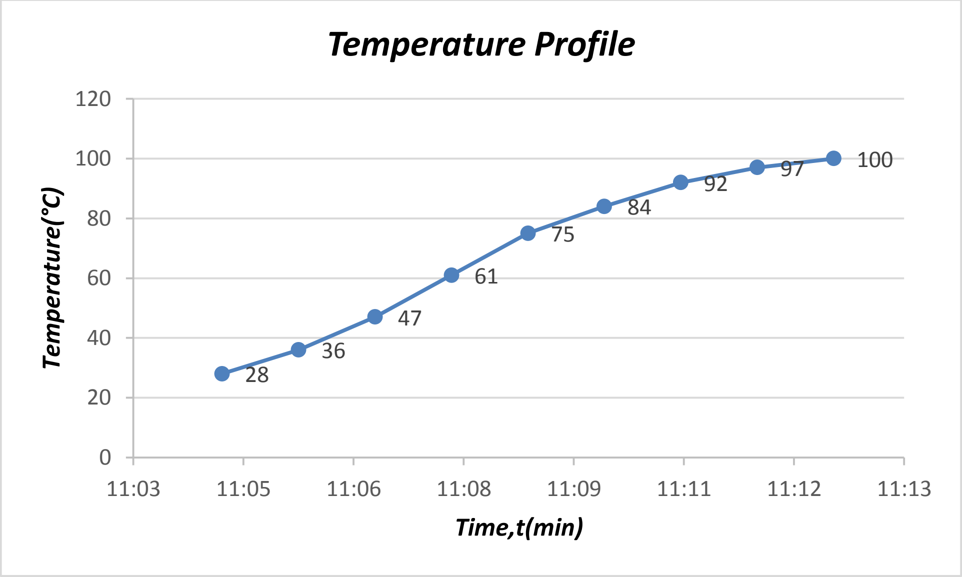
Figure V1.9: Flat surfaced pot used for TEST 2.

6.4 TEMPERATURE PROFILE

FOR TEST 1



FOR TEST 2



CHAPTER SEVEN

CONCLUSION

From efficiency test we have got pretty good values. The acceptable efficiency value for open fire aluminium pot is 15% whereas we have got 17.27% in test 1 and 21.5% in test 2.

From emission test we also find that the amount of co is very low (140 ppm) which is the indication of more complete combustion. So we can say that this stove can be a great solution to the upcoming energy scarcity of gas and a good solution for efficient and convenient domestic cooking.

VOLUME TWO

CARBON NANO TUBES FROM BANANA PEELS

CHAPTER ONE

INTRODUCTION

1.1 OBJECTIVES

- To find the existence of activated carbon
- To produce carbon Nano tube from banana peel

1.2 WHAT IS ACTIVATED CARBON?

Activated carbon, also called **activated charcoal**, **activated coal**, or **carbo activatus**, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions.

Activate carbon is usually derived from charcoal and increasingly, high-porosity bio char.

- Due to its high degree of micro porosity, just one gram of activated carbon has a surface area in excess of 500 m^2, as determined by gas adsorption. An activation level sufficient for useful application may be attained solely from high surface area; however, further chemical treatment often enhances adsorption properties.

1.3 APPLICATION OF ACTIVATED CARBON

Activated carbon is used in gas purification, decaffeination, gold purification, metal extraction, water purification, medicine, sewage treatment, air filters in gas masks and respirators, filters in compressed air and many other applications.

1.4 WHAT IS A CARBON NANOTUBE?

A **Carbon Nanotube** is a tube-shaped material, made of carbon, having a diameter measuring on the nanometre scale. A nanometre is one-billionth of a meter, or **about one ten-thousandth of the thickness of a human hair**. The graphite layer appears somewhat like a rolled-up chicken wire with a continuous unbroken hexagonal mesh and carbon molecules at the apexes of the hexagons.

Carbon Nanotubes have many structures, differing in length, thickness, and in the type of helicity and number of layers. Although they are formed from essentially the same graphite sheet, their electrical characteristics differ depending on these variations, acting either as metals or as semiconductors.

As a group, Carbon Nanotubes typically have diameters ranging from <1 nm up to 50 nm. Their lengths are typically several microns, but recent advancements have made the nanotubes much longer, and measured in centimetres.

1.4 CARBON NANOTUBES CAN BE CATEGORIZED BY THEIR STRUCTURES:

- Single-wall Nanotubes (SWNT)
- Multi-wall Nanotubes (MWNT)
- Double-wall Nanotubes (DWNT)

1.5 POTENTIAL APPLICATIONS FOR CARBON NANOTUBES:

Carbon Nanotube Technology can be used for a wide range of new and existing applications:

- Conductive plastics
- Structural composite materials
- Flat-panel displays
- Gas storage
- Antifouling paint
- Micro- and Nano-electronics
- Radar-absorbing coating
- Technical textiles
- Ultra-capacitors
- Atomic Force Microscope (AFM) tips
- Batteries with improved lifetime
- Biosensors for harmful gases
- Extra strong fibres

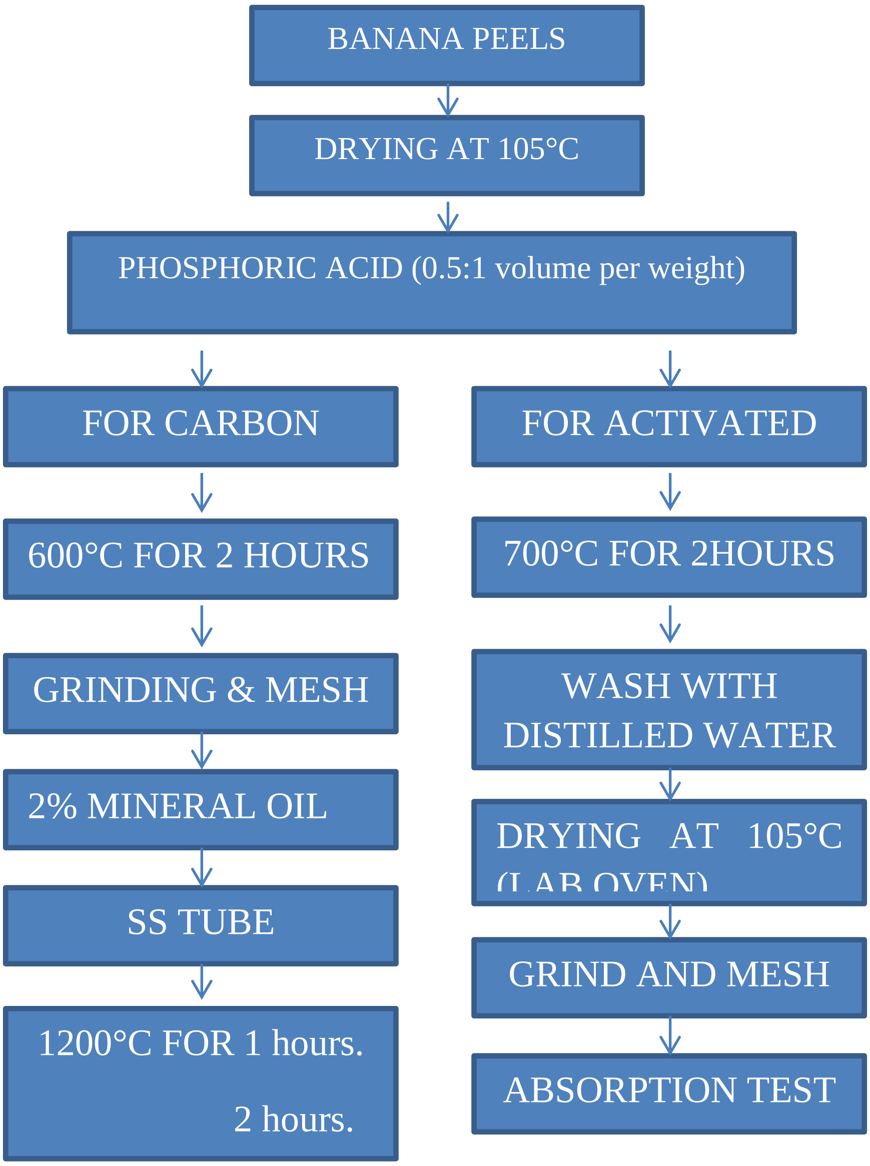
CHAPTER TWO

METHODOLOGY AND PROCEDURES: BANANA PEELS TO NANO TUBES

2.1 BANANA PEEL:

Banana peel has a great potential to be used as a source of carbon Nano tube. Banana is comparatively cheap and also available in our country. So it could be a very good opportunity for us.

2.2 METHODOLOGY:



2.3 PROCEDURE TO PRODUCE SAMPLE:

Figure V2.10: Step 1: Collecting banana

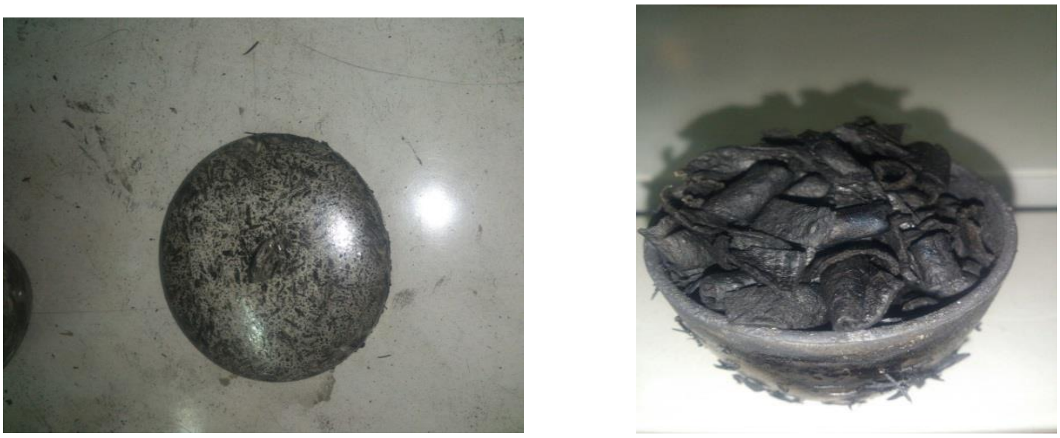
Figure V2.11: Step 2: Taking the peel

Figure V2.12: Step 3: drying the sample in the lab oven at 105°C for 24 hour

Figure V2.13: Step 4: Taking out the dried sample and cutting into small pieces.

Figure V2.14: Step 5: Carbonize the sample at 450°C for 2 hours in the Muffle Furnace.

Figure V2.15: Step 6: Taking out the sample from furnace for grinding.



2.4 FOR ACTIVATED CARBON:

After grinding the sample is mixed with phosphoric acid at a ratio of 0.5:1.0 by volume per weight (phosphoric: dried banana peel carbon)

- Then the sample is heated at 700°C for 2 hours in the muffle furnace
- The sample is then grinded again
- Grinded sample is washed with distilled water for three times to remove phosphoric acid.
- The sample is then dried in the lab oven for 24 hours at 105°C
- After drying the sample is meshed through 45µm screen
- The sample after meshing is kept for adsorption test to find the existence of activated carbon.

2.5 FOR NANO TUBE:

- The sample is heated in the muffle furnace at 600°C for 2 hours.
- Then the sample is grinded and meshed
- Sample found after meshing is mixed with 2% Mineral oil and put in the stainless steel pipe for pyrolysis at about 1200°C.

CHAPTER THREE

CONCLUSION

Despite our efforts, the project has not been fruitful and reasons and consequences for that are chalked out as follows:

- The project was time consuming and labour intensive as well.
- Within this short period we have already prepared the entire sample properly.
- Unfortunately we were unable to carry out the experiments and reach the desired outcome. However, we are optimistic, further experimentation might bring the desired output.
- The sample in hand needs to be experimented and tested (absorption test for activated carbon and for carbon Nano tubes, SEM, XRD and TEM test) for further advancement.

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