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A Project Report on

"DEVELOPMENT OF BIOMASS BRIQUETTE AND FABRICATION OF BIOSTOVE FOR RURAL APPLICATION"

Carried out by

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Submitted in partial fulfillment for the award of

BACHELOR OF ENGINEERING
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Under the Guidance Of

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DEPARTMENT OF MECHANICAL ENGINEERING
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CERTIFICATE

This is to certify that the project work entitled **"DEVELOPMENT OF BIOMASS BRIQUETTTE AND FABRICATION OF BIO STOVE FOR RURAL APPLICATION"** is a bonafide work carried out by

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In partial fulfillment for the award of **Bachelor of Engineering** in **Mechanical Engineering** from **Visvesvaraya Technological University**, Belagavi during the academic year 2015-2016. It is certified that all the corrections/suggestions indicated for the internal assessment have been incorporated in the report deposited in the department. The project has been approved as it satisfies the academic requirements.

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DECLARATION

We, VARUN C, RAKESH B R, DEEPAK E AND SHASHIKUMAR C R students of 8th semester B.E, Mechanical Engineering, K.S. Institute of Technology, Bengaluru hereby declare that the project report entitled "**DEVELOPING BIOMASS BRIQUETTE AND FABRICATION OF BIO STOVE FOR RURAL APPLICATIONS**" embodies the record of the project work carried out by us, for the fulfillment of the course requirement for the award of Degree in Bachelor of Engineering in Mechanical Engineering, Visvesvaraya Technology University, Belagavi during the academic year 2019-2020. Further, the matter embodied in dissertation has not been submitted previously by anybody for the award of any Degree or Diploma to any other University.

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ABSTRACT

This project motto is mainly to develop a biomass stove and briquette, briquetting is a process converting Agro waste and forestry Waste into biomass briquettes/Bio coal. The biomass briquetting is the best renewable source of energy for healthy environment and economy. It's entirely Eco-friendly green energy project.

Main concept of this project is to make the material as a bio-coal, which is made from the wastages. We cannot destroy the wastages totally but we can use it with the help of briquetting plant and can produce the briquettes which ultimately generate energy. 'To provide the energy in low cost' is the main concept of the project.

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CHAPTER 1

INTRODUCTION

1.1 Biomass briquettes

Biomass briquettes are a bio fuel substitute to coal and charcoal. Briquettes are mostly used in the developing world, where cooking fuels are not as easily available. There has been a move to the use of briquettes in the developed world, where they are used to heat industrial boilers in order to produce electricity from steam. The briquettes are coffered with coal in order to create the heat supplied to the boiler. But this project supports the use of the Bio mass briquettes for rural application.

Fig: 1.1 Briquette

Almost any Biomass can be briquetted. Briquetting plants set so far in India are using saw dust, bamboo dust, bagasse, cotton stalk, coffee husk, groundnut shell, mustard husk/stalk, pine needles, rice husk, sugar mill waste, jute waste, coir pith and other wastes & residues like castor shell, tobacco stem, tea waste, tree bark, wild grasses & shrubs i.e. any type of agriculture waste or forestry waste can be also briquetted individually or in combination without using any binder.

We all are well aware with the importance of energy and its sources. Energy is the key factor in the economic development of every country. The demand of energy is increasing day by day and the supplies of sources are limited. It is globally red alert for fossil fuel like petrol, kerosene, natural gas, LPG and lignite etc. this has made a huge space between demand and supply of energy. Renewable energy is the ultimate solution, which can fill this gap. Most of advanced countries have adopted this concept and accepted this project and have retained their natural resources to get the solution of energy and fuels.

1.2 Brief idea about composition and production of Biomass briquette

Biomass briquettes, mostly made of green waste and other organic materials, are commonly used for electricity generation, heat, and cooking fuel. These compressed compounds contain various organic materials, including rice husk, bagasse, ground nut shells, municipal solid waste, and agricultural waste. The composition of the briquettes varies by area due to the availability of raw materials. The raw materials are gathered and compressed into briquette in order to burn longer and make transportation of the goods easier. These briquettes are very different from charcoal because they do not have large concentration of carbonaceous substances and added materials. Compared to fossil fuels, the briquettes produce low net totally greenhouse gas emissions because the material used are already a part of the carbon cycle.

One of the most familiar variables of the biomass briquette manufacture process is the way the biomass is dried out. Manufacturers can use torrefaction, carbonization, or varying degrees of pyrolysis. Researchers concluded that torrefaction and carbonization are the largely efficient forms of drying out biomass, but the use of the briquette determines which process should be used.

Compaction is another factor affecting production. Some materials burn more efficiently if compacted at low pressures, such as corn stover grind. Other resources such as wheat and barley-straw require high amounts of pressure to produce heat. There are also different press technologies that can be used. A piston press is used to make solid briquettes for a wide array of purposes. Screw extrusion is used to compact biomass into loose, homogeneous briquettes that are substituted for coal in cofiring.

1.2 Purpose of using Biomass Briquettes

- Renewable energyfuel.
- Pollution free because there is no any sulfurmaterial.
- Briquettesareusuallyproducedneartheconsumptioncentresandsuppliesdonot depend on erratic transport from longdistances.
- Biomass briquettes have a higher practical thermalvalue.
- Lower ash content (1to3%) compared to coal(20to25%).
- There is no fly ash when burningbriquettes.
- Briquettes contain low moisture (2to3%) compare to coal(20to25%).
- A briquette produces white smoke where coal produces blacksmoke.
- Have high burning efficiency and are cheaper thancoal.
- Best substitute source ofenergy.
- Contain high density Higher fixed carbonvalue
- Demandable market due to high rise in fossil fuelprices.
- Using briquettes will beneficial for the industries as they will get carboncredit.

1.4 Final product application

Briquettes are ready substitute. Biomass briquettes are Non-conventional Source of energy, Renewable in nature, Eco friendly, non-polluting and economical. Process of converting biomass to solid fuel is also non-polluting.

- Gasifier SystemApplications.
- Ceramic Industries.
- Refractoryindustries.
- Solvent ExtractionPlant.
- ChemicalIndustries.
- DyingUnits.
- Milk plant.
- Food ProcessingIndustries.
- Vegetable Plants TextileUnit.
- SpinningMill.

1.5 History

People have been using biomass briquettes in Nepal since before recorded history. Though inefficient, the burning of loose biomass created enough heat for cooking purposes and keeping warm. The first commercial production plant was created in 1982 and produced almost 900 metric tons of biomass. In 1984, factories were constructed that incorporated huge improvements on efficiency and the quality of briquettes. They used a mixture of rice husks and molasses. The King Mahendra Trust for Nature Conservation (KMTNC) along with the Institute for Himalayan Conservation (IHC) created a mixture of coal and biomass in 2000 using a unique rolling machine.

In 1925, Japan independently started developing technology to harness the energy from sawdust briquettes, known as "Ogalite". Between 1964 and 1969, Japan increased production fourfold by incorporating screw press and piston push technology. The member enterprise of 830 or more existed in the 1960s.The new compaction techniques incorporated in these machines made briquettes of higher quality than those in Europe. As a result, European countries bought the licensing agreements and now manufacture Japanese designed machines.

1.6 Bio Stove

In this project, we have developed a Bio Stove which is low in cost and affordable by the people in rural area, this stove can be used for heating and cooking applications, and is intended to burn Bio mass briquettes, this stove has many good advantages like, easily it can be carried from one place to another and easy to handle.

Here there is no danger of leakage of the fuel unlike in Lpg stoves where care has to be taken in turning on and off of the gas supply, For example if a person forgets to turn off the gas knob by any chance then there would be chances of bursting which creates disaster.

But this Bio stove has no such problems of leakage or bursting, we have prepared the combustion chamber where there is no problem of oxygen supply in burning of the fuel, as we have installed blowers at the bottom of the stove in opposite directions which is again controlled by electronic module based upon the temperature of the fuel. This stove is automated by using few electronic components whose application will be detailed in the later chapters of the report.

CHAPTER 2

BRIQUETTE COMPOSITION

2.1 Various Agricultural Waste with their ash content and calorific values are given below

Table: 2.1 Different wastes and their Ash content, calorific values

Biomass	Ash Content%	Calorific ValueKcal/Kg.
Sugarcane Bagasse	1.80	4380 K.
Castor Seed Shell	8.00	3862 K.
Castor Stick	5.40	4300 K.
Coconut Wastes	6.31	3720 K.
Coffee Husk	5.30	4045 K.
Coir Pith	9.10	4146 K.
Corn Cobs	0.20	4100 K.
Corn Dental Stick	3.00	4050 K.
Cotton Stalk & Shell	3.00	4252 K.
Groundnut Shell	3.80	4524 K.
Lemon Grass	5.80	4030 K.
Mulberry Stick	2.49	4380 K.
Rice husk	17.65	3950 K.
Saw Dust	1.20	4400 K.
Sugar Cane Leaves	5.00	3996 K.
Sun Flower Stalk	4.30	4300 K.
Sweet Sorghum Stalk	7.40	4100 K.
Tobacco Waste	31.50	2910 K.
Gum Arabic tree [Wood]	0.90	4707 K.
Paddy Straw	15.50	3436 K.
Mustard Shell	3.70	4300 K.
Barks Wood	4.40	4270 K.
Wheat Straw	8.00	4100 K.
Soya Bean Husk	4.10	4170 K.
Jute Waste	3.00	4428 K.
Cashew Husk	20.00	4100 K
Palm Husk	4.90	3900 K.
Bamboo Dust	8.00	4160 K.
Napier Grass	8.55	4051 K.
Forestry Waste	7.00	3000 K.
Mustard Stalk	3.40	4200 K.
Wood Chips	1.20	4785 K.
Rice Straw	21.20	3200 K.

2.2 Wastes that are being used in our project

The wastes or agro wastes which are used for making briquettes are saw dust, coffee husk and other agro wastes

Our Bio mass briquette composition is,

- 45% of Saw dust
- 45% of coffee husk
- 10% of other agro wastes

Briquettes are made with the same composition in variable sizes

Table: 2.2 Wastes used for making Briquettes

Biomass	Ash content%	Calorific value Kcal/Kg
Saw Dust	1.20	4400 K.
Coffee Husk	5.30	4045 K.

2.2.1 Saw dust

Fig: 2.2.1 Saw dust

Sawdust or wood dust is a by-product or waste product of woodworking operations such as sawing, milling, planning, routing, drilling and sanding. It is composed of fine particles of wood. These operations can be performed by woodworking machinery, portable power tools or by use of hand tools. Wood dust is also the byproduct of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. In some manufacturing industries it can be a significant fire hazard and source of occupational dust exposure.

Sawdust is the main component of particleboard. Wood dust is a form of particulate matter, or particulates. Research on wood dust health hazards comes within the field of occupational health science, and study of wood dust control comes within the field of indoor air quality engineering.

Saw dust formation

Two waste products, dust and chips, form at the working surface during woodworking operations such as sawing, milling and sanding. These operations both shatter lignified wood cells and break out whole cells and groups of cells. Shattering of wood cells creates dust, while breaking out of whole groups of wood cells creates chips. The more cell-shattering that occurs, the finer the dust particles that are produced. For example, sawing and milling are mixed cell shattering and chip forming processes, whereas sanding is almost exclusively cell shattering

Saw dust Uses

A major use of sawdust is for particleboard; coarse sawdust may be used for wood pulp. Sawdust has a variety of other practical uses, including serving as a mulch, as an alternative to clay cat litter, or as a fuel. Until the advent of refrigeration, it was often used in icehouses to keep ice frozen during the summer. It has been used in artistic displays, and as scatterin miniature railroad and other models. It is also sometimes used to soak up liquid spills, allowing the spill to be easily collected or swept aside. As such, it was formerly common on barroom floors. It is used to make Cutler's resin. Mixed with water and frozen, it forms pykrete, a slow-melting, much stronger form of ice.

Sawdust is used in the manufacture of charcoal briquettes. The claim for invention of the first commercial charcoal briquettes goes to Henry Ford who created them from the wood scraps and sawdust produced by his automobile factory.

2.2.2 Coffee husk

Fig: 2.2.2 Coffee husk

Coffee is one of the top commodities produced and commercialized worldwide, and the processing of coffee generates significant amounts of agricultural waste, ranging from 30% to 50% the weight of the total coffee produced, depending on the type of processing. Coffee husks and pulp are the major solid residues from the processing of coffee, for which there are no current profitable uses, and their adequate disposal constitutes a major environmental problem. Thus, in compliance with the concept of sustainable development, innovative techniques and products for the profitable and adequate use of this type of residue are being sought. Several research works presenting proposals for such endeavours have been published in the literature and are reviewed herein.

. Nowadays, almost all countries have been facing the decreasing of fossil energy resource that can be a big problem if it not be solved wisely. A utilization of alternative energy such as bio-methane, hydrogen, biodiesel, bio ethanol, solar cell, and etc. is considered as a prominent alternative to solve that problem. One of them can be made from agricultural wastes such as corn, sugarcane bagasse, foliage, trunk, rice husk and coffee pulp as raw materials in their process

The husk is the outer layer of the coffee bean that breaks away and gets discarded during the roasting process

In coffee producing countries, coffee wastes and by-products constitute a source of severe contamination and a serious environmental problem. For this reason, since the middle of the last century, efforts have been made to develop methods for its utilization as a raw material for the production of feeds, beverages, vinegar, biogas, caffeine, pectin, pectic enzymes, protein, and compost. The use of fresh or processed coffee pulp has been the subject of numerous studies which, in general, lead to the conclusion that coffee by-products and wastes can be used in a variety of ways, some of which are summarized here. The Pulp: Coffee pulp is a waste material from the coffee industry.

Coffee Husk as a fuel: Coffee husk is practically pure lignocellulose and has no fertilizer value at all. It is normally burnt in crude furnaces to dry our coffee parchment. If most of the parchment is partially sun dried for quality reasons then, even with today’s crude single pass hot air driers, it is still possible to have a surplus of fuel after a finish drying operation. Burn the husk in a gas producer, and then run an engine on that producer gas to produce electricity. Once again as with biogas, the waste heat from the gas producer and the engine can be used to heat a clean air stream, and that can still be used to dry even more coffee than before.

- Coffee waste can be as a good feed for biogass production
- Coffee husk has much higher gas potential than spent coffee husk
- The use of coffee husk for mushroom production did not improve gas production and its rate
- The pulp collected from wet processing gives much higher gas production coffee husk
- Spent coffe husk has still significant gas production

Uses of coffee waste

- Coffee pulp can be used for low grade fertilizer which can support in briquetting
- Pulp can also be used as substrate for growing mushrooms
- Used substrate can be fed to animals
- They produce high grade fertilizers

CHAPTER 3

LITERATURE SURVEY

Literature review is an assignment of previous task done by some authors and collection of information or data from research papers published in journals to progress our task. It is a way through which we can find new ideas, concepts. There are lot of literatures published before on the same task; some papers are taken into consideration to know the design and analysis aspects of the problem.

American Journal of Engineering Research (AJER)
Biomass Briquette Production: A Propagation of Non-Convention Technology and Future of Pollution Free Thermal Energy
By Manoj Kumar Sharma in the year 2015

Biomass briquettes are a biofuel substitute to coal and charcoal. Briquettes are mostly used in thedeveloping world where cooking fuels are not as easily available. Briquettes are used to heat industrial boilersin order to produce electricity from steam. The briquettes are con-fired with coal in order to create the heatsupplied to the boiler. People have been using biomass briquettes since before recorded history. Biomassbriquettes are made from agriculture waste and are a replacement for fossils fuels such as oil or coal, and canbe used to heat boiler in manufacturing plants. Biomass briquettes are a renewable source of energy and avoidadding fossils carbon to the atmosphere. The extrusion production technology of briquettes is the process ofextrusion screw wastes (straw, sunflower husks, buckwheat, etc.) or finely shredded wood waste (sawdust)under high pressure. There is a tremendous scope to bring down the waste of convention energy sources to aconsiderable level through the development, propagation of non-convention briquettes technology i.e. briquettesmachine , briquettes plant, biomass briquettes plant for production of agro residue briquettes to meet thermalenergy requirement . Therefore this substitute energy medium is given national priority as appears to be theonly permanent solution into restriction of the national laws and avoid pollutions.

International Journal “Evaluation of different binding materials in forming biomass briquettes with saw dust”

Published by N.S Senanayaka in the year March 2015

Briquettes made from biomass are used as a source of energy intended for cooking purpose as well as in some industries like bricks industries and many more. Biomass briquettes are fundamentally fashioned by the densification of different biomass wastes. In this context, the physical densification of sawdust when tested with three diverse binding agents is explained.

Here the main perception of this study is to ensure and evaluate the briquette made of sawdust by using dissimilar binding agents. The binding agents are dry cow dung, wheat flour and paper pulp, samples made by cow dung as binding agent failed with mould detachment. The binder percentage required for other two binders for perfect forming was 30%. Density of wheat flour as well as paper pulp for 30% of binder was found to be 373.7 kg/m^3 and 289.8 kg/m^3 correspondingly. Natural drying time was evaluated at 86~89% relative humidity and 25~30oC ambient temperature. The time for achieving 15% moisture content was 55 hours. Briquettes' compressive strength is tested for 30%, 40%, &50% of the binder (wheat flour and paper pulp). Outcome obtained was that, the compressive strength increased with raise in binder percentage, briquettes by means of paper binder exhibited more compressive strength when compared to wheat flour binder. For the same percentage of binders the calorific value of paper binder was found to be 18.14MJ/kg and for wheat flour binder it was 20.04MJ/kg, the briquettes formed with paper pulp gave the minimum energy cost.

Zackary, I. Y*, Ismaila, A, Sadiq U and Nasiru R

The impacts of biomass molecule size and expansion of folio on the high calorific qualities (HCVs) of five (5) chosen biomass briquettes is considered. Investigations of the test results demonstrate that finely crushed particles (about 1.75mm and 2.00mm) had low calorific qualities as the crushing brought about lost some warmth and made the example helpless against air oxidation. Addition of gum Arabic folio extraordinarily increases the high calorific estimation of all examples pursued by starch and best paste cover tend to decrease the HCVs for the scope of biomass tried in the request 25.3201> 23.2985>20.0023 respectively. Thus showing gum Arabic and starch improves the caloric esteem while top paste and polyvinyl Chloride (PVC) diminishes the calorific estimation of the examples. A broad examination on the PVC broke up in Toluene compound (organic) as synthetic cover was seen to diminish the calorific estimations of all the briquette tests aside from those made of coconut shell and rice husk. Watchwords: Biomass, Bio fuel, Binder, Briquette, High warming quality

Harshita Jain1 , Y. Vijayalakshmi2 , T. Neeraja3

An experimental research design was adopted to conduct the present investigation. For the present study six biomass materials namely Charcoal Dust, Saw dust Rice Husk, Dry Leaves, Wood Chips, Groundnut Shells and two binders namely Cow dung and Starch were identified. The commercially available briquetting machine of 5 horsepower motor was selected for making the briquettes. Subjective evaluation of physical properties of briquette i.e. texture, cohesiveness, moisture, shape, evenness of surface and appearance of surface was conducted by a panel of 6 judges comprising of staff and PhD graduate students of College of Home Science. The data obtained from the experimental tests was compiled, tabulated and statistically analyzed by mean and standard deviation. The data obtained from subjective evaluation was consolidated by averages, standard deviation. The calorific value of all prepared briquettes was measured by using bomb calorimeter. The results indicate that briquettes made from charcoal dust and other biomass materials with starch combinations were found to be best in physical characteristics with highest scores whereas briquettes made from charcoal dust other biomass materials with cow dung combinations were found to be highest in calorific value. The results show that when cow dung is used as binder with charcoal dust and other biomass materials, it was giving higher calorific value. The use of starch as binder with charcoal dust and other biomass materials was making briquettes smooth in texture, compact, dry, uniform, even without cracks and shiny

CHAPTER 4

OBJECTIVES OF THE PROJECT

The main objective of this project is to develop a biomass briquette (bio fuel) using saw dust, coffee husk and other agricultural waste by varying the sizes of briquette, which can suitable for their use in rural applications. Two samples are created in different sizes and are tested in the laboratory for ash content, moisture content, calorific value, volatile matter and fixed carbon content, We have develop an efficient biomass stove which can be use for cooking purposes.

- Development of briquette suitable for domestic application
- Performance study of briquette for the various sizes
- Development of modified and efficient biomass stove.
- To test the viability of making fuel briquettes with selected biomass materials
- To estimate the calorific value of the biomass briquettes prepared.

CHAPTER 5

METHODOLOGY

5.1 Biomass Briquette production

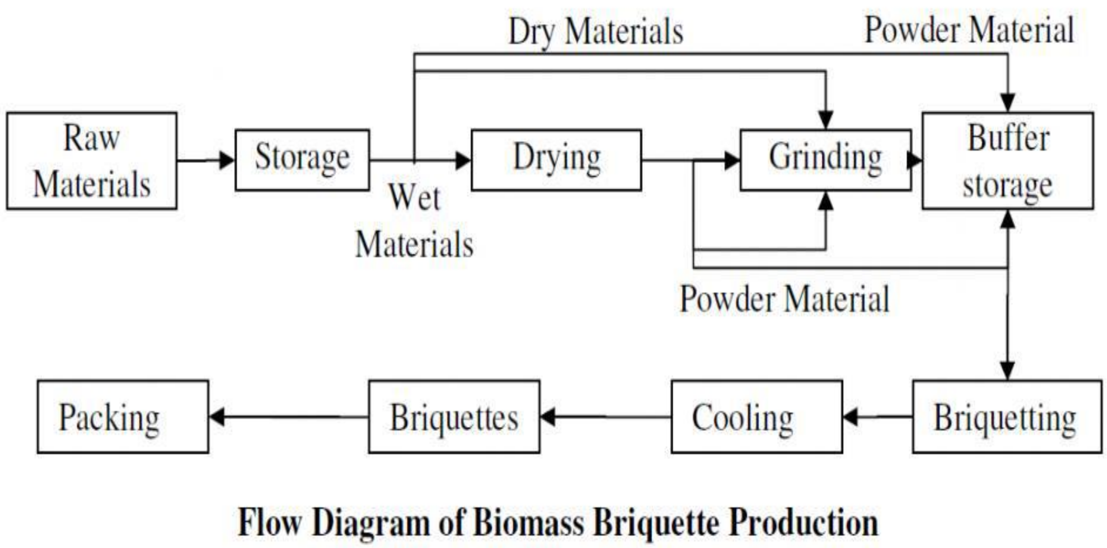

Fig: 5.1 Biomass Briquette Production

5.1.1 Raw materials

There are many raw materials available abundantly in nature, few of them are mentioned here like, groundnut shell, biogases, castor seed shell, saw dust, cotton stalks, bamboo dust, coffee husk, tobacco waste, tea waste, paddy straw, mustard straw, mustard shell, wheat straw, sunflower stalk, jute waste, palm husk, soya bean husk, sugarcane, rice husk, wood chips, forest waste and others.

All the raw materials have different calorific value and ash content of their own when burnt. Here we have chosen saw dust, coffee husk in major proportion and other agro waste in minor proportion.

- Foreign material

The raw material should be clean without foreign material that may cause excessive wear on vital parts like dies, pistons and compression screws. It will likewise result in an increased ash content in the finished products.

An ash content of more than 0.4% of the finished briquettes means, as a rule of thumb, dramatically increase of wear on all vital parts of the press.

- Moisture content

As the optimum moisture content for briquetting purposes varies with the raw material, the recommended water content is from min 6% to max 16%.
From 16% and higher quality will deteriorate considerably until briquetting becomes impossible.

5.2 Storage

One of the key steps of the briquette-making process is the provision and storage of the raw material. It is very important to adequately size the storage capacity in order to compensate eventual problems or seasonal changes in raw material supply, whether planned or not.
Furthermore, it is essential to take advantage of the storage time in order to allow natural drying, thus minimizing the need to dry the raw material to reach the minimum moisture content required for the compressing process.
The storage area must be covered and with sufficient capacity to enable the continuous operation of the installation during the periods of lower supply of raw material

It is also important to store the raw material on cemented floors, especially outdoors, to prevent the mixing of sand, stones or other impurities that can both affect the briquetting machinery as well as the quality of briquettes.
In order to ensure that the moisture content of the raw material is reduced to the required levels for compressing, drying machines are often considered to complement the natural drying achieved during the storage period.

- Storage of Forest wood, sliver, wood sawdust

Forest wood and sliver can be stored in pieces (bulk), or chipped, or crushed as sawdust. It must be noted that within wood chips or sawdust heaps moisture content can vary due to physical, chemical, and biological processes. To minimize this variation, trunk storage is recommended for 4-6 months, prior to subsequently proceeding to crushing just before briquetting.

It would be convenient to use sawdust from the timber industry, to minimize the energy used in the production of briquettes process; in principle, this sawdust should have a low moisture content.

- Storage Agricultural waste

Agricultural waste is typically stored in similar ways to forest wood. Depending on the moisture content of agrowaste, in certain cases it may be appropriate to pre-dry or even pyrolize it before the process of briquetting in order to increase its calorific value. Fluctuations in the supply chains may be more frequent than forest wood, thus making it advisable to consider an oversized storage area whenever possible.

5.3 Drying

In warm climates, it is beneficial to link the storage with natural drying, as aforementioned, with the purpose of reducing the level of moisture content of biomass before the forced drying phase.

- Natural drying

Natural drying is based on exposing the biomass to favorable environmental conditions to reduce the moisture contents in the biomass without supplying any heat externally. It is achieved by means of a controlled exposure of the biomass to solar radiation, wind and other natural processes such as the thermogenesis.

- Forced drying

Forced drying is the industrial process that reduces the moisture content of biomass fuel down to a specified range (5% to 15%) suitable to start densification.

5.3.1 Direct driers (pneumatic)

In direct driers (figure 10 and 11), biomass is circulated throughout an externally heated tunnel, and is dried by hot and dry air in direct contact with wood. The drying process can be adjusted to the moisture contents and volumes per hour to be dried.

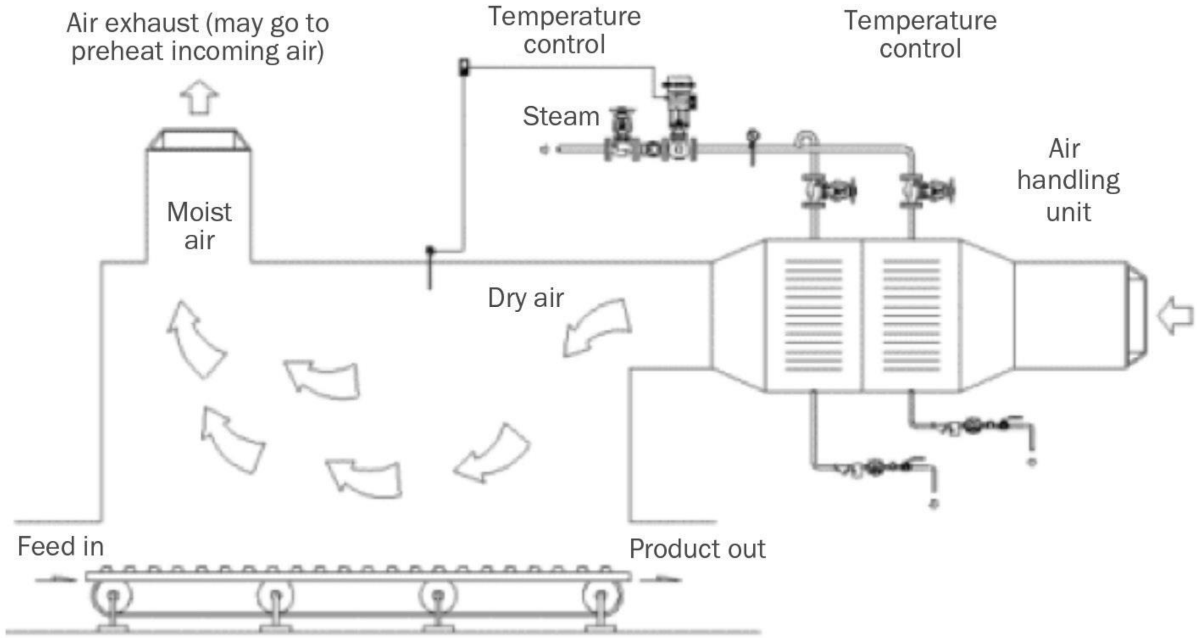

Fig: 5.3.1 Schematic diagram of direct dryer

Fig: 5.3.1 Direct dryer

5.3.2 Indirect driers (rotary drum or trommel)

In cases of high moisture content (more than 50%), direct driers may not be effective enough. In this case, indirect driers are required that enable a higher retention time and that also enable mixing biomass. Spinning the biomass in a heated, rotating cylinder, typically performs this task. Here, the biomass is dried by contact with the hot internal surface of the cylinder. Regulating the internal slope and the rotational speed controls material movement.

5.4 Crushing/Grinding

Crushing is a set of processes that allows the reduction of particle sizes to the needs required by the final energy conversion technology. According to the size of the product, crushed biomass is classified as chopped (50-250 mm), chipped (8-50 mm) or grinded (< 8 mm)

The **precrusher** process (optional) is done in robust mechanical machines, not by cutting but by actually pressing. They are used to crush the biomass to sizes that are coarse, and they can contain sieving systems to extract hard materials or impurities (nails, stones).

Crushers are machines designed to reduce the size of biomass by moving metallic tools (typically hammers or teeth). The crushers are mounted on the periphery of a rotating cylinder that works at a high speed in order to take advantage of the centrifugal force to enable a more effective impact of the hammer on the material to shred.

Chippers are designed to process soft materials, usually tree trunks, wood and wood products not containing hard elements that can reduce solid wood particles through a mechanism of cutting blades. The blades are mounted on a rotating element with high speed.

5.5 Briquetting/compacting

The most widely used briquetting technologies are described below. Impact densification (figure) – Piston Briquetting: A piston driven by a flywheel pushes the crushed biomass throughout a cylinder mould. Achieved densities are generally in the range 1,000 to 1,200 kg/m3.

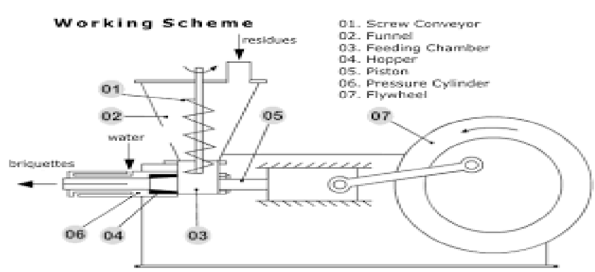

Fig: 5.5 Compacting

Extrusion densification (figures) – Screw Briquetting: This system is based on the pressure of a special screw that pushes raw material within a chamber that becomes progressively narrower. This technology enables the creation of inner holes in the briquettes thus favoring its later combustion.

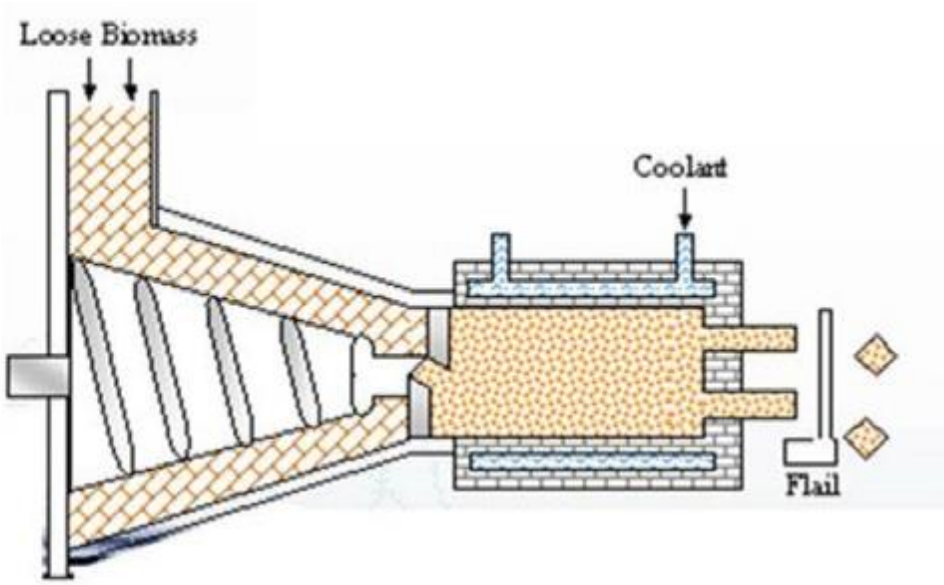

Fig: 5.5.1 Screw pressing briquetting machine

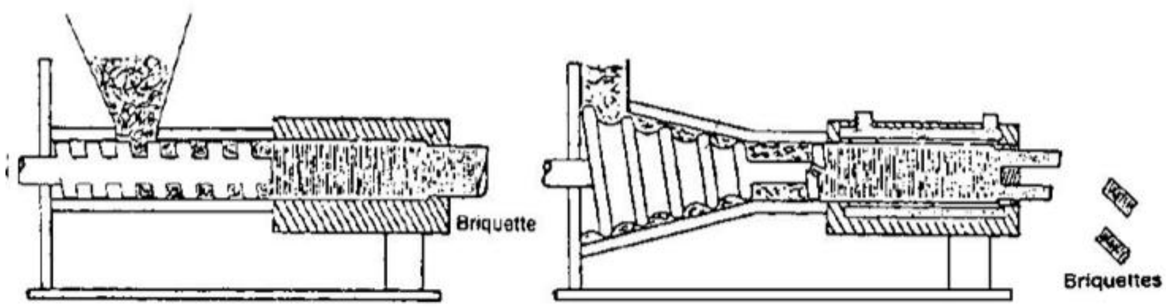

Fig: 5.5.2 Schematic diagram of screw pressing briquetting machine

The system can achieve higher briquette densities, ranging between 1,300 to 1,400 kg/m3. However, this process requires more energy consumption and more maintenance.

- Hydraulic or pneumatic briquetting

Through hydraulic briquetting (figure), the pressure is exerted by a cylinder operated by a hydraulic or pneumatic system. This process is commonly used when the raw material has poor quality, such as a high moisture content (above 30%) or when a very detailed definition (clearly cut and shaped) of the briquette form is not required.

Hydraulic briquetting is energy efficient equipment with low maintenance costs. The briquettes density produced by this technology will have a density between 700 and 1,000 kg/m3.

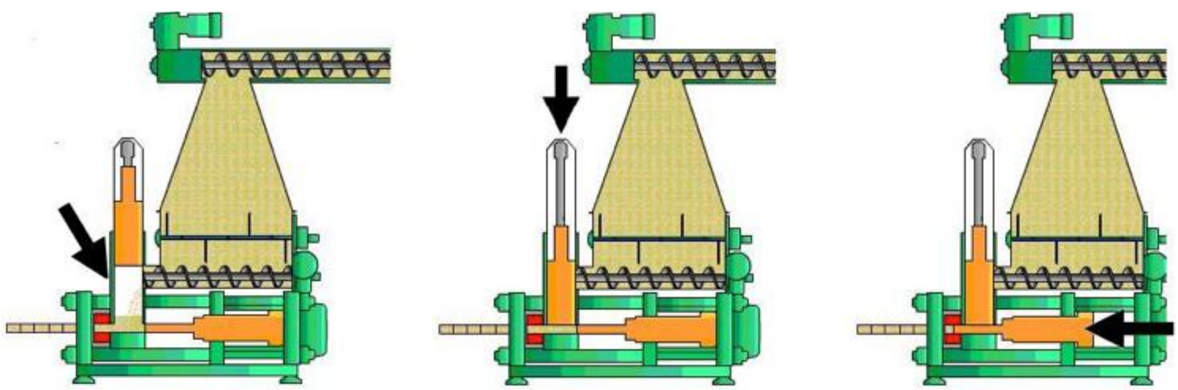

Fig: 5.5.3 Hydraulic pressing briquetting machine

5.6 Cooling of briquettes

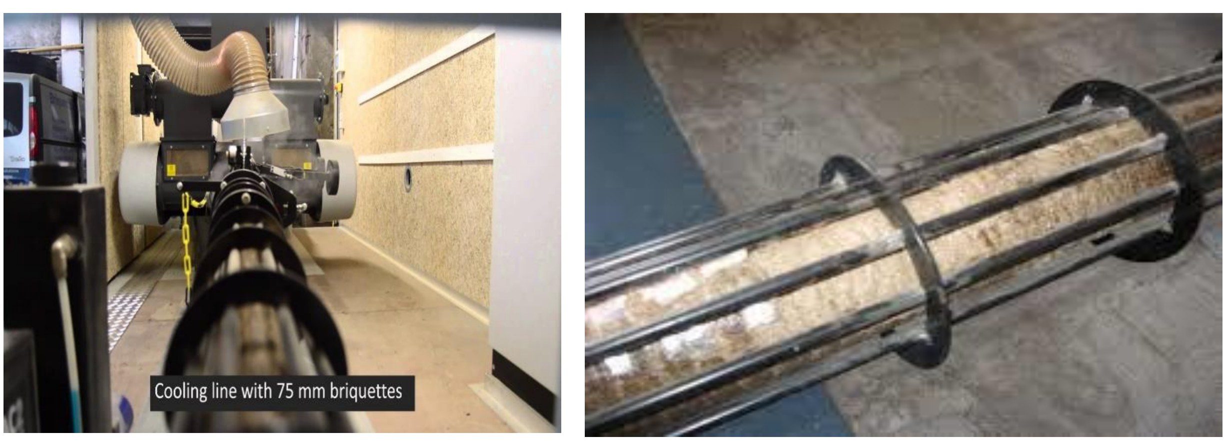

Fig: 5.6 Briquette cooling

Cooling of briquettes During pressing and extruding the temperature of briquettes rises and in extreme cases can reach 200 °C. Pressing phase is followed by cooling phase which releases moisture and hardens briquettes. Cooling of briquettes is an important step in briquette production technology. As cooling happens naturally, less attention has been paid to this production step, as can be seen from the literature survey. The initial cooling is usually performed by natural convection at the production line during transport of briquettes. After pressing, briquettes are easily breakable. The cooling releases moisture and hardens briquettes. Dynamics of cooling has a substantial influence on the quality of briquettes. If the cooling is too fast, the central zone of briquettes is still warm and humid. If immediately stored, the briquettes soften and can stick to each other. Also, cracks and fissures can appear on the surface which lowers the resistance of briquettes to abrasive wear. If the cooling is too slow, briquettes can become too dry leading also to the increase of the abrasive wear. The humidity of ambience can affect briquettes, as well. If the ambience air humidity is too low the stresses in the outer layers of briquette can cause cracks and loss of materials, which, in turn, degrades its quality. The opposite situation, when the ambience humidity increases (briquettes in water, in the rain, or high air humidity), may be associated with swelling, accompanied by decrease of hardness, which can result in the appearance of cracks and softening of the structure of briquettes, followed by loss of material.

At the end of production line briquettes are cut to the desired length. Briquette cutting is done by a saw or by a barrier. In the first case, the exact length briquettes have smooth cross sections. The second, simpler method, gives briquettes of approximate dimensions, uneven surface sections, less attractive to buyers. The time of cooling should be selected on the spot and continuously monitored keeping in mind possible changes of raw materials and other influential parameters, including the ambient conditions.

It is interesting to note that the available literature lacks data on surface temperature behavior of wood briquettes during cooling phase. Actually the authors have not found in the available literature published data on temperature dynamics of wood briquettes during cooling phase. This paper is aiming at contribution to further understanding of the dynamics of briquette cooling.

5.7 Packaging

5.7.1 Briquettes packing with thermo sealing

A frequent semi-automatic technology is the packing of briquettes in plastic bags and then sealing them by applying heat to melt and close the plastic (figure 31) bags.

Fig: 5.7.1 Thermo sealing machine

The only maintenance required here is the regular checkup of the bag's sealer condition and cleaning loose pieces of plastic. Fully automated briquette packaging technology (figure 32), which usually wraps the briquettes in plastic or cardboard boxes is available on the market. The transfer of briquette bags unto pallets is done manually.

Fig: 5.7.2 Automatic briquette packing machinery

This type of equipment does not require significant maintenance.

Pallet wrapping machine

A pallet wrapping machine gives the briquettes a standard form to facilitate storage and subsequent distribution to end users. This machine wraps the contents of the pallet with a plastic layer.

The main components of this machine are:

• The turntable deposition pellet. When operated, it rolls around itself.

• The arm containing the carriage roll plastic, and in the case of automated models, the sensor that detects the end of the packaging, and the dashboard.

Fig 5.7.3: Automatic pallet wrapper machine

Fig 5.7.4: Packed briquettes in wrapped pallets for warehousing

CHAPTER 6

DESIGN CONSIDERATIONS OF BIO STOVE

Stove is an apparatus used for cooking or heating that operates by burning fuel, the stove which we have fabricated is very much useful and easily affordable by the people in rural area.

6.1 Modelling and Design

The stove is designed by using mechanical design software

Software name: CATIA (V5)

Initially the dimensions of the stove were took care manually, and then considering the same plan of dimensions, the stove was modelled using this software.

6.1.1 Dimensions of the stove

- Outer frame of the stove

  Outer diameter = 26 cm

  Inner diameter=25.70 cm

  Thickness of the sheet= 0.15

  Inner diameter (combustion chamber rest) =17 cm

  Height of the stove= 24.5cm

  Material= Galvanized Iron (G.I) sheet

- Combustion chamber

  Outer diameter= 16.5 cm

  Inner diameter= 15.9 cm

  Thickness of the sheet= 0.3 cm

  Material= Galvanized Iron (G.I) sheet

The stove is designed as per the above dimensions and the model in both 3D and 2D are shown below

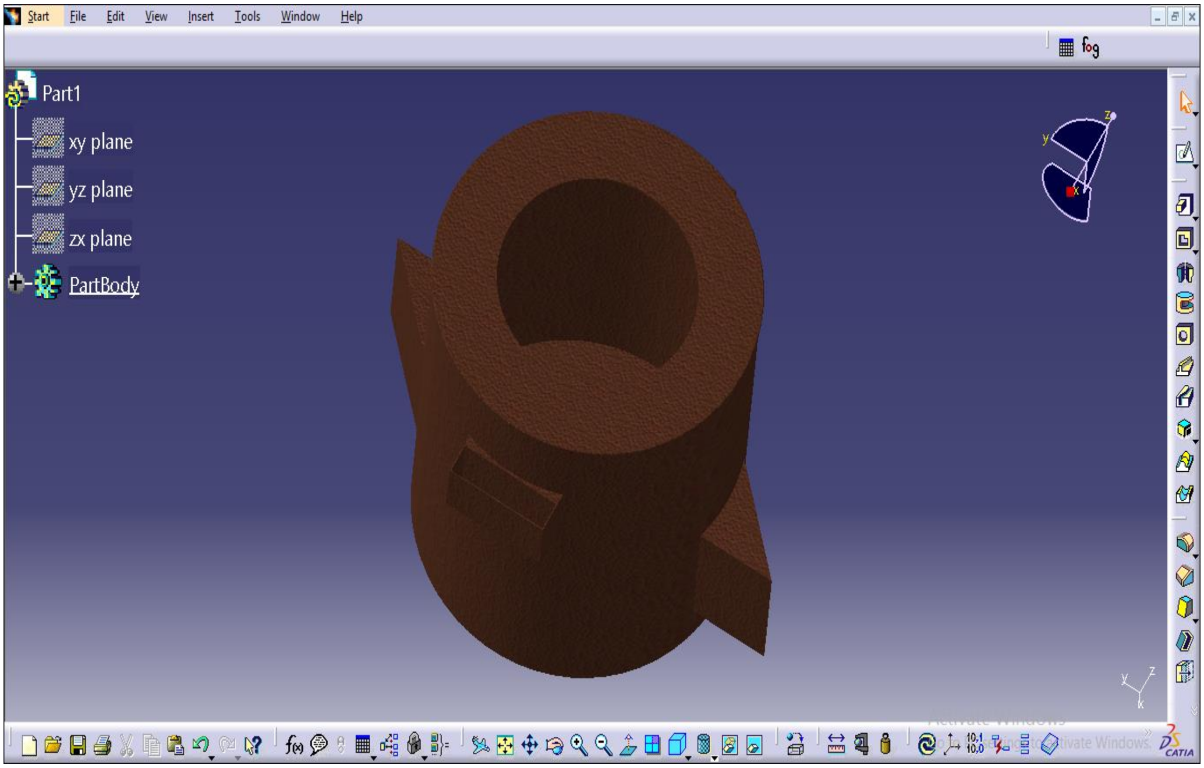

Fig:6.1.1 3D model of Outer frame of stove

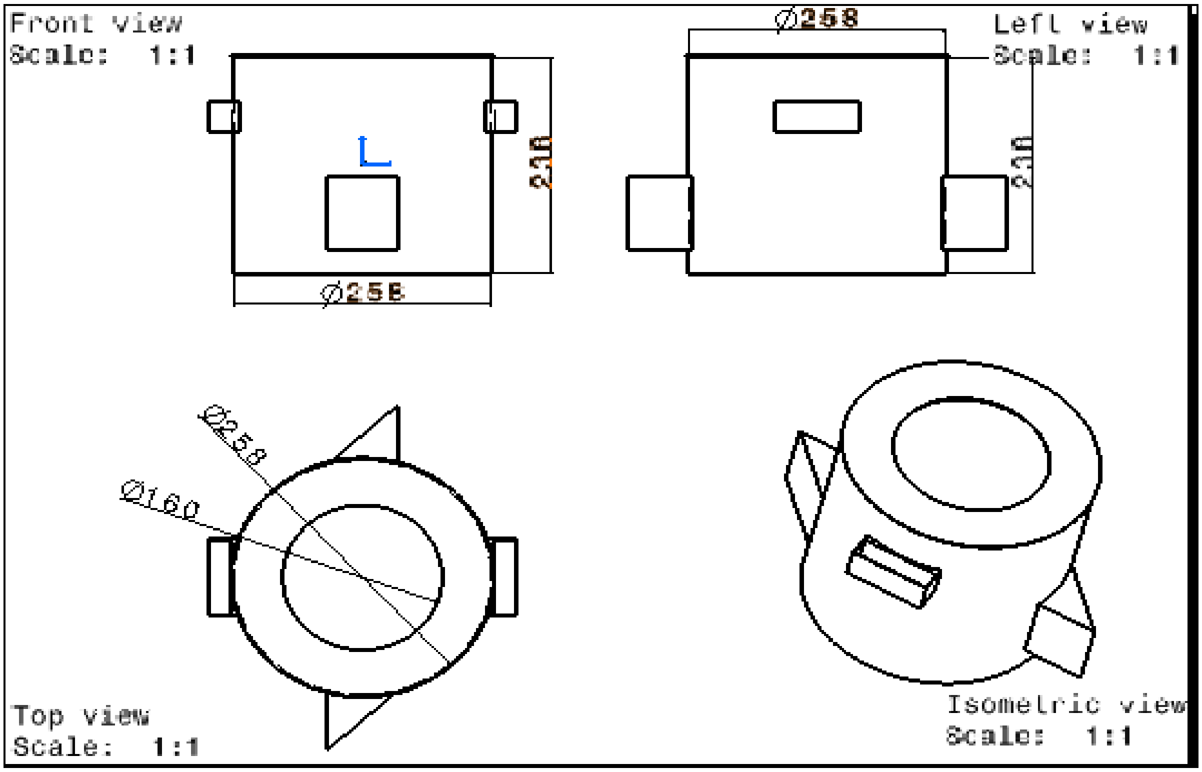

Fig 6.1.2: 2D Drafting of Outer fame of stove

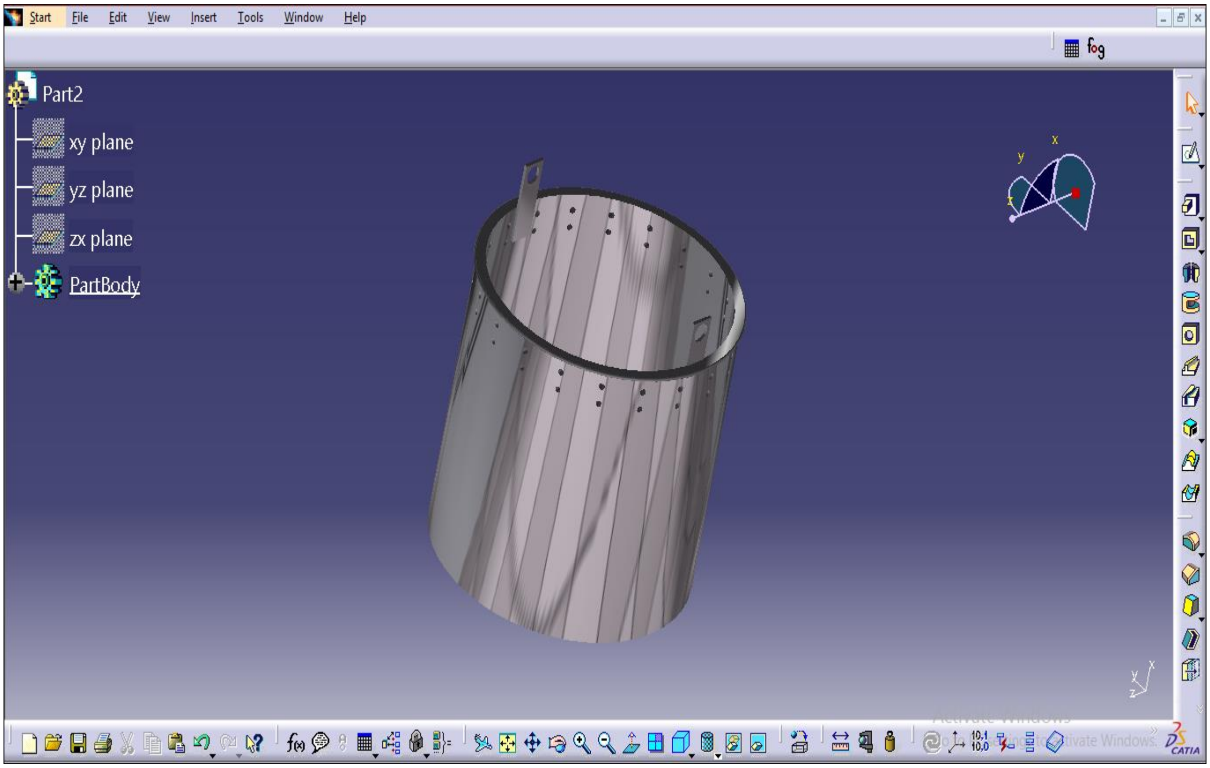

Fig 6.1.3: 3D model of Combustion chamber

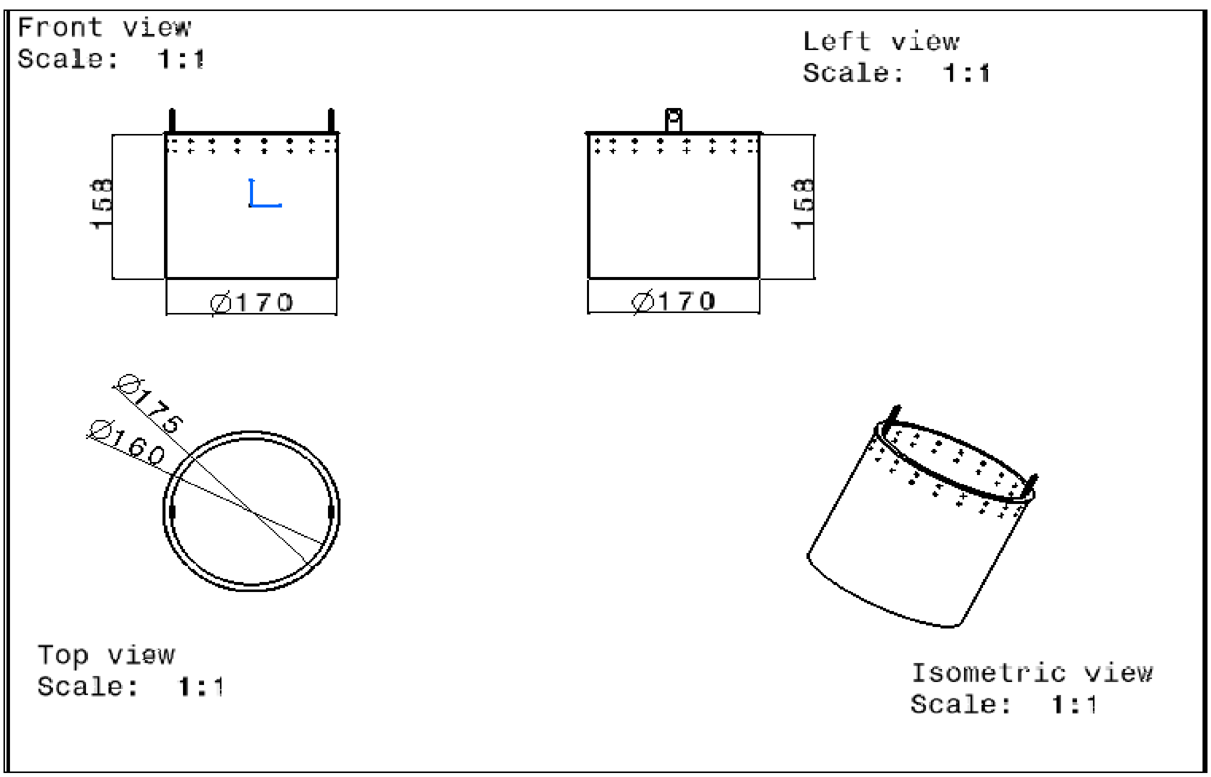

Fig 6.1.4: 2D Drafting of Combustion chamber

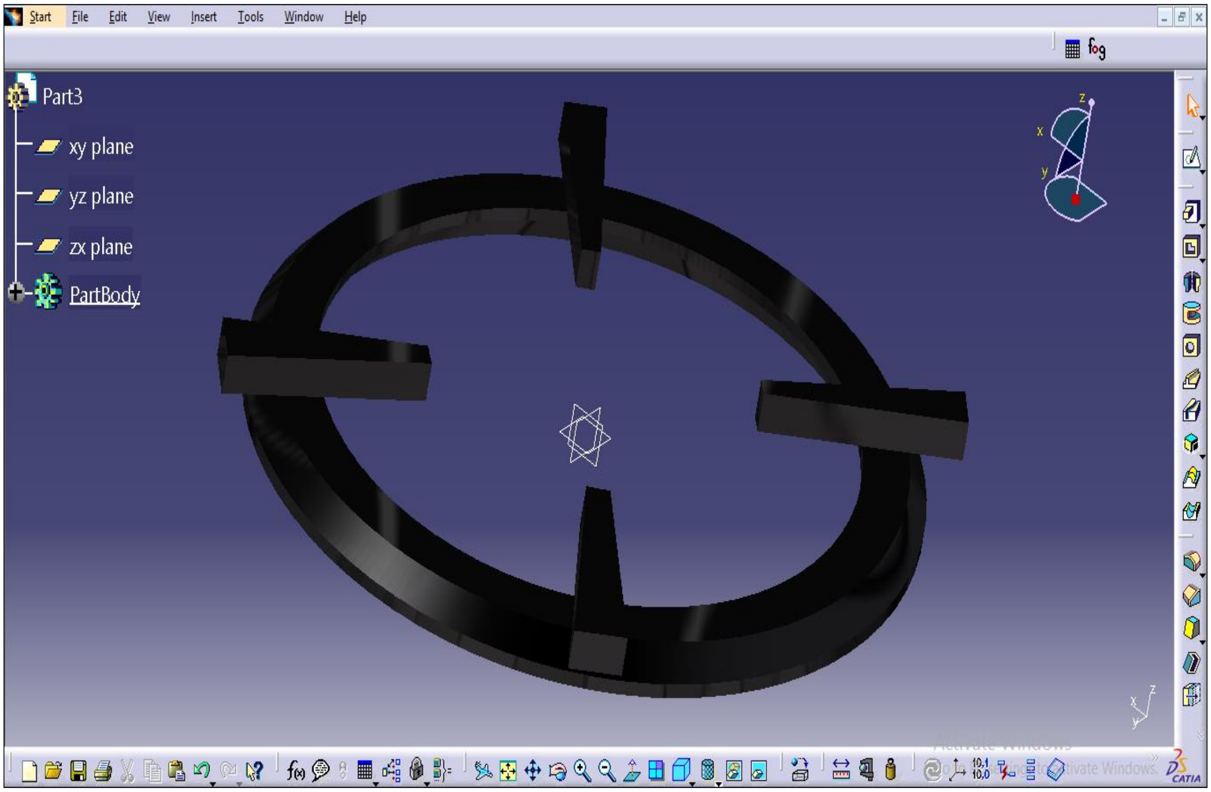

Fig 6.1.5: 3D model of Pan support

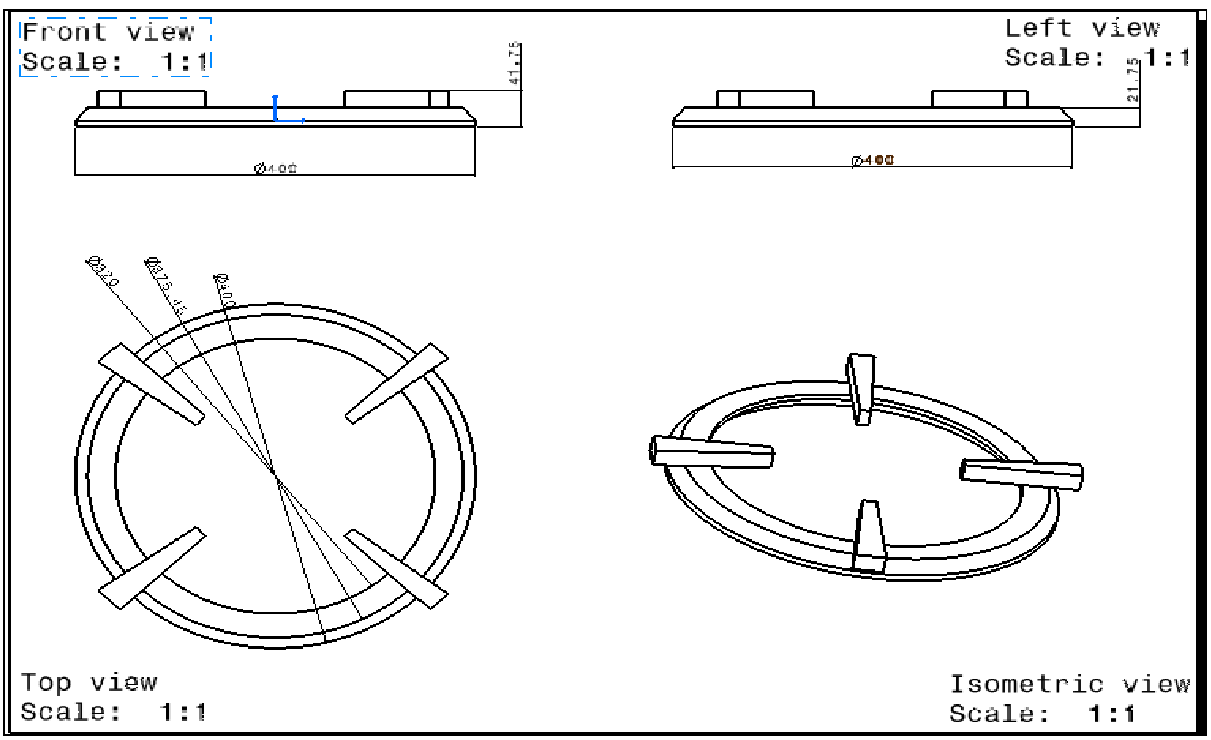

Fig 6.1.6: 2D Drafting of Pan Support

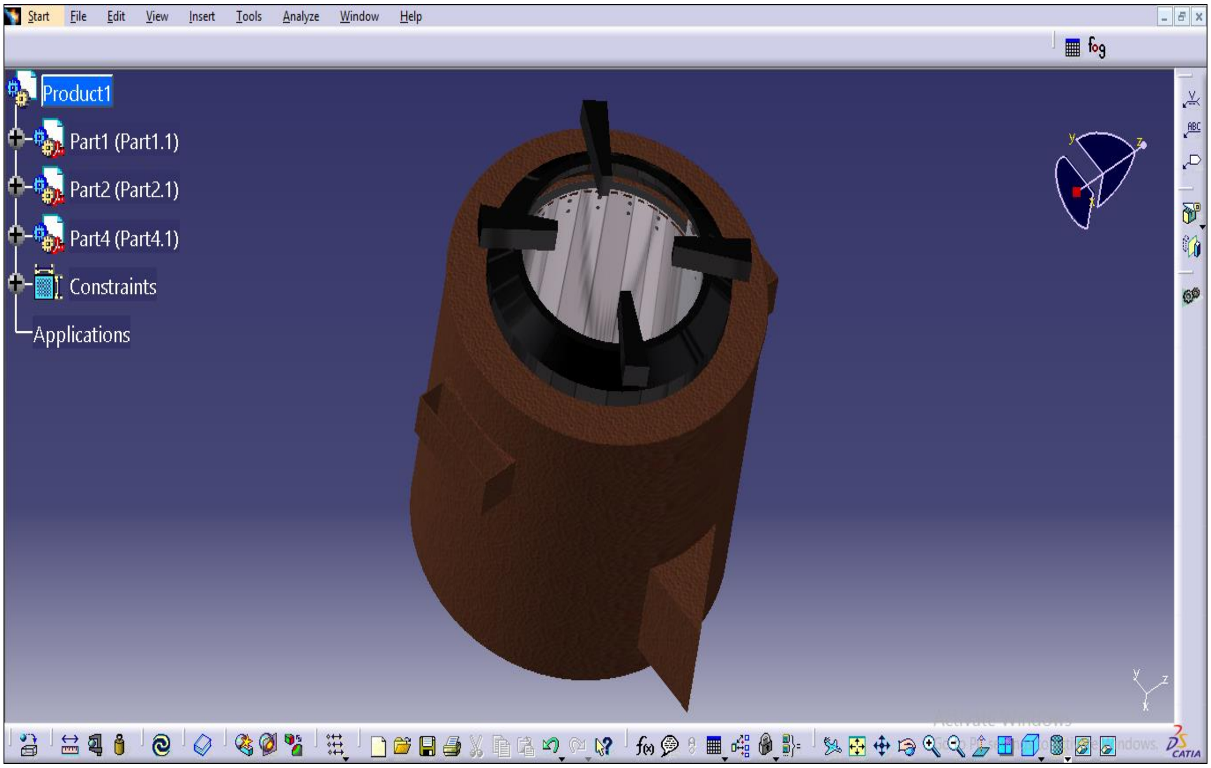

Fig 6.1.7: 3D model of Bio Stove

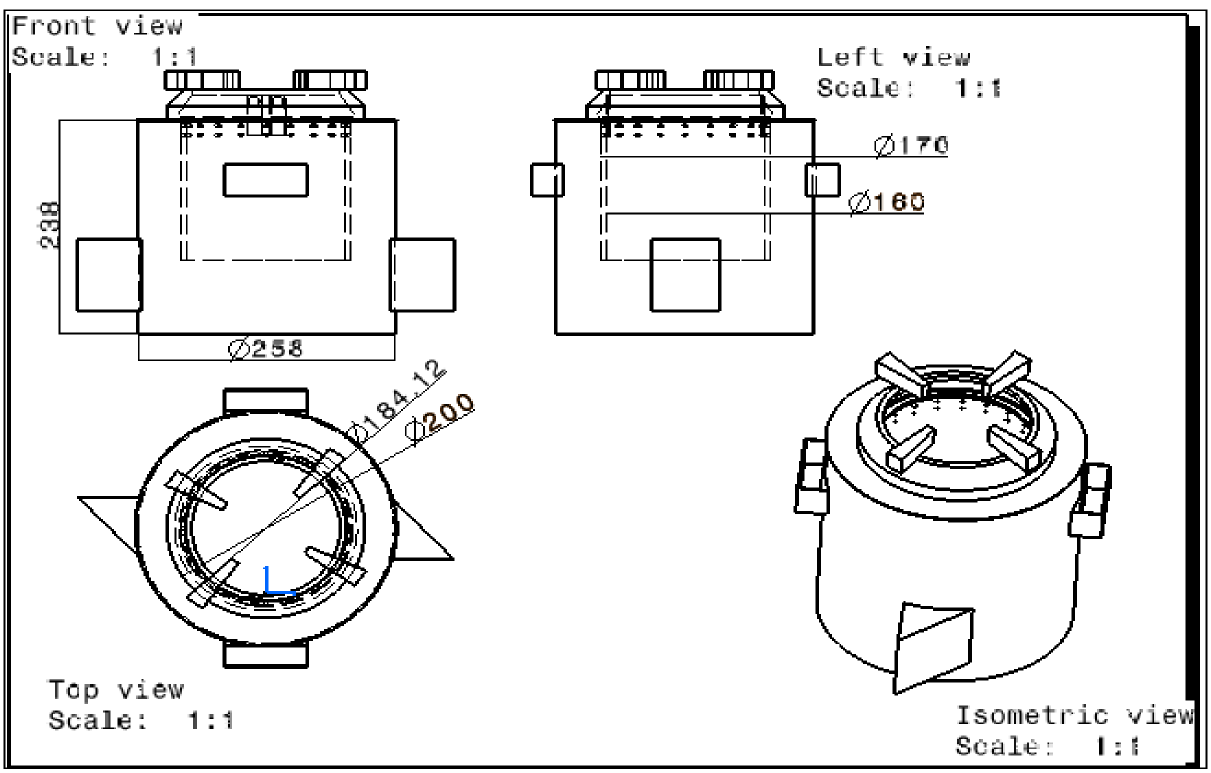

Fig 6.1.8: 2D sketch of Bio Stove

Material Properties

- Tensile Strength = 215 Mpa
- Modulus of Elasticity = 193-200 Gpa
- Poissons ratio = 0.29
- Shear Stress = 96 Gpa

Design of Outer frame

- Tensile Stress = Pd/4t = 600000*258/4*0.21= 184.28 Mpa

Hence design is safe

- Shear stress = P*d/8*t =600000*258/8*0.21= 92.14 Mpa

Hence design is safe

Design of Combustion chamber

- Tensile Stress = P*d/4*t =600000*170/4*0.2= 127.5 Mpa

Hence design is safe

- Shear stress =P*d/8*t=600000*170/8*0.2=63.75 Mpa

Hence design is safe

6.2 Fabricated Model

Fig 6.2: Fabricated model of Bio Stove

6.3 Parameters considered for fabricating stove

This stove is fabricated by considering many parameters

- By considering the weight of the stove

  Stove is made by using sheet metal (304 stainless steel) which is less in weight
- Cost of the stove

  Less in cost
- Portable

  Can be carried from one place to another easily
- Occupies less space
- Automatic stove

6.4 Parts of stove

The stove totally has 3 parts

- Outer frame (fitted with blower)
- Combustion chamber
- Pan support
- Additional electronic modules (to automate the stove)

6.5 Composition of various materials

- Outer frame and Combustion chamber

The outer frame and Combustion chamber both are made of same materials i.e, Galvanized Iron sheet.

6.5.1 Galvanized iron sheets

Galvanization is the process of applying a protective zinc coating to steel or iron in order to prevent it from rusting. The term is derived from the name of Italian scientist Luigi Galvani. Galvanized iron (GI) sheets are steel sheets which are basically coated with zinc and include a range of hot dip galvanized and electro-galvanized steel sheets. Zinc weathers at a very slow rate, so the coating generally has a long life. Zinc has a greater electro-negativity than iron and hence provides cathodic (or sacrificial) protection to the steel. This results in the zinc corroding in preference to the steel if the coating is chipped or damaged to expose the base metal.

6.5.2 Process of galvanizing

The process of galvanizing steel sheet was developed simultaneously in France and England in 1837. Both of these methods employed a 'hot dipping' process to coat steel sheet with zinc.
Galvanizing is carried out on cold rolled sheets/cold rolled strips. Galvanizing process is broadly divided into hot dipping and electro-galvanizing. The hot dip process is more suitable for heavy coating weights, and electro-galvanizing for lighter coatings. For reasons of efficiency,

- Hot dip galvanizing – The principle of the process consists of the immersion of steel strips in molten zinc. The zinc used for galvanizing is high grade with a zinc content of minimum of 99.95 %. After passing through the pretreatment tanks for degreasing, pickling, and cleansing, the strip passes through the annealing furnace and a pot containing molten zinc. The annealing furnace is used to apply the heat cycle needed to obtain the required mechanical properties and activate the surface with a reducing gas, which makes it easy to coat zinc on the strip surface. The coating weight is controlled by a purge gas jet blown on both surfaces of the strip from a nozzle above the pot, to remove excessive molten zinc. This process gives a relatively thick coating of zinc that freezes into a crystalline surface pattern known as spangles. During the process, a multiple layered structure of iron-zinc alloys is formed between the inner surface of the zinc coating and the steel strip.
- Electro-galvanizing – The principle of the process consists of immersion of steel sheet in an electrolyte, a solution of zinc sulfate or cyanide. Electrolytic action deposits a coating of pure zinc on the surface of the iron or steel. The advantages of this process is that the thickness of the coating can be accurately controlled while the limitation of this process is that the thick coatings provided by the hot dip galvanizing process are not usually possible with this method.

The cross section of a galvanized strip is composed of the steel substrate, iron-zinc alloy layers, and a zinc layer. Because the paint adhesion and weldability of the surface of this zinc layer are not necessarily good, galvannealing has been developed to improve these properties. In the basic process for galvannealed strip, the zinc-coated strip emerges from the pot and is heated in a galvannealing furnace, forming an iron-zinc alloy layer by the inter-diffusion of iron and zinc coating layer, so that the surface of the zinc layer also contains some amount of iron.

6.5.3 GI sheets specification

The galvanized iron (GI) sheets are produced as plain coils / sheets (GP) and corrugated sheets (GC). Corrugated sheets are also known as corrugated galvanized iron (CGI) sheets. These are value added steel products which are tough, sturdy, light weight, bright, corrosion resistant and easy to transport. These are usually produced in the thickness range of 0.15 mm to 2.0 mm and width range of 800 mm to 1560 mm. The weight of zinc coating varies from 100 grams square meter (gsm) to 750 grams square meter. The weight of zinc coating varies with the thickness of the steel sheet and the application of the GI sheet.

CHAPTER 7

ELECTRONIC COMPONENTS

In this project the stove is added with few electronic components which enable it to run automatically. In rural places where the domestic stoves are in use, the air is blown manually to support the combustion of the fuel, this requires human effort where a person has to blow the air from his mouth through a pipe. Due to the smoke, dust and other gases coming out of the stove human beings will be exposed to various diseases.

Considering this problem we have added two blowers to the stove in opposite direction placed at the lower level of the stove and made it to run automatically from the electronic modules. The blower speed can be adjusted using a regulator which can be used to raise or lower the speed of the blower. Along with this blower there are few other electronic modules added to the stove which makes it to run automatically.

7.1 List of electronic components

The electronic components used are as follows;

- W 1209 temperature relay controller
- DC voltage regulator
- 12V DC fan (blower)
- EACHBID 10A, 12V-24V ABS solar panel charge controller
- 12.7V EXCIDE battery
- 2.9V LED light
- Max 21V, 10W solar panel 5A

This is the list of the electronic modules used in our project to support the stove. The application of all these components is detailed in this chapter.

7.1A. W 1209 temperature relay controller

Fig 7.1 W 1209 temperature relay controller

7.1.1 Description

The W1209 is an incredibly low cost yet highly functional thermostat controller. With this module we can intelligently control power to most types of electrical device based on the temperature sensed by the included high accuracy NTC temperature sensor. Although this module has an embedded microcontroller no programming knowledge is required. 3 tactile switches allow for configuring various parameters including on & off trigger temperatures. The on board relay can switch up to a maximum of 240V AC at 5A or 14V DC at 10A. The current temperature is displayed in degrees Centigrade via its 3 digit seven segment display and the current relay state by an on board LED.

7.1.2 Specifications

- Temperature Control Range: -50 ~ 110 C
- Resolution at -9.9 to 99.9: 0.1 C
- Resolution at all other temperatures: 1 C
- Measurement Accuracy: 0.1 C

7.1.2 Specifications

- Temperature Control Range: -50 ~ 110 C
- Resolution at -9.9 to 99.9: 0.1 C
- Resolution at all other temperatures: 1 C
- Measurement Accuracy: 0.1 C
- Control Accuracy: 0.1 C
- Refresh Rate: 0.5 Seconds
- Input Power (DC): 12V
- Measuring Inputs: NTC (10K 0.5%)
- Waterproof Sensor: 0.5M
- Output: 1 Channel Relay Output, Capacity: 10A

7.1.3 Power consumption

- Static Current: <=35mA
- Current: <=65mA

7.1.4 Environmental requirements

- Temperature: -10 ~ 60 C
- Humidity: 20-85%

7.1.5 Applications

This module has a temperature sensor (can be seen in the above picture), the sensor can measure the temperature and it is indicated in the digital display. The module is provided with the adjusting buttons so as to adjust that whenever the temperature level falls below the set temperature (30 C) the signal hits the buzzer and the output will be in the form of sound, by this we can come to know that the stove has stopped burning. When the temperature of the stove is >30 C the buzzer doesn’t give any sound indicating that the stove is continuing burning.

By considering the effect of temperature the blower speed is increased or decreased depending upon the temperature, when the temperature level falls down then the blower speed has to be increased to support the combustion and when the temperature is high then the blower speed has to be reduced, this can be explained in the later stages of the chapter.

7.2A. DC voltage regulator

The main purpose of the DC voltage regulator in this project is to regulate the voltage supplied to the blower (fans) in turn increasing or decreasing the speed of the blower depending upon the temperature.

As we know that oxygen is the supporter of the combustion whenever the air supply comes down the burning action decreases and at certain point of time the flame is no more, inorder to correct this problem the DC voltage regulator is used. So whenever we feel like the flame is coming down we can support the combustion by increasing the voltage supply to the fan which will in turn increase the speed of the fan and the combustion would go smoothly.

7.3A. DC fan (blower)

Fig 7.3: Blower

The above component is a 12V DC fan or blower, this is basically used for pushing the atmospheric air into the combustion chamber to support the burning action occurring inside the stove. Earlier people used to manually blow the air to the stove which was pretty much difficult for the people, by using this fan the effort of human being can be reduced and this will reduce the ailments caused to the people when blowing the air manually while they will be in contact with smoke, dust etc.

The fan is powered by the electrical connections (12V DC) and thus it rotates. The air is supplied to the combustion chamber through this fan itself, there are two fans used each fan is placed one fan opposite in direction to that of the other inorder to facilitate the effective combustion. The speeds of these fans are increased or decreased by using the voltage regulator.

7.4A. ABS solar panel charge controller

Fig 7.4: Solar panel charge controller

The component shown above is a solar panel charge controller, this module can be used for various purposes as it is directly connected to the battery. This module can show the level of battery and the voltage level of battery. It receives the power from the solar panel and adjust the voltage required by the load.

The module is also incorporated with the 2 USB ports where they can be used to charge mobile phones or other accessories related to it, in other words we can say that this can be used as a power bank to charge few accessories. The power supply specification of this module is as follows, it consumes current of 10A, and the voltage range is between 12-24V.

7.5A. EXCIDE battery

Fig 7.5: Exide Battery

The component above is a EXIDE battery which gives the output of about 12.7V, it is a zero maintenance battery, the inner material is made of lead acid and capacity is 5AH, it weighs about 3kgs and a rated charging voltage is 12.5V, rated output voltage at full charge is 12.7V.

The battery is charged using a solar charge controller and the power supply from the solar panel is connected to the charge controller, the charge controller adjusts the voltage from the battery and the solar panel and the required output at the load can be varied and controlled.

This battery is less in cost and easily affordable by the people in rural area, in those places electricity will not be available always at that time the alternate source is none other than battery. This battery can be further charged by solar panels when the battery is completely charged, then without depending upon electricity we can directly use the power from the battery to control all the components of the stove.

7.6A. LED light

Fig 7.6: LED light

As we know that in rural places, electricity is not always available and there will be power fluctuations sometimes. When there is no electricity then it becomes difficult to see the things and during cooking it would be hard to see and people can barely see without electricity.

Considering this problem we have used a LED light which operates on very less voltage of 2.9V and it gives enough light for cooking, this could definitely help the people in rural areas who seriously face electricity problem.

This LED light doesn't need any additional power supply, the battery which supports the working of all other components of stove itself energizes the LED light and enables it to glow, by this people can see and the cooking can happen very easily

CHAPTER 8

TESTING AND RESULTS

The testing is done for the two briquette samples which we have prepared, both the samples are made with the same composition (40% coffee husk, 40% saw dust and 10% various agro wastes) but in different sizes. Though the composition is same but the size difference brought a huge difference in testing, when both the samples were tested the sample in large dimension gave less calorific value when compared to the sample in the comparatively smaller size. The bigger sample was created using briquetting machine and the comparatively smaller sample was created using pelleting machine, and these samples were tested in ESSEN & CO laboratory (analytical chemists and assayers) which has the certification under ISO 9001:2015.

8.1 Parameters tested

The testing of the briquette and pellete was done for 5 parameters;

- Moisture content
- Volatile matter
- Ash content
- Calorific value
- Fixed carbon content

Here is the brief explanation about how these parameters are calculated

8.1.1 Moisture content

Weigh a known weight of material in a crucible and dry in hot air oven about 4 hours and weigh until the constant weight.

$$\text{\% of Moisture} = \frac{(\text{Dish weight} + \text{material weight before drying} - \text{weight after drying}) * 100}{\text{Weight of the material}}$$

8.1.2 Volatile Matter

After determining the moisture content keep the sample in muffle furnace at 900 C for a period of about 7 minutes. After 7 minutes keep it in a desiccator. After cooling weigh again.

$$\text{Volatile Matter} = \frac{(\text{weight of the crucible} + \text{material} - \text{weight of the material after ignition}) * 100}{\text{Weight of the sample}}$$

8.1.3 Ash content

After calculating the volatile matter keep the crucible in the muffle furnace for 2 hours, after ashing take the crucible and keep it in a desiccator. After cooling weigh the material.

$$\% \text{ of Ash} = \frac{(\text{Empty crucible} + \text{Ash} - \text{Empty crucible}) * 100}{\text{Weight of the material}}$$

8.1.4 Calorific Value

Weigh 1 gram in a steel crucible and keep it in a bomb and pass the oxygen and keep it in a water jacket and stir it for 5 minutes. Take the initial reading of the temperature and fire it, after firing take the final reading.

$$\text{Calorific Value} = \frac{(\text{Final reading} - \text{initial reading}) * \text{water equivalent}}{\text{Weight of the sample} - 40(\text{blank of the copper wire thread})}$$

8.1.5 Fixed carbon content

The fixed carbon content is calculated using a formula

Fixed Carbon= 100- (Moisture%+ Volatile matter%+ Ash%)

The test reports for both the samples are added to this report, it determines how efficient the briquette and pellette is.

CHAPTER 9

CONCLUSION

- In this project we have prepared totally two samples, one for briquette which is of 2 cm diameter and another sample for pellet which is of 1cm in diameter.
- The testing report showed that the sample of small size (pellets) came out with higher calorific value of 4528 calories/gm where as the comparatively bigger sample (briquette) came out with the calorific value of 4241 calories/gm. Hence pellets have high efficiency.
- As an application we have fabricated a stove made up of Galvanized iron sheet by considering design parameters, The stove is capable of carrying 6 Kg of load, for example vessels and utensils with eatables in it.
- This stove is of low cost and economical, easily affordable by people in rural areas and portable, because it can be easily carried from one place to another place.
- Flame can be easily controlled by using a regulator added to it, the cooking happens faster than LPG stove, there is no danger of leakage or bursting as in LPG stoves, whenever the temperature falls below certain temperature or when the fuel is empty the buzzer gives a signal in the form of sound so that person nearby can take care of it

CHAPTER 10

SCOPE FOR FUTURE IMPROVEMENT

Our main task is to stop and minimize the emission of carbon as far as possible while producing briquettes by blending and mixing with some other material in order to save the environment from toxic sulphur pollutants and carbon emission.

Proper utilization of agro waste leads towards **“swachh bharatha”.** Every year million tones of wastes are produced for example agricultural waste, if this waste is used properly as we used in this project then it can definitely leads to swachh bharatha.

In future these Biomass briquettes can replace coal fuels since they pollute the atmosphere and cause diseases to the people, these briquettes when produced in large quantity the cost will be comparatively reduced.

The stove which is fabricated can be used in the rural areas as it can replace LPG based stoves, because there is a danger of leakage and bursting in LPG based stoves, but this stove is safe to use, it is portable and easily affordable. Efficient cooking can be done using this stove as the flame can be controlled.

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