

Technology Packages:

Screw-press briquetting machines
and briquette-fired stoves



Editors:

S. C. Bhattacharya

S. Kumar

Contributors:

Md. Nawsher Ali Moral

Gyani Ratna Shakya

Pham Khanh Toan

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Foreword

Economic growth, industrialisation and growing population in the developing countries of Asia contribute to a rapidly growing demand for energy in the region while global environmental concerns call for limiting use of fossil fuels. Renewable Energy Technologies (RETs) present a viable option of meeting the growing energy demand, especially in remote and rural areas. However, before full commercialization of RETs can be achieved, many barriers need to be overcome. Apart from adaptive technological improvements, this also calls for appropriate financial mechanisms, institutional/research capacity enhancement and public awareness through demonstration and dissemination. The Governments of Asian countries have a key role to play in promotion of RETs through appropriate policy interventions. To address these issues 'Renewable Energy Technologies in Asia: A Regional Research and Dissemination Programme' was launched in 1997 by the Swedish International Development Cooperation Agency (Sida) and the Asian Institute of Technology (AIT). The programme involved thirteen institutes from Bangladesh, Cambodia, Nepal, Lao PDR, Philippines and Vietnam.

The programme activities carried out in the thirteen participating institutes and at AIT included adaptive research, demonstration of RETs systems, dissemination of research outcomes to the stakeholders and capacity building. The wide range of activities and achievements of the RETs in Asia programme in the six countries have been presented in six booklets:

1. Technology Packages: Solar, Biomass and Hybrid Dryers
2. Technology Packages: Screw-press Briquetting Machines and Briquette-fired Stoves
3. Technology Packages: Low-Cost PV System Components
4. Lessons Learnt from Monitoring of PV Systems
5. PV Technology Fact Sheets
6. Renewable Energy Technology Promotion in Asia: Case Studies from six countries

The information presented in the above booklets is expected to be useful to a number of stakeholder groups, including those who are involved in renewable energy development projects in the Asian region, the business community, policy personnel, NGOs and research institutions.

June 2005

Dr. Gity Behravan
Senior Research Advisor, Sida

Preface

It is increasingly becoming evident that current pattern of rising conventional energy consumption cannot be sustained in the future due to two reasons: the environmental consequences of heavy dependence on fossil fuels, particularly climate change, and the depletion of fossil fuels. Therefore, at present, a near consensus appears to be emerging that renewable energy technologies need to be promoted if global energy supplies are to be placed on an environmentally sustainable path.

Despite the efforts of various government institutions, universities, NGOs and international development organizations, renewable energy technologies are yet to make a substantial contribution towards betterment of the quality of life in the developing countries. To find a wider acceptance, it is very important to make sure that renewable energy solutions are accessible, affordable and appropriate. Research and development institutes in developing countries have a vital role to play in the development, local adaptation and promotion of renewable energy technologies. These institutes have much to gain through regional networking with similar institutes in other countries by sharing experience and carrying out joint coordinated research.

In this background, the Swedish International Development Cooperation Agency (Sida) sponsored a regional programme entitled “Renewable Energy Technologies in Asia: A Regional Research and Dissemination Programme (RETs in Asia)”. The programme, executed during 1997-2004, was coordinated by the Asian Institute of Technology (AIT) and involved thirteen National Research Institutes (NRIs) from six Asian countries: Bangladesh, Cambodia, Lao PDR, Nepal, Philippines and Vietnam. Three technologies/applications were identified for research, promotion and dissemination: solar photovoltaics, renewable energy based drying and biomass briquetting/briquette-fired stoves.

Six books have been prepared to disseminate the findings of the RETs in Asia programme. This document presents technical information on the different biomass briquetting systems and briquette-fired stoves developed at AIT and in the three participating countries: Bangladesh, Nepal and Vietnam. The information is expected to be useful to those who are involved in biomass briquetting related development projects in the Asian region, the business community as well as NGOs/research institutes.

We are grateful to the Swedish International Development Cooperation Agency (Sida) for providing financial assistance for all the activities carried out within the programme. We are also thankful to Dr. Gity Behravan of Sida for her continuous support and guidance over the implementation period.

May 2005

Prof. S. Kumar
RETs in Asia Coordinator

RETs in Asia Team

Swedish International Development Cooperation Agency (Sida)

Dr. Gity Behravan – Senior Research Advisor

Principal Investigators

Prof. S.C. Bhattacharya – Energy Field of Study, AIT (until December 2004)

Prof. S. Kumar – Energy Field of Study, AIT

National Research Institute (NRI) Team Leaders

Bangladesh

Mr. Dipal C. Barua, Managing Director, Grameen Shakti (GS), Grameen Bank Bhaban, Mirpur - 2, Dhaka - 1216, Bangladesh, Tel: +88 02 9004081, Fax: +88 02 803559, E-mail: g_shakti@denbd.com

Prof. Muhammad Ibrahim, Executive Director, Centre for Mass Education in Science (CMES), House #828, Road #19, Dhanmondi Residential Area, Dhaka - 1209, Bangladesh, Tel: +88 02 811898, Fax: +88 02 803559, E-mail: cmes@citechco.net

Prof. Md. Nawsher Ali Moral, Mechanical Engineering Department, Khulna University of Engineering and Technology (KUET), Khulna 9203, Bangladesh, Tel: +88 041 774900, Fax: +88 041 774403, E-mail: nali@bttb.net.bd

Cambodia

Dr. Sat Samy, Under Secretary of State, Ministry of Industry Mines and Energy (MIME), No. 47, Preah Norodom Blvd. Phnom Penh, Cambodia. Tel: 855-23-427851, Fax: 855-23-990602, E-mail: mimedet@forum.org.kh

Dr. Phoeurng Sackona, Director, Cambodia Institute of Technology (ITC), Cambodia, Tel: +855 23 880 370, Fax: +855 23 880 369, E-mail: sackonap@bigpond.com.kh

Lao PDR

Dr. Phouvong Sayalath, Technology Research Institute, Science Technology and Environment Agency (STEA), P.O Box 2279, Vientiane, Lao PDR, Tel: +856 21 218711, Fax: +856 21 21 3472, E-mail: tri@steno.gov.la

Nepal

Er. Rishi K. B. Shah, Vice President, Centre for Renewable Energy (CRE), O. Box 589, Ga-2/717 Bag Bazaar, Kathmandu, Nepal, Tel: +977 1 248852, Fax: +977 1 226976, E-mail: cre@ccslnp.com

Prof. Mohan Bikram Gewali, Executive Director, Research Centre for Applied Science & Technology (RECAST), Tribhuvan University, P. O. Box 1030, Kirtipur, Kathmandu, Nepal, Tel: +977 1 330348, Fax: +977 1 331303, E-mail: turecast@mail.com.np

Mr. Gyani Ratna Shakya, Director, Technology Division, Royal Nepal Academy of Science and Technology (RONAST), P. O. Box 3323, Khumaltar, Patan, Nepal, Tel: +977-1-547719, Fax: +977 1 490190/ 547713, Email: grshakya@hotmail.com

Philippines

Prof. Rowaldo R. del Mundo, Head of Solar Laboratory, University of the Philippines (UPERDFI), Diliman, Quezon City, Philippines 1101, Tel: +632 434 3661, Fax: +632 434 3660, E-mail: rmundo@info.com.ph

Dr. Arnold R. Elepaño, Associate Professor, College of Engineering and Agro-Industrial Technology, Institute of Agricultural Engineering, Division of Agricultural & Bio-Process Engineering, University of the Philippines Los Baños (UPLBFI), College, Laguna 4031, Philippines, Fax: (+63 49) 536 3291, Email: retsas@laguna.net

Vietnam

Dr. Pham Khanh Toan, Director, Institute of Energy, Khuong Thuong - Dong Da, Hanoi, SR Vietnam, Tel: +844 8522453, Fax: +844 8523311, E-mail: ret@fpt.vn

Mr. Trinh Quang Dung, Director, Solar Laboratory, 01 Mac Dinh Chi St., 1 District Ho Chi Minh City, SR Vietnam, Tel: +84 8 8222 028, Fax: +84 8 8295 905, Email: t-q-dung@hcm.fpt.vn

Research Staff at AIT

Mr. Mathias Augustus Leon – Energy Field of Study, AIT, Email: augustusleon@gmail.com

Mr. Md. Anisuzzaman – Energy Field of Study, AIT, Email: anism@yahoo.com

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Introduction

Background

In 1997, the Swedish International Development Cooperation Agency (Sida) launched a regional programme entitled “Renewable Energy Technologies in Asia: a Regional Research and Dissemination Programme (RETs in Asia)”. The objective of the programme, which was coordinated by the Asian Institute of Technology (AIT), was to promote a few selected mature/nearly mature renewable energy technologies in six Asian countries. Thirteen national research institutes (NRIs) from the six participating countries were involved in the regional programme. Activities of the programme involved adaptive research; development of technology packages and their demonstration; capacity building of different stakeholder groups; and dissemination.

Three renewable energy technologies were selected for promotion within the programme: photovoltaics, renewable energy-based drying and biomass briquetting/ briquette-fired stoves. One of the major objectives of the RETs in Asia programme was to develop appropriate 'packages' of briquetting systems and briquette-fired stoves. These packages to be disseminated to interested entrepreneurs and other stakeholders in the participating countries and the region as a whole.

This booklet documents the technology packages developed by the biomass briquetting group of RETs in Asia consisting of AIT and three NRIs. The participating NRIs were the Institute of Energy (IE), Vietnam; Khulna University of Engineering and Technology (KUET), Bangladesh (formerly Bangladesh Institute of Technology/BIT); and, the Royal Nepal Academy of Science and Technology (RONAST), Nepal. Four packages were developed at AIT, which include one complete heated-die, screw-press biomass briquetting system and three gasifier stoves, which can use biomass briquettes as fuel. NRIs developed their own briquetting systems, adapting the generic design to their specific country's requirements, and also developed several briquette-fired stoves.

Packages developed by AIT, Thailand

Research on the heated-die screw press briquetting system were aimed at (i) reducing the overall electrical energy consumption by the briquetting system, (ii) enhancing the briquetting screw life, and (iii) reducing smoke in the vicinity during operation.

Electrical energy consumption was reduced by replacing the electrical coil die-heaters with a biomass stove, and by incorporating a raw material pre-heater. Screw life was enhanced by hard-facing the first three flights with a welding electrode suitably identified for the operating conditions of the screw. The pre-heater also contributed to longer screw life since the lignin in the biomass raw material was softened during pre-heating, causing lesser abrasion on the screw. Smoke released during the briquetting process was collected and returned to the die-heating stove where any unburnt gases were burnt and released through a chimney.

Briquettes are a more convenient form of fuel compared to loose biomass, but they are difficult to be burnt in conventional combustion stoves. Several stoves were developed at AIT and in the other participating institutions for burning the biomass briquettes efficiently. At AIT, three types of gasifier stoves were developed for three sectors of users – domestic, institutional and commercial. The stoves are efficient, smoke-free, and can operate for several hours continuously with occasional fuel loading.



Rice husk briquettes, AIT

2.1 Improved biomass briquetting system

Utilization of agricultural residues is often difficult due to their uneven and troublesome characteristics. The process of compaction of residues into a product of higher density than the original raw material is known as densification. Densification has aroused a great deal of interest in developing countries all over the world lately as a technique for upgrading residues as an energy source. The process offers the following advantages:

- *the net calorific value per unit volume is increased*
- *the densified product is easy to transport and store*
- *disposal of residue is facilitated*
- *the fuel produced is uniform in size and quality.*



Biomass briquetting system. A

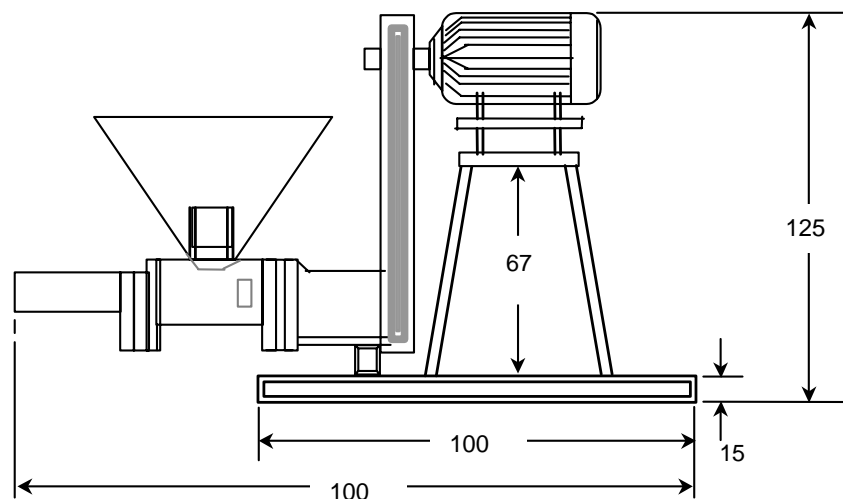
The process also helps to reduce deforestation by providing a substitute for fuelwood. Several methods are available for densifying biomass. Heated-die screw-press briquetting is a popular densification method suitable for small-scale operations in developing countries. In this method, the raw material from the hopper is conveyed and compressed by a screw that forces it through a heated die. This process can produce denser and stronger briquettes compared with piston presses. The briquetting machines employed in the technology packages of RETs in Asia programme are of the single extrusion heated-die screw-press type.

2.1.1 Design and Construction Details

The improved briquetting system developed at AIT consists of the following: a briquetting machine (of Bangladeshi design), a biomass pre-heater, a biomass-fired die-heating stove and a smoke removal system.

Briquetting Machine

The schematic diagram of the basic heated-die screw-press biomass briquetting machine is presented in Figure 1.1.



All dimensions are in cm

Figure 1.1: Schematic diagram of the heated-die screw-press briquetting machine

The briquetting machine used in this package is based on a Bangladeshi design. Table 1.1 presents the technical specifications of the machine.

Biomass Pre-heater

Pre-heating biomass before extrusion reduces briquetting energy consumption and also extends the life of the briquetting screw. Therefore, a pre-heater was incorporated in the briquetting package.

The biomass pre-heater essentially consists of two concentric pipes. Biomass is passed through the inner pipe under the action of a screw rotated by a variable speed motor. The raw material is pre-heated while being conveyed through the inner pipe. The hot flue gas from the die-heating stove of the briquetting machine enters the pre-heater at one end, passes through the space between the inner and outer pipes, transfers heat to the biomass (ricehusk), which is conveyed through the inner pipe, and exits to the atmosphere at the other end. The pre-heater is mounted on a frame, which is 1.2 m long and 42 cm wide. The outer pipe is insulated by a 2.5 cm thick layer of rockwool to reduce heat losses to the surroundings. The heated raw material from the pre-heater exit is fed directly to the briquetting machine. The speed of the pre-heater screw can be selected based on the required biomass flow rate into the briquetting machine.

Table 1.1. Technical Specifications of the Briquetting Machine

| GENERAL SPECIFICATIONS | SCREW |
|---|---|
| Induction Motor: 20 hp/1450 rpm; 380V/50 Hz | Total length: 450 mm Outer diameter: 55 mm |
| Screw speed: 320 rpm | Material: Mild Steel round rod |
| Die-heater: Briquette-fired metal stove (AIT design) | DIE |
| Production rate: 80 kg/h | Length: 300 mm |
| Raw material: ricehusk | External dia: 97 mm |
| Electricity consumption: 0.13 kWh/kg | Internal dia. 55 mm |
| Power transmission: Pulleys & V-belts | Tapered length: 75 mm |
| Main shaft: Bright steel round rod | No. of grooves: 8 |
| Machine bed: Mild Steel 'C' channel | Material: Cast Iron |
| Length: 1600 mm | Weight: 6 kg |
| Width: 500 mm | BEARINGS |
| Height: 1165 mm (excluding motor) | Type N 6312 & N 6311 |

Biomass-fired Die-heating Stove

Electric coil heaters are generally used for heating the die, and account for about a quarter of the total electricity consumption during the briquetting process. Since electricity is high-grade energy, alternates were explored to replace the electric heaters. Accordingly, a biomass-fired stove was designed and developed (Figure 1.2).

The stove is made of mild steel (1.5 mm sheet), with a combustion chamber of size 20 cm x 35 cm x 40 cm (w x b x h); the flue gas from the stove passes through either the biomass pre-heater or a 2 m long chimney attached to it at the top and is finally exhausted to the atmosphere. The die of the briquetting machine passes through the combustion chamber, exposing its outer surface to the flames inside the chamber.

The combustion chamber is insulated with a 30 mm refractory lining at its inner surface. Doors are provided for loading fuel and removing ash. An ash scraper is fixed below the grate of the stove to remove ash from the combustion chamber through the openings in-between the rods of the grate.

Two steel baffles are fixed just above the die, to converge the flames towards the die surface. They are insulated at both sides using refractory cement. The baffles serve to improve heat transfer from the flames to the die considerably.

Fuel (briquette pieces) is loaded through the side doors upto the bottom level of the die and ignited using some wood chips and kerosene. When the die temperature reaches 350°C, the briquetting machine is started. During production, the temperature drops to 320-330°C; this temperature level can be maintained by adding fuel periodically (nearly every 5 minutes) to the stove. Primary air for combustion is taken through the ash pit door, which is kept partially open during operation. Secondary air is taken through the fuel doors, which are also kept open partially.

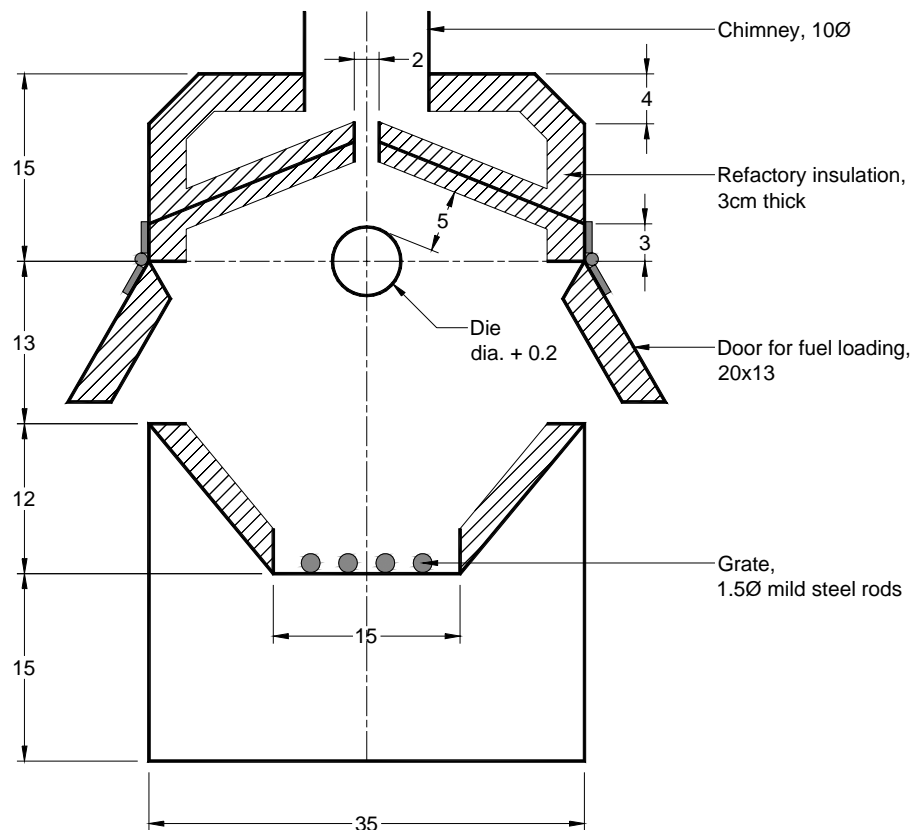


Figure 1.2: Die-heating stove for briquetting machine

Good quality briquette is obtained at a die temperature of around 320°C. Briquettes can be produced with die temperature as low as 250°C; the color of briquette surface changes from black at higher temperatures to gray at lower temperatures. It takes

around 35 minutes to bring the die temperature to 350°C, after which briquetting could be started. The die temperature may sometime go out of control, irrespective of primary air supply control. This is normally due to blockage of fuel flow inside the stove; the ash scraper should be operated at regular intervals (once in 15-20 minutes) to avoid this problem.

Smoke Removal System

Smoke generated during briquetting may pose a health risk to the machine operators. It is therefore desirable to incorporate a system that eliminates or reduces smoke generation during the briquetting process; a smoke removal system was designed and developed for this purpose.

The system has three main components: (i) a smoke collection box, (ii) a suction line connecting the primary air supply port of the biomass stove to the smoke collection box at the top, and (iii) another suction line which connects the exhaust of the die-heating stove to the biomass pre-heater. The schematic diagram of the system is given in Figure 1.3.

Smoke produced from briquettes is collected in the box and combusted in the stove. The exhaust from the stove is used for pre-heating the biomass raw material; for this purpose, unburned gases, along with the exhaust flue gas of the stove, are sucked through the biomass pre-heater using a suction blower, and exhausted through a chimney.

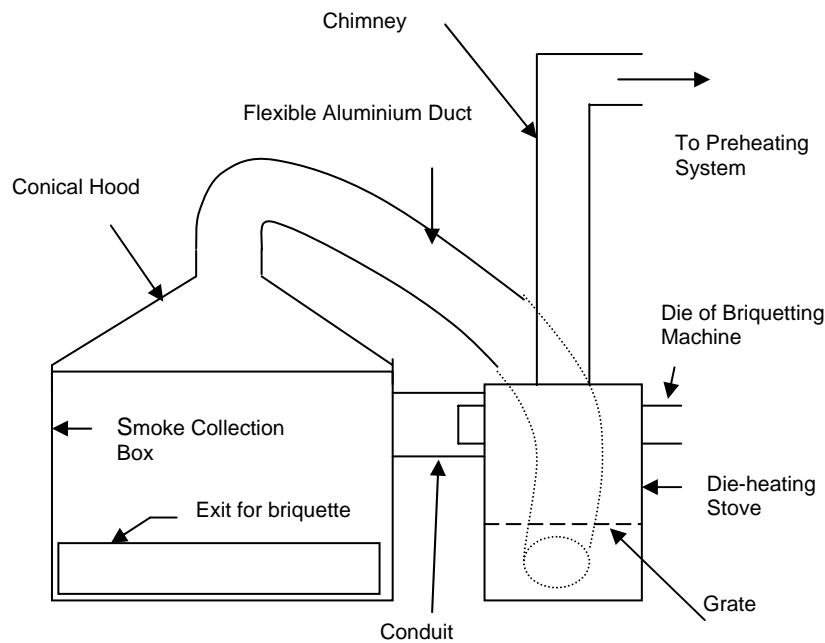


Figure 1.3: Schematic diagram of the smoke removal system

The smoke collection box is constructed of a mild steel sheet of 1.5 mm thickness. A circular conduit is fixed at one end of the box, through which briquette from the die of the briquetting machine enters the box. A deflector plate, which is rigidly fixed to

the metal box, serves to snap the briquette at the edge of the circular duct. Handles are provided on the metal box for easy handling.

A slider plate is provided below the path of the briquette so that the broken pieces of briquette slide over the plate and exit the box at the bottom. A conical cover (hood) is fixed to the box using a water-seal, which prevents smoke from escaping the joint.

It was found that the briquette entering the smoke collection box tended to bend sideways occasionally, thus affecting normal operation. Two guide plates, one located below, and the other above the level at which briquette enters the smoke collection box, and fixed along the path of the briquette, eliminate this problem. The top plate was perforated so as not to obstruct the flow of smoke upwards.

The exhaust from the smoke collection box is connected to a flexible aluminium duct, the other end of which is connected to the die-heater stove below its grate. The smoke thus enters the stove along with its primary air supply, and is burnt up in the stove.

A 150 W suction blower, fixed at the pre-heater exit, provides the required suction to overcome the resistance to the flow of flue gas through the pre-heater. The capacity of the blower is selected such that the airflow provided the required pre-heat temperature (110-120°C), while maintaining the die temperature at 300-320°C.

2.1.2 Operational Details

During operation, the die temperature should be maintained at 300-320°C by adjusting the fuel feeding to the stove. The pre-heat temperature normally fluctuates (in the range of 90-130°C), as there is no provision in the set-up to control it independently. It is felt that the benefit from such a system to independently control pre-heat temperature will not be economically justifiable.



Figure 1.4: The improved briquetting system in operation

It is found, from experimental results, that a pre-heat temperature of 110-120°C for a screw speed of 370 rpm is the optimum for minimising briquetting energy consumption. The moisture content of ricehusk should not exceed 7-8% for smooth operation of the machine.

Several experiments were carried out to evaluate the effect of raw material type on the performance of the integrated biomass briquetting system, consisting of the biomass pre-heater, die-heating stove and smoke removal system. Results indicate that considerably less energy is consumed when other raw materials are mixed with ricehusk (ricehusk and sawdust, at 1:1 ratio by volume) in comparison with pure ricehusk as raw material. Significant reduction in electrical energy consumption is realised with the introduction of a die-heating stove to replace the electrical coil heaters. Also, the smoke removal system improves the working environment at the briquetting plant, by significantly reducing the smoke level in the vicinity of the briquetting machine.

2.2 Institutional-type gasifier stove

A gasifier stove is essentially a small gasifier-gas burner system. The main advantage of a gasifier stove is the almost total elimination of smoke with this design. Considering that it is normally not possible to operate a blower in rural areas of most developing countries due to lack of electricity supply, a natural draft gasifier stove becomes a particularly interesting alternative.

An improved biomass-fired gasifier stove for institutional kitchens and traditional industries has been developed at the Asian Institute of Technology (AIT). This stove is suitable for community type cooking applications such as in schools, hospitals and hostels. It has two pots, of about 15 liters capacity each. Apart from rice husk briquettes, the gasifier stove can also use other fuels such as wood chips, wood twigs and coconut shells. The efficiency of this stove, estimated from water boiling tests, ranged 24-28% depending on the fuel used. The heating power of the stove is 4.7 kW.

Institutional type biomass gasifier stove, AIT



2.2.1 Design and Construction Details

The stove is basically a small natural draft cross-flow gasifier coupled to a gas burner. The primary air enters the hot fuel bed on one side, and the gas leaves it from the opposite side. The gasifier-gas burner component of the stove (Figure 2.1) consists of four main parts i.e. fuel chamber, reaction chamber, primary air inlet and combustion chamber; these parts are attached together by using bolts and nuts. Above the gas burner and connected with it, is a pot support on which the cooking pots are placed. Figure 2.2 illustrates the design details of the gasifier-gas burner component.

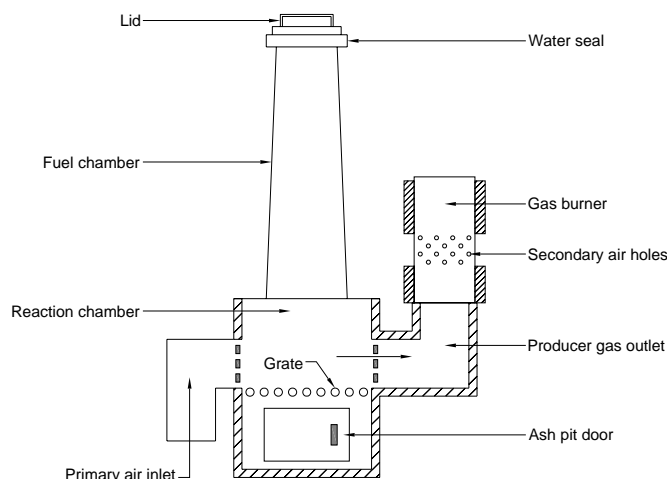


Figure 2.1: Schematic diagram of the gasifier stove

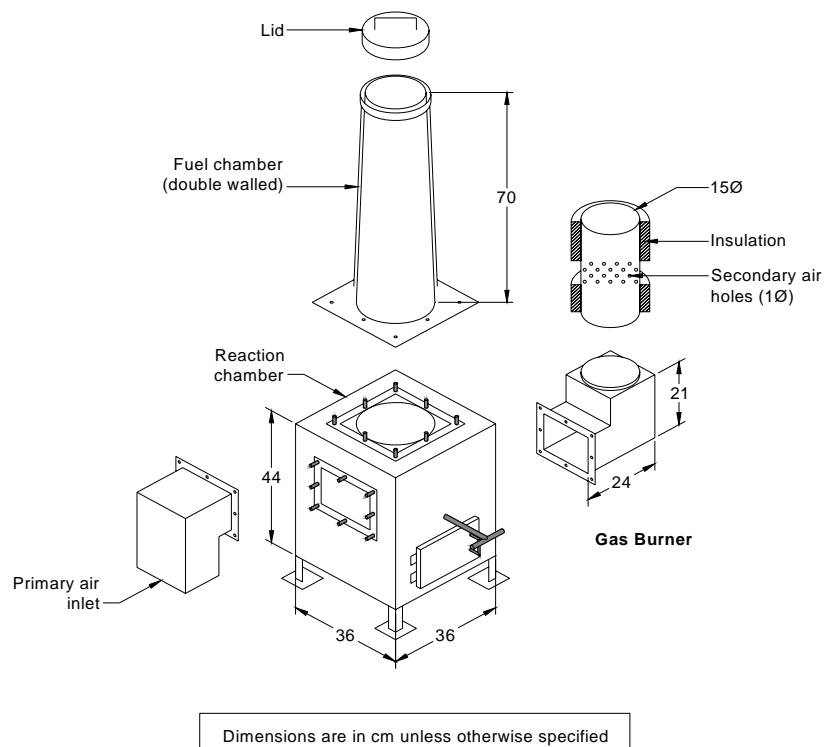
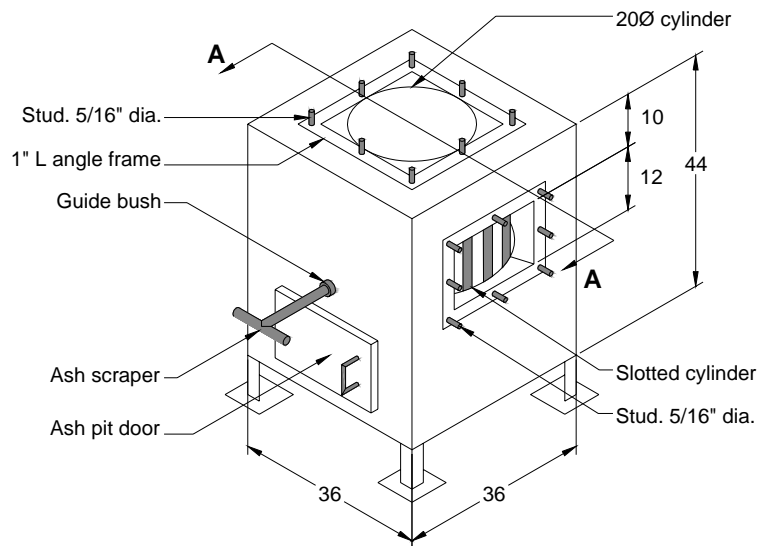


Figure 2.2: Exploded view of the gasifier stove

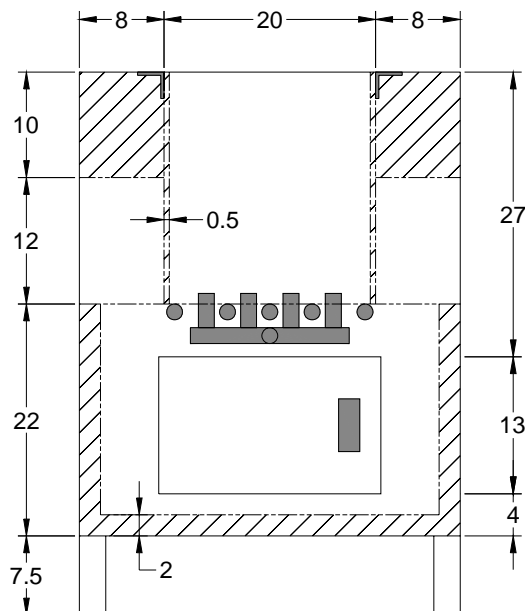
Reaction chamber

The reaction chamber is the heart of the stove where producer gas is generated. The outside wall of the chamber is made of 2 mm thick mild steel sheet, and fabricated over an L-angle frame of outside dimensions 36 x 36 x 44 cm. The inside wall is a slotted mild steel cylinder with a layer of bricks, cemented together by Castable-13 refractory cement placed in-between the two walls.



Dimensions are in cm unless otherwise specified

Figure 2.3: Isometric view of the reaction chamber



Dimensions are in cm unless otherwise specified

Figure 2.4: Top view and front view of reaction chamber

A 5 mm thick mild steel cylinder (Figure 2.5), with an open top and a grate welded to its base, is fixed inside the reaction chamber. The cylinder has slots for air inlet and gas outlet, through which primary air enters into the reaction chamber at one side, and the producer gas exits the reaction chamber at the other side. The slots, six at each side, are provided as illustrated in Figure 2.5.

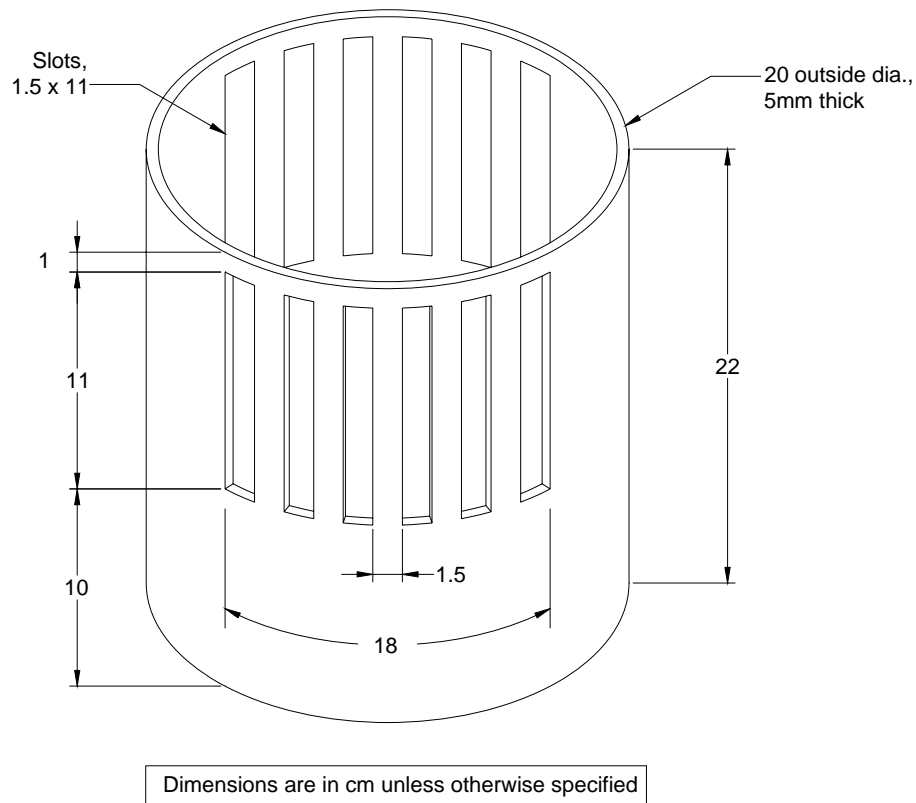


Figure 2.5: Slotted cylinder (shown upside down)

The grate welded to the base of the slotted cylinder (Figure 2.6) is made of mild steel round rods of 15 mm diameter, and allows ash to fall through it into the ash pit. An ash scraper (Figure 2.7) is fixed below the grate, to remove ash accumulated inside the reaction chamber.

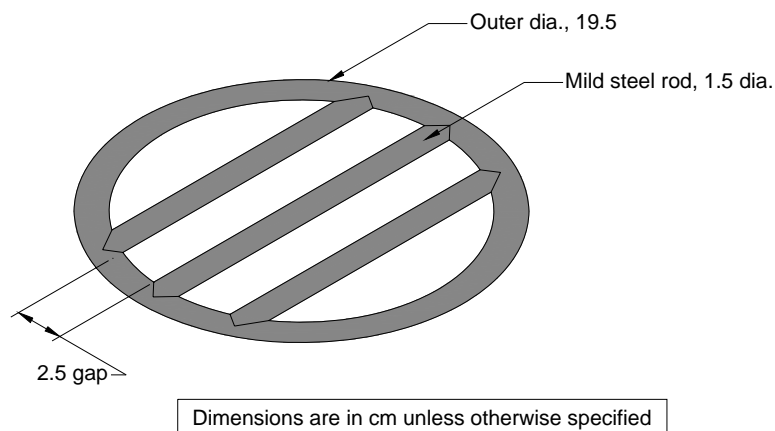
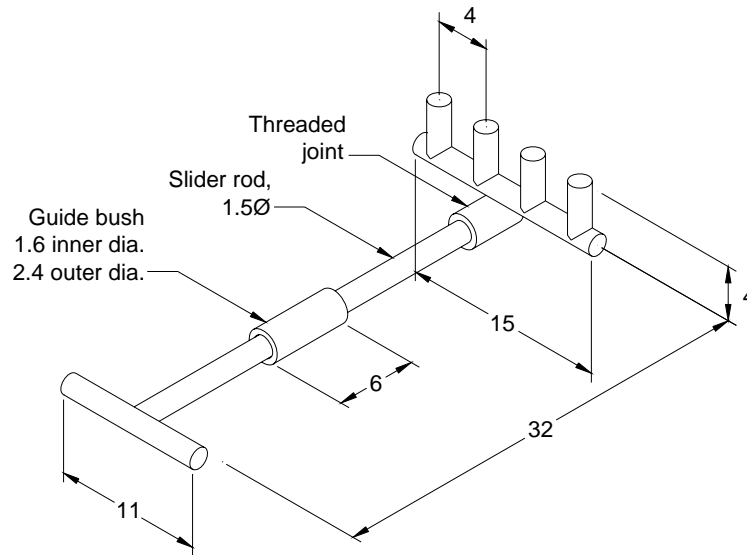


Figure 2.6: Mild steel grate welded to the base of the perforated cylinder

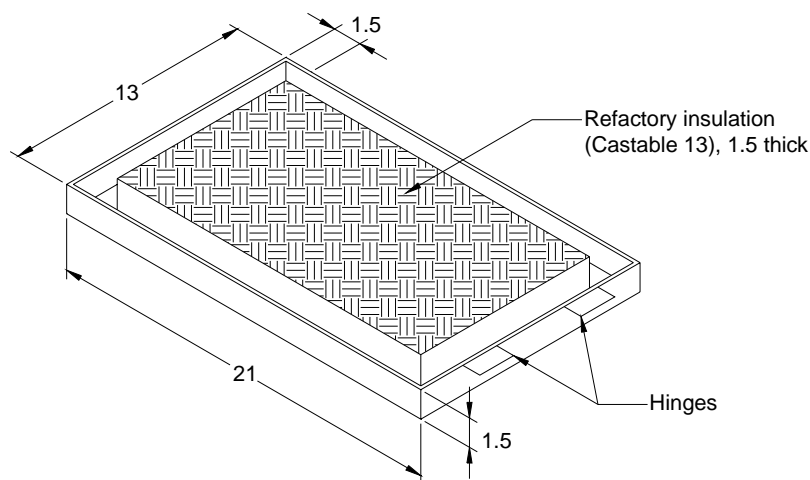
The ash scraper slides through a cylindrical guide bush, which is welded to the body of the reaction chamber. For easy assembling, the slider rod is connected to the 'fingers' of the scraper by a threaded joint. The ash scraper is operated by sliding it in and out horizontally, generally once in 10-20 minutes, depending on the ash content of the fuel. It is especially useful while using fuels of high ash content, such as ricehusk briquettes, since ash could otherwise block the flow of fresh fuel from the fuel chamber into the reaction chamber.



Dimensions are in cm unless otherwise specified

Figure 2.7: Ash scraper with guide bush

The reaction chamber is provided with a mild steel door below the grate level in order to access the ash pit. The door, made of 2 mm thick mild steel sheet, is fixed to the reaction chamber body using two hinges.



Dimensions are in cm unless otherwise specified

Figure 2.8: Inside view of ash pit door

A handle is welded to the door for easy opening and closing. The door is insulated with a refractory cement (Castable 13) layer of 1.5 cm thickness (Figure 2.8). The ash accumulated in the ash pit is periodically removed by opening this door. The door is also used for igniting the stove, by introducing a flame torch from below the grate supporting the fuel bed inside the reaction chamber.

Fuel chamber

The fuel chamber (Figure 2.9) is made of 2 mm thick mild steel sheet and is located above the reaction chamber. Fuel from the fuel chamber flows into the reaction chamber by gravity. The chamber is designed to be conical in shape, to avoid ‘fuel bridging’ inside the chamber, and to facilitate easy flow of fuel. The top end of the chamber has a water seal and a cup-type lid for easy loading of fuel; the water seal also prevents gas/smoke leakage from the top of the fuel chamber during operation. The fuel chamber has a flange attached at its bottom for the purpose of connecting it to the reaction chamber.

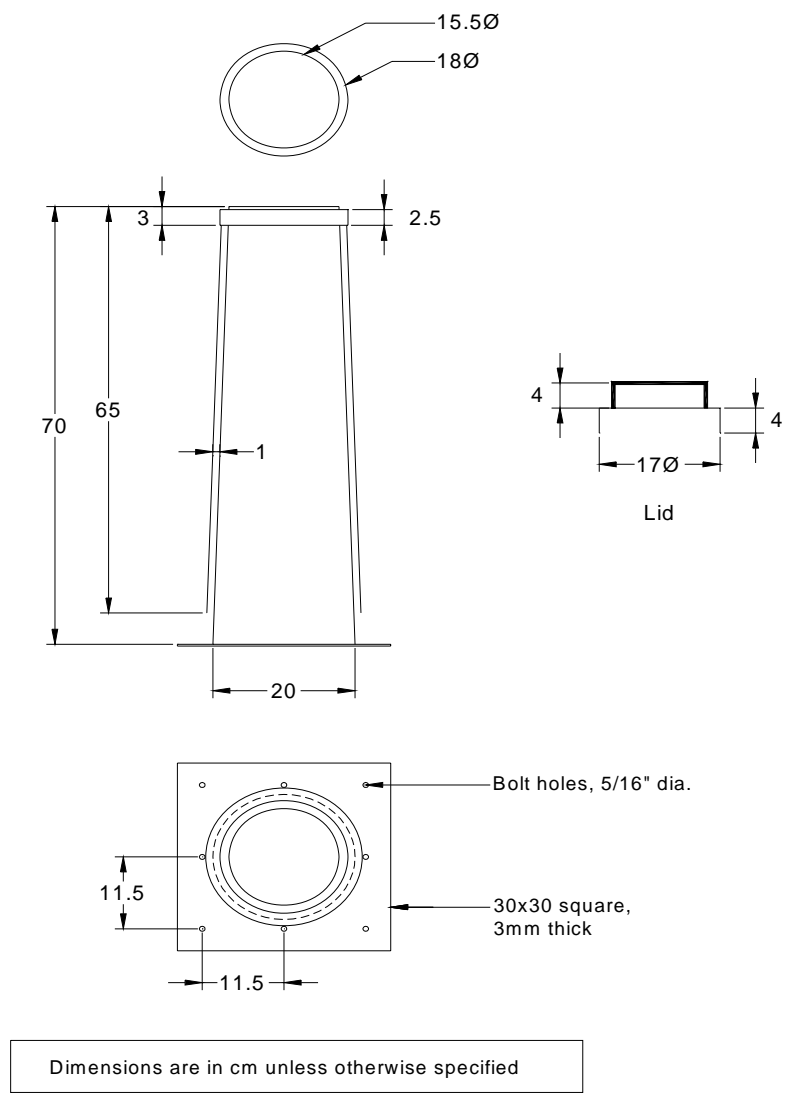


Figure 2.9: Fuel chamber

Primary air inlet

The primary air inlet (Figure 2.10) is made of 2 mm thick mild steel sheet, and is attached on one side of the reaction chamber. A sliding door provided at the bottom of the primary air inlet can be used to control the gasification rate inside the reaction chamber by controlling the primary air flow.

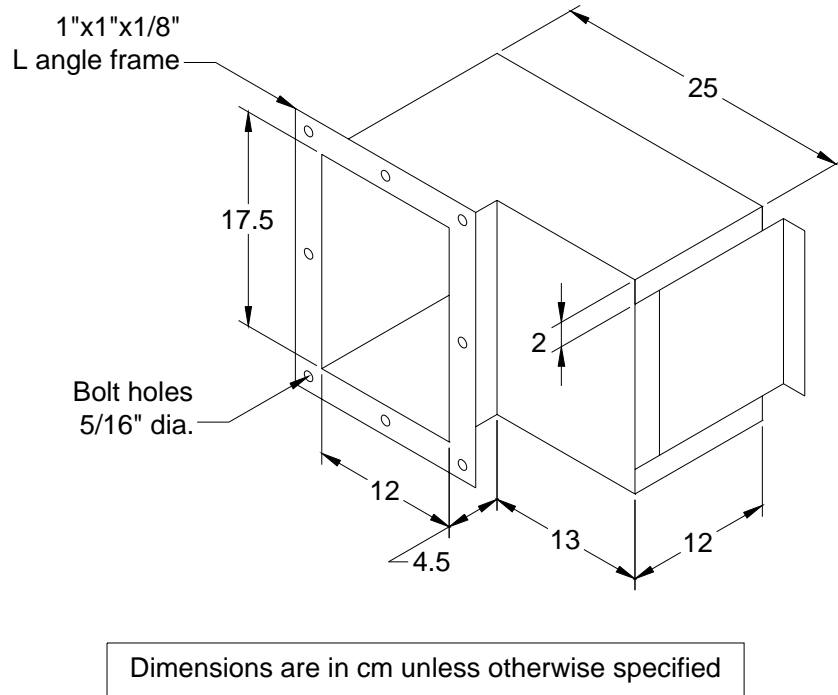


Figure 2.10: Isometric view of primary air inlet manifold

Gas Burner

The gas burner has two parts: the support at the bottom or Gas Burner Base (Figures 2.11 and 2.12), and the burner pipe (Figure 2.13) which is fitted over the Base. The burner pipe has forty-four holes of diameter 10 mm drilled on it in four rows, through which secondary air flows in, for combustion of the producer gas.

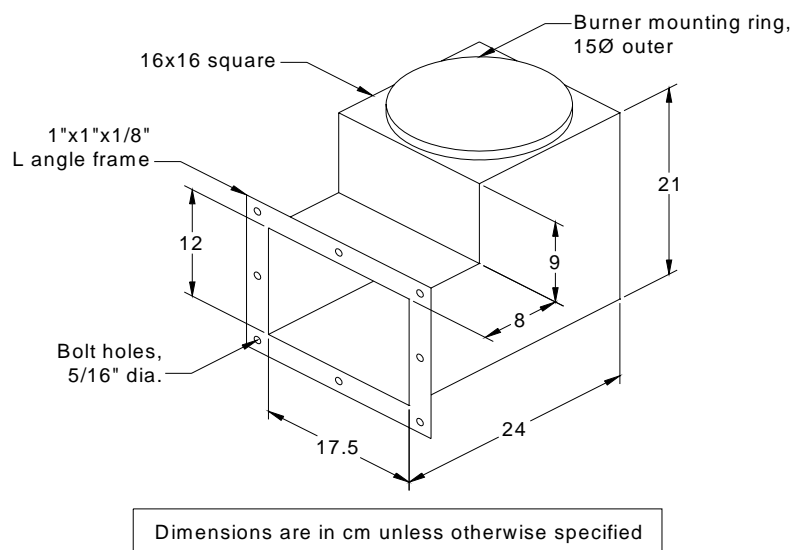


Figure 2.11: Isometric view of gas burner base

To reduce heat losses, the surfaces above and below the secondary air holes are insulated with rockwool and clad with a 1 mm thick galvanized iron (GI) sheet. The top 1 cm of the burner pipe is left uninsulated so that it can fit into the pot support which will be placed over it.

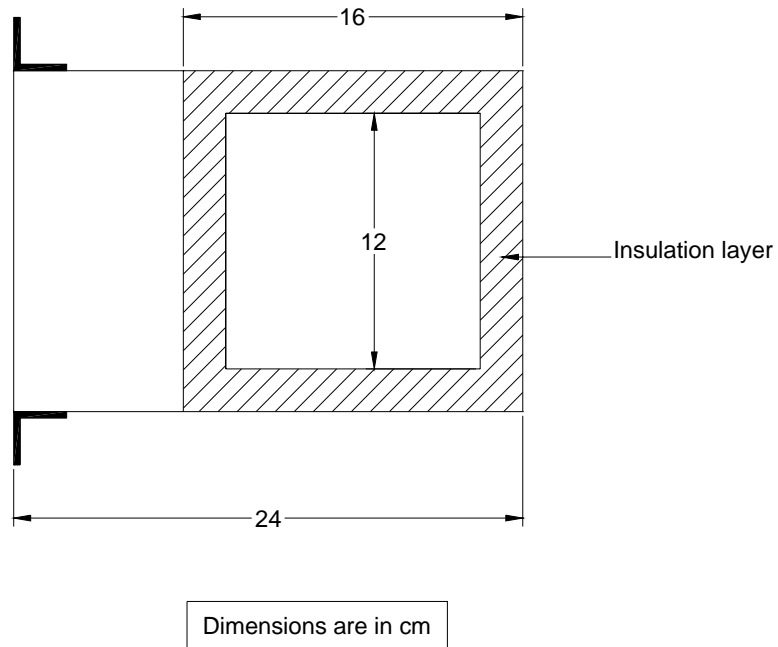


Figure 2.12: Cross section of the burner base

The entire inner surface of the gas burner base is insulated with a 2 cm layer of refractory cement (Castable 13). The insulation reduces heat loss from the gas leaving the reaction chamber before it is burnt in the gas burner.

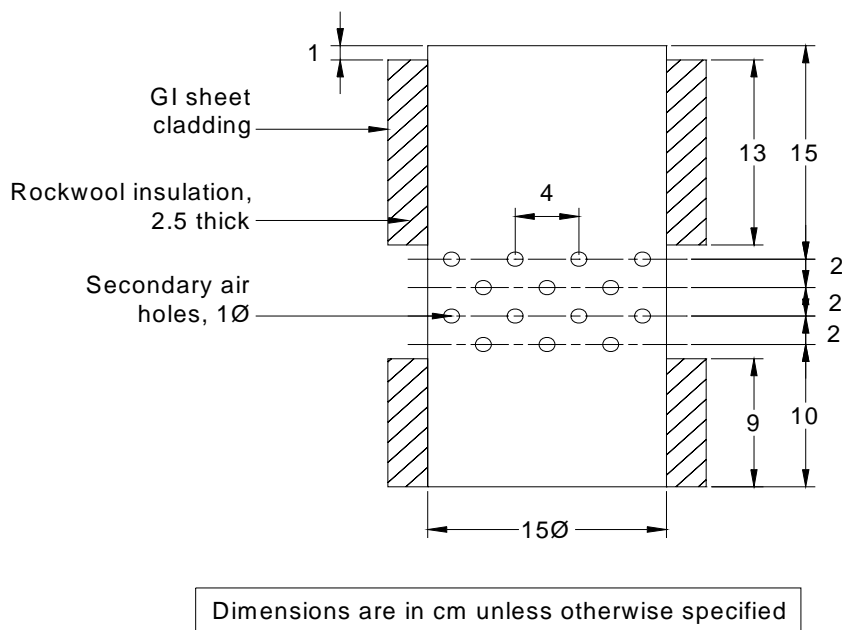


Figure 2.13: Sectional view of the gas burner

Asbestos gaskets are used while assembling the individual components together. Three gaskets, of size 30 cmx30 cm, 23.5 cmx17.5 cm and 23 cmx17 cm (outer dimensions), are used for connecting the fuel chamber, primary air inlet, and the gas burner respectively to the reaction chamber. A fourth gasket, of size 26 cmx26 cm is used to connect the two parts of the gas burner together.

2.2.2 Pot Support

The pot support is designed to hold two pots of 32 cm diameter each. The pot support allows the flue gas from the gas burner to come in contact with the two pots, which project to a depth of 22 cm into its passage on way to the chimney, the position of the first pot being directly above the combustion chamber. The pot support is made of 2 mm thick mild steel sheet and insulated with a 2 cm layer of Castable 13 refractory cement. A 110 cm high mild steel chimney is attached to the pot support at exit of the flue gas from the second pot. To reduce heat losses from the chimney, its outer surface is insulated with a 2.5 cm thick layer of fiberglass wool and clad with aluminium sheet. A piece of GI pipe or mild steel 'L' angle leg is attached to the pot support below the position of the second pot for stability. Design details of the pot support are presented in Figure 2.14.

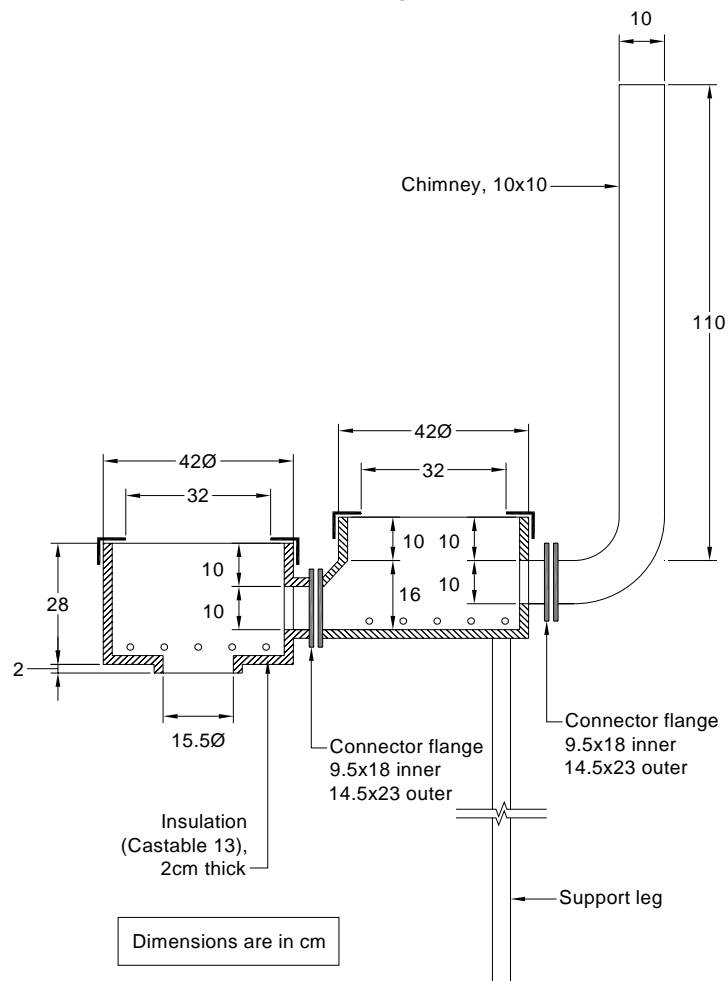


Figure 2.14: Detailed dimensions of the pot support

Operational Details

Fuel and Fuel Characteristics

IGS2 is reasonably versatile in terms of the types of fuels it can handle. A number of fuels were tested and found to be suitable for the gasifier stove. These include ricehusk and saw dust briquettes, wood chips, wood twigs and coconut shells. The fuel should be sized before loading into the fuel chamber. Figure 2.15 illustrates the types of fuels and the average size of fuel pieces that can be used in the stove, which is in the range of 1-1 ½ inch.



(i) Ricehusk briquettes



(ii) Wood chips



(iii) Coconut shells

Figure 2.15: Fuels used in the gasifier stove

Stove ignition

Fuel is first loaded in the fuel hopper and the lid is closed. Water is filled in the water seal. The fuel is then ignited from below the grate using a flame torch introduced through the ash pit door.

About five minutes later, the torch is removed and the ash pit door is closed. The stove warms up slowly, and it takes about 20 minutes to generate combustible gas at the gas burner side. The gas is then ignited in the gas burner by introducing a flame through the secondary air holes in the burner.

Once the gas gets ignited, its flow becomes smooth. Figure 2.16 shows the stove in operation. The stove can operate continuously until the fuel in the fuel chamber is used up. Additional fuel can be loaded through the top of the fuel chamber to further extend its operation.

The ash scraper should be operated occasionally, to remove the ash accumulated inside the reaction chamber. This allows flow of fresh fuel from the fuel chamber into the reaction chamber.



Figure 2.16: Combustion in the gas burner

Stove efficiency

Water-boiling tests were conducted to measure the efficiency of the gasifier stove. A known quantity of water was taken in both the pots, which were then placed on the gasifier stove. The quantity of fuel consumed and the amount of water evaporated during a test run were used to calculate the efficiency.



Figure 2.17: Fully assembled gasifier stove IGS2, with pot support

The highest efficiency of the gasifier stove (28%) was obtained with wood as fuel. The flame of the stove was normally steady and smoke free.

2.3 Commercial-type biomass gasifier stove

This stove was designed to cater to the needs of small restaurants, food outlets and similar commercial establishments where the cooking demand is somewhat larger. With three pots, each of 20 liters capacity, the stove offered a higher water boiling efficiency than the institutional type stove, at about 30%. While the first two pots immediately after the burner can be used for cooking, the third pot can be used for simmering. Fuels such as rice husk briquettes, wood chips, wood twigs and coconut shells can be used with this stove. The heating capacity of the stove is 8.4 kW.



Commercial type biomass gasifier stove, AIT

2.3.1 Design and Construction Details

The stove (Figure 3.1) is basically a small natural draft cross-flow gasifier coupled to a gas burner. The primary air enters into the hot fuel bed of the stove from one side, and the gas leaves it at the opposite side. It consists of five main parts i.e. fuel chamber, reaction chamber, primary air inlet, combustion chamber, and pot support.

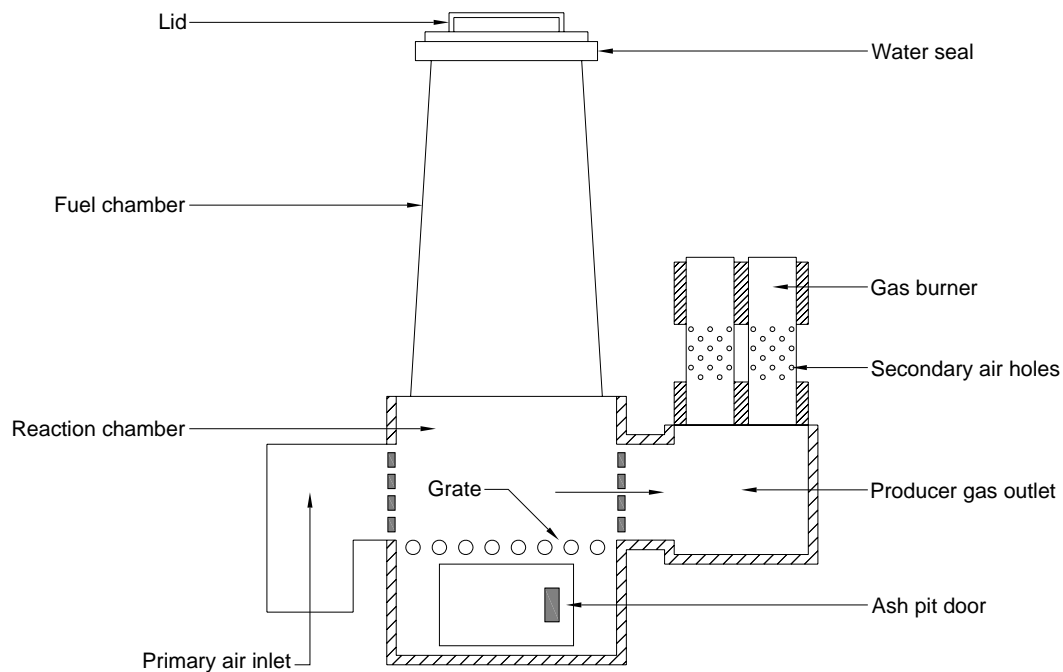


Figure 3.1: Schematic diagram of the Commercial Gasifier Stove CGS

The design details and engineering drawings of the various components of the stove are presented in Figures 3.2-3.7.

Reaction chamber

The reaction chamber (Figure 3.3) is the key component of the stove where producer gas is generated. The outside wall of the chamber is made of 2 mm thick mild steel sheet, fabricated over an L-angle frame of outside dimensions 56 cm x 56 cm x 56 cm. The inside wall is made of a layer of bricks, cemented together by Castable-13 refractory cement. Two pre-cast cylindrical segments are fixed at air inlet and gas outlet to and from the reaction chamber respectively. A square frame of size 56 cm x 56 cm (outer dimensions), made of 1" mild steel L-angle, is embedded into the refractory cement at the top. Twelve studs of diameter 5/16" are welded to the square frame as shown in Figure 3.3, for mounting the fuel chamber.

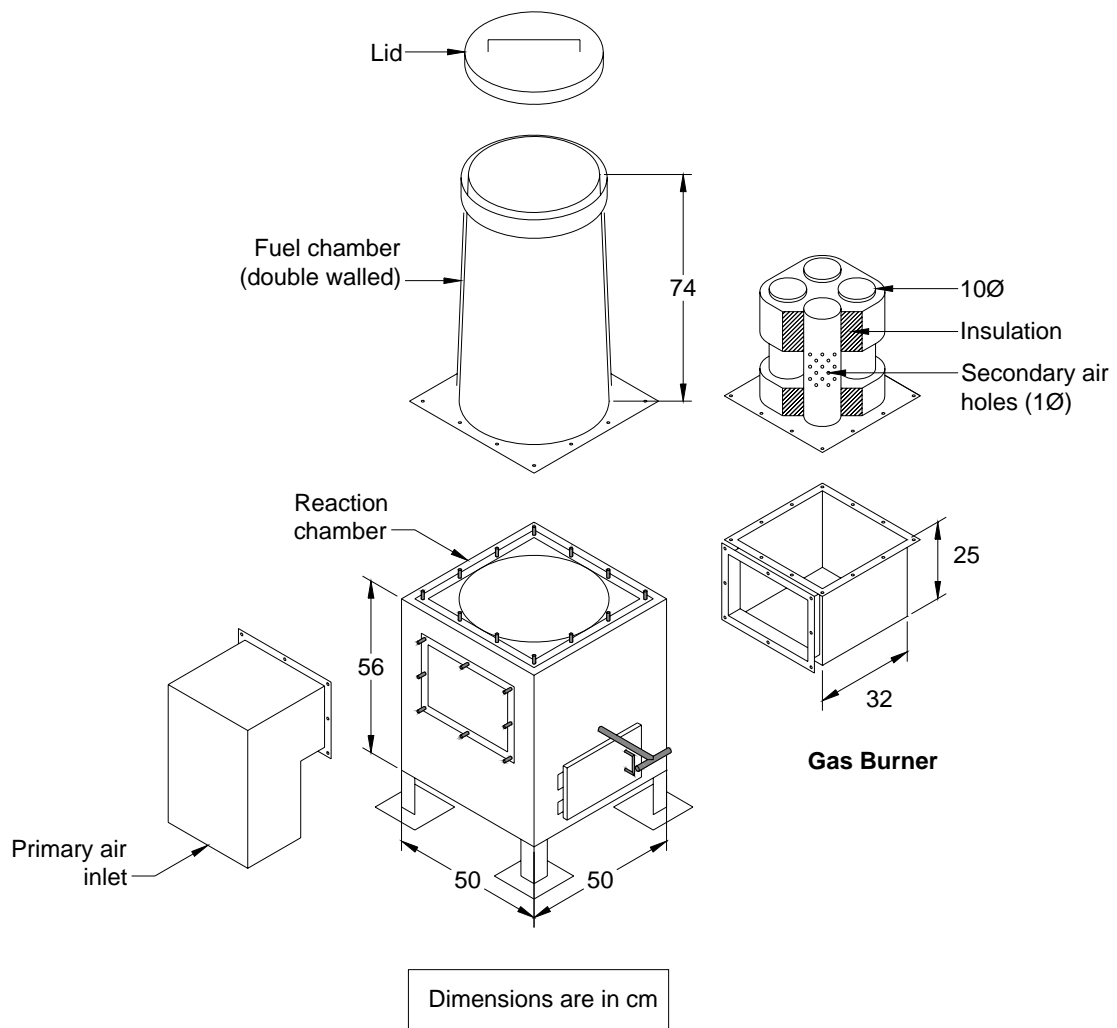


Figure 3.2: Exploded view of the CGS

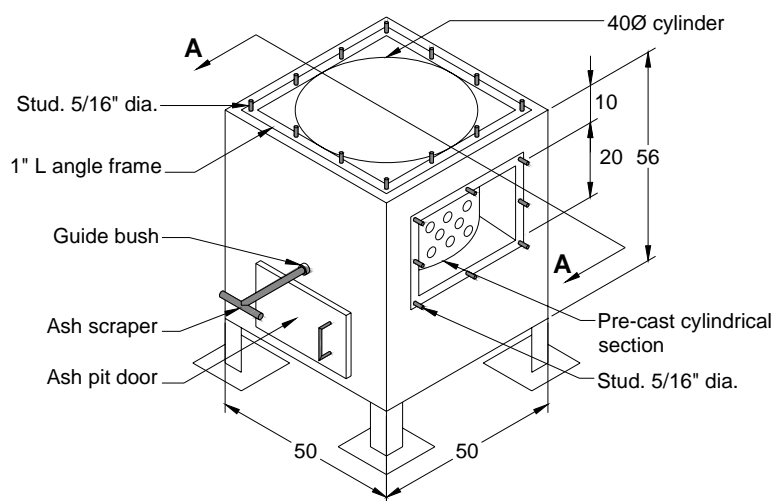


Figure 3.3: Top view of reaction chamber

The cylindrical segments are cast on a mild steel mold; Figure 3.6 illustrates the design of the mold. Five cm long pieces of PVC pipes of diameter $\frac{3}{4}$ " were used as core for the 51 holes in each cylindrical segment.

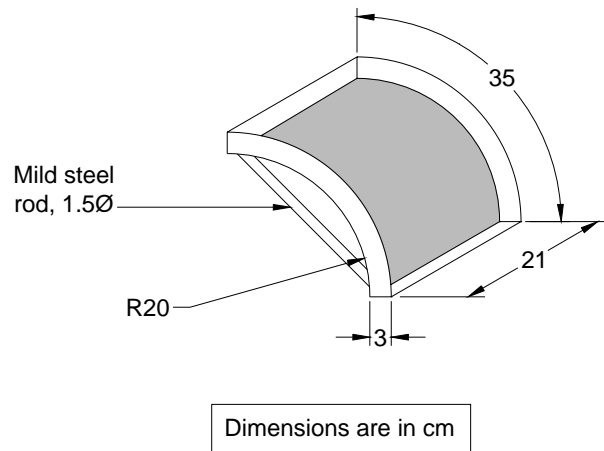


Figure 3.6: Sheet metal mold used to cast the cylindrical sections

A mild steel grate is fixed just below the bottom edge of the inlet and outlet sections. The grate (Figure 3.7) is made of mild steel round rods of 15 mm diameter, and supported on four legs, also made of 15 mm mild steel round rods. Ash falls through the grate into the ash pit. An ash scraper (Figure 3.8) is fixed below the grate to remove ash accumulated inside the reaction chamber. Ash scraper is especially useful while using fuels of high ash content, such as ricehusk briquettes. Removal of ash from inside the reaction chamber is necessary to allow the flow of fresh fuel from the fuel chamber into the reaction chamber.

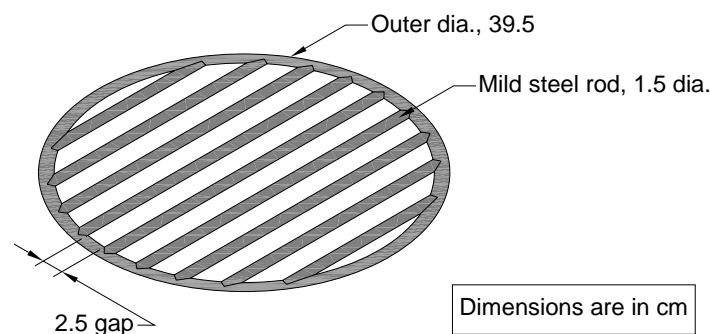


Figure 3.7: Mild steel grate

The ash scraper slides through a cylindrical guide bush, which is welded to the body of the reaction chamber. For easy assembling, the slider rod is connected to the ‘fingers’ of the scraper by a threaded joint. The ash scraper is operated by sliding it in and out horizontally, generally once in 10-20 minutes, depending on the ash content in the fuel.

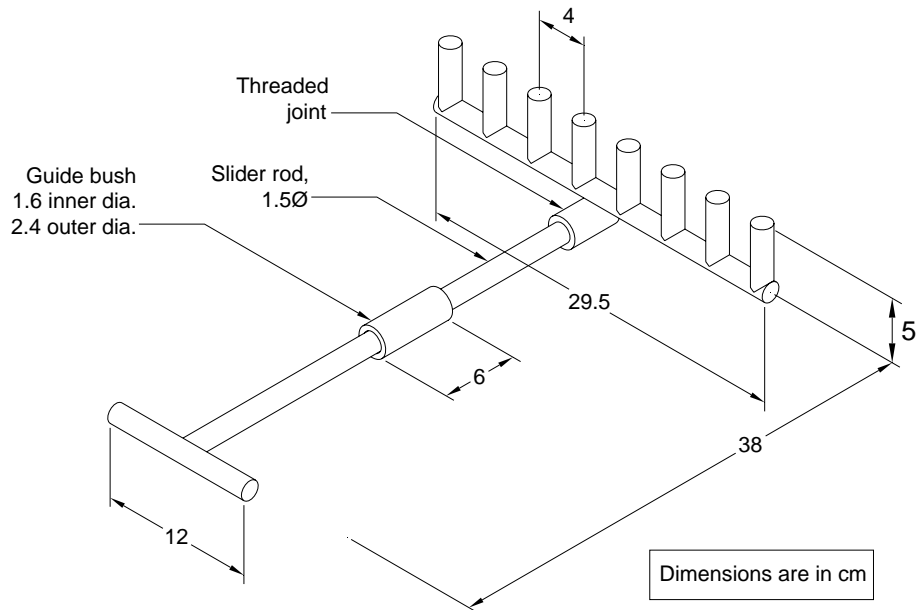


Figure 3.8: Ash scraper of 15 mm dia. mild steel rod with support bush

A mild steel door is provided below the grate level in the reaction chamber, in order to access the ash pit. The door, made of 2 mm thick mild steel sheet, is fixed to the reaction chamber body using two hinges. A handle is welded to the door for easy opening and closing. The door is insulated with a refractory cement (Castable 13) layer of 1.5 cm thickness (Figure 3.9). The ash accumulated in the ash pit is periodically removed by opening this door. The door is also used while igniting the stove, by introducing a flame torch from below the grate, which supports the bed of fuel inside the reaction chamber.

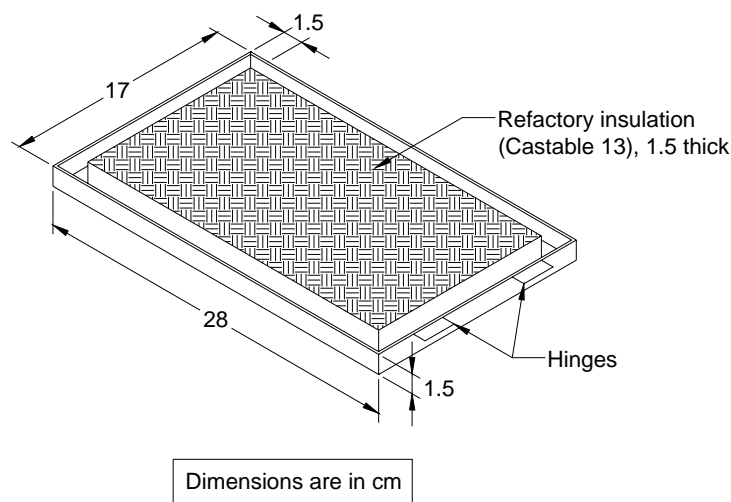


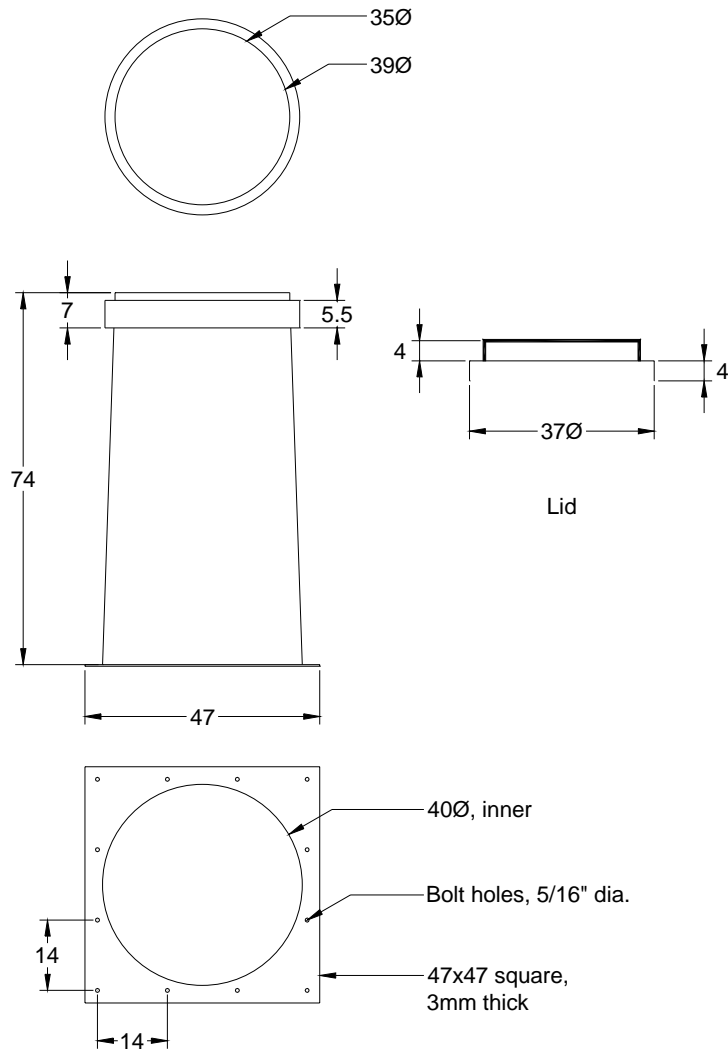
Figure 3.9: Ash pit door (inside view)

Fuel chamber

The fuel chamber (Figure 3.10) is made of 2 mm thick mild steel sheet and is located above the reaction chamber. Fuel from the fuel chamber flows into the reaction chamber by gravity. The chamber is designed to be conical in shape, to avoid 'fuel

bridging' inside the chamber, and to facilitate easy flow of fuel. The top end of the chamber has a water seal and a cup-type lid for easy loading of fuel; the water seal also prevents gas leakage from the joint during operation.

The fuel chamber has a flange attached at its bottom, to be connected to the reaction chamber.



Dimensions are in cm unless otherwise specified

Figure 3.10: Fuel chamber

Primary air inlet:

The primary air inlet (Figure 3.11) is made of 2 mm thick mild steel sheet, and is attached on one side of the reaction chamber. A sliding door provided at the bottom of the primary air inlet can be used to control the gasification rate inside the reaction chamber by controlling the flow of primary air.

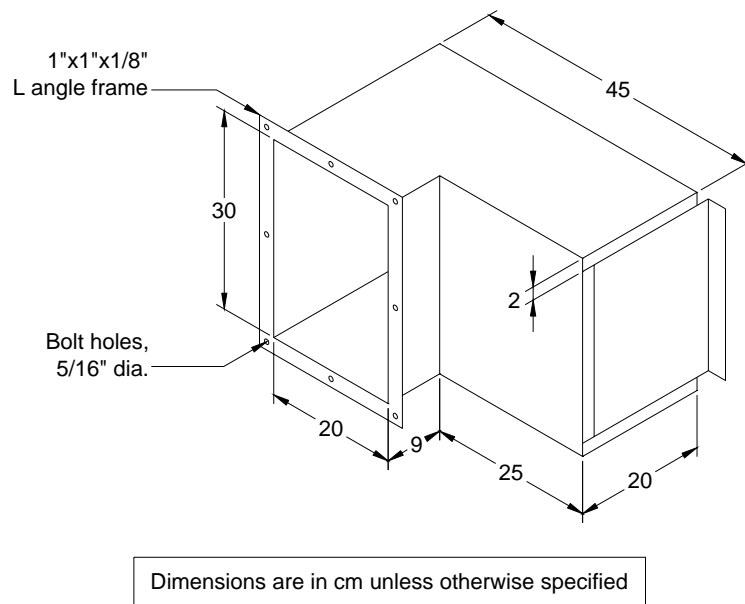


Figure 3.11: Isometric view of primary air inlet manifold

Gas Burner

The gas burner has two parts: the support at the bottom or Gas Burner Base (Figures 3.12 – 3.13), and a gas burner section consisting of four burner pipes (Figure 3.13) which are fitted over the base. Each of the four burner pipes has forty-four holes of diameter 10 mm drilled on it in six rows, through which secondary air flows in, for combustion of the producer gas.

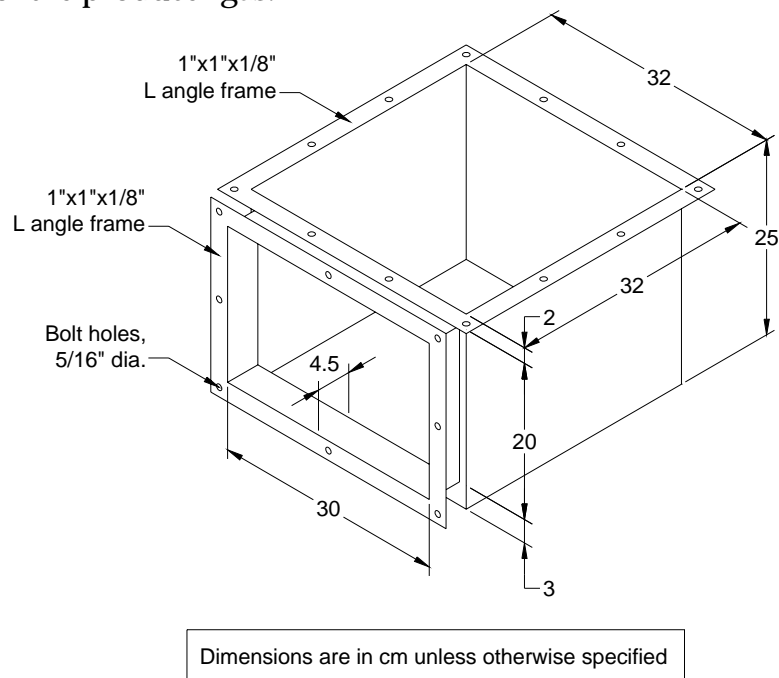
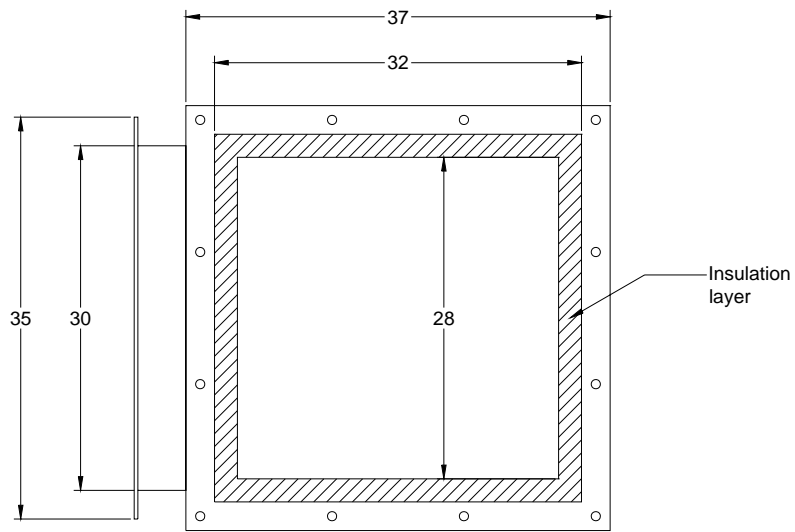


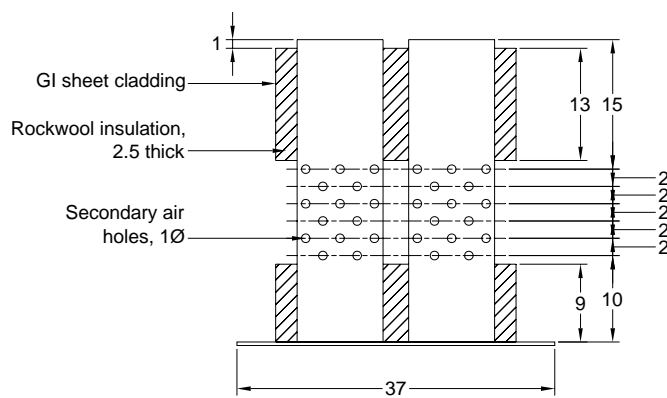
Figure 3.12: Isometric view of the gas burner base

To reduce heat losses, the surfaces above and below the secondary air holes are insulated with rockwool and clad with 1 mm thick GI sheet. The top 1 cm of the burner pipe is left uninsulated so that it can fit into the pot support, which will be placed over it.



Dimensions are in cm

Figure 3.13: Top view of the gas burner base



Dimensions are in cm

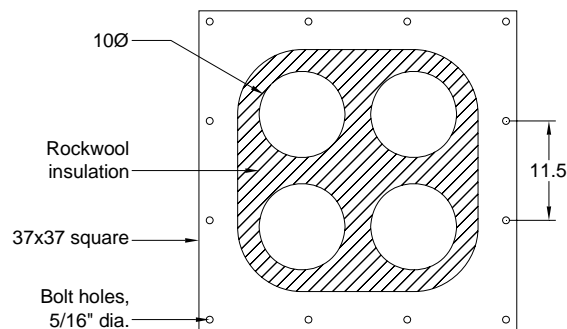


Figure 3.14: Sectional side view and top view of the gas burner

The gas burner base is insulated with a 2 cm layer of refractory cement (Castable 13) on its entire inner surface (Figure 3.13). The insulation reduces heat loss from the gas leaving the reaction chamber before it is burnt in the gas burner.

Asbestos gaskets are used while assembling the individual components together. Three gaskets, of size 47 cm x 47 cm, 35 cm x 25 cm and 35 cm x 25 cm (outer dimensions), are used for connecting the fuel chamber, primary air inlet and the gas burner respectively, to the reaction chamber. A fourth gasket, of size 37 cm x 37 cm is used to connect the two parts of the gas burner together.

2.3.2 Pot Support

The pot support is designed to hold three pots of 36 cm diameter each. The pot support allows the flue gas from the gas burner to come in contact with the pots, which project to a depth of 26 cm into its passage on way to the chimney, the position of the first pot being directly above the combustion chamber. The pot support is made of 2 mm thick mild steel sheet and insulated with a 2 cm layer of Castable 13 refractory cement. A 110 cm high mild steel chimney is attached to the pot support at exit of the flue gas from the third pot. To reduce heat losses from the chimney, its outer surface is insulated with a 2.5 cm thick layer of fiberglass wool and clad with aluminium sheet.

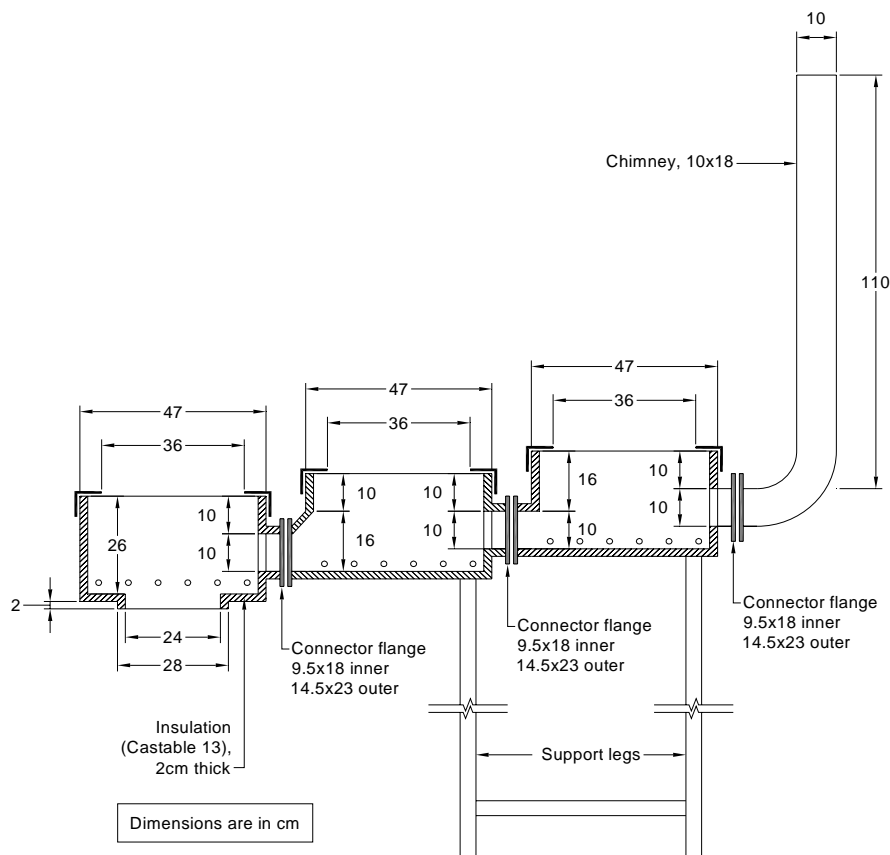


Figure 3.15: Detailed dimensions of the pot support

The pot support is provided with two GI pipe or mild steel 'L' angle legs below the position of the second pot for stability. It has a third leg below the third pot position. Design details of pot support are presented in Figure 3.15.



Figure 3.16: Fully assembled gasifier stove CGS3 with three-pot support.

2.3.3 Operational Details

Fuel and Fuel Characteristics

CGS3 is reasonably versatile in terms of the types of fuels it can handle. It can be operated using ricehusk/saw dust briquettes, wood chips, wood twigs or coconut shells. Sized fuels are generally preferred to avoid fuel flow problems.

Stove ignition

Fuel is first loaded in the fuel hopper, the lid is then closed and the water seal is filled with water. The fuel is then ignited from below the grate using a flame torch through the ash pit door.

About five minutes later, the torch is removed and the ash pit door is closed. The stove warms up slowly, and it takes about 20 minutes to generate combustible gas at the gas burner side. The gas is then ignited in the gas burner by introducing a flame through the secondary air holes in the burner.

Once the gas gets ignited, its flow becomes smooth. The stove can operate continuously until the fuel in the fuel chamber is used up. Additional fuel can be loaded through the top of the fuel chamber to further extend its operation.

Efficiency Tests

Water-boiling tests were conducted to measure the efficiency of the gasifier stove. Known quantities of water were taken in all the three pots, which were then placed on the gasifier stove. The total quantity of water evaporated and the total quantity of fuel consumed during a test run were measured to calculate the efficiency. The lower calorific value of the fuel is used in the efficiency calculation. Highest efficiency of the stove (31.8%) was obtained using wood as fuel.

2.4 Domestic-type biomass gasifier stove

The domestic-type gasifier stove is similar in construction to the other models, but down-sized. With 3.6 kW heating power, the stove can be used for the daily cooking needs. The stove gives a water boiling efficiency of about 22%.



Domestic type biomass gasifier stove, AIT

2.4.1 Design and Construction Details

The gasifier-gas burner component of the stove (Figure 4.1) consists of four main parts i.e. fuel chamber, reaction chamber, primary air inlet and combustion chamber; these parts are attached together using bolts and nuts. Above the gas burner and connected with it, is a pot support on which the cooking pots are placed.

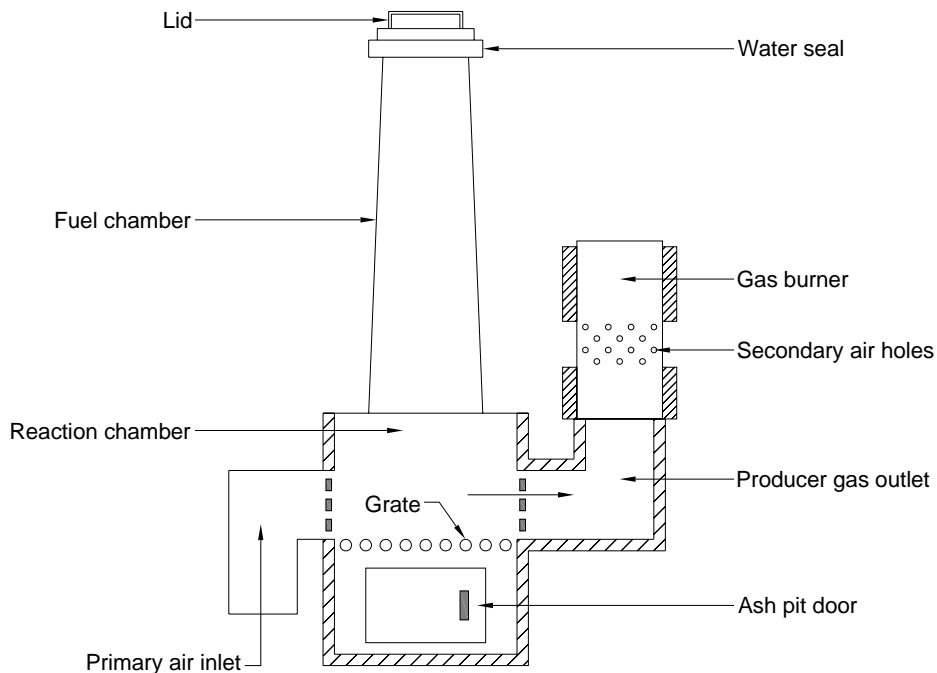
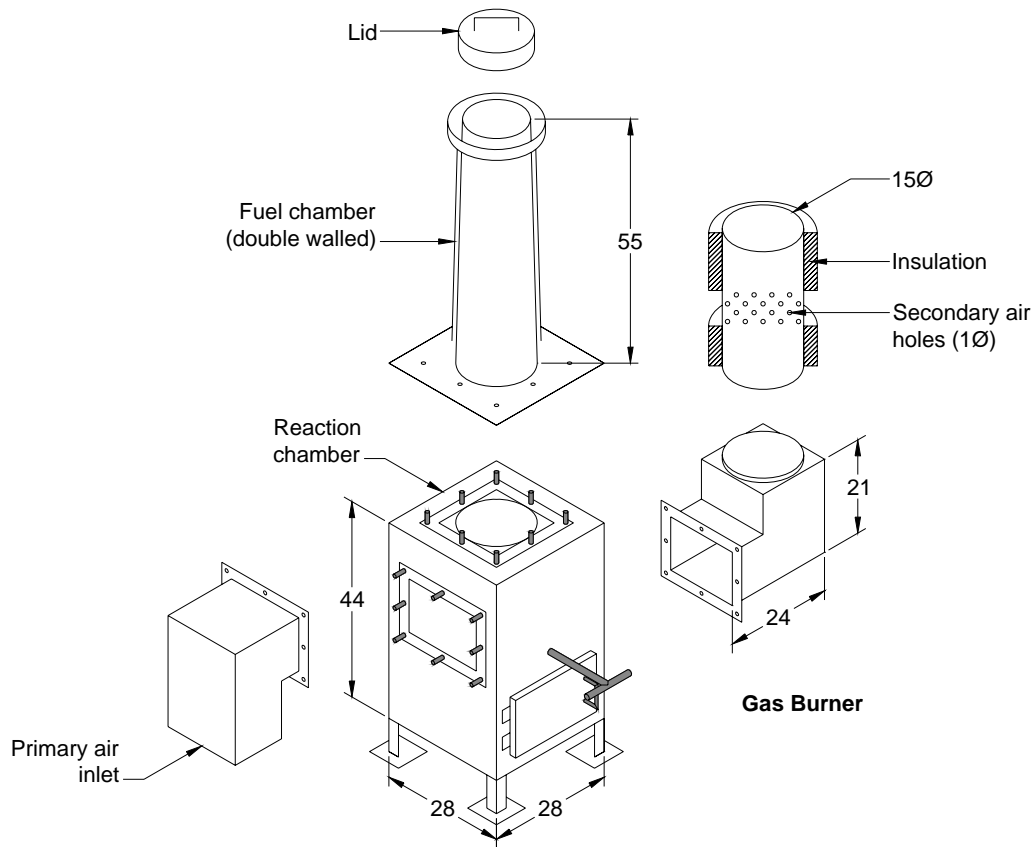


Figure 4.1: Schematic diagram of the domestic gasifier stove DGS2

The design details and engineering drawings of the various components of the stove are presented in figures 4.2 to 4.13.

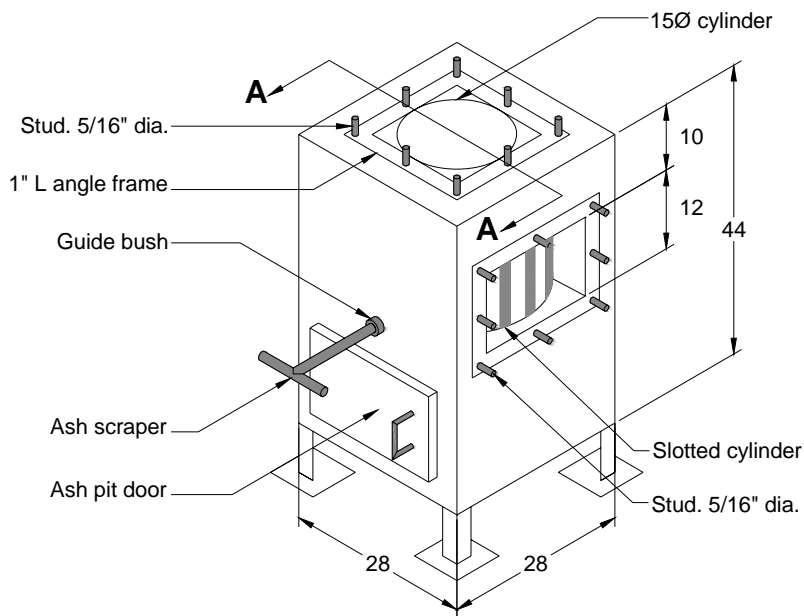
Reaction chamber

The reaction chamber is the key component of the stove where producer gas is produced. The outside wall of the chamber is made of 2 mm thick mild steel sheet, and fabricated over a L-angle frame of outside dimensions 28 cm x 28 cm x 44 cm. The inside wall is a perforated mild steel cylinder with a layer of bricks, cemented together by Castable-13 refractory cement placed in-between the two walls.



Dimensions are in cm unless otherwise specified

Figure 4.2: Exploded view of the gasifier stove



Dimensions are in cm unless otherwise specified

Figure 4.3: Isometric view of the reaction chamber

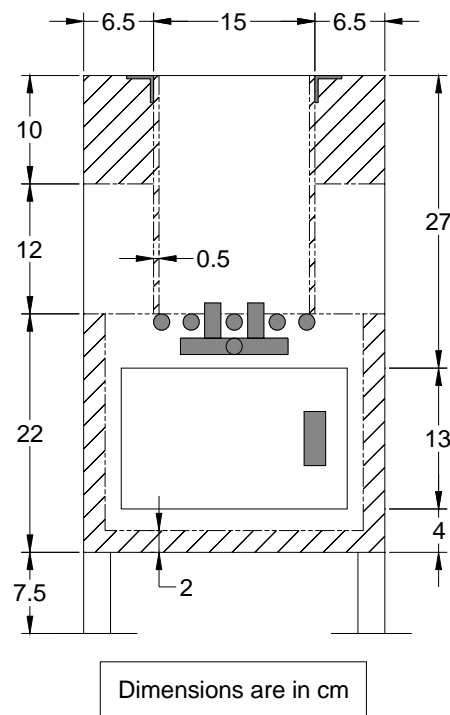


Figure 4.4: Sectional view of the reaction chamber

A 5 mm thick mild steel cylinder, with an open top and a grate welded to its base, is fixed inside the reaction chamber. The cylinder has slots for air inlet and gas outlet, through which primary air enters into the reaction chamber at one side, and the producer gas exits the reaction chamber at the other side. The slots, six at each side, are provided as illustrated in Figure 4.5.

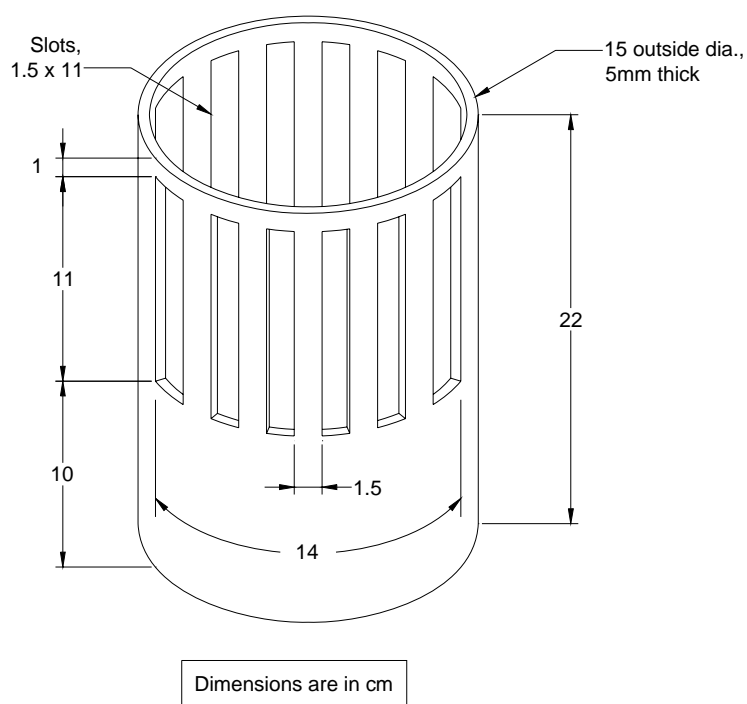


Figure 4.5: Slotted cylinder shown upside down

A mild steel grate is welded to the base of the cylinder. The grate (Figure 4.6) is made of mild steel round rods of 12.5 mm diameter, and allows ash to fall through it into the ash pit. An ash scraper (Figure 4.7) is fixed below the grate, to remove ash accumulated inside the reaction chamber. The ash scraper is especially useful while using fuels of high ash content, such as ricehusk briquettes, since accumulated ash could otherwise block the flow of fresh fuel from the fuel chamber into the reaction chamber.

The ash scraper slides through a cylindrical guide bush, which is welded to the body of the reaction chamber. For easy assembling, the slider rod is connected to the 'fingers' of the scraper by a threaded joint. The ash scraper is operated by sliding it in and out horizontally, generally once in 10-20 minutes, depending on the ash content of the fuel.

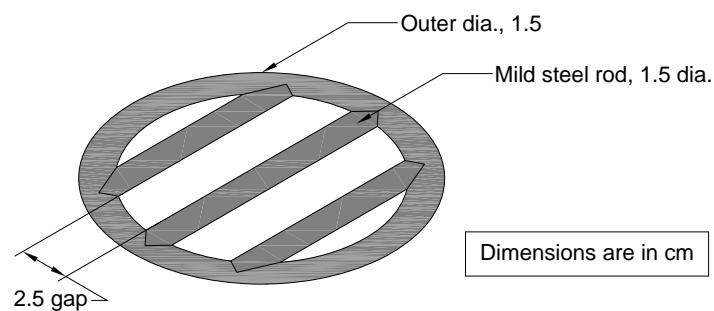


Figure 4.6: Mild steel grate

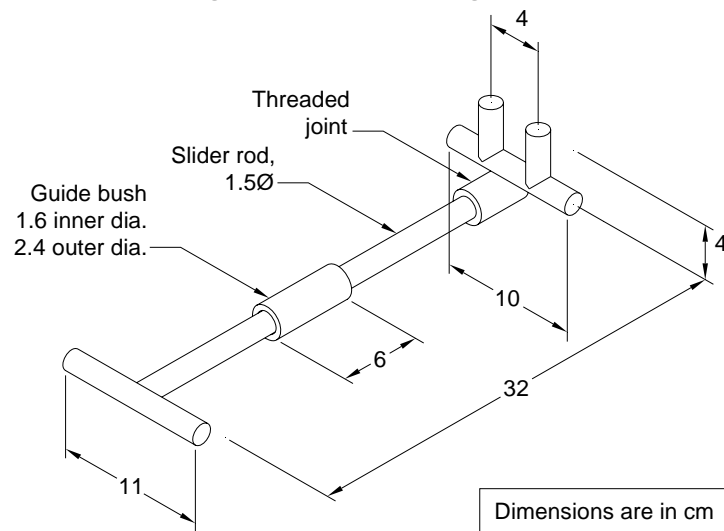


Figure 4.7: Ash scraper with support bush

A mild steel door is provided below the grate level in the reaction chamber, to access the ash pit. The door, made of 2 mm thick mild steel sheet, is fixed to the reaction chamber body using two hinges. A handle is welded to the door for easy opening and closing. The door is insulated with a refractory cement (Castable 13) layer of 1.5 cm thickness (Figure 4.8). The ash accumulated in the ash pit is periodically removed by opening this door. The door is also used while igniting the stove, by introducing a

flame torch from below the grate supporting the fuel bed inside the reaction chamber.

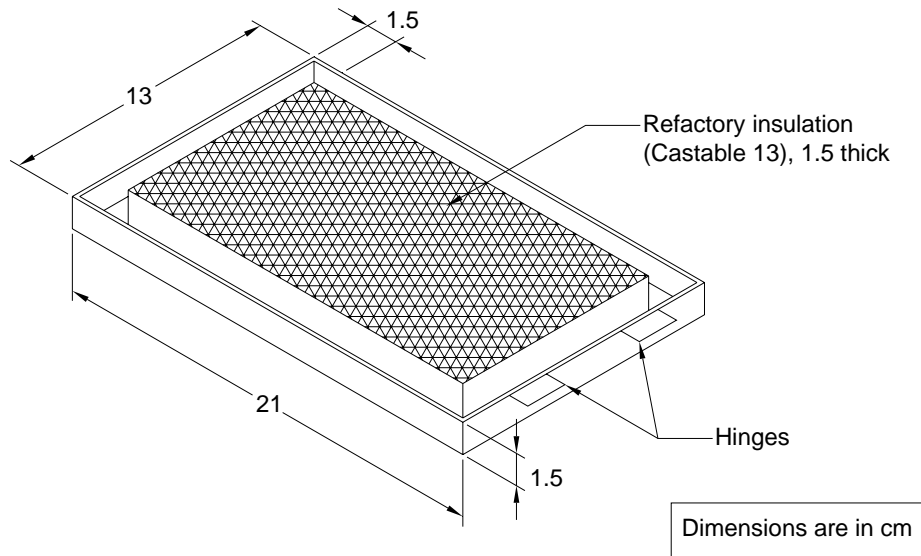


Figure 4.8: Ash pit door (inside view)

Primary air inlet

The primary air inlet (Figure 4.9) is made of 2 mm thick mild steel sheet, and is attached on one side of the reaction chamber. A sliding door provided at the bottom of the primary air inlet can be used to control the gasification rate inside the reaction chamber by controlling the primary air flow.

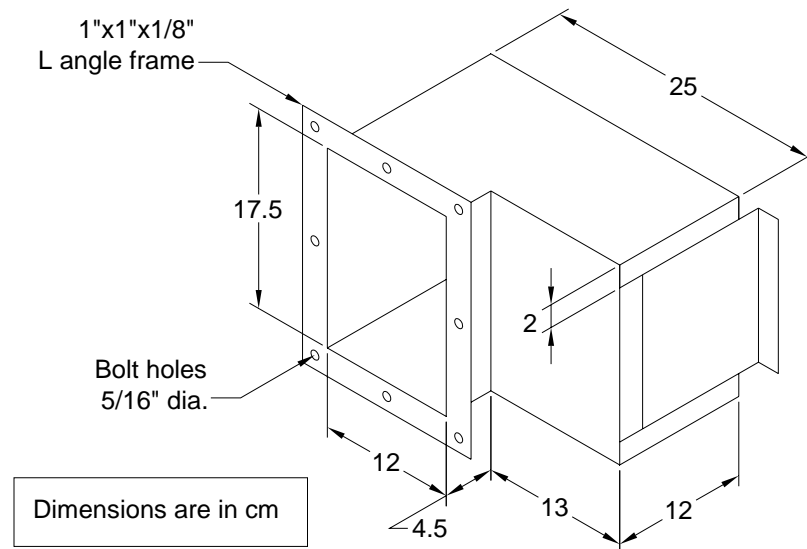


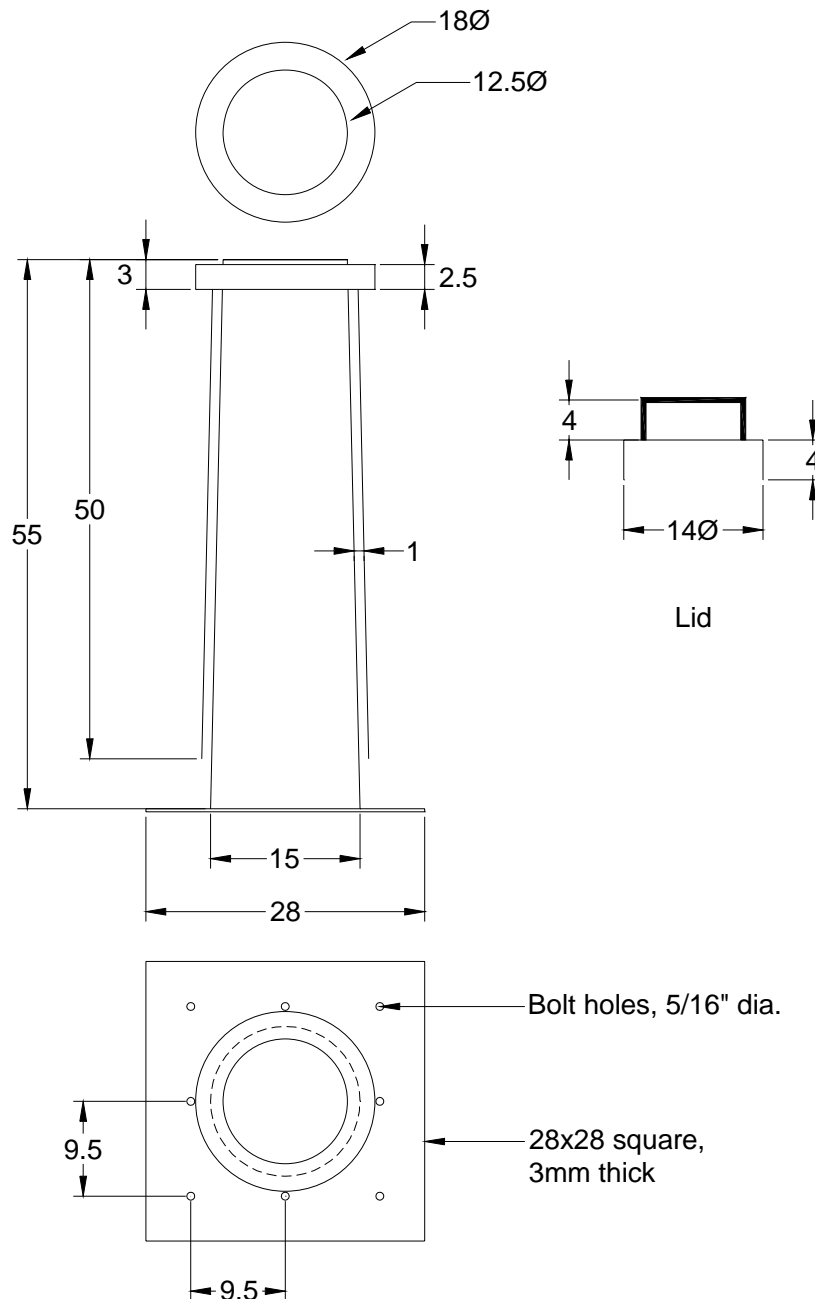
Figure 4.9: Isometric view of the primary air inlet manifold

Fuel chamber

The fuel chamber (Figure 4.10) is made of 2 mm thick mild steel sheet and is located above the reaction chamber. Fuel from the fuel chamber flows into the reaction chamber by gravity. The chamber is designed to be conical in shape, to avoid 'fuel bridging' inside the chamber, and to facilitate easy flow of fuel. The top end of the

chamber has a water seal and a cup-type lid for easy loading of fuel; the water seal also prevents gas leakage from the joint during operation.

To protect the stove operator from accidental burns, and to reduce the heat losses further, the fuel chamber is covered at the outside with a mild steel shell, which is welded at the top with the water seal. The fuel chamber has a flange attached at its bottom; this is used for connecting the fuel chamber with the reaction chamber.



Dimensions are in cm unless otherwise specified

Figure 4.10: Fuel chamber

Gas Burner

The gas burner has two parts: the support at the bottom or Gas Burner Base (Figure 4.11), and the burner pipe (Figure 4.12) which is fitted over the Base. The burner pipe has forty-four holes of diameter 10 mm drilled on it in four rows, through which secondary air flows in, for combustion of the producer gas.

To reduce heat losses, the surfaces above and below the secondary air holes are insulated with rockwool and clad with 1 mm thick GI sheet. The top 1 cm of the burner pipe is left uninsulated so that it can fit into the pot support, which will be placed over it.

The gas burner base is insulated with a 2 cm layer of refractory cement (Castable 13) on its entire inner surface. The insulation reduces the heat loss from the gas exiting from the reaction chamber before it is burnt in the gas burner.

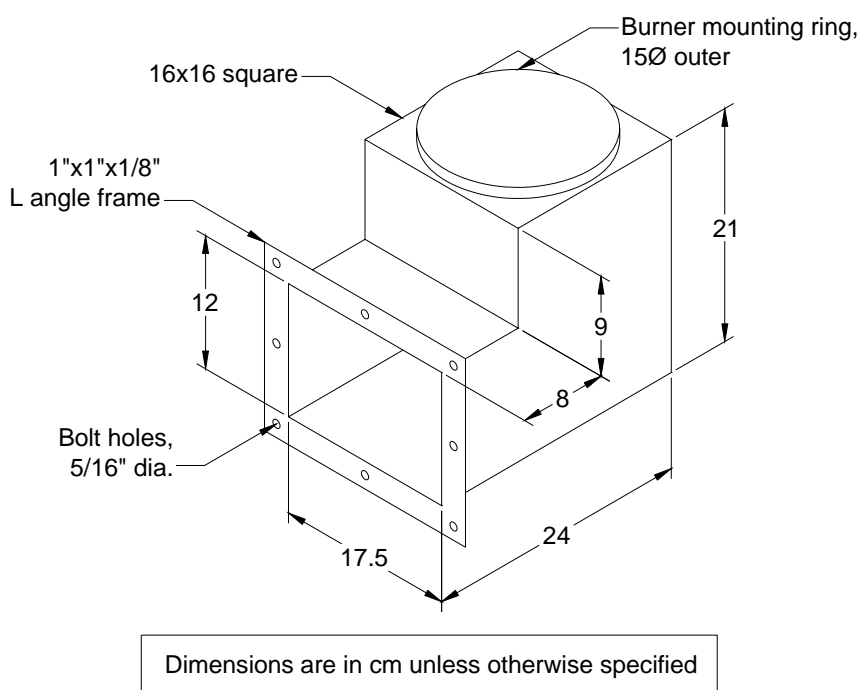
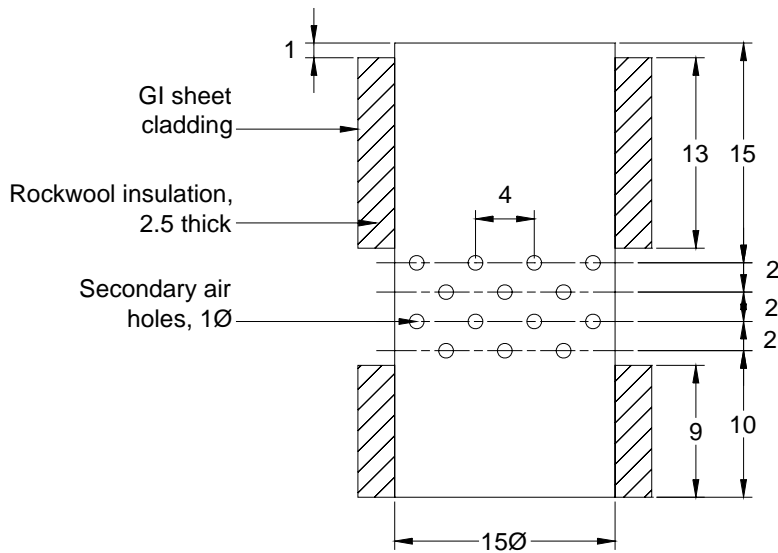


Figure 4.11: Isometric view of the gas burner base

Asbestos gaskets are used while assembling the individual components together. Three gaskets, of size 28 cm x 28 cm, 17.5 cm x 12 cm and 17 cm x 20 cm (outer dimensions), are used for connecting the fuel chamber, primary air inlet and the gas burner respectively, to the reaction chamber.



Dimensions are in cm unless otherwise specified

Figure 4.12: Sectional view of the gas burner

2.4.2 Pot Support

The pot support is designed to hold two pots of 32 cm diameter each. The pot support allows the flue gas from the gas burner to come in contact with the two pots, which project to a depth of 26 cm into its passage on way to the chimney, the position of the first pot being directly above the combustion chamber. The pot support is made of 2 mm thick mild steel sheet and insulated with a 2 cm layer of Castable 13 refractory cement. A 110 cm high mild steel chimney is attached to the pot support at the flue gas exit of the second pot. To reduce heat losses from the chimney, its outer surface is insulated with a 2.5 cm thick layer of fiberglass wool and clad with aluminium sheet.

The pot support has a GI pipe or mild steel 'L' angle leg attached to it below the second pot position for stability. Design details of pot support are presented in Figure 4.13.

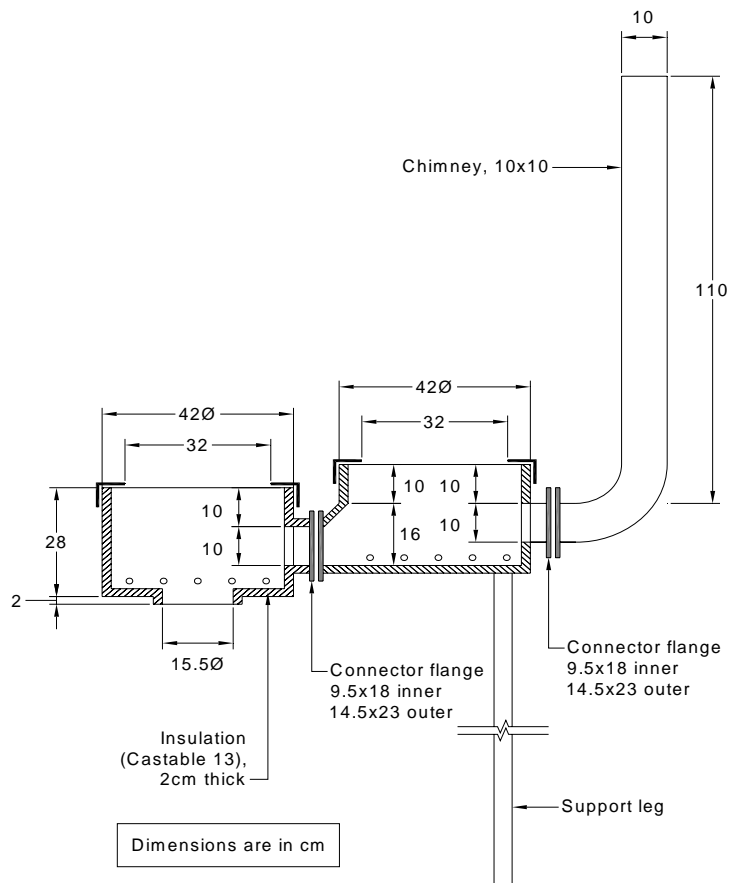


Figure 4.13: Detailed dimensions of the pot support

The components detailed above are assembled together to make the stove. Figure 4.14 shows the assembled view of the stove without the pot support.



Figure 4.14: Fully assembled Domestic Gasifier Stove without pot support

2.4.3 Operational Details

Fuel and Fuel Characteristics

DGS2 is reasonably versatile in terms of the types of fuels it can handle. Ricehusk briquettes, wood chips and coconut shells were tested and found to be suitable for use in the gasifier stove. Other fuels such as sawdust briquettes and wood twigs could also be used. The fuel should be sized before loading into the fuel chamber. Figure 4.15 illustrates the types of fuels used in the stove. 1 inch is the average size of fuel pieces that can be used.



(i) *Ricehusk briquettes*

(ii) *Wood chips*

(iii) *Coconut shells*

Figure 4.15: Fuels that can be used in the stove

Stove ignition

Fuel is first loaded in the fuel hopper, the lid is then closed and water is filled in the water seal. The fuel is next ignited from below the grate using a flame torch through the ash pit door. About five minutes later, the torch is removed and the ash pit door is closed. The stove warms up slowly, and it takes about 20 minutes to generate combustible gas (producer gas) at the gas burner side. The gas is then ignited in the gas burner by introducing a flame through the secondary air holes in the burner. Once the gas gets ignited, its flow becomes smooth. The stove can operate continuously until the fuel in the fuel chamber is used up. Additional fuel can be loaded through the top of the fuel chamber to further extend its operation. The ash scraper should be operated occasionally, to remove the ash accumulated inside the reaction chamber. This will facilitate easy flow of fresh fuel from the fuel chamber into the combustion chamber.

Efficiency Tests

Water-boiling tests were conducted to measure the efficiency of the gasifier stove. For this purpose, a known quantity of water was taken in both the pots, which were then heated on the gasifier stove. The quantity of water evaporated and the amount of the fuel burned in a test run were used to calculate the stove efficiency. The lower calorific value of the fuel is used in the efficiency calculation. With a fuel consumption of 3.2 kg/h (wood chips) the heat output of the stove was 3.6 kW; the average water boiling efficiency of the stove was 25.9%.

Chapter 3

Packages developed by KUET, Bangladesh

KUET's packages incorporate briquetting screws designed to enhance operating life and reduce energy consumption. The screw profile and pitch are designed for low energy consumption with ricehusk as raw material. Special hard-facing welding electrodes are used for enhancing the screw life to eight hours of continuous operation.

In addition, a raw material pre-heater and a smoke removal system are incorporated into the system to reduce wear/electricity consumption and reduce smoke level near the briquetting machine during operation.



Commercial use of briquettes, Bangladesh

3.1 Improved briquetting system with diesel engine

The package consists of a briquetting system and two briquette-fired stoves, namely, a single-pot briquette-fired stove for domestic use, and a two-pot briquette-fired stove for commercial/community/large family. Design details of the stoves and other components of the package are included in a dissemination CD on RETs in Asia, available from the Coordinator of the RETs in Asia programme.

The briquetting system consists of:

- ◆ *briquetting machine fitted with a 27 hp diesel engine, and having a screw and die pair for producing 55 mm diameter briquettes,*
- ◆ *briquette-fired die-heater stove,*
- ◆ *biomass pre-heater, and*
- ◆ *smoke removal system.*



Improved briquetting machine with diesel engine, Bangladesh

3.1.1 Screw fabrication

The complete screw, with all the screw flights, is fabricated by machining a single mild steel round rod of 56 mm diameter in a lathe. After machining, the first two flights of the screw are hard-faced by welding the surface with a general-purpose hard-facing electrode HardCraft 650B, which is readily available in the local market in Bangladesh. Table 5.1 shows the technical specifications of the briquetting system. Figures 5.1 and 5.2 show the detailed dimensions of the screw and die.

Table 5.1: Technical Specifications of the Bangladesh design Briquetting Machine

| Hopper | | | |
|---------------------------|---------------|------------------------|-------------------------|
| Width (at top) | 460 mm | Width (at bottom) | 140 mm |
| Length (at top) | 460 mm | Length (at bottom) | 140 mm |
| Height | 520 mm | Material | 20 SWG Mild Steel sheet |
| Diesel Engine | | | |
| Rated Capacity | 27 HP /20 HP | Weight | 220 kg/ 180 kg |
| Speed | 2200 rpm | | |
| Driving Pulley | | | |
| Diameter | 130 mm | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Driven Pulley | | | |
| Diameter | 460 mm | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Bearing Housing | | | |
| Width | 130 mm | Material | Cast Iron |
| Length | 264 mm | Bearing 1 size | 120 mm |
| Height | 130 mm | Bearing 2 size | 127 mm |
| Biomass Pre-heater | | | |
| Outer cylinder length | 1575 mm | Inner cylinder length | 1750 mm |
| Outer cylinder dia. | 380 mm | Inner cylinder dia. | 280 mm |
| Insulation | Asbestos rope | Material | 20 SWG Mild Steel sheet |
| Inclination | 27.5 deg | | |
| Briquetting Die | | | |
| Length | 305 mm | Outer dia. at rear end | 95 mm |
| Outer dia. at front end | 83 mm | Inner dia. at rear end | 73 mm |
| Inner dia. at front end | 60 mm | Material | Cast Iron |
| Taper | 2.45 deg | | |

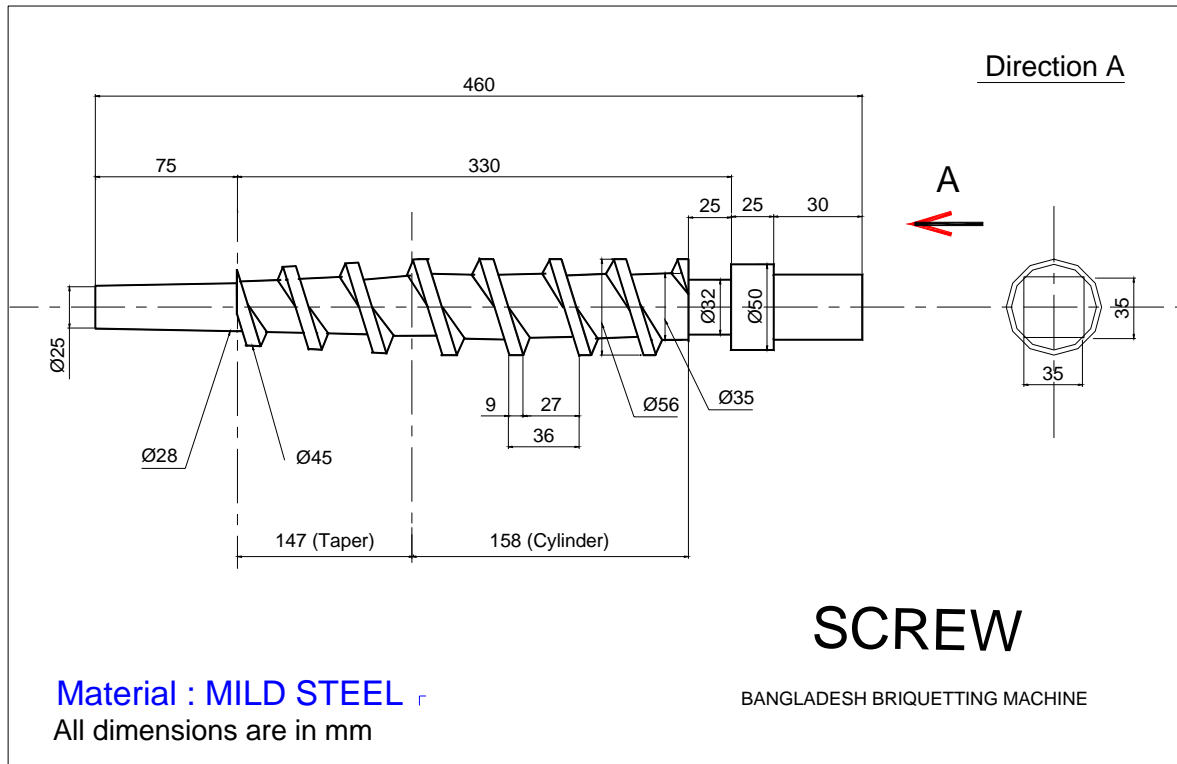


Figure 5.1: Dimensional details of Bangladeshi Screw for 55mm briquettes

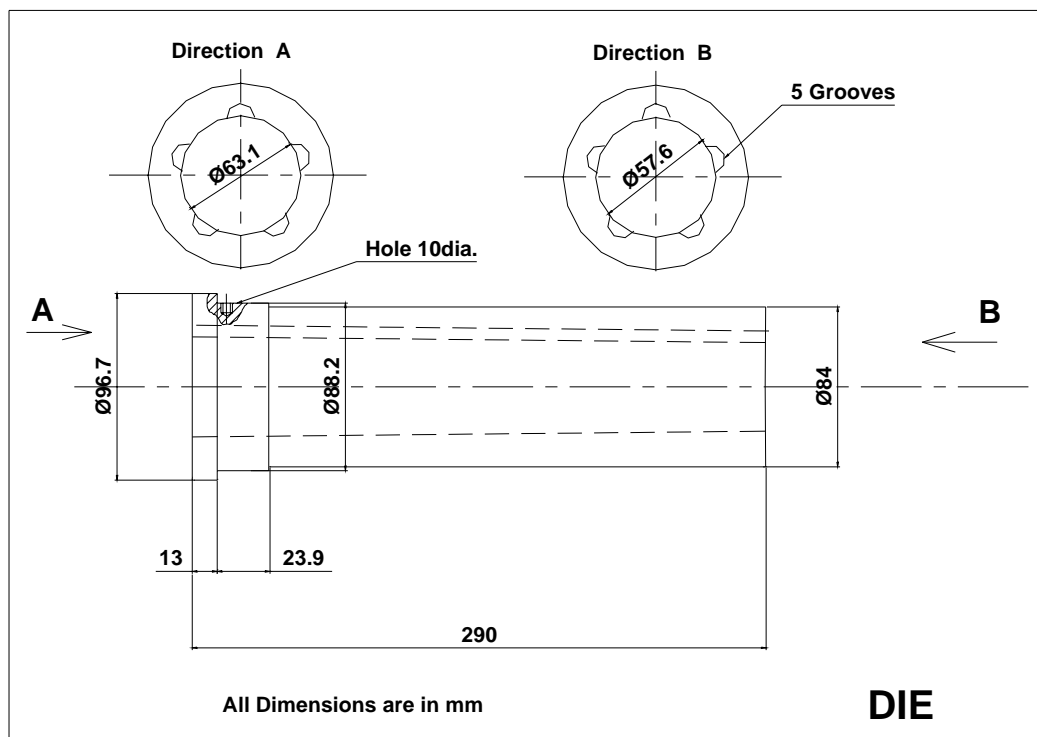


Figure 5.2: Dimensional details of Bangladeshi die for 55mm briquettes

The die is made of cast iron, and machined in a lathe to the required dimensions. Five semi-circular grooves are provided on the inner surface of the die to prevent

twisting of the briquette, which would otherwise happen due to screw rotation. The inner grooves are machined using a slotting machine. Figure 5.3 shows the briquettes produced using the package.



Figure 5.3: Ricehusk briquettes

3.2 Improved briquetteing system with electric motor

The package consists of a briquetting system and two briquette-fired stoves, namely, a single-pot briquette-fired stove for domestic use, and a two-pot briquette-fired stove for commercial/community use. Design details of the stoves and other components of the package are included in a dissemination CD on RETs in Asia, available from the Coordinator of the RETs in Asia programme. This package was developed using (i) Bangladeshi briquetting machine and (ii) Vietnamese briquetting machine.



Improved birquetting machine with electric motor, Bangladesh

3.2.1 System using Bangladeshi briquetting machine

The briquetting system using Bangladeshi machine consists of:

- a) a briquetting machine of Bangladeshi design fitted with a 18.5 hp electric motor, and having a screw and die pair of Bangladeshi design for producing 55 mm diameter briquettes,
- b) a briquette-fired die-heater stove,
- c) a biomass pre-heater, and
- d) a smoke removal system.

Table 6.1: Technical Specifications of the Bangladeshi design Briquetting Machine

| Hopper | | | |
|---------------------------|---------------|------------------------|-------------------|
| Width (at top) | 460 mm | Width (at bottom) | 140 mm |
| Length (at top) | 460 mm | Length (at bottom) | 140 mm |
| Height | 520 mm | Material | 20 SWG Mild Steel |
| Motor | | | |
| Capacity | 20 HP | Speed | 1470 rpm |
| Rating | 30 A | Voltage | 380/440V; 50 Hz |
| Driving Pulley | | | |
| Diameter | 130 mm | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Driven Pulley | | | |
| Diameter | 460 mm | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Bearing Housing | | | |
| Width | 130 mm | Material | Cast Iron |
| Length | 264 mm | Bearing 1 size | 120 mm |
| Height | 130 mm | Bearing 2 size | 127 mm |
| Biomass Pre-heater | | | |
| Outer cylinder length | 1575 mm | Inner cylinder length | 1750 mm |
| Outer cylinder dia. | 380 mm | Inner cylinder dia. | 280 mm |
| Insulation | Asbestos rope | Material | 20 SWG Mild Steel |
| Inclination | 27.5 deg | | |
| Briquetting Die | | | |
| Length | 305 mm | Outer dia. at rear end | 95 mm |
| Outer dia. at front end | 83 mm | Inner dia. at rear end | 73 mm |
| Inner dia. at front end | 60 mm | Material | Cast Iron |
| Taper | 2.45 deg | | |

3.2.2 System using Vietnamese briquetting machine

The briquetting system using Vietnamese machine consists of:

- a) a briquetting machine with pulleys for power transmission, fitted with a 15 HP electric motor and a screw and die pair of Vietnamese design for producing 71 mm diameter briquettes,
- b) a briquette-fired die-heater stove, and
- c) a smoke removal system.

Table 7.1: Technical Specifications of the Vietnamese design Briquetting Machine

| GENERAL SPECIFICATIONS | SCREW |
|--|--|
| Motor: 15 hp; 980 rpm 220/380V/ 50 Hz | Total length: 340 mm Length of threaded portion: 212 mm |
| Screw speed: 200-240 rpm | Weight: 3 kg |
| Die-heater: Briquette-fired metal stove (BIT/Bangladesh design) | Outer diameter of screw: 70 mm |
| Production rate: 75-90 kg/h | No. of screw thread: 4.5 |
| Raw materials: Ricehusk, coffee husk, saw dust | Material: Mild steel rod – 35 mm dia. Mild steel washer: 4 mm thick |
| Electricity consumption: 0.12 kWh/kg | DIE |
| Power transmission: Pulleys & V-belts | Length: 250 mm |
| Machine bed: Mild Steel 'C' channel | Internal dia. Front: 71 mm; Rear: 78 mm |
| Weight: 400 kg | External dia. Front: 80 mm; Rear: 92 mm |
| Length: 1340 mm | Tapered length: 75 mm |
| Width: 500 mm | No. of grooves: 8 |
| Height: 1165 mm (excluding motor) | Material: Hardened steel Weight: 2.5 kg |

Figure 7.1 shows the briquettes produced by the machines described above.



Figure 7.1: The 71 mm and 55 mm briquettes produced with the above briquetting machines

Packages developed by IE, Vietnam

*B*riquetting machines in two of the three packages developed by IE use bigger screws and dies to produce 71 mm diameter briquettes and consume less electricity per kg of briquette produced. IE developed and fabricated a briquetting machine screw. The core of the screw is machined from a mild steel round rod of 35 mm diameter. The screw flights are marked on the outer surface of the machined core on a lathe machine. Five 4 mm thick (35 mm inner diameter and 70 mm outer diameter) mild steel washers are then used to build the screw flights on the screw core. The washers are radially cut open, twisted, and inserted over the screw core. They are then hammered to form the required screw shape, and welded to the core one by one. Apart from reducing material cost, this technique of fabricating screw also reduces labour cost. The die is machined from hard steel round rod in a lathe, and the inner grooves are formed by further machining in a slotting machine.



Improved briquetting machine, Vietnam

Due to the ready availability of coal in Vietnam, a coal-fired die-heating stove has been introduced. A chimney-type smoke removal system is incorporated into the system in order to reduce smoke level near the briquetting machine during operation.

Three packages were developed based on electric motor and using:

- i. Bangladeshi briquetting machine
- ii. Vietnamese briquetting machine with gearbox
- iii. Vietnamese briquetting machine without gearbox

4.1 Using Bangladeshi briquetting machine

Table 8.1: Technical Specifications of the Bangladeshi design briquetting machine

| Hopper | | | |
|-------------------------|-------------|------------------------|-------------------------|
| Width (at top) | 18.5 inches | Width (at bottom) | 5.5 inches |
| Length (at top) | 18.5 inches | Length (at bottom) | 5.5 inches |
| Height | 14.5 inches | Material | 20 SWG Mild Steel sheet |
| Motor | | | |
| Capacity | 18.5 HP | Speed | 1470 rpm |
| Rating | 32.3 A | Voltage | 220/380; 50 Hz |
| Driving Pulley | | | |
| Diameter | 3.75 inches | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Driven Pulley | | | |
| Diameter | 18 inches | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Bearing Housing | | | |
| Width | 5 inches | Material | Cast Iron |
| Length | 10 inches | Bearing 1 size | 4.75 inches |
| Height | 5 inches | Bearing 2 size | 5 inches |
| Briquetting Die | | | |
| Length | 12 inches | Outer dia. at rear end | 3.75 inches |
| Outer dia. at front end | 3.25 inches | Inner dia. at rear end | 2.88 inches |
| Inner dia. at front end | 2.38 inches | Material | Cast Iron |
| Taper | 2.45 deg | | |

4.2 Using Vietnamese briquetting machine with gearbox

The package consists of a briquetting system and two briquette-fired stoves, namely, a single-pot briquette-fired stove for domestic use, and a two-pot briquette-fired stove for institutional/community use. Design details of the stoves and other components of the package are included in a dissemination CD on RETs in Asia, available on request from the Coordinator of the RETs in Asia programme. The briquetting system consists of

- a) A briquetting machine of Vietnamese design with gearbox for power transmission, a 15 HP electric motor, and a Vietnamese screw and die pair for producing 71 mm diameter briquettes,
- b) A coal/briquette-fired die-heaterstove, and
- c) A smoke removal system (chimney type).

Table 9.1 shows the technical specifications of the briquetting machine of Package 9, while Figures 9.1 and 9.2 show the detailed dimensions of the screw and die used in the briquetting machine.

Table 9.1: Technical Specifications of the briquetting machine

| GENERAL SPECIFICATIONS | SCREW |
|---|---|
| Motor: 15 hp; 1450 rpm 220/380V; 50 Hz | Total length: 340 mm Length of threaded portion: 212 mm |
| Screw speed: 200-240 rpm | Weight: 3 kg |
| Die-heater: 10.6 kW coal stove; can also use biomass briquettes. | Outer diameter of screw: 70 mm No. of screw thread: 4.5 Material: Mild Steel rod – 35 mm dia. |
| Production rate: 75-90 kg/h | Mild steel washer: 4 mm thick |
| Raw materials: Ricehusk, coffee husk, saw dust | DIE |
| Electricity consumption: 0.12 kWh/kg | Length: 250 mm |
| Power transmission: Gear Box | Internal dia. Front: 71 mm; Rear: 78 mm |
| Weight: 400 kg | External dia. Front: 80 mm; Rear: 92 mm |
| Length: 1340 mm | Tapered length: 75 mm |
| Width: 500 mm | No. of grooves: 8 |
| Height: 1165 mm (excluding motor) | Material: Hardened steel Weight: 2.5 kg |

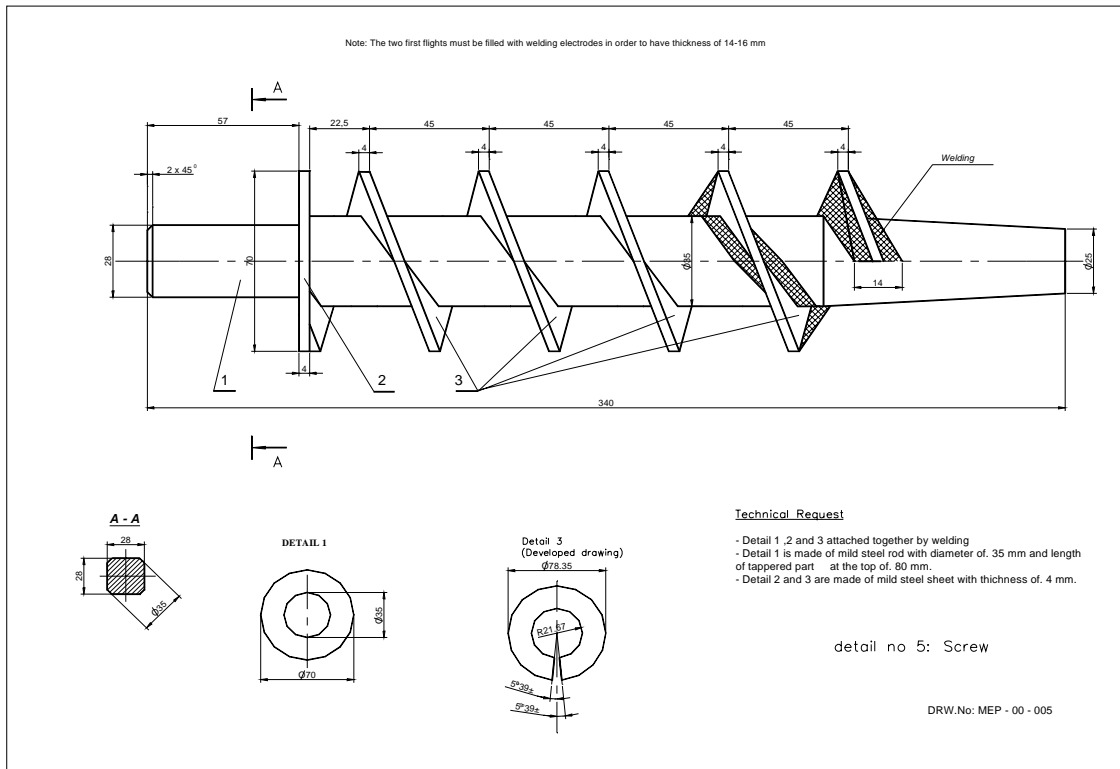


Figure 9.1: Dimensional details of Vietnamese screw for 71mm briquettes

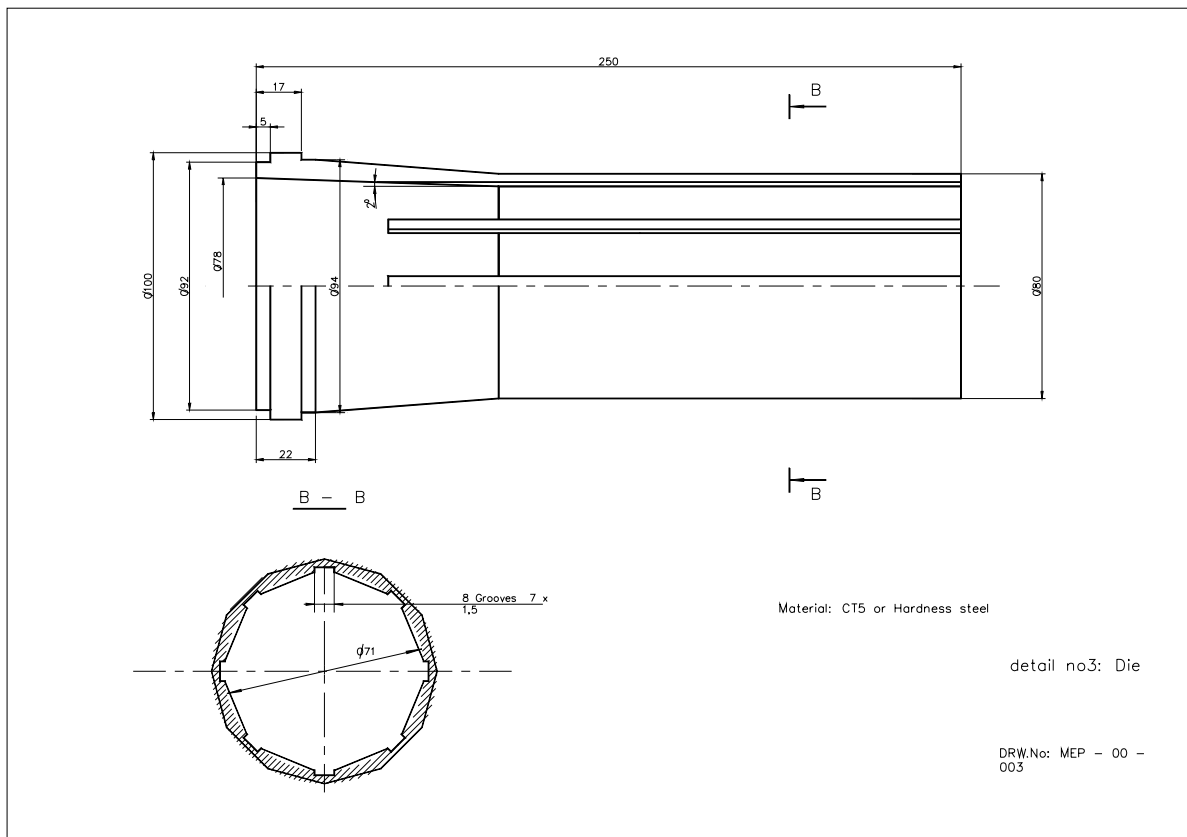


Figure 9.2: Dimensional details of Vietnamese die for 71mm briquettes

The steps involved in the screw fabrication are illustrated in figure 9.3.



(i). Screw shaft turned in a lathe



(ii). Washers as screw threads



(iii). Inserting washers over the screw shaft



(iv). Completed screw, ready for installation

Figure 9.3: Steps involved in the fabrication of Vietnamese design screw

4.3 Using Vietnamese briquetting machine without gearbox

The package consists of a briquetting system and two briquette-fired stoves, namely, a single-pot briquette-fired stove for domestic use, and a two-pot briquette-fired stove for institutional/community use. Design details of the stoves and other components of the package are included in a dissemination CD on RETs in Asia, available on request from the Coordinator of the regional programme. The briquetting system consists of:

- a) a briquetting machine of Vietnamese design, with pulleys and V-belts for power transmission, a 15 HP electric motor, and a Vietnamese screw and die pair for 71 mm briquettes
- b) a coal/briquette-fired die-heater stove, and
- c) a chimney-type smoke removal system.

Table 10.1: Technical Specifications of the Vietnamese briquetting machine

| GENERAL SPECIFICATIONS | SCREW |
|---|--|
| Motor: 15 hp; 980 rpm/220/380V/ 50 Hz | Total length: 340 mm Length of threaded portion: 212 mm |
| Screw speed: 200-240 rpm | Weight: 3 kg |
| Die-heater: 10.6 kW coal stove; can also use biomass briquettes. | Outer diameter of screw: 70 mm No. of screw threads: 4.5 Material: Mild Steel rod – 35 mm dia. |
| Production rate: 75-90 kg/h | Mild steel washer: 4 mm thick |
| Raw materials: ricehusk, coffee husk, saw dust | DIE |
| Electricity consumption: 0.12 kWh/kg | Length: 250 mm |
| Power transmission: Pulleys & V-belts | Internal dia. Front: 71 mm; Rear: 78 mm |
| Weight: 400 kg | External dia. Front: 80 mm; Rear: 92 mm |
| Length: 1340 mm | Tapered length: 75 mm |
| Width: 500 mm | No. of grooves: 8 |
| Height: 1165 mm (excluding motor) | Material: Hardened steel Weight: 2.5 kg |

Packages developed by RONAST, Nepal

*R*ONAST's packages incorporate briquetting screw and die to produce 55 mm diameter briquettes. While the dimensions of the briquetting screw used in the packages of RONAST are the same as those of the Bangladeshi screw, RONAST developed and fabricated the screws. The core of the screw is machined from a mild steel round rod of 55 mm diameter. The screw flights are just marked on the outer surface of the machined core using a lathe machine. A 8mm square rod of hardened steel is then wound on the screw core along the marking by heating the rod to red-hot condition and hammering it.

After fabrication, the first two flights of the screw are hard-faced by welding the surface with a general-purpose hard-facing electrode available in the local market. The screw flights are then finished using a grinding wheel to make the surface smooth.



Improved briquetting machine, Nepal

Apart from reducing the material cost, RONAST's technique of screw making also reduces labour cost. A briquette-fired stove (based on AIT's design) is used for die-heating. Electrical coil type of die-heaters is also available as an option. A smoke removal system using a smoke box to trap the smoke (based on AIT's design) is also incorporated into the system

Two different packages were developed (i) using Bangladeshi briquetting machine, electric motor and electric die-heater and (ii) using Bangladeshi briquetting machine, electric motor and metal stove die-heater.

5.1 Using Bangladeshi briquetting machine, electric motor and electric die-heater

The briquetting system consists of:

- a) a Bangladesh design briquetting machine
- b) a 15 hp electric motor, a cast Iron die for 55 mm briquettes and a machined Bangladeshi screw (Option 1), or a RONAST screw (Option 2)
- c) a cast iron die for 55 mm briquettes,
- d) an electrical die heater, and
- e) a smoke removal system.

The smoke removal system incorporated in this package has a smoke collection box and a suction line connecting a suction blower to the smoke collection box at the top. The metal box traps the smoke produced during the briquetting process; the smoke is sucked by the suction blower and exhausted through a chimney.

The smoke collection box is constructed of mild steel sheet of 1.5 mm thickness. A circular conduit is fixed at one end of the box, through which briquette from the die of the briquetting machine enters the box. Briquettes are deflected by a metal piece after it enters the box, and are broken as a result. The broken pieces of briquettes slide over a plate and exit the box at the bottom.

Table 11.1: Technical Specifications of the briquetting machine

| Hopper | | | |
|-------------------------|------------------------|------------------------|-------------------------|
| Width (at top) | 18.5 inches | Width (at bottom) | 5.5 inches |
| Length (at top) | 18.5 inches | Length (at bottom) | 5.5 inches |
| Height | 14.5 inches | Material | 20 SWG Mild Steel sheet |
| Motor | | | |
| Capacity | 15 HP | Speed | 1470 rpm |
| Rating | 32.3 A | Voltage | 220/380; 50 Hz |
| Driving Pulley | | | |
| Diameter | 3.75 inches | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Driven Pulley | | | |
| Diameter | 18 inches | Type of grooves | V-type |
| No. of grooves | 2 | Material | Cast Iron |
| Bearing Housing | | | |
| Width | 5 inches | Material | Cast Iron |
| Length | 10 inches | Bearing 1 size | 4.75 inches |
| Height | 5 inches | Bearing 2 size | 5 inches |
| Briquetting Die | | | |
| Length | 12 inches | Outer dia. at rear end | 3.75 inches |
| Outer dia. at front end | 3.25 inches | Inner dia. at rear end | 2.88 inches |
| Inner dia. at front end | 2.38 inches | Material | Cast Iron |
| Taper | 2.45 deg | | |
| Die-heater | | | |
| Type | Electrical coil heater | No. of heater coils | 3 nos. |
| Capacity | 2 kW each | Voltage | 220/380 |

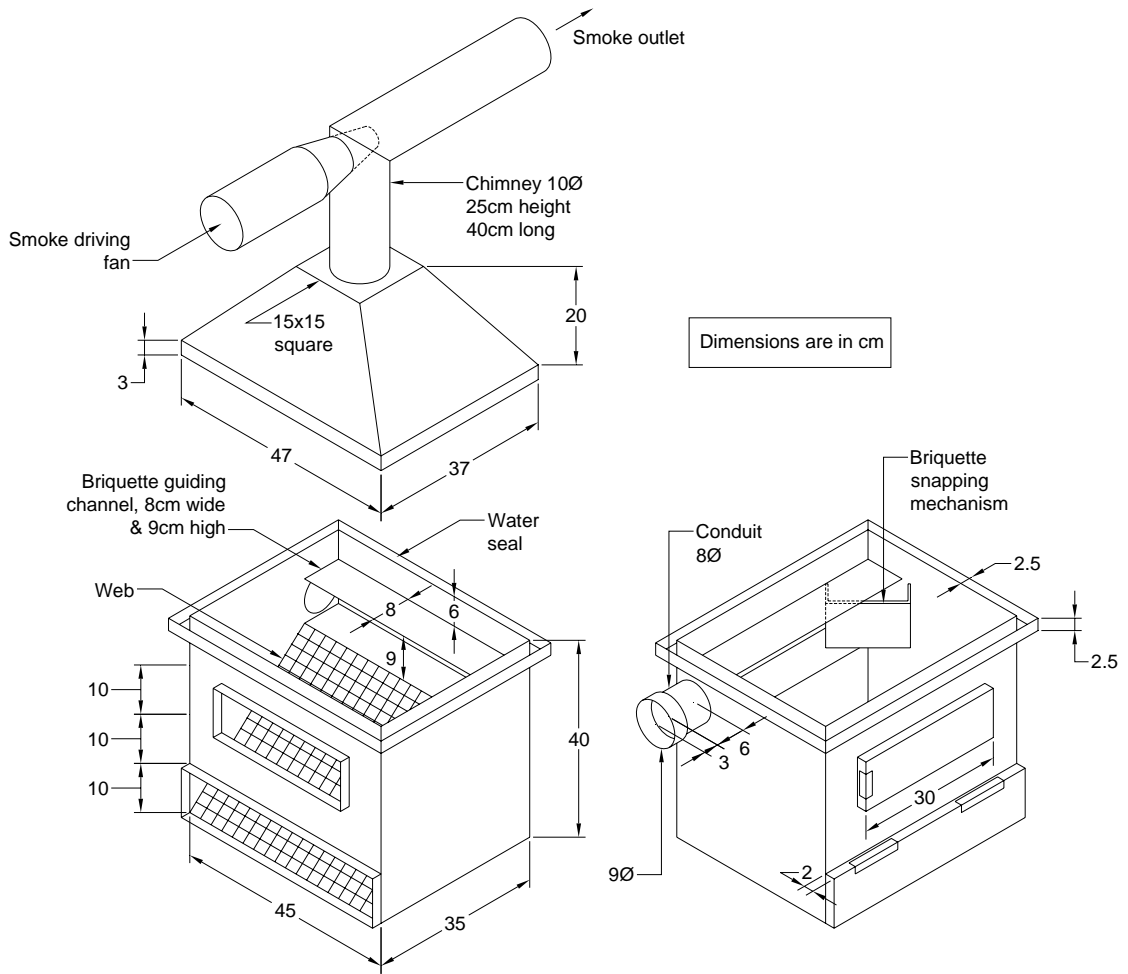


Figure 11.1: Smoke removal system developed by RONAST.

5.2 Using Bangladeshi briquetting machine, electric motor and metal stove die-heater

The briquetting system consists of:

- f) a briquetting machine of Bangladeshi design fitted with a 15 hp electric motor, a cast Iron die for 55 mm briquettes and a machined Bangladeshi screw (Option 1), or a RONAST screw (Option 2)
- g) a briquette-fired die-heating stove, and
- h) a smoke removal system.

Specifications of the briquetting machine including the screw, die, and the smoke removal system are the same as in Package 11. The design details of the briquette-fired die-heating stove are illustrated in Figure 12.1.

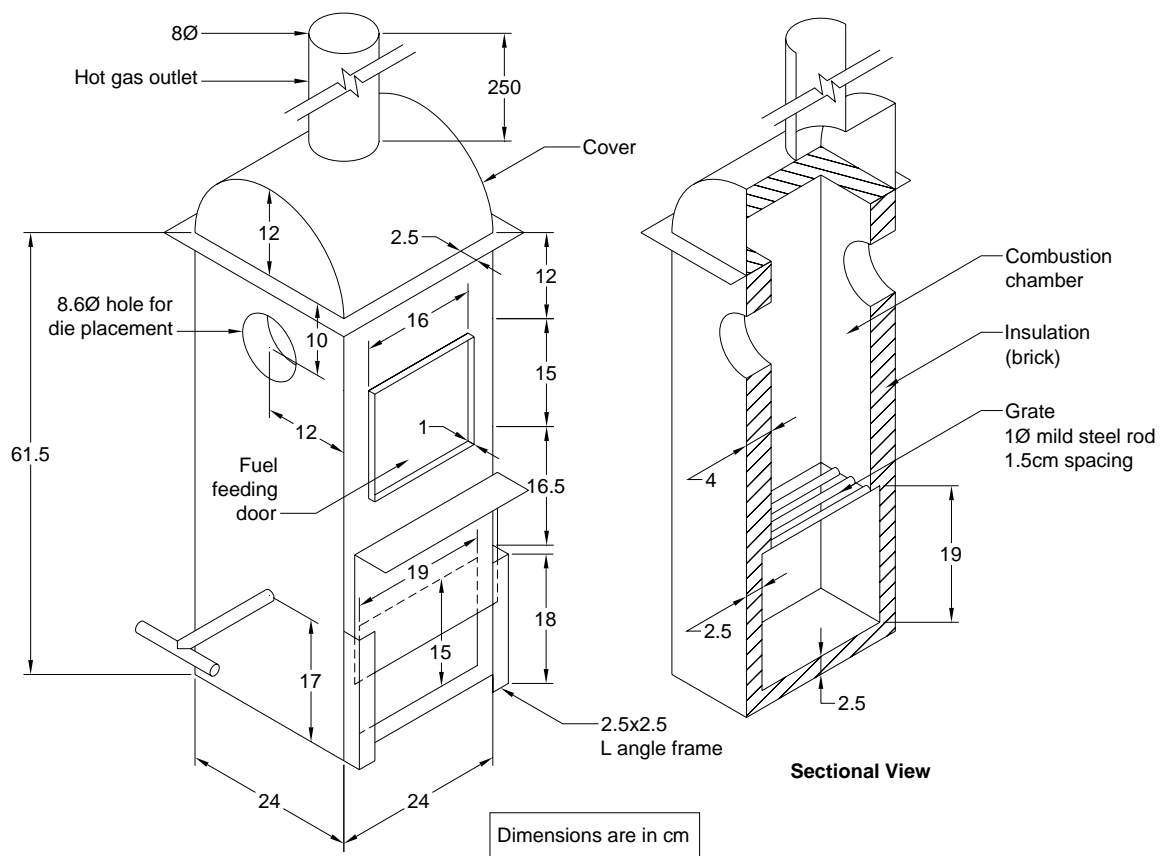


Figure 12.1: The briquette-fired die-heating stove developed by RONAST, Nepal

The stove design is based on a similar stove developed at AIT for the same purpose. It is made of 1.5 mm thick mild steel sheet, with a furnace of size 24 cm x 24 cm x 60 cm (w x b x h), and a 2.5 m long chimney attached to it at the top. The die of the briquetting machine passes through the furnace, exposing its outer surface to the flames inside the furnace. The furnace is insulated with a 25 mm refractory lining at its inner surface. Doors are provided for loading the fuel as well as to remove the

ash. An ash scraper is fixed below the grate to remove excess ash from the furnace, which will fall through the grate.

Two steel baffles were fixed just above the die, to converge the flames towards the die surface. They were insulated at both sides using refractory cement. The baffles were found to improve the heat transfer from the flames to the die considerably.

Fuel (briquette pieces of size 40 x 40 mm size) is loaded through the side doors up to the bottom level of the die and ignited using some wood chips and kerosene. When the die temperature reached 350°C, the briquetting machine is started. During production, the temperature drops to 320-330°C, and this can be maintained by adding fuel periodically (every 5 minutes) to the stove. Primary air for combustion is taken through the ash pit door, which is kept open during operation. Secondary air is taken through the fuel doors, which are also kept open partially.

Other publications of RETs in Asia

Technology packages: Low-cost PV System Components

Presents detailed information on the different PV system components developed under the RETs in Asia programme.

Technology packages: Solar, Biomass and Hybrid Dryers

Presents detailed information on the different renewable energy based drying systems developed under the RETs in Asia programme.

Lessons Learned from Monitoring of PV Systems

Presents the monitoring methodology of the PV systems installed under the RETs in Asia programme with an analysis of monitoring results, and includes the lessons learned.

PV System components: Technology Fact Sheets

Presents a directory of PV system/components available in the five Asian countries: Bangladesh, Cambodia, Lao PDR, Nepal and Vietnam.

Renewable Energy Technology Promotion: Case Studies from six Asian Countries.

Presents selected cases from the RETs in Asia programme. This details the technical, financial and management aspects from the different case studies in biomass briquetting, drying and PV technologies, and their applications.

For further information:

Prof. S. Kumar
Coordinator, *RETs in Asia* Programme
Energy Field of Study
Asian Institute of Technology
P.O. Box 4, Klong Luang
Pathumthani 12120, Thailand
Fax: +66-2-524 5439
E-mail: kumar@ait.ac.th

Renewable Energy Technologies in Asia: A Regional Research and Dissemination Programme

'Renewable Energy Technologies in Asia: A Regional Research and Dissemination Programme (*RETs in Asia*)' was initiated in 1997 with the broad aim of contributing to sustainable development of the Asian region by promoting selected mature/nearly mature renewable energy technologies.

The programme activities, namely adaptive research, demonstration and dissemination were carried out in Bangladesh, Cambodia, Nepal, Lao PDR, Philippines and Vietnam, and at the Asian Institute of Technology (AIT).

The renewable energy technologies/accessories considered in the programme included development of solar dryers, solar-biomass hybrid dryers, PV solar home systems, PV systems for community uses, improved PV accessories and appliances, improved biomass briquetting systems, biomass briquette stoves and gasifiers. These were designed and adapted to the local conditions and requirements. Demonstration systems were installed to promote awareness on the technical and financial viability of Renewable Energy systems. Construction, operation and maintenance manuals of the developed devices were prepared and disseminated to entrepreneurs and users. Technology transfer programs were organized among the participating institutions. Training programs were conducted for entrepreneurs, users and technicians. Results of the programme were disseminated to researchers, policy makers, entrepreneurs and users through publications, conferences, seminars and other media.

The 'Renewable Energy Technologies in Asia: A Regional Research and Dissemination Programme' was supported by the Swedish International Development Co-operation Agency (Sida) and coordinated by the Asian Institute of technology (AIT).

