IMPROVED INSTITUTIONAL WOODFUEL STOVE PRODUCTION MANUAL

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PRODUCTION MANUAL ON IMPROVED SeTa INSTITUTIONAL WOOD COOKSTOVES

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1.0 INTRODUCTION

Energy is an essential ingredient in meeting the basic needs of mankind and in stimulating and supporting economic growth and rising standard of living. From time immemorial, mankind has depended on energy for survival and development.

In early years of mankind existence, the cooking of food was not known. During that time, people ate food in the condition in which they found it. As man discovered fire, they found that the fire could be controlled and be used to cook food. Eating cooked food became the culture of civilization of mankind. For millions of years, wood was the only fuel known to man for cooking, and heating and driving early steam engines. This important discovery revolutionized scientific thinking which led to the discovery of other sources of energy we see today.

However, in spite of worldwide research and development advancements, unfortunately, the situation in developing countries has not changed significantly where the majority still depend on biomass based fuels in terms of firewood, agricultural residues and charcoal. This dependence has handicapped them to subsistence existence. Observations across developing countries reveal that firewood is still the major source of energy for cooking and other heat related uses. Many attempts have been made to improve one of its most inefficient uses, namely cooking. One of the ways to do this has been by replacing the traditional 'three-stones' technique for cooking by improved cookstoves.

Research on cookstoves has attracted several groups of research workers and cookstove programmes in the world. Attempts to develop different types of cookstoves were made even when firewood was abundantly available. Nevertheless, the success has been modest.

A great deal of effort is still needed in research and development of improved cookstoves. Past failure in cookstoves programmes indicated the need to link research activities with practical field experience. It is important to avoid the creation of laboratory curiosities with no practical field application. In terms of human resources motivation, means of rewarding researchers that successfully see their work to commercialization need to be explored.

The work that is presented in this Production Manual, represents the best designs that modern engineering can offer. The purpose of the manual is to provide Engineers, Technicians and Artisans a practical guide to use in design and production of improved institutional wood cookstoves.

2.0. BASIC FACTS OF IMPROVED SeTa INSTITUTIONAL WOODFUEL STOVES

These stoves are designed based on current best practices. Thus, they are able to achieve high combustion efficiency (to reduce smoke and harmful emissions that damage health) and high heat transfer efficiency to the cooking pot (thus reduce fuel use). They heat 80-90% of the pot surface area and have insulation around the combustion chamber and the outer body.

The stoves are portable. They are made of steel and are not complicated to produce. The stoves are recommended for use with pots of 25-200L.

2.1. ADVANTAGES OF USING IMPROVED SeTa INSTITUTIONAL WOODFUEL STOVES

The advantages of using improved institutional wood stoves are as explained below.

2.1.1. Saving money

The stoves have been field tested and proven to be economical firewood consumption. By using less firewood (high heat transfer efficiency), the stoves therefore reduce firewood expenses.

2.1.2. Cook faster

When compared to traditional and other cookstoves (currently in the market), they cook food in a much shorter time.

2.1.3 Less smoke

These improved cookstoves hardly produce smoke (high combustion efficiency). Some smoke is produced only when lighting the fire.

2.1.4. Easy to use

A user does not have to blow air into the stove to fan the flame. Once lit the stove fire burns continuously unless one stops putting firewood into the firewood magazine which simplifies feeding of firewood.

2.1.5 Safe to use

The cookstove are safe to use because the fire is shielded. The user is protected from fires and burns.

2.1.6 Environmentally friendly

The stoves use less firewood and do not produce smoke, thus leading to reduction of deforestation rate and contributed to climate change mitigation.

2.2. TOOLS REQUIRED FOR COOKSTOVES PRODUCTION

S/No	Tools/ equipment	Purpose
1	Measuring tape	Taking linear measurements.
2	Angle grinder	Cutting metal sheets/smoothing welded joints.
3	Chipping hammer	Removing slug from welded metal parts.
4	Wire brush	Cleaning metal surfaces prior/after welding.
5	Arc welding set	Joining metal pieces/edges (including stainless steel).
6	File	Smoothing metal pieces/ edges
7	Vice	Holding metal sections when being cut to length/other operations.
8	Chisel	Cutting metal sheet.

S/No	Tools/ equipment	Purpose
9	Anvil (or equivalent)	Base for hammering
10	Hammer	Driving chisel /hammering tasks.
11	Try square	Inspecting right angled corners.
12	Guillotine metal sheer (10mm)	Cutting metal sheets and flat bar
13	Metal Roller (1.5m)	Rolling metal sheets and flat bar
14	Power Hack saw	Cutting angel iron and round bar
15	Hydraulic metal bender (1.5m)	Bending metal sheets and flat bar
16	• Bench drilling machine • Pillar drilling machine	Drilling metal pieces
17	• Grinding machine • Portable angle grinder	Grinding and sharpening of tools, smoothening welded joints and metal cutting operations
18	Air compressor	Generation of compressed air for cleaning of machines, tools and spray painting

2.3. SAFETY GEAR

S/No	Device	Purpose
1	Eye Shield	Protection of eyes against radiation during welding.
2	Eye goggles	Protection of eyes when grinding or cutting.
3	Leather gloves	Protection of hands from burns when welding or other risks.
4	Leather apron	Protection of body and clothes during welding.
5	Nose mask	Protection against inhaling of toxic gases during welding.
6	Industrial boots	Protection of feet during workshop activities.
7	Helmet	Protection of head during workshop activities.

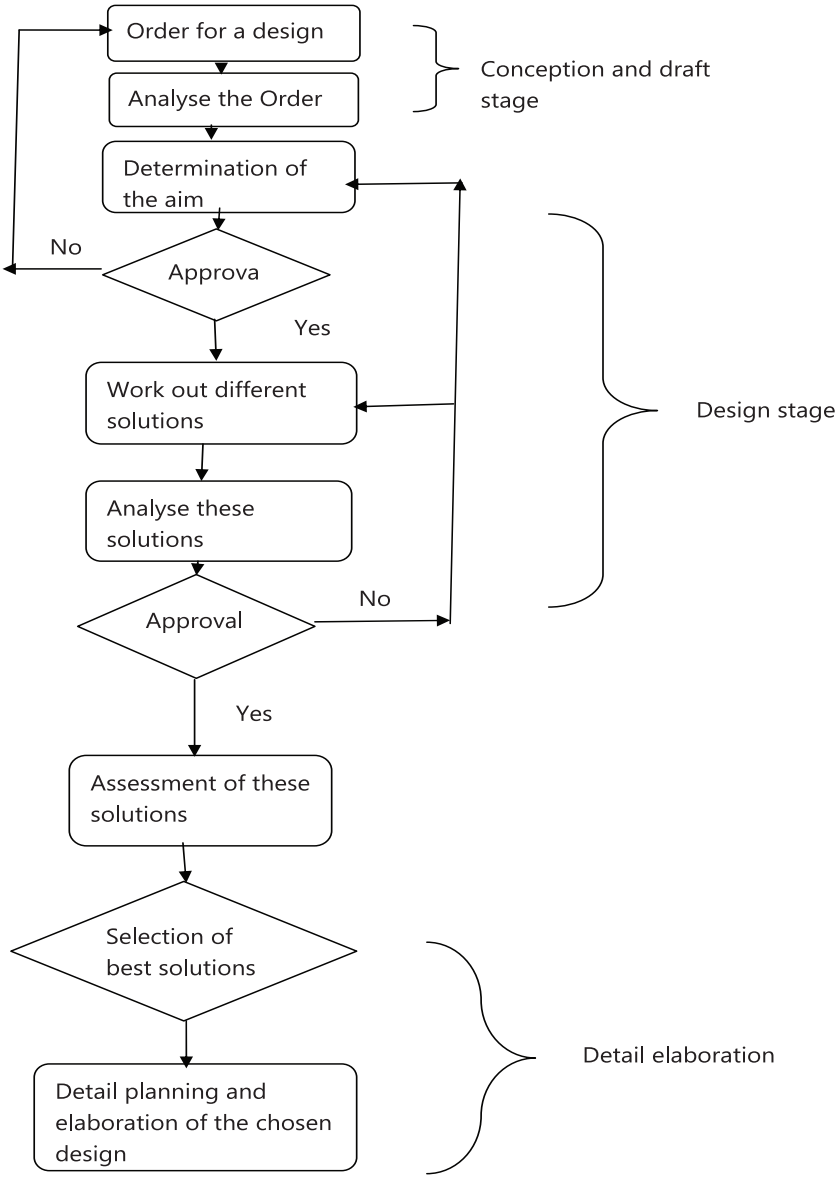
8	Overalls	Protection of clothes during workshop activities.
9	First Aid Kit	Treatment for injuries.

3.0. IMPROVED COOKSTOVE DESIGN PROCESS

Product design is the creation of new and better product and improving the existing ones. A new or better product is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one, from the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. In the preparation of these drawings, care must be taken of the availability of resources in finance, human resource, machinery and materials required for successful competition of the new idea into actual reality.

- Product design is a critical activity because it has been estimated that 70 to 80% of the cost of product development and manufacture is determined by decision made in the initial design stages.
- The design process may be broadly sub-divided into three broad stages.
  - The conception or draft stage.
  - The design stage
  - The details elaboration stage.
- From the information obtained in section 3.0 up to 3.3.3 a designer should be able to come up with a desired cookstove design

3.1 FLOW DIAGRAM FOR THE DESIGN PROCESS



3.2 COOKSTOVE SIZING

The size of a cookstove is determined by the size of the pot that will be used for cooking. The size of the cooking pot is therefore the first thing that should be determined.

3.2.1 DETERMINATION OF COMBUSTION CHAMBER PARAMETERS.

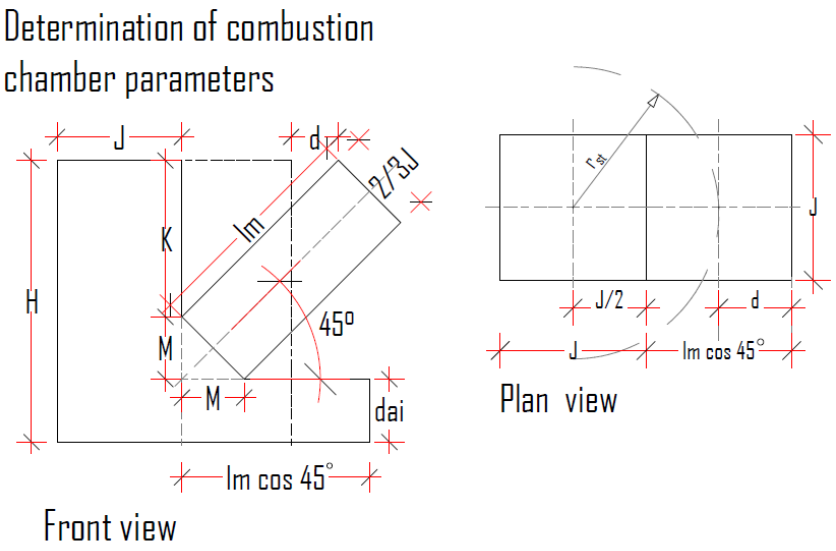


Fig. 1 Combustion Chamber Diameter (Gravity Type)

Fig 1 shows a sketch of a Gravity-type combustion chamber. This type of a combustion chamber is one whose firewood magazine is inclined at an angle of 45 degrees to the horizontal. A combustion chamber consists of three major parts namely; a riser, a firewood magazine and an air inlet.

The three parts are sized as follows:

i. Riser

In sizing the riser, the parameters H, J and K are found in Table No.2 after the capacity of the pot has been determined. Alternatively, these parameters have the following relationship.

- **Height of the riser**

  H=2.5J (For even numbered chambers eg 16×16cm)

  H=2.52J (For un-even numbered chambers eg 15×15cm)

  K=1.5J

  $M= \frac{\sqrt{2}}{3} J$

- Chamber sizing: The chamber is sized as J×J, where J is selected depending on the capacity of the pot.

ii. Firewood magazine

In sizing the firewood magazine, motivating assumptions have to be used using the following equations.

Let, lm =assumed length of the firewood magazine.

d=distance from the outer diameter of the stove to the edge of the firewood magazine centre. (d=25mm in the present designs) rst = radius of the stove from stove design.

Referring to Fig 1 and resolving the length of the firewood magazine we get;

$$lmcos45° = \left(rst - \frac{J}{2}\right) + d$$

$l_m = \frac{1}{\cos 45°} = [(r_{st} - \frac{J}{2}) + d]$ .....(1)

The total length of the firewood magazine.

$$lmt = lm + \frac{J}{3}$$

ie $$lmt = [\frac{\left(rst - \frac{j}{2}\right) + d}{cos45°}] + \frac{j}{3}$$ ..... (2)

iii. Air Inlet

In sizing the Air Inlet (AI) the following procedure gives sufficient results.

The length of the air inlet is obtained as a horizontal projection of the firewood magazine.

Thus $l\,ai = lm\,Cos\,45^c$

$$\left(rst - \frac{J}{2}\right) + d = \text{..... (3)}$$

The length of the air inlet including the bottom of the riser is obtained as $lait = \left(rst - \frac{J}{2}\right) + d + J$

$$lait = rst + \frac{J}{2} + d = \text{..... (4)}$$

The depth of the air inlet is obtained as

d_{AI} =H-(K+M)

$$=2.5J - (1.5J + \frac{\sqrt{2}}{3}J)$$

$$d_{ai} = J\left(1 - \frac{\sqrt{2}}{3}\right) \quad \text{..... (5)}$$

The width of the air inlet is equal to the length of the square side (J) of the riser.

3.2.2 DETERMINATION OF POT PARAMETERS

The capacity / volume of the pot is determined depending on the number of people to be served. The volume is then selected from tables.

Alternatively, the volume of the pot: V_p is given by

$V_p = 0.7854 d_p^2 h_p$ ..... equation (6)

Where d_p = Pot diameter

h_p = height of the pot

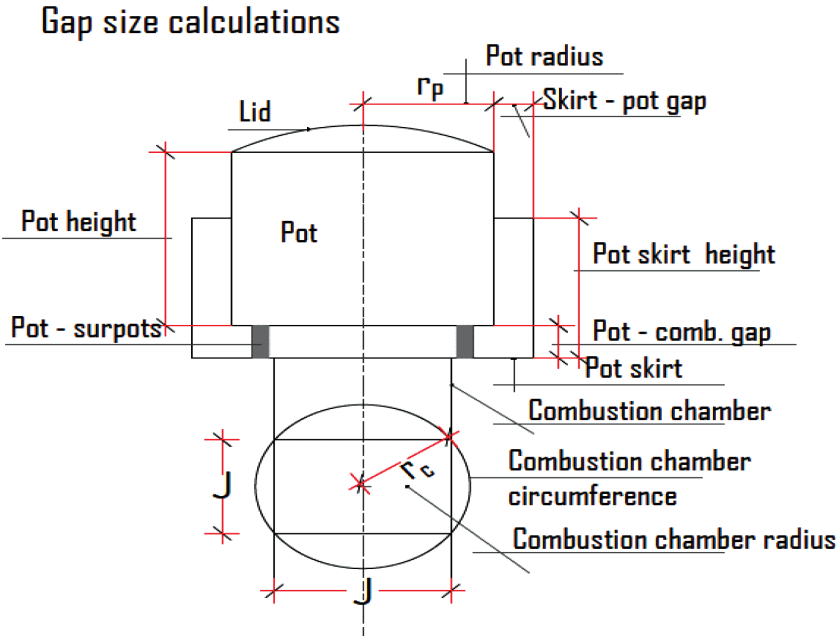
$0.7854 = \frac{\pi}{4}$ = a constant

Motivating assumptions have to be made on hp in order to calculate d_p

$$\therefore d_p = \sqrt{\frac{V_p}{0.7854 h_p}} \quad \text{.....equation (7)}$$

Note; The height to diameter ratio (hp/dp) is very important in assessing pot/stove efficiency. Higher ratios result in low efficiency.

3.3. GAP SIZE CALCULATIONS



3.3.1 AREA OF THE COMBUSTION CHAMBER. Ac

Assuming a square cross sectional area combustion chamber.

$Ac = J^2$ ..... equation (8)

The circumference of the area at the corner of the combustion chamber is obtained as follows

Combustion radius $r_c = \frac{1}{2}\sqrt{J^2 + J^2} = \frac{\sqrt{2J^2}}{2} = \frac{J\sqrt{2}}{2}$

Since, $C_C = 2\pi r_c = 2\pi J\frac{\sqrt{2}}{2}$

Then $C_c = \pi\sqrt{2}J$..... equation (9)

The gap at the edge of the combustion chamber ($P_o t$ - combustion chamber gap)

$$P_c = \frac{Ac}{Cc} = \frac{J^2}{2\pi\sqrt{2}J}$$

$\therefore$ P_c =……equation (10)

3.3.2 The gap between the pot and pot skirt along the side walls; p_{ps}

Circumference of the pot bottom C_p

$$C_P = 2\pi r_p$$

$$\therefore \quad P_{ps} = \frac{Ac}{Cp} = \frac{J^2}{2\pi rp} \quad \text{..... equation (11)}$$

3.3.3 Determination of the pot skirt height HPS

$h_{ps} = P_c + 0.8h_p$

Where, h_p =height of the pot

$$\therefore \quad h_{ps} = \frac{J^2}{\pi\sqrt{2}J} + 0.8h_p$$

ie $h_{ps} = \frac{\sqrt{2}J}{2\pi} + 0.8h_p$ ..... equation (12)

3.3.4. Summary Of Improved Cookstove Parameters

The following tables contain the summary of the various calculated parameters used in design and production of Improved Institutional Wood Stoves.

Table No 1: cookstoves and pot sizes

Stove type	Stove size			Pot size			Feeding capacity
	Diameter (dst) (mm)	Height (hst) (mm)	$\frac{dst}{hst}$ ratio	Diameter (dp) (mm)	Height (hp) (mm)	$\frac{dst}{hst}$ ratio	Students/ People
25L	507	738	0.687	375	250	0.666	10- 50
50L	628	822	0.7644	500	350	0.7	50-150
100L	750	932	0.805	615	350	0.569	150-200
150L	864	980	0.88	720	370	0.514	200- 250
200L	970	988	0.98	830	370	0.446	200-350

Table No 2: Relationship between Pot capacity and combustion chamber size

Pot capacity (L)	J(cm)	K(cm)	H(cm)	Chamber sizing (cm)	Chamber Area Ac (cm^2)
20-40	15	23	38	15×15	225
41-60	16	24	40	16×16	256
61-80	18	27	45	18×18	324
81-100	20	30	50	20×20	400
101-150	21	32	53	21×21	441
151-200	22	33	55	22×22	484
201-230	23	35	58	23×23	529
231-300	24	36	60	24×24	576

Table no 3: Relationship between Pot size and Gap size

Pot capacity (L)	Chamber size (cm)	Gap size	
		Pot-combustion chamber Pc (cm)	Pot-pot skirt: Pps (cm)
25	15×15	3.5	1.9
50	16×16	4	2
100	20×20	5	2
150	21×21	5	2
200	22×22	5	2

Note:

It is good practice to slightly widen the gap between the pot and pot skirt beyond the theoretical best calculated gap, in order to provide some degree of protection against clogging by products of incomplete combustion.

4.0 PARTS OF AN IMPROVED SeTa INSTITUTIONAL WOOD FUEL STOVE

An improved institutional wood cookstove presented in this production manual is made up of the following main parts, namely.

4.1 COOKING POT WITH LID

The pot is a cooking vessel into which the food to be cooked is put. The cooking of food is associated with heat losses from the cooking vessel which are evaporative losses from the food and radiation and convective losses from the

surface of the cooking vessel.

The largest heat loss from the food is due to evaporation of water from the food thus, considerable heat losses can be reduced by keeping the cooking pot covered with a lid. In this particular cookstove, the cooking pot is made of heat resistant stainless steel and the lid is made of aluminium.

4.2 TOP RING

The top ring is that part of the stove which supports the cooking pot at its flange. The flange of the pot rests on the top ring and seals off exhaust gases emission in the kitchen and minimizes air pollution by directing the exhaust gases to the outer part of the pot skirt through the chimney. The top ring enhances the pot support, thus, reducing the wear of the main pot supports which support the pot at its bottom. It is very important to have a good clearance between the pot and the top ring. The top ring is made of mild steel flat bar.

4.3 POT SKIRT

The pot skirt houses the cooking pot during cooking. The narrow gap between the pot and pot skirt increases convective heat transfer to the pot. The pot skirt is welded onto a pot skirt bottom. The pot skirt is made of galvanised steel sheet.

4.4 POT SKIRT BOTTOM

This is a circular galvanised steel sheet which forms the base of the pot skirt. The pot skirt and pot supports are welded on the pot skirt bottom. This part is also welded to the top of the combustion chamber riser.

4.5 COMBUSTION CHAMBER (GRAVITY -TYPE)

The combustion chamber is one of the most important part of the cook stove. The combustion chamber supplies all the heat energy required for cooking to the cooking pot. It consists of three major parts namely, a riser, a firewood magazine, an air inlet and is surrounded by an insulation cover.

4.5.1 RISER

The riser is a short chimney of the combustion chamber. The function of the riser in the combustion chamber is to increase draft and help the fire to burn hot and fierce. Smoke (un- burnt gas) will contact flame in the riser and combust, thus, reducing emissions. The riser should be about 2.5 times taller than its width / diameter in order to effectively bring hotter gases to the pot. A taller riser more than 2.5 times its width / diameter will clean up more smoke, but will also develop too much draft bringing in too much cold air that will decrease heat transfer to the cooking pot.

4.5.2 FIREWOOD MAGAZINE

A firewood magazine of a combustion chamber is a part that facilitates feeding of firewood sticks into the riser of the combustion chamber and is also a part that facilitates feeding of firewood sticks into the riser of the combustion chamber. In a gravity – type of a combustion chamber, the firewood magazine is inclined at an angle of 45 degrees with respect to the riser and the air inlet.

This angle is greater than the angle of friction for wood on steel (26 degrees). In this case, the firewood exhibits self -feeding into the combustion chamber unless it is held on the plane by a force opposing motion due to improper spacing of firewood sticks in the firewood magazine.

- When burning firewood sticks, it is best to have them close together with an air space in between each stick. High and low heat are created by how many firewood sticks are pushed into the fire. The amount of heat required can be controlled by opening or closing the firewood magazine cover. A stove grate is used to lift up the firewood in the combustion chamber because air needs to pass under the burning firewood.

4.5.3 AIR INLET

For complete combustion, air is necessary. An air inlet facilitates air passage into the combustion chamber. Air needs to pass under the burning firewood, up through the charcoal and into the fire. It is optimum if the air is preheated when it reaches the fire to help gases reach complete combustion. Air that passes above the firewood (eg through the firewood magazine) is not helpful because it is colder and cools the fire.

4.5.4 INSULATION COVER

The combustion chamber is insulated along its heat flow path with lightweight heat – resistant ceramic fibre blanket. The insulation cover protects the insulation material. Insulation around the fire keeps it hot, which helps to reduce smoke and harmful emissions. The insulation around the combustion chamber keeps the heat from going into the

stove body instead of into the cooking pot. Dense insulation materials soak up heat and divert it from cooking food. In the present work, the insulation cover is made of galvanised steel sheet.

4.6 STOVE BOTTOM COVER

The stove bottom cover supports the combustion chamber and is welded to the bottom part of the outer cylinder of the stove body. The combustion chamber insulation cover is also welded on the bottom cover. The bottom cover is made of galvanised steel sheet.

4.7 STOVE LEGS

The stove legs are designed depending on the size of the stove, in order to obtain an ergonomically acceptable operating /working height for the cook.

- In the present work, the cook stove has four legs spaced at 90 degrees apart and are welded below the stove bottom. The legs support the stove and clear its bottom off the ground for easy of cleaning and avoiding the risk of rust. The legs are made of galvanised steel sheet for stoves of 25L-150L and of mild steel round bar for the 200L stove.

4.8 STOVE BODY

The stove body consists of an inner and outer cylinder. The inner cylinder's height is about half of the outer cylinder measured from the top of the stove body. At the bottom of the inner cylinder, there is a ring that forms a cover and is welded on the inner and outer cylinders respectively. The space between these cylinders is filled with ceramic fibre

blanket insulation.

- The outer cylinder is also cut to form an opening for assembly of the combustion chamber firewood magazine and air inlet. This opening is sealed off by welding after assembly. There is also a hole cut on the outer cylinder for assembly by welding of a T-elbow for a stove chimney. The stove body is sealed off with a top cover and welded to the stove bottom.
- This construction feature makes the stove safe to use, since it houses the cooking pot, the combustion chamber and is insulated thus, protects the user from fires and burns.
- The stove body is made of galvanised steel sheet.

4.9 TOP COVER

The top cover is welded on the top rig and outer cylinder. This part covers the top of the stove from the top ring to the outer body. The top cover also protects effects of food spillage. This part is made of galvanised steel sheet.

4.10. CHIMNEY

It is always best practice to use a chimney to any wood burning cook stove. The chimney takes smoke and other emissions out of the cooking environment, thus, protects the user of the cookstove and other people by reducing exposure to pollutants and health risks.

- The chimney is fitted on a T-elbow that is welded on the outer body and is held in its vertical position by bracket which is welded on the stove body. It is normally produced in short interpenetrating pieces

and assembled on site depending on the roof structure of the kitchen. Under these conditions, site visit or communication with the customer before product production is necessary.

- A chimney is made of a thin gauge galvanised steel sheet.

5.0 MANUFACTURING OF IMPROVED SeTa INSTITUTIONAL WOODFUEL STOVES

What is manufacturing?

If you take a few moments and inspect various objects at home such as a refrigerator, a household charcoal stove, an electric cooker or a gas cooker, etc, you will soon realize that all these objects have different shapes and you would not find then in nature as they appear. These objects have been designed and transformed from raw materials into various shapes and assemble into the product you now see. All of these products have been made by various processes called manufacturing.

- Manufacturing in its comprehensive sense is the process of converting raw materials into products. The word ‘‘manufacturing’’ is derived from the Latin word ‘‘manu factus’’, meaning made by hand. The word ‘‘manufacture’’ first appeared in 1567, and the word ‘‘manufacturing’’ appeared in 1683. The word product means something that is produced, and the words ‘‘product’’ and ‘‘production’’ first appeared sometime during the 15th century. The word ‘‘production’’ and ‘‘manufacturing’’ are often used interchangeably.

- Manufacturing is generally a complex activity involving a wide variety of resources and activities such as; product design, machinery and tooling, process planning, materials, manufacturing, production control, support services, marketing, sales transportation and customer service.
- It is essential that production activities be responsive to several demands and trends such as;
    - A product must fully meet design requirements, product specification and standards.
    - A product must be produced by the most economical and environmentally friendly methods.
    - Quality must be built in the product and producer at each stage from design to assembly rather than relying on quality testing after the product is manufactured.
    - The manufacturer must work with the customer for timely feedback for continuous product improvement.

5.1 SELECTION OF MANUFACTURING PROCESS.

An extensive and continuously expanding variety of manufacturing processes are used to produce parts and there is usually more than one method of producing a part from a given material.

- The manufacture of Improved Institutional Wood cookstoves falls under the joining manufacturing process which includes operations such as welding, brazing, soldering, riveting, screw fastening, pressing etc. Most of the stove and Pot parts are joined by

welding, therefore, electric Arc Welding was selected as a major manufacturing process.

5.1.1 ELECTRIC ARC WELDING

A welded joint is a permanent joint which is obtained by fusion of the edges of the two parts to be joined together with or without the application of pressure and a filler material. The heat required for the fusion of the material may be obtained by burning of gas (in case of gas welding). Electric arc welding is extensively used because of greater speed of welding.

- In electric arc welding, the filler material is supplied by metal welding electrode. The operator with eyes and face protected by a welding shield, strikes an arc by touching the work of the base metal with the electrode. The base metal in the path of the arc stream is melted, forming a pool of molten metal, which seems to be forced out of the pool by the blast from the arc. A small depression is formed in the base metal and the molten is deposited around the edge of this depression. The slag is brushed off after the joint has cooled.
- This shielded -metal -arc welding employs covered electrodes and can be performed with alternating current (ac) or direct current (dc) power sources. It is the most widely used of all welding processes and finds applications on mild and alloy steels and stainless steels.
- In summary, the process is as follows, the electrode is clamped in an electrode holder which has a cable leading to the power source. The work is electrically grounded (earthed). The electrode tip is touched to the

work to establish the circuit and then retracted slightly, initiating the arc.

5.1.2 TYPES OF WELDED JOINTS IN INSTITUTIONAL COOKSTOVES

The main considerations involved in the selection of weld type are:

- The shape of the welded component required
- The thickness of the materials to be welded.
- The direction of the forces applied on the welded part.
  - In the manufacture of the cookstoves, the types of welded joints used are, butt joint, corner joint, edge joint, tee joint and lap joint respectively. In the manufacture of stoves and pots, all materials involved are not more than 5mm thick except for top rings and pot supports, thus, material edges do not require bevelling as is the case with thicker materials.

5.1.3 BASIC WELD JOINTS USED

Form of weld	Sectional Representation
But joint	
Corner joint	
Edge joint	
Tee joint	
Lap joint	

5.2 COOKSTOVES MANUFACTURING PROCESS

An improved cookstove consists of two major parts, namely the stove and the pot. In the following production processes, the two parts have been treated separately. In order to produce a desired part/ component or sub – assembly, one is required to refer to detailed drawings to meet design requirements.

5.2.1 PRODUCTION OF STOVE PARTS.

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
1	**Combustion chamber**	Firewood magazine -Sides(2pcs)	3×100×380	3×110×442	3×134×491	3×140×568	3×148×640
		-Top and bottom (2pcs)	3×150×380	3×160×387	3×200×424	3×210×498	3×220×566
		-Cover (1pc)	3×106×156	2×116×166	3×140×206	2×146×216	2×154×226
		-Grate (1pc)	3×140×300	3×155×300	3×195×340	3×205×385	3×115×400
		Air inlet -Sides (2pcs)	3×50×200	3×82×274	3×105×300	3×116×352	3×120×440
		-Top (1pc)	3×150×200	3×160×190	3×200×200	3×210×248	3×220×290
		-Bottom (1pc)	3×150×200	3×160×434	3×200×500	3×210×562	3×220×660
		Riser -long sides(3pcs)	3×150×421 3×150×421 3×150×571	3×160×400	3×200×500	3×210×530	3×220×550
		-Short sides(1pc)	3×150×230	3×160×240	3×200×295	3×210×315	3×220×325

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		-Ash tray (1pc)	1.2×185×371(1) 1.2×76×176 (1)	1.2×195×516(1) 1.2×108×196(1)	1.2×235×516(1) 1.2×131×226(1)	1.2×245×577(1) 1.2×136×231(1)	1.2×255×636(1) 1.2×146×256(1)
		Production process • Lay down a stainless-steel sheet of 3mm thick. Using a measuring tape, 1- metre ruler, try square and scriber, measure and mark off dimensions of four sides of the chosen stove firewood magazine on the sheet, in a sequence of one piece at a time after cutting a bending line. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the firewood magazine. • Bend the four sides, check dimensions, squareness and spot weld the magazine					
		• Measure and mark off dimensions of four sides of the air inlet on the sheet in a sequence of one piece at a time after cutting a bending line. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the air inlet. • Bend the three sides, check dimensions squareness and sport -weld the air inlet sides					
		• Measure and mark off dimension of four sides of the riser on the sheet, in a sequence of one piece at a time after cutting a bending line. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the riser. • Bend the four sides, check dimensions, squareness and sport weld the riser sides.					
		• Assemble the air inlet, riser and firewood magazine by sport -welding, check squareness, straightness and then do full welding on all inside and outside edges of the combustion chamber. • Using an angle grinder with grinding disc, grind all welded edges of the combustion chamber to obtain good surfaces without sharp edges.					

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		• Measure and mark off dimensions of the grate on the sheet. • Using an angle grinder with a cutting disc, cut out slots and a bending line. • Using a welding machine, do finishing on slots by cutting with electrode. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the grate. • Using a vice and hammer, bend one side of the grate. • Using an angle grinder with a grinding disc, grinding the grate to obtain a smooth surface without sharp edges. • Sport weld the bent side to strengthen it and put the grate through the firewood magazine to rest on riser bottom. • Lay down a galvanised steel sheet of 2mm thick, measure and mark off dimensions of a firewood magazine cover • Using an angle grinder with a cutting disc, cut out the magazine cover. • Using a bench -vice and hand file, remove sharp edges in all sides and corners. • Using welding machine, weld a hinge onto the firewood magazine upper end and onto the cover to form an openable firewood magazine cover. • Grind all welded edges of the cover to obtain a smooth surface without sharp edges.					
		• Lay down a 1.2 mm thick galvanised steel sheet. Measure and mark off dimensions of an ash tray cum air regulator. • Using an angle grinder with a cutting disc, cut out all bending lines. after that cut out all outer dimensions of the ash tray. • Using a bench vice, hammer and hand file, bend the three sides and remove all sharp edges. • Using a drilling machine, drill holes on the end-cover of the ash tray and then grind the burrs to obtain a smooth surface. • Using welding machine, weld the end cover to the ash - tray to complete the part.					
2	**Combustion chamber insulation cover**	Insulation cover Sides (4pcs).	1.2×421×1000	1.2×400×1040	1.2×500×1240	1.2×528×1240	1.2×550×1280

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 1.2mm thick galvanised steel sheet. Measure and mark off dimensions of four sides of the combustion chamber cover on the sheet, in a sequence of one piece at a time after cutting a bending line. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the insulation cover. Check the dimensions, squareness, straightness and sport -weld at intervals the interior edges to strengthen the cover. • Cut an opening on one side to facilitate housing of the combustion chamber firewood magazine and air inlet.					
3	**Stove leg**	Legs (4pcs)	1.5×130×150	1.5×130×150	1.5×130×150	1.5×160×1	Φ16 ×100
		• Production process • Lay down a 2mm thick galvanised steel sheet. Using a measuring tape,1- metre ruler, try square and scriber, measure and mark off dimensions of the four legs on the street and then cut bending lines with an angle grinder. • Using an angle grinder with a cutting disc, cut out the outer dimensions of the four legs. • Using a bench -vice and hammer, bend the four sides of each leg, check for squareness and weld the edges of each leg. • Grind all welded edges to obtain smooth surfaces.					
4	**Stove bottom cover**	Bottom cover(1pc)	Φ507×1.5	Φ628×1.5	Φ750×1.5	Φ864×1.5	Φ970×1.5

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 1.5mm thick galvanised steel sheet. Using a measuring tape, divider, try square, scriber, centre punch and hammer, measure and draw a circle of the required diameter on the sheet. • Using an angle grinder with a cutting disc or other appropriate methods, cut out the circle to form the bottom cover of the stove. • Using a protractor, a 1 – metre ruler, and scriber, measure, mark and draw two diameters to intersect at 90degrees at the centre to form location of the four legs on the circle. • Take the four legs, position them on the stove bottom, check for squareness and straightness, then weld them onto the stove bottom cover. • Grind all welded edges to obtain good surfaces.					
5	**Pot skirt bottom**	Skirt bottom (1pc)	Φ421×2	Φ550×2	Φ664×2	Φ778×2	Φ884×2

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 2mm thick galvanised steel sheet. Using a try square, a 1-metre ruler, measuring tape, hammer, centre punch, scriber and divider, measure, mark and draw a circle of the required diameter. • Measure, mark and draw a circle of the required squire at the centre of the circle. • Measure, mark and draw a circle of the required diameter for positioning of the four pot supports which are spaced at 90 degrees intervals. • Using an angle grinder with a cutting disc or other appropriate methods, cut out the circle to form the skirt bottom. • Using an angle grinder with a cutting disc or other methods, cut out the square at the centre of the circle to form a slot for the combustion chamber outlet. • Remove sharp edges and burrs on the skirt bottom by using an angle ○ Grinder with a grinding disc or hand file.					
6	**Pot supports**	Pot support (4pcs)	5×30×150	40×46×80	50×56×80	50×56×100	50×56×100

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a mild steel angle iron of a selected size depending on the required size of the pot support. • Using a measuring tape, try squire and scriber, measure mark and cut out eight pieces of angle iron in a sequence of one piece at a time using an angle grinder with a cutting disc or other appropriate methods. • Take two pieces of angle iron at a time and weld them together to form four pot supports. • Take the four pot supports and spot -weld them onto the pot skirt bottom obtained in no 5.					
7	**Pot skirt**	Pot skirt (1pc)	2×235×1318	2×323×1722	2×330×2080	5×346×2438	2×346×2770
		Production process • Lay down a 2mm thick galvanised steel sheet. Using a measuring tape, a 1-metre ruler, try square and scriber, measure and mark off dimensions of a selected pot skirt. • Using an angle grinder with a cutting disc, cut out the marked sheet to obtain a rectangular piece of the required dimensions. • Using a metal rolling machine, roll the sheet metal obtained above. • Sport – weld the edges of the curved metal together to form a cylinder. • Roll again the cylinder using the metal roller to obtain a cylinder of the required dimensions • Weld the cylinder and then grind the welded edge to obtain a smooth joint. • Spot-weld the pot skirt onto the pot skirt bottom.					

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
8	**Top ring**	Top ring (1pc)	5×30×1230	6×50×1625	6×50×2000	6×50×2325	6×50×2670
		Production process. • Lay down a mild steel flat bar of 6mm×50mm. Using a measuring tape, try square and scriber, measure and mark off a length on the flat bar depending on a selected top ring. • Using an angle grinder with a cutting disc or other methods, cut off the marked flat bar to obtain a piece of required measurement. • Using a metal rolling machine, roll the piece obtained above. • Sport weld the edges of the curved metal to form a ring and continue rolling the ring to obtained the required dimensions. • Weld the spot -welded edge of the ring using a welding machine. • Using an angle grinder with a grinding disc, grind the welded edge to make a smooth joint.					
9	**Top cover**	Top cover (1pc)	Φ 396/507 x 2	Φ 523/628 x 2	Φ 640/750 x 2	Φ746/864 x 2	Φ 852/970 x 2

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 2mm thick galvanised steel sheet. Using a measuring tape, a 1-metre ruler, divider, hammer, try square, centre punch and scriber, measure, mark and draw two concentric circles of a selected top cover on the sheet metal • Using an angle grinder with a cutting disc, cut out the internal diameter and then the external diameter of the top cover. • Remove the burrs and sharp edges of the cover by using an angle grinder with a grinder with a grinding disc or a hand file.					
10	**Stove Inner Cylinder**	Inner cylinder (1pc)	5×30×1230	5×30×1230	5×30×1230	5×30×1230	5×30×1230
		Production process • Lay down a 1.5mm thick galvanised steel sheet. Using a measuring tape, a 1- metre ruler, a try square and scriber, measure and mark off the dimensions of the selected inner cylinder on the sheet metal. • Using an angle grinder with a cutting disc or other methods, cut out the marked rectangle. • Using a metal rolling machine, roll the rectangular sheet metal, spot- weld the edges of the curved metal and continue rolling to form the cylinder with required dimensions. • Weld the spot – welded part using a welding machine. • Using an angle grinder with a grinding disc, grind the welded edges to make smooth joints					
11	**Stove outer cylinder**	Outer cylinder (1pc)	5×30×1230	5×30×1230	5×30×1230	5×30×1230	5×30×1230

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 1.5mm thick galvanised steel sheet. Using a measuring tape, a 1-metre ruler, a try square and scriber, measure and mark off the dimensions of the selected outer cylinder on the sheet metal. • Using an angle grinder with a cutting disc or other method, cut out the marked rectangle. • Using a metal rolling, machine, roll the rectangular piece obtained above, sport -weld the edges of the curved metal and continue rolling to form the cylinder with the required dimensions. • Weld the sport-welded part on both sides using a welding machine. • Using an angle grinder with a grinding disc, grind the welded edges to make smooth joints.					
12	**Inner and outer cylinders cover.**	Cylinders cover (1pc)	Φ454/504 x 1.5	Φ625/572 x 1.5	Φ697/747 x 1.5	Φ811/861 x 1.5	Φ918/968 x 1.5

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process • Lay down a 1.5mm thick galvanised steel sheet. Using a measuring tape, a 1-metre ruler, divider, hammer, try square, centre punch and scriber, measure, mark and draw two concentric circles of a selected inner and outer cylinders cover on the sheet metal. • Using an angle grinder with a cutting disc, cut out the internal diameter of the cylinders cover. • Remove the burrs and sharp edges of the cover by using an angle grinder or a hand file. • Sport – weld the cover onto the inner cylinder's bottom to form an outer flange. • Turn the inner cylinder with flange top down and assemble the outer cylinder to fit with the flange. • Weld the cover onto the inner and outer cylinders respectively using a welding machine. • Grind the welded edges to obtain good surfaces. • Turn the inner and outer cylinders' top down again and park insulation material (ceramic fibre blanket) between the inner and outer cylinders.					
13	**Stove Elbow**	Elbow (1pc)	Φ127×217 ×247	Φ127×217 ×247	Φ127×217 ×247	Φ160×250×280	Φ160×250 ×280

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
		Production process. • Lay down a 1.2 mm thick galvanised steel sheet. Using a template and scriber, mark off the dimensions of a rectangular piece for a selected horizontal pipe of the elbow. • Using an angle grinder with a cutting disc or other methods, cut out the marked sheet metal to obtain a rectangular piece. • Using a metal rolling machine, roll the rectangular piece obtained above to form a pipe. Sport – weld the edges of the curved metal and continue rolling to obtain the required pipe dimensions. • Using a template and a scriber, mark off the dimensions of a rectangular piece for a vertical pipe of the elbow. • Using an angle grinder with a cutting disc or other methods, cut out the marked sheet metal to obtain a rectangular piece. • Using a metal rolling machine, roll the rectangular piece to form a pipe. Spot- weld the edges of the curved metal and continue rolling to obtain the required pipe dimensions. • Assemble the horizontal and vertical pipes, check for squareness, then weld them together to form a tee – elbow. After that grind the welded edges to obtain a good finishing. • Using a divider, try square, centre punch and scriber, measure, mark and draw a circle of required diameter to form a cover for the elbow. • Cut out the circular piece and remove sharp edges. • Using an angle grinder with a cutting disc, cut out a round bar of • φ6mm×50mm, remove sharp edges and weld it on the cover to form a handle for operation of the cover. • Using a bolt and nut of M 8×50mm, weld the bolt on the elbow and the M8 nut on the edge of the cover to enable the cover to swivel. • Cut with an angle grinder a round bar of φ6mm×45mm, clamp it in a bench -vice, bend it with a hammer and weld it on the lower part of the elbow to form a lock for the handle. • Assemble the T- elbow with the outer cylinder of the stove body by welding after having ensured for squareness of the elbow on the stove body, then grind to obtain a good finishing.					

No	Part name	Component name	Stove size and component dimensions (mm)				
			25L	50L	100L	150L	200L
	Chimney bracket	Chimney bracket (1pc)	2×30×520	2×30×520	2×30×520	2×30×646	2×30×646
		Production process • Lay down a 2mm thick galvanised steel sheet. Using a measuring tape, a 1-metre ruler, try square and scriber, measure and mark off dimensions of a selected chimney bracket on the sheet metal. • Using an angle grinder with a cutting disc, cut out a rectangular piece marked on the sheet metal. • Mark off from each end dimensions equal to the required distance between the stove body and the chimney. using a metal roller or other methods, roll the rectangular piece obtained above to form a ring. • Straighten the portions marked from the two ends and sport- weld them to form the bracket. • Weld the chimney bracket onto the stove body and then grind welded edges to obtain a good finishing.					
15	**Stove handles**	Handle (2pcs)	φ12×300	φ12×300	φ12×300	φ12×340	φ12×340
		Production process. • Lay down a 12mm diameter mild steel round bar. • Using a measuring tape and scriber, measure and mark off one piece at a time. • Using an angle grinder with a cutting disc, cut out one piece for a handle at a time and remove its sharp edges on both ends by grinder. • Using a bench-vice or other methods bend at marked lengths its on both ends and check for accuracy as required. • Weld the two handles at 180 degrees apart onto the stove body and grind the welded edges to obtain good surfaces.					

5.2.2. PRODUCTION OF STAINLESS STEEL POT PARTS.

No	Part name	Component name	Pot size and component dimensions (mm)				
			25L	50L	100L	150L	200L
1	Pot cylinder	Cylinder (1pc)	2×270×1173	2×375×1566	2×375×1927	2×385×2258	2×395×2603
		Production process. • Lay down a 2mm thick stainless steel sheet. Using a measuring tape, a 1 metre ruler, try square, and scriber, measure and mark off dimensions of a pot cylinder of a selected pot size on the sheet metal. • Using an angle grinder with a cutting disc or other methods, cut out the marked rectangular piece. Bend one topside along the length and straight the before rolling. • Using a metal rolling machine, roll the rectangular piece, spot – weld the edges of the curved metal and continue rolling to form a pot cylinder of required dimensions. • Using an angle grinder with a grinding disc, grind the welded edge to remove sharp edges.					
2	Pot flange	Flange (1pc)	Φ 375/425 x 2	Φ500/560 x 2	Φ615/675x2	Φ720/790 x 2	Φ 830/900 x 2
		Production process • Lay down a 2mm stainless steel sheet. Using a measuring tape, a 1-metre ruler, try square, centre punch, divider, hammer and scriber, measuring mark, and draw two concentric circles with diameters of the required pot flange of a selected pot size. • Using an angle with a cutting disc, cut out the internal diameter first and then cut out the external diameter form the flange. • Remove burrs and sharp edges by using a hand file or an angle grinder with a grinding disc.					

No	Part name	Component name	Pot size and component dimensions (mm)				
			25L	50L	100L	150L	200L
3	Pot Bottom	Bottom (1pc)	Φ382×3	Φ507×3	Φ622×3	Φ726×3	Φ837×3
		Production process. • Lay down a 3mm stainless stainless-steel sheet. Using a measuring tape, a 1-metre ruler, try square, centre punch, divider, hammer and scribe, measure, mark and draw two concentric circles and use the internal diameter as a bending line of the bottom on the sheet. • Using an angle grinder with a cutting disc, cut out the external diameter of the pot bottom for cupping. • Remove sharp edges by angle grinder with a grinder with a grinding disc. • Using a hammer or other appropriate methods bend the piece obtained above on a metal forming block along the bending line to form a vertical fold which is the required cupping depth.					

No	Part name	Component name	Pot size and component dimensions (mm)				
			25L	50L	100L	150L	200L
4	Pot handles	Handle flats (4pcs)	3×30×110	3×30×115	3×30×115	3×30×115	3×30×115
		Pipe (2pc)	Φ22×110	Φ22×120	Φ380×2	Φ22×120	Φ22×120
		Production process. • Lay down a 3mm stainless steel sheet. ○ Using a measuring tape, try square and scriber, measure, mark off four handle flats (one piece at a time). • Using an angle grinder with a cutting disc, cut off the four handle flats including 45 degree bevels at one end on each flat. • Remove sharp edges on the four handle flats.					
		• Lay down a 22mm outer diameter galvanised steel pipe. Using a tape measure, try square and scriber, measure and mark off two pieces of pipes (one at a time after cutting with a grinder). • Using an angle grinder with a cutting disc or other methods, cut off two pieces of pipes and remove sharp edges by a hand file. • Take the four stainless steel flats and the two galvanised steel pipes and assemble them by welding to get two stove handles (two flats and one pipe per handle) • Grind the handles on welded edges to obtain smooth surfaces.					
5	Pot lid	Lid (1pc)	Φ380×2	Φ515×2	Φ626×2	Φ742×2	Φ846×2
		Production process • Lay down a 2mm thick aluminium sheet. Using a measuring tape, a 1-meter ruler, try square, centre punch, divider, hammer and scriber, measure, mark and draw two concentric circles with internal diameter as a bending line of the lid on sheet. • Using an angle grinder with cutting disc, cut out the external diameter of the lid for cupping. • Remove sharp edges by a hand file or angle grinder with a grinding disc. • Using a hammer or other appropriate methods bend the piece obtained above on a metal forming block along the bending line to form the required cupping depth.					

No	Part name	Component name	Pot size and component dimensions (mm)				
			25L	50L	100L	150L	200L
6	Pot lid Handle	Lid Handle (1pc)	2×40×120	2×40×150	2×40×192	2×40×192	2×40×192
		Production process • Lay down a 2mm aluminium sheet. Using a measuring tape, try square, and scriber, measure, and mark off dimensions of a rectangular piece for a lid handle. • Using an angle grinder with a cutting disc or other methods, cut out the rectangular piece and remove burrs and sharp edges by a hand file. • Using a bench-vice and hammer, bend the two long sides of the piece obtained above and flatten them to form a rectangular strip of double its thickness. • Using a forming tool or other methods, form the lid handle. • Take the lid and handle and drill them together at two places by using a hand drill machine. • Separate the lid and handle and remove any burrs or chips by a hand file so as to have a tight flush joint between the lid and handle. • Assemble the lid and handle by cold riveting using a riveting machine or by hand.					

5.2.3 ASSEMBLY OF THE POT

No	Production process
	• Assemble the pot cylinder and pot bottom by welding the two parts together both internally and externally. • Using an angle grinder, grind the welded edges to obtain a good finishing. • Assemble the pot flange from the bottom of the pot and weld it on the cylinder, then use an angle grinder to grind the welded edges. • Assemble the two handles on the pot flange and cylinder by welding. The two handles are spaced 180 degrees apart. After that, grind the welded edges to obtain a good finishing. • Fill the pot bottom with water to test for leakages on welded edges between the pot cylinder and pot bottom. Parts detected with leakages must be re-welded to clear defects. • Using an angle grinder with stainless polisher, polish the whole pot both internally and externally. • Paint all outer welded edges of the pot with aluminium paint. • Put the aluminium lid to fit on top of the pot.

5.2.4 ASSEMBLY OF THE STOVE

No	Production process
	• Lay down the stove bottom cover assembled with stove legs. • Take the combustion chamber and align it at the centre of the stove bottom and spot- weld it to keep in position. • Put the combustion chamber insulation cover through the top of the combustion chamber and weld it on the stove bottom so that it houses the combustion chamber properly. • Pack insulation material (Ceramic Fibre Blanket) in the gap between the combustion chamber and insulation cover to form an insulated combustion chamber. • Take the sub- assembly of the pot skirt bottom, pot supports and pot skirt and align it with the combustion chamber outlet through the central square slot. Sport – weld this sub assembly and then do full welding between the combustion chamber outlet and pot skirt bottom, pot supports and skirt bottom and the pot skirt with the skirt bottom. After the welding process, grind all welded edges to obtain a good finished surface. • Take the stove body sub- assembly comprising of the inner and outer cylinders, elbow, chimney bracket and handles and align it to fit through the combustion chamber firewood magazine and rest on the stove bottom cover and then sport – weld it on the bottom cover. • Take the stove top cover and sport – weld it on to the stove outer cylinder. • Take two pieces of mild steel round bars about φ12mm×300mm and sport-weld them on the top ring outer diameter, spaced at 180 degrees apart to be used as supporting handles. • Align the top ring to fit in the internal diameter of the top cover. • Put the pot (without the lid) through the top ring internal diameter to rest properly on pot supports on the pot skirt bottom. While in this position, lift the top ring by using the supporting handles until the top ring rests on the flange of the pot, then, sport – weld the lower part of the top ring onto the stove top cover. • Take out the pot and then cut off the two round bar supporting handles by using an angle grinder. • Cover the opening on stove outer cylinder between the firewood magazine and air inlet by welding a piece of material previously cut off from the same slot. • Carry out full welding between the top ring and top cover, the top cover and outer cylinder of the stove and between the outer cylinder and stove bottom cover. • Using an angle grinder with a grinding disc, grind all outer welded edges to obtain good Finishing. • Assemble the outer sourced part (chimney) and then the ash tray cum air inlet pot and lid and prepare the stove for painting and riveting of the stove serial number plate.

Table No 4: Calculated stove weights

No	Part name	Stove size and weight (kg)				
		25L	50L	100L	15OL	200L
1	Stove body	35	52	70	93	97
2	Combustion chamber	15	20	25	30	33
3	Pot	7	12	19	24	30
4	Total weight	57	84	114	147	160

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Disclaimer

Whereas relate to other cookstoves currently in the market, the Improved Institutional Wood Cookstoves described in this Production Manual are believed to offer significant benefits to the users and whereas this Production Manual is believed to be a useful tool/guide for instruction in the production process of the Improved Institutional Wood CookStoves, neither TaTEDO nor the author assumes responsibility for the completeness or usefulness of the information therein. Additional to this, neither TaTEDO nor the author assumes any liability in respect of any claim(s) that may arise in the event of any injuries and /or damages that may occur during

the design, production, use, maintenance or misuse of any cookstoves that may be produced on the basis of the design or procedure described herein.

Appendix A - Nomenclature

Ac - Area of combustion chamber
a- Length of a side
Ai - air inlet
b - breadth
cc- circumference of combustion chamber
d-diameter, distance
di- internal diameter
dm- mean diameter
do-outside diameter
dp- diameter of the pot
dst- diameter of stove
H- height of combustion chamber, riser
hp- height of the pot.
hps- height of the pot skirt
J- length of a side of a combustion chamber.
K- depth/length of short side of a comb chamber
Kg- kilogram
lm – length of firewood magazine
lai- length of air inlet.
lait- total length of air inlet
Ldev – developed length
Pc- gap between the pot and combustion chamber.

Pps – gap between the pot and pot skirt
rc- radius of combustion chamber
rst- radius of stove
t- thickness, total
Vp – Volume of the pot
w- width

subscripts.
ai- air inlet
ait-air inlet total
c -combustion chamber
dev-developed
i-internal
m- mean diameter, firewood magazine
o- outside
p- pot
ps- pot skirt
st- stove

Appendix B: Weights C alculation

In selection of materials, it is important that the designer should have a thorough knowledge of the properties of the materials and their behaviour under working conditions. Some of the important characteristics of materials are; strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, weldability, electrical conductivity, machinability, thermal expansion, thermal conductivity etc.

- The weight characteristic of materials is an important factor to keep in mind, when designing a piece of equipment/product.

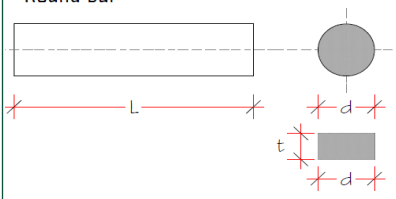
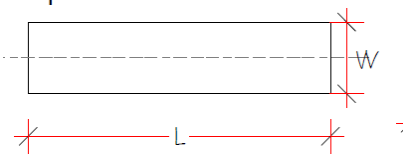
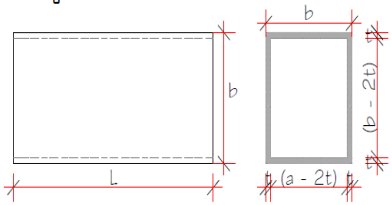
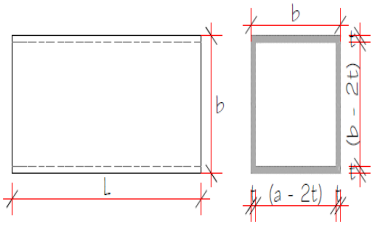
  Weight saving for example is important particularly for specialized structures such as aircraft, automotive bodies and components for air craft, automotive bodies and components for other products where power limitations and energy consumption are major concerns.

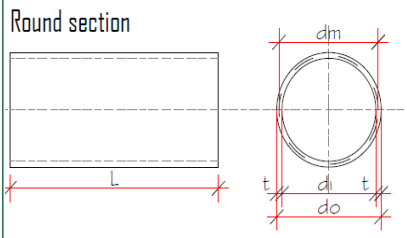
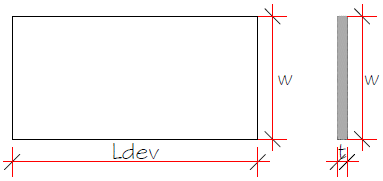
- Substitution of materials for the sake of weight saving and economy is also a major factor in design of both advanced equipment and machinery of consumer products. On the other hand, there are applications where weight is desirable. Examples are counterweights for various mechanisms, for flywheels etc.

- The equations presented in this Production Manual will serve as tools for simplified weights calculation of steels of various standard sections such as; rectangular flats, squares, rounds and hollow sections.

Appendix C: Selected Standard Steel Sections

No	Steel section	Equation for weight calculation
1	Flat bar 	Weight =t× w ×l ×0.00785(kg) Where; t=thickness(mm) W=width (mm) L= length(m) 0.00785= constant Converted factor representing density of steel.

2	Round bar 	Weight =0.7854× d^2 ×L ×0.00785(kg) Where; 0.7854 = π/4 = constant d= diameter (mm) L= Length (m)
3	Square bar 	Weight = w^2x L x 0.00785 (kg) Where, w=width of a side (mm) L=length (m) 0.00785=a constant
4	Rectangular Hollow section of uniform thickness 	Weight = ((axb)- (a-2t) (b-2t))x L x0.00785 (kg) Where; a = width (mm) b= breadth (mm) L= length (m) 0.00785= constant
5	Square Hollow section of uniform thickness 	Weight= (a^2 –$(a-2t)^2$) x L x 0.00785 (kg) Where; a= length of a side (mm) t= thickness (mm) L= length (m) 0.00785= constant

6.1	Round hollow section of uniform thicknes 	Weight = 0.7854 ($d_o^2 - d_i^2$) x L x 0.00785 (kg) Where; do=outside diameter (mm) di=inside diameter (mm L= length(m) d_m=mean diameter= ½ (d_i +d_0) 0.00785= a constant
6.2	Developed view (rectangular) 	Weight =t×w×ldev×0.00785 =t×w×π/2(d_i +d_0) ×0.00785 (kg) Where; t=thickness (mm) w= width(mm) di=inside diameter (mm) do=outside diameter (mm) Ldev= developed length(m) π= constant=3.142 0.00785= constant

Appendix D: Efficiency Test Results Summary

TaTEDO is developing, fabricating and promoting various improved bioenergy technologies such as ovens, stoves and briquetting production. They are available for sale to the public and there by disseminating renewable energy technologies that conserve the environment. Periodically as the need may be, these products are subjected to

tests that forms a basis for improvement and technology documentation.

In the current work, two types of tests were carried out by TIRDO to institutional base 50 Litre firewood cooking stove of the type designated as SeTa – IS 50 that included various temperature measurements to perform boiling and evaporation test. From these tests it was possible to establish fire power and thermal efficiency of the cooking stove. Results are;

i) Evaporation tests:-

Cold start (thermal efficiency, 49.46% with fire power, 4.53kW).

Hot start (thermal efficiencies, 54.82% and 48.42% with fire power, 4.63kW and 4.46kW respectively).

ii) Boiling tests

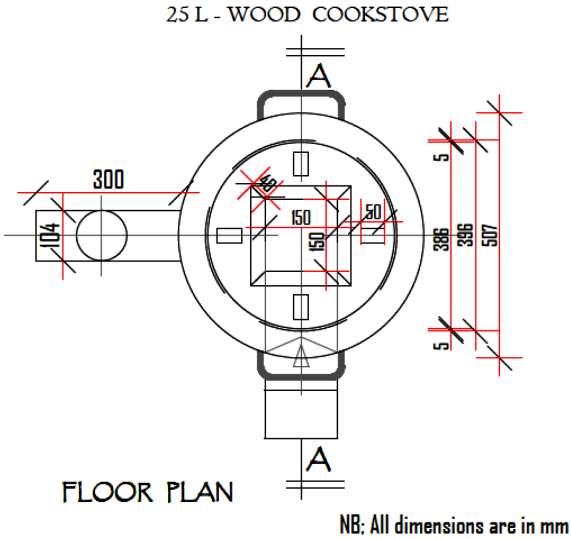
Cold start (thermal efficiency, 44.83% with fire power, 4.06kW)

Hot start (thermal efficiency, 48.57% with fire power, 5.76kW) After performance tests of the stove, results show a relatively high efficiency as above. High efficiency is attributed by; good design for heat transfer, increased surface area for heat exchange, high efficiency of the combustion chamber and reduction of heat energy loss by application of ceramic fibre blanket insulation to areas where useful heat exchange take place.

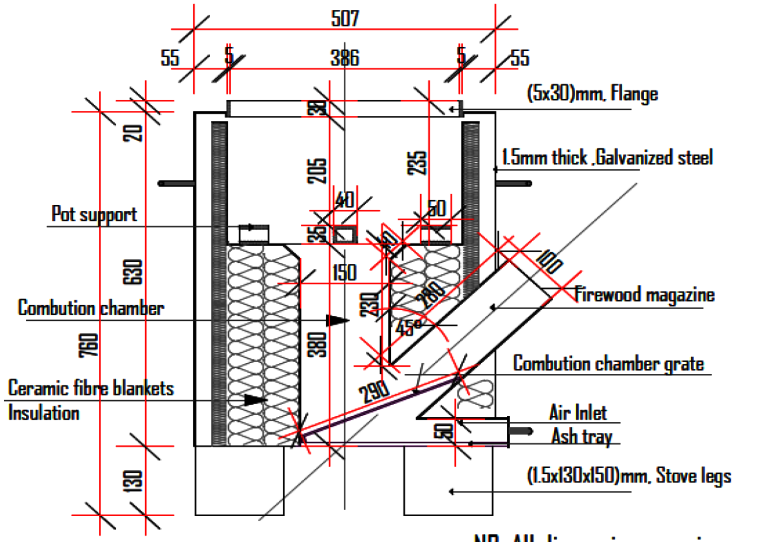
Based on the results observed after the test for thermal efficiency, it recommended to: -

- Conduct further tests to determine quality level of emission by the stove, this will help in quantification of combustion chamber efficiency.
- Carry out tests to determine optimum operating parameters of the stove for establishment of optimum wood fuel consumption.
- Deep assessment of impact of manufacturing defaults and their impact on thermal efficiency results.
- Since insulation is a key component in improving efficiency, design should be focused on better insulation practices

Appendix E: Technical Drawings of Institutional Firewood Cook Stoves (SeTa Institution)

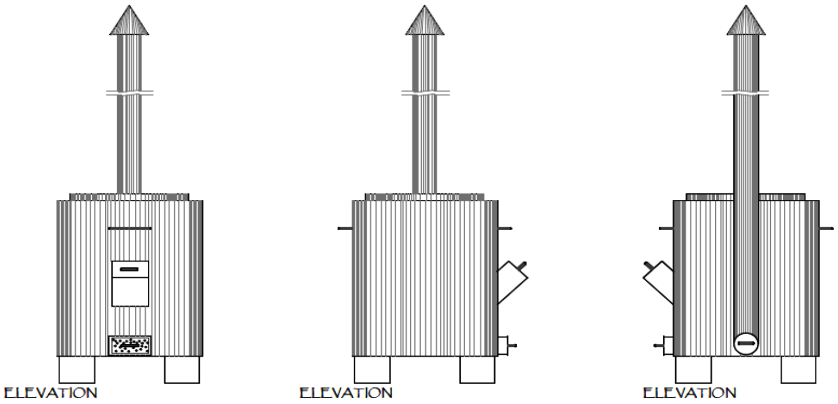


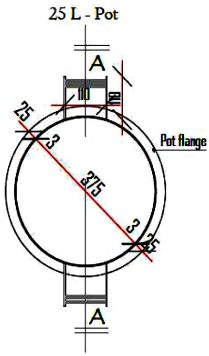
25 L WOOD COOKSTOVE



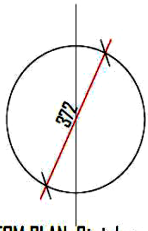
Section

25 L WOOD COOKSTOVE



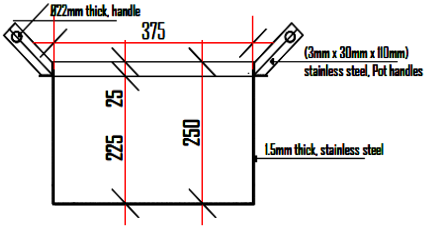


POT TOP PLAN; Stainless steel materials

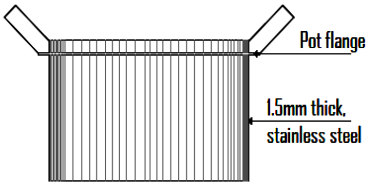


POT BOTTOM PLAN; Stainless steel materials

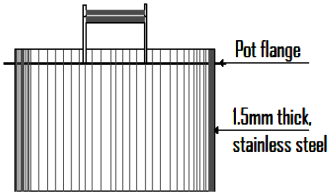
25 L - Pot



Section

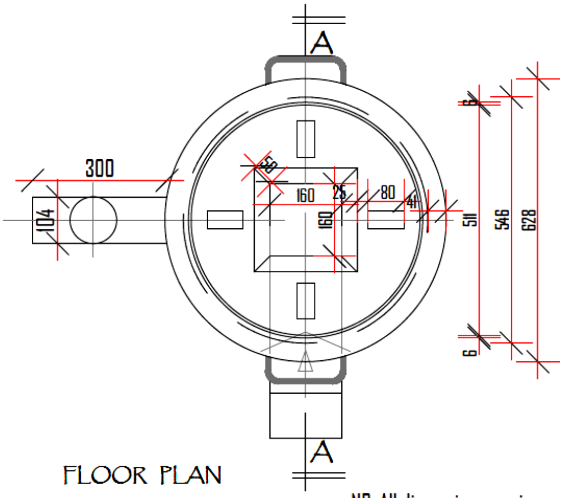


ELEVATION



ELEVATION

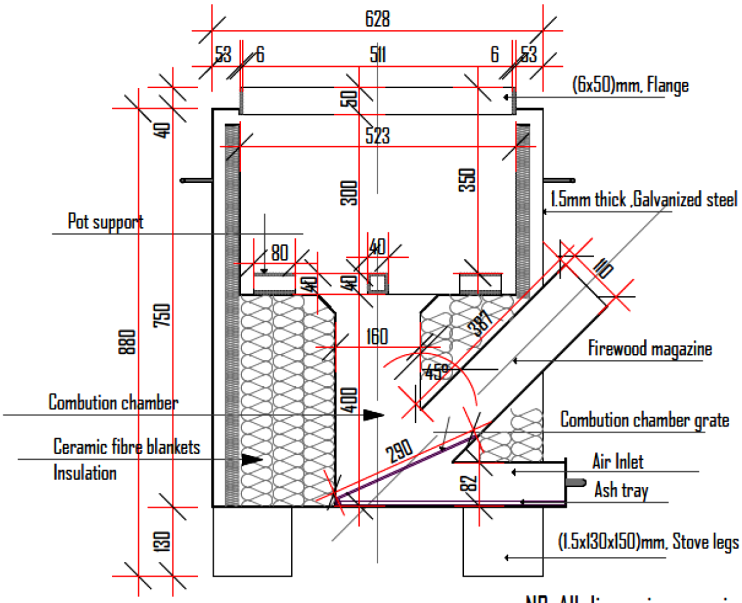
50 L - WOOD COOKSTOVE



FLOOR PLAN

NB: All dimensions are in mm

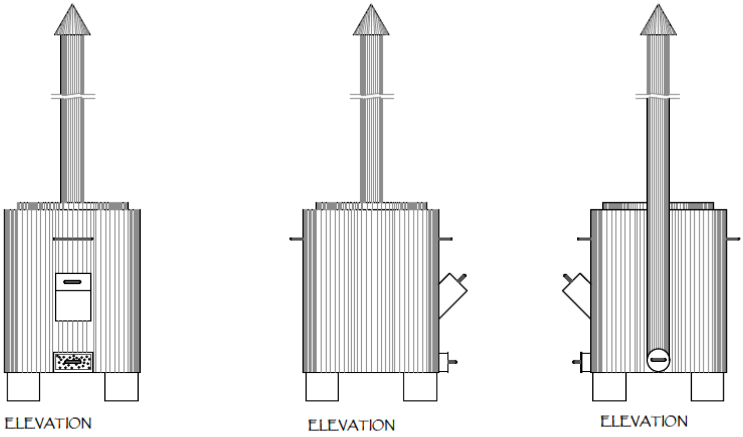
50 L WOOD COOKSTOVE



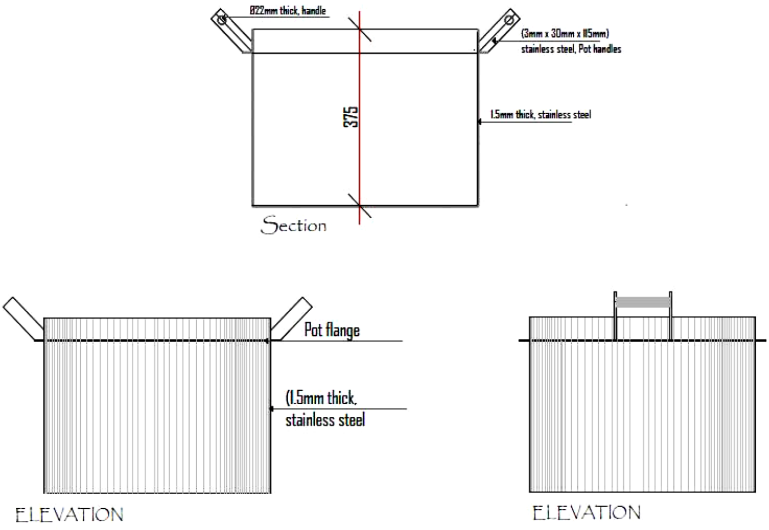
Section

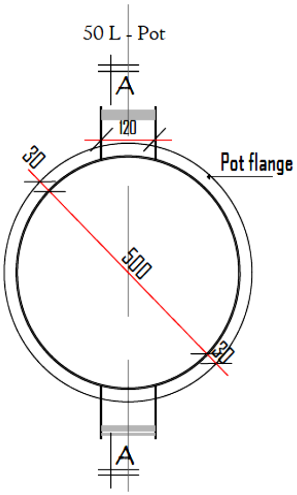
NB: All dimensions are in mm

50 L WOOD COOKSTOVE

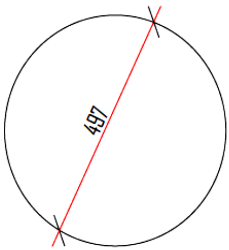


50 L - Pot





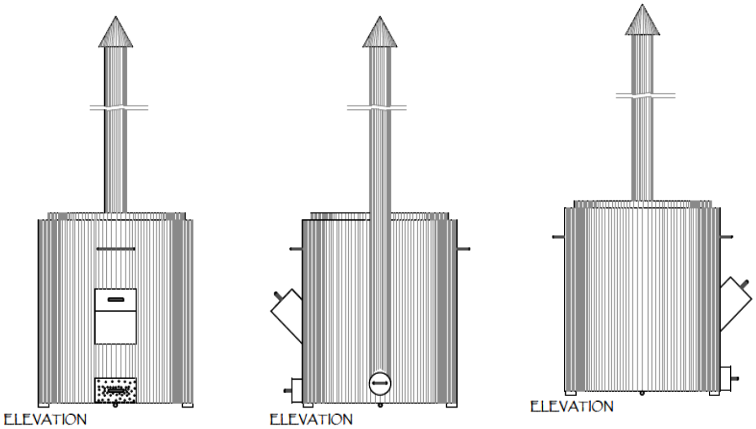
POT TOP PLAN; Stainless steel materials

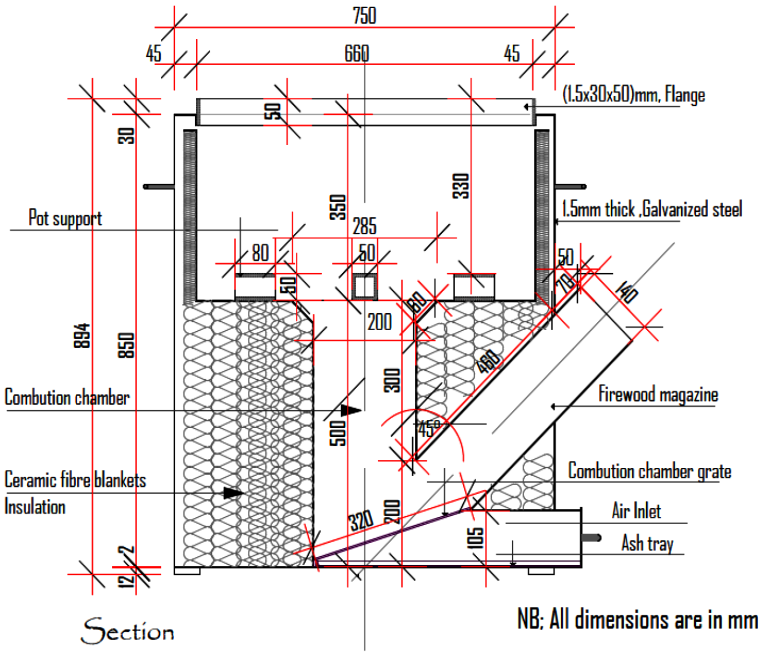


POT BOTTOM PLAN; Stainless steel materials

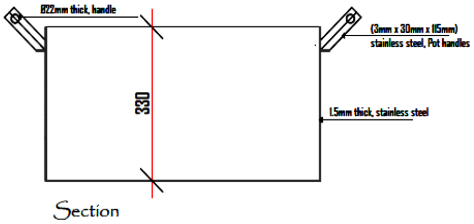
POT TOP PLAN; Stainless steel materials

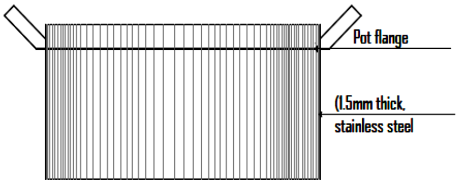
100 L WOOD COOKSTOVE



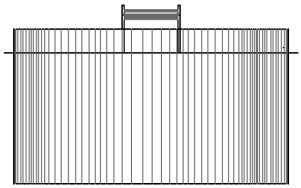


I00 L - POT

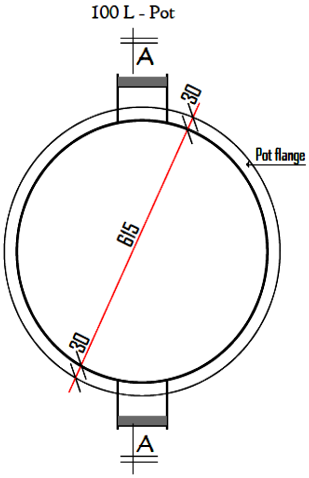




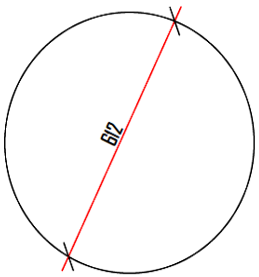
ELEVATION



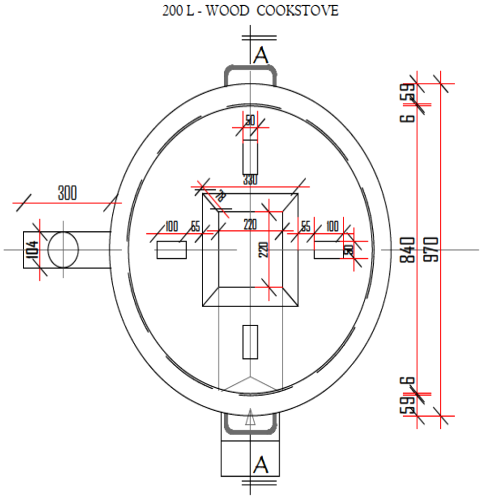
ELEVATION



POT TOP PLAN; Stainless steel materials

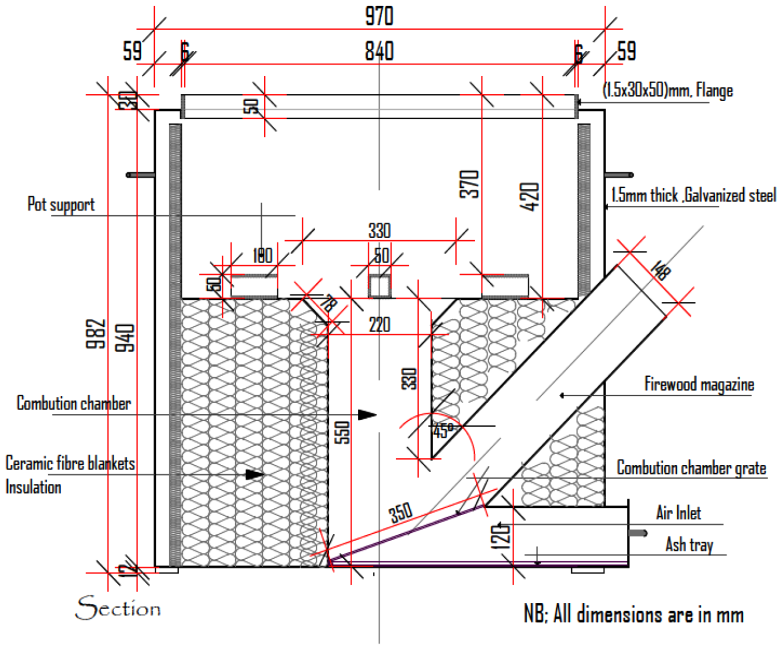


POT BOTTOM PLAN; Stainless steel materials

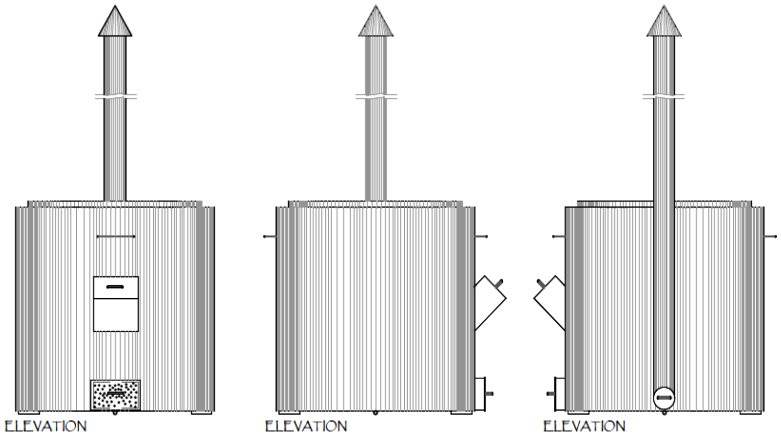


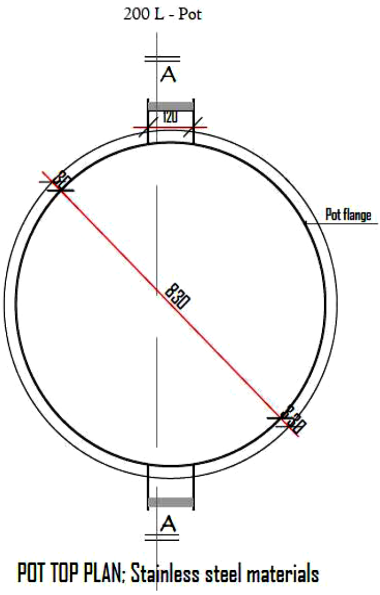
FLOOR PLAN

NB; All dimensions are in mm

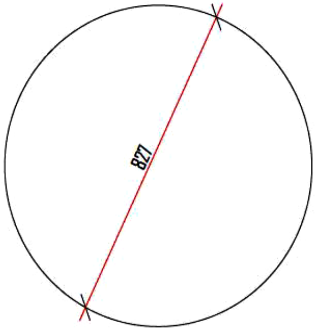


200 L WOOD COOKSTOVE





POT TOP PLAN; Stainless steel materials



POT BOTTOM PLAN; Stainless steel materials