EIE-06-256 REEPRO

Promotion of the Efficient Use of Renewable Energies in Developing Countries

Level 1 Course 1

Workshop Training on construction of Low cost small gasifier

11-14.11.2008

Report

Author

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November 2008

The SOLPOOL project receives funding from the European Commission within the ALTENER programme.

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Book ‘Draft Specification rural gasifier below 5kW’

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List of Acronymes

FE	Faculty of Engineering
NUOL	National Uniersity of Laos

1. Summary Sheet

Event:	REEPRO Level 1 Training
Task number	
Date, Location, Time:	11-14.11.2008, 9:00-16:30 Sokpaluang campus Faculty of Engineering, National University of Laos
Theme:	Training workshop on construction of low cost gasifier
Target group:	☒ REEPRO trainers ☒ Students
Performance:	• Brief theoretical presentation • Practical works in construction of simple gasifier
Participants:	27 participants, see attached list of participants
Success:	Dr. Jens Berkan and Dr. Jan K. Dobelmann presented principle of design and construction of a low cost small scale gasifier, using as much as possible cheap local construction materials. Trainees have learned how to design and construct a simple gasifier by using mostly local available materials such as mud, used 200-littre oil drum, wood, rice husk, so that the construction costs are significantly reduced and there is a possibility for locally made gasifier At the ending session, the reactor was run for structure test and drying up. Then discussions were going on themes how to test the reactor and to do further modification Some students and staff of FE/NUOL were interested in gasifier tesing and improvement.
Download:	This report and some more photos of the training can be downloaded under www.reepro.info

Vientiane, Lao PDR

Dr. Khamphone Nanthavong

Faculty of Engineering (NUOL), REEPRO Training coordinator

2. Workshop Preparation

Preparation of Construction materials:

- mud, rice husk were delivered in advance
- other construction materials were procured before and during the training

The preparation of the workshop based on the book 'Draft Specification rural gasifier below 5 kW' that is shown in appendix (page 12). After completing revision the book will be used as REEPRO Level 2 training manual.

3. Workshop Performance

Day 1, 11 November 2008

- Procurement of necessary construction materials: used 200-L oil drum, steel bars and sheets, welding materials, wood materials, charcoal, etc

Day 2, 12 November 2008

- Short theoretical session was conducted at Mechanical Lab building, FE/NUOL
- Then the trainees were grouped into three groups to perform tasks three tasks independently, such as: (1) Reactor preparation; (2) Mud preparation; (3) wood frame preparation
- The practical works were conducted at Mechanical workshop

Day 3, 13 November 2008

- Continuation of preparation works for Reactor and wood frame preparation
- Building of reactor was started before noon with filling the reactor with pure mud (as seal) and mud-rice husk mixture (as insulation).

Day 4, 14 November 2008

- Building of gasifier was almost finished just after noon.
- The reactor then was loaded with charcoal and fired
- The test run has shown satisfactorily working condition of constructed gasifier: reactor, air holes,

3.1. Presentation

- Short theoretical presentation was done by Dr. Jens Berkan and Dr. Jan K. Dobelmann, moderated by Dr. Khamphone Nanthavong (see details of design sketches of the gasifier in book 'Draft Specification rural gasifier below 5kW' - Appendix)
- Further detailed instruction and guidance in construction of gasifier were done along with the practical works

3.2. Discussion

During the training, some discussions were going on regarding such issues as:

- Fabrication of fuel feeder cone: using of oil drum seems more expensive and difficult than use of cheaper galvanized steel sheets, and easier fabrication
- Steel tubes may also be replaced by ready galvanized one or even bamboo
- Outsider walls can be built of cement blocks or bricks, which are more resistant to weather, but of course, slightly some more money added
- Blower must have speed regulator in order to control air speed for using different raw feeding materials, which may have different resistance to air flow

3.3. Conclusion

The training was very good opportunity for our trainers and students to learn how to construct a simple low cost gasifier by make use of local cheap construction materials.

4. Workshop Documentation

4.1. Invitation

To: All REEPRO trainers

Subject: Invitation for Training workshop on construction of low cost gasifier.

Dear all REEPRO trainers,

Coordination of REEPRO project would like to inform you that the training on design and construction of community's gasifier for power production will be held at Faculty of Engineering (NUOL, Sokpaluang campus) between 11-15 November 08, from 9:00 with participation of experts from Australia and Germany, and some trainees from Cambodia (to be confirmed).

This will be good opportunity to learn how to construct simple low cost gasifier for community use (power generation with ordinary engine-set, or any small thermal applications). So, all of you are cordially invited to join the training.

Your prompt feedback would be appreciated very much

Best regards

Khamphone Nanthavong
Faculty of Engineering,

REEPRO Training coordinator
Tel.: (856-20)541 4347 or 246 7192

E-mail: khamphon@fe-nuol.edu.la

4.2. Programme

EIE-06-256 REEPRO

Promotion of the Efficient Use of Renewable Energies in Developing Countries

Training workshop on low cost small gasifier construction

Tentative Training program

Date: 11-14 November 2008

Venue: Sokpaluang campus, Faculty of Engineering

National University of Laos

Prepared by
Khamphone Nanthavong

October 2008

REEPRO training on small low cost gasifier construction

Day 1: 11 November 2008		
9:40	Arrival of experts	
12:00-16:00	Procurement of necessary for the training equipments and materials	
Day 2: 12 November 2008		
8:30-9:00	Registration	Thongvanh
9:00-9:10	Some remarks	Khamphone
9:10-9:30	Introduction: Workshop's objectives and activities	Dr Kai Dobelmann
9:30-10:30	Principle and design of low cost gasifier:	Dr. Jens Berkan (moderated by Dr. Khamphone Nanthavong)
11:00-12:30	Groups' work: Gasifier Components	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
13:30-16:30	Groups' work:	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
Day 3: 13 November 2008		
9:00-12:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
13:30-16:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
Day 4: 14 November 2008		
9:00-12:30	Groups' work	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
13:30-16:30	Finalizing works ▪ Reactor test run	Dr. Jens Berkan Dr. Kai Dobelmann (moderated by Dr. Khamphone Nanthavong)
Day 5: 15 November 2008 8:00 Departure of experts		

4.3. Registration Form

Training on Design and Construction of gasifier for REEPRO project

Vientiane, Lao PDR, 12-14 November 2008

Registration

Full name	Organi-zation	E-mail address	Tele-phone	Signa-ture
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4.4. Signed list

Training on Design and Construction of gasifier for REEPRO project
Vientiane, Lao PDR 12-14 November 2008
Registration

Full Name	Organization	e-mail	telephone	Signature
1. Mr. Bounangern	CDEA	bsayalath@yahoo.com	2453828	[signature]
2. Mr. Khambang	sunlabob	-	2458579	[signature]
3. Mr. Volachit	STRI	Triresearch@hotmail.com	218711	[signature]
4. Mr. Phouang	FE	pphouthavong@yahoo.com	2400879	[signature]
5. Mr. Sengratry	FE (NUoL)	sengratrys@yahoo.com	7704904	[signature]
6. Mr soulivouth	FE (NUOL)		2432563	[signature]
7. Mr Sengsouly	FE (NUOL)		7488519	[signature]
8. Mr Somnit	FE (NUOL)		6406579	[signature]
9. Mr SOUKSANH.	FE (NUOL)	Kittesd@Hotmail.com	7536518	[signature]
10. Mr. Vongsavanh	FE		6012707	[signature]
11. Mr Sayvang	NEM	x.sayvang@yahoo.com	7518777	[signature]
12. Mr. In pone	ME		7222747	In pone
13. Mr. xayalak	FE (NUOL)	xayalak VILAIDA@yahoo.com	7814613	[signature]
14. Mr. Sivanhsay	ME		2254662	[signature]
15. Mr Phai pa phai	ME		6957086	[signature]
16. Mr Mak no	ME		7672240	[signature]
17. Mr. Vitaya Sayavong	ME		2511221.	Vitaya.
18. Mr. Phou khamVOLACHITH	ME		6004925	[signature]
19. Mr Soukanh	STRI		218711	[signature]
20. Mr MANG KONE	STRI		7916198	Manuel
21. Mr Pon	ME		7840058	[signature]

Training on Design and Construction of gasifier for REEPRO project
Vientiane, Lao PDR 12-14 November 2008
Registration

Full Name	Organization	e-mail	telephone	Signature
22 1. Mr Hong Khon vom	ME		6650355	[signature]
23 2. Mr. Phout tha vong	ME		6819582	[signature]
24 3. Mr: Somsavart	ME		7453764	[signature]
25 4. Mr: Keomanevone	ME		2666800	[signature]
26 5. Mr. Phetpaphai	Live		5679260	[signature]
27 6. Khamphone Na...	NUOL	khamphonek.ns@...	6.541454	[signature]
7. Mr. Phonesavanh	STRI	Trireserch@hotmail.com	7706357	[signature]
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4.5. Photos

Figure 1 Theoretical session

Figure 2 Fuel feeder cone is made of used oil drum

Figure 3 Groups' work: mud preparation

Figure 4 Tubes fabrication

Figure 5 Wood frame construction

Figure 6 Reactor building

Figure 7 Fuel feeder assembling

Figure 8 Ash trap and Gas Cooler assembling

Figure 9 Gasifier is ready for test run

Figure 10 Test run

Figure 11 Constructed gasifier is running to heat up and be dried

Figure 12 Dr Kai Dobelmann is checking frame in the reactor if it was bright or not.

Appendix: Book ‘Draft Specification rural gasifier below 5kW’

Technical Product and Build Specification

Rural Gasifier <5 kW

1 Overview

The following concept for a simplified small scale rural gasifier version is an approach to utilize limited and local resources and support in order to design and build small scale gasification units.

1.1 Functional Requirements

A few of the main features of the system are robustness and simplification. It shall be use- and operable by anyone after a short training / introduction session. It shall be suitable to gasify solid fuel (wood) stock chopped into small pieces of not larger than 5 cm side lengths, pre-dried with a lower water content of approximately 35 %.

The targeted power output is less than 5 kW and the duty cycle of operation between refuelling and maintenance shut downs shall be greater than 8 hours.

1.2 Technical Data Summary

Gasifier Overall Dimensions		
Height	mm	
Widths	mm	
Lengths	mm	
Gas Cleaner Overall Dimensions		
Height	mm	
Widths	mm	
Lengths	mm	
Gas Cooler Overall Dimensions		
Height	mm	
Widths	mm	
Lengths	mm	
Rated Power Output (@ engine)	kW	<5
Fuel	Wood chips, < 5 cm, < 35 % humidity	

1.3 Definitions

2. Components and Sub-Systems

This section describes the baseline requirements for the sub-systems and components. **Picture 2.1** shows a draft of the final rural gasification system. Different customer specific applications may require alteration of this standard layout.

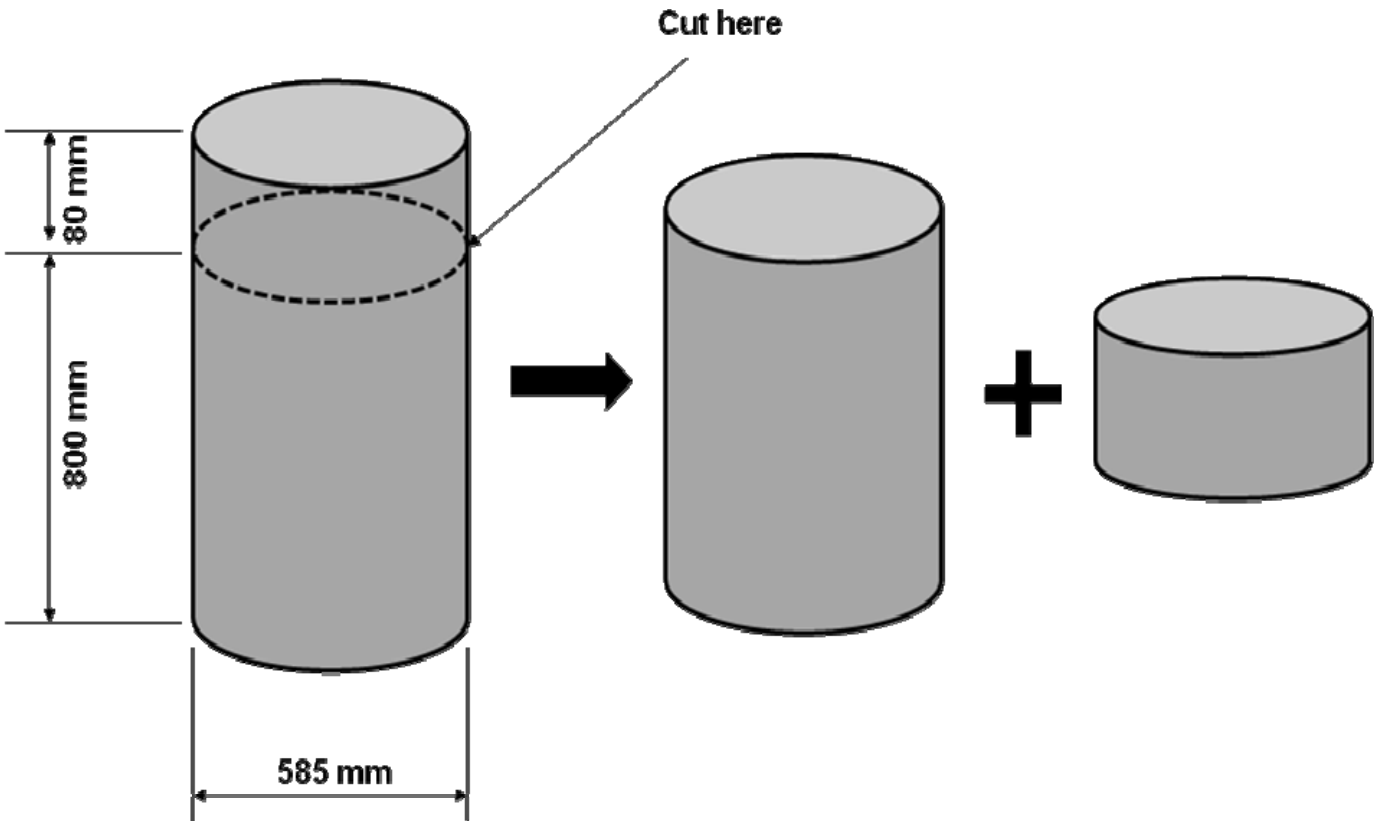
Picture 2.1: Rural Gasifier

Main characteristics are the utilization of simplest and locally available materials and resources such as clay, mud, wood, glue, plastic foil or paper as well as simple metal components such as 200 litre oil drums, 30 litre oil drums or low grade steel rods.

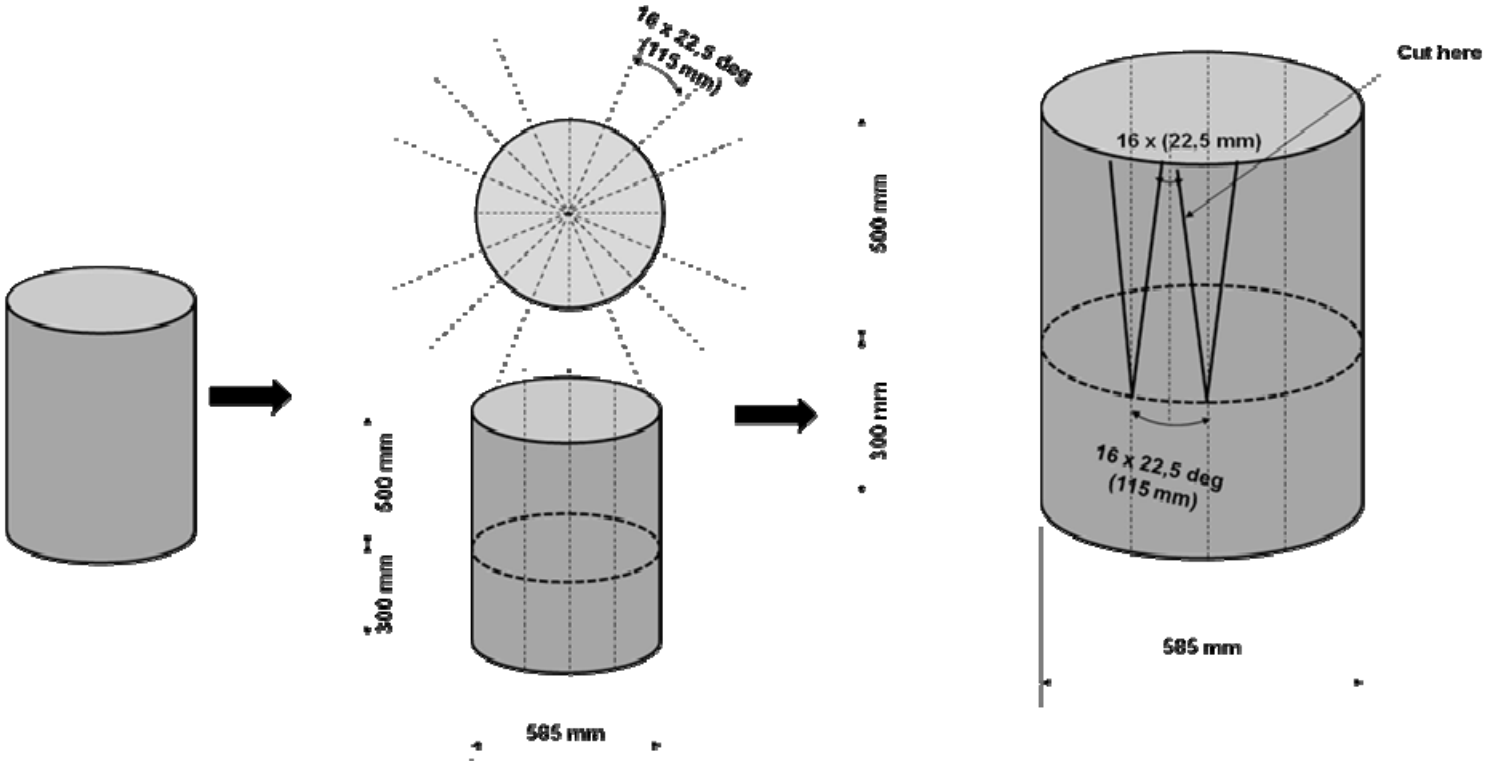
The aim is to use most of the materials for building the basic structure into a clay coating respectively mud grouting. It is expected that once fired up and operating the heat will decompose most of the used material within short time that what is left is most of the entire functional gasifier made from clay and mud.

2.1 Fuel Storage Volume

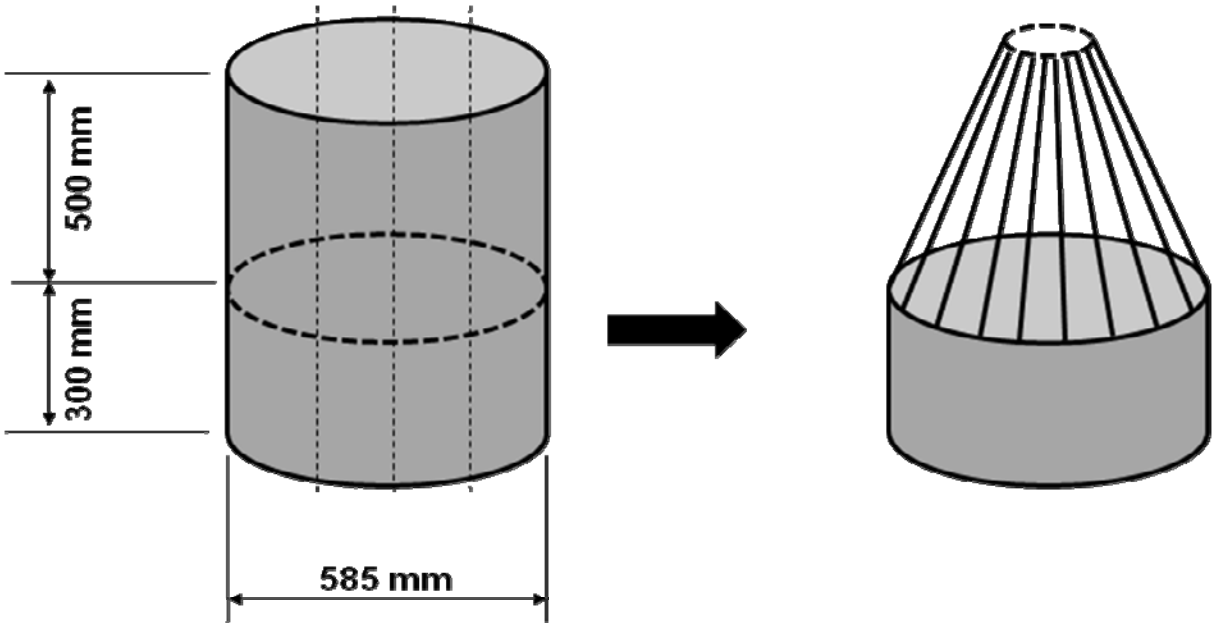
The fuel storage volume is based on a 200 liter standard oil drum as shown in **picture 2.1**. The drum is to be cut into two pieces as indicated. The smaller part will be utilized as gas tight sealed lid (using a water seal). The larger part is to be further modified as shown in **picture 2.2** and **picture 2.3**.



Picture 2.1: 200 Liter Oil Drum – Cut Specification



Picture 2.2: 200 Liter Oil Drum – Cut Specification – Conical Cut

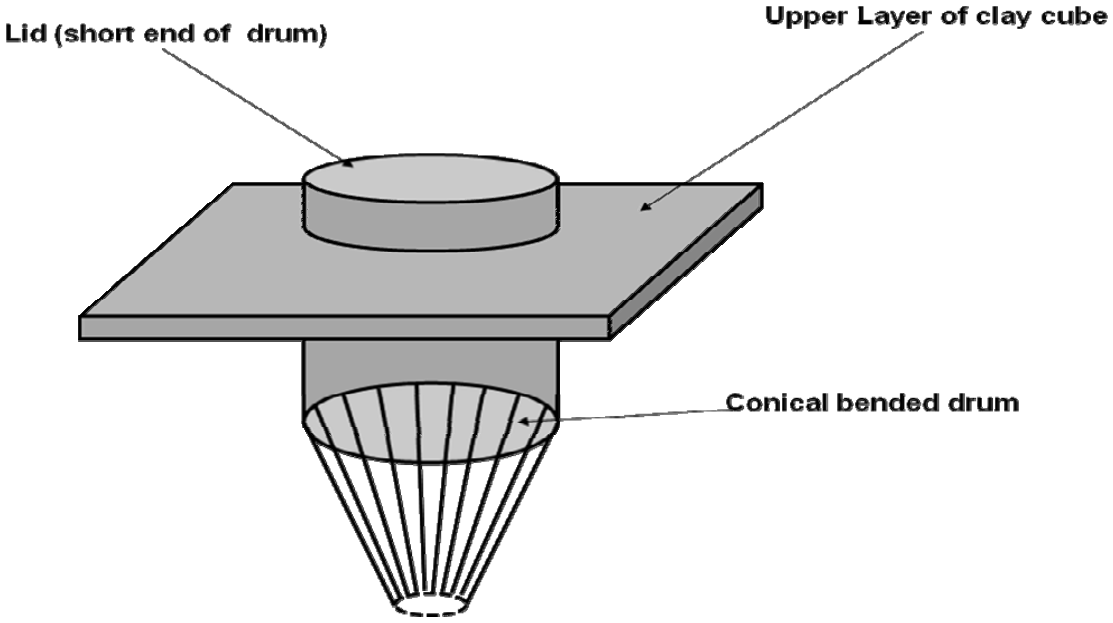


Picture 2.3: 200 Liter Oil Drum – Bend Specification – Conical Bend

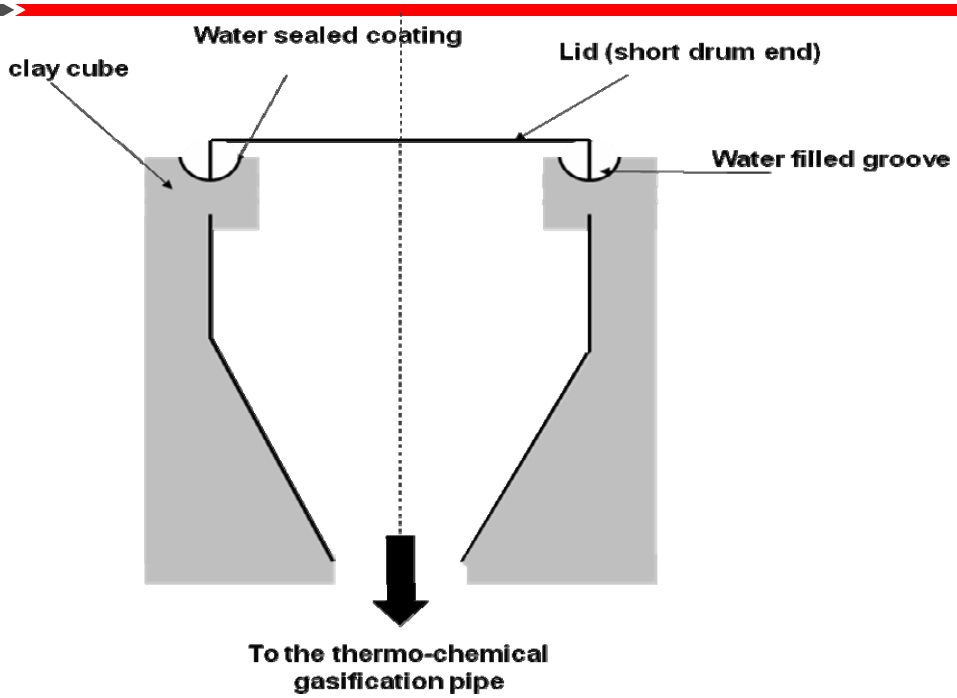
2.1.1 Lid and Sealing

The conical bended drum is to be put on the top of the thermo-chemical reaction pipe and to be gas tight sealed connected with it (clay) as described in 2.1.2. A supporting frame helps to fix the drum within the assembly to allow for build up of clay and mud until hardened.

Picture 2.4 and **picture 2.5** show details for the lid construction. In **picture 2.4** only the upper layer of clay is shown for illustration. Supporting frame and interconnection to the thermo-chemical reaction pipe are not shown.



Picture 2.4: Cross section solid heat exchanger pipe into barrel

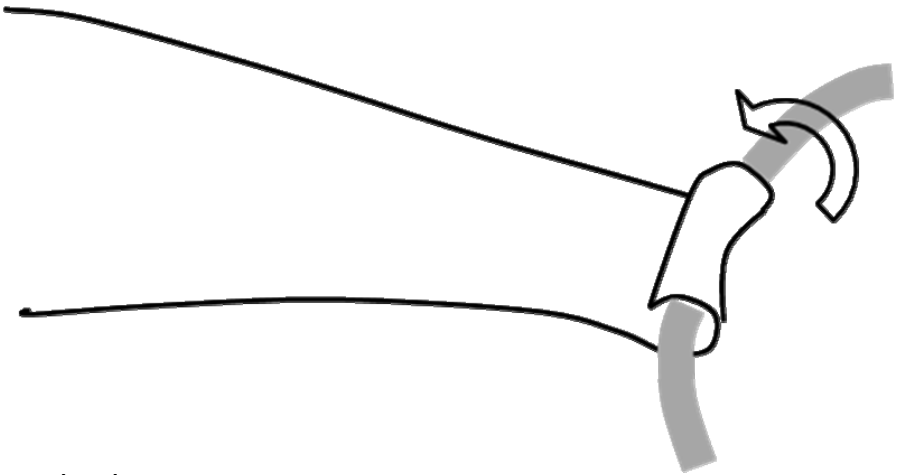


Picture 2.5: Cut-away draft of the assembly

After the conical drum is fixed to the thermo-chemical gasification reaction pipe, the conical shaped drum is to be embedded with clay and mud to add structural strengths. The upper layer of this clay / mud substrate is to be planed and a groove to be put in as shown in **picture 2.5**. The groove's design requirements are low; however the lid (the short cut of the drum end) must easily fit in it, is has to have the capability to be filled up with water to seal the lid and it will require a water sealing coating which can fir instance be made from silicone, paint, grease etc…

2.1.2 Conical Transition to the Gasification Reaction Pipe

As in **picture 2.3** shown the cone is made from the remaining steel cut offs of the drum. Bended inside and fixed in round shape by means of a strong metal wire the bended single sheet elements shall be tightly crimped backwards to the wire as shown in **picture 2.6**.



Picture 2.6: Detail: sheet crimping

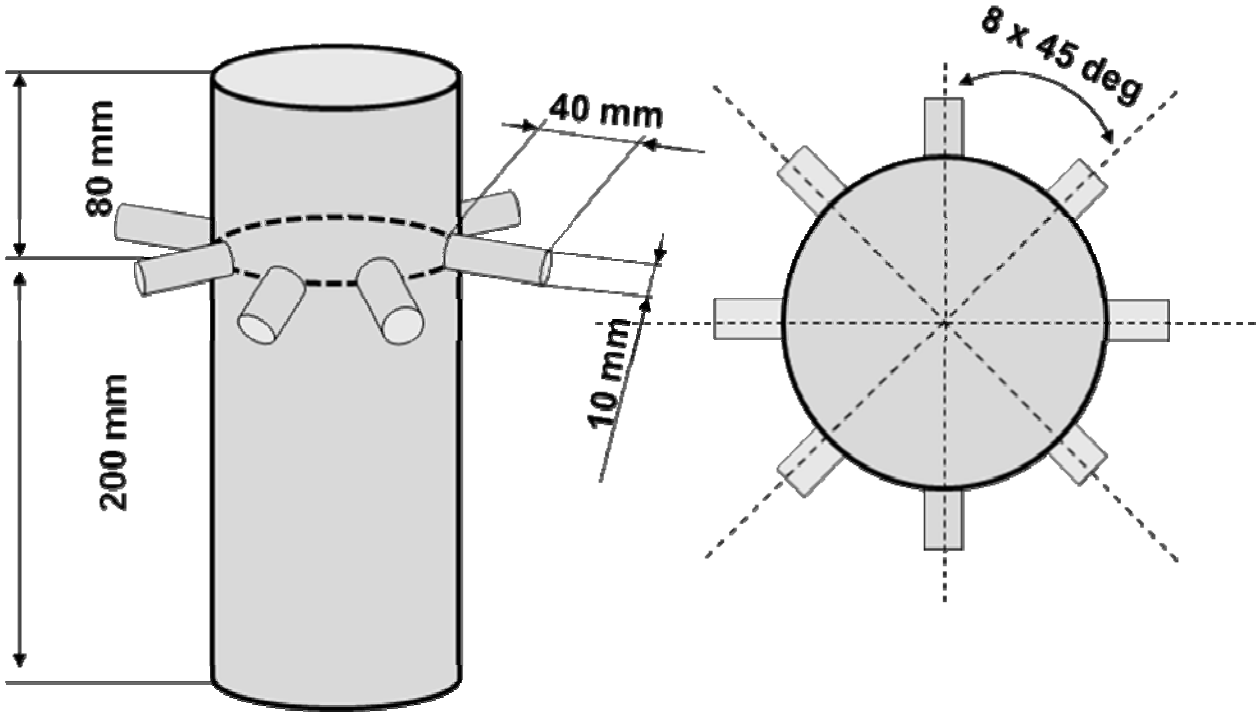
2.1.3 Supporting Wooden Frame, Clay and Mud Filler, general

The Whole gasifier will be build in stages starting with the syn-gas exit-connection pipe on the bottom level, followed by the grate, then by the thermo-chemical reaction pipe with its air nozzles. After this assembly is cast in clay and mud and dried, the supporting frame will be attached to the top of it to allow assembly of the conical drum and to embedding it with clay and mud likewise.

2.2 Thermo-Chemical Reaction Pipe

The heart of the gasifier is the thermo-chemical reaction pipe with its air intake nozzles and the grate at the bottom. Below the grate the syn-gas pipe is connected and above the cone of the storage drum is connected.

The expected thermal and chemical stress on this pipe during operation does not allow for the employment of low grade steel material for sustainable structural purpose. The employment of high alloy steel material is not feasible for cost and supply reasons. Instead it shall be entirely made from high grade clay. To build up the final structure in clay a lost foam approach can be made. For this a poly-styrene mock-up is built as shown in **picture 2.7**.



Picture 2.7: Poly-styrene mock-up of the gasification pipe

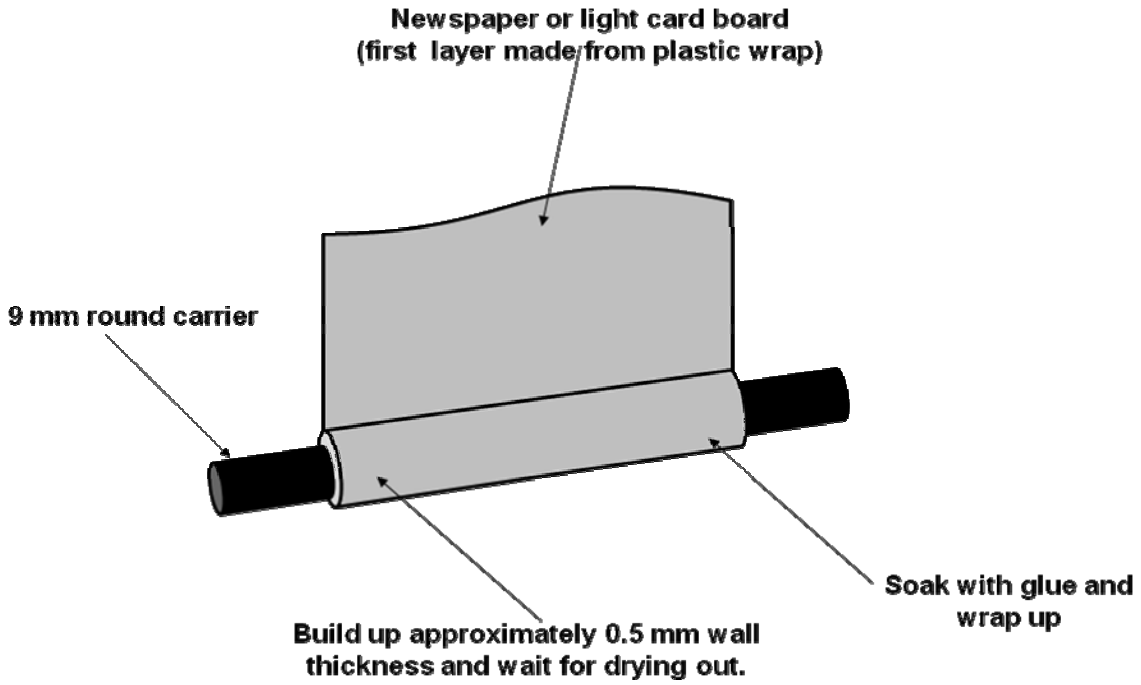
Alternatively the assembly can be build from low grade metal sheet / pipes which will corrode away during operation leaving over the clay structure of the gasifier.

2.2.1 Air Intake Nozzles

Dimensions as shown in **picture 2.7**.

2.2.2 Air Intake Pipes

The expected thermal and chemical stress on the air intake pipe during operation does not allow for the employment of low grade steel material for structural purpose. The employment of high alloy steel material is not feasible for cost and supply reasons. Instead it shall be entirely made from low grade clay or mud. To build up the final structure in clay/mud the pipes are made from a compound of plastic foil, paper and glue before connected to the air intake nozzles and embedded into the clay/mud. **Picture 2.8** shows as an example the make of those pipes. The anticipated length is 0.5 m at the minimum and the anticipated inner/outer diameter is 9 mm / 10 mm.

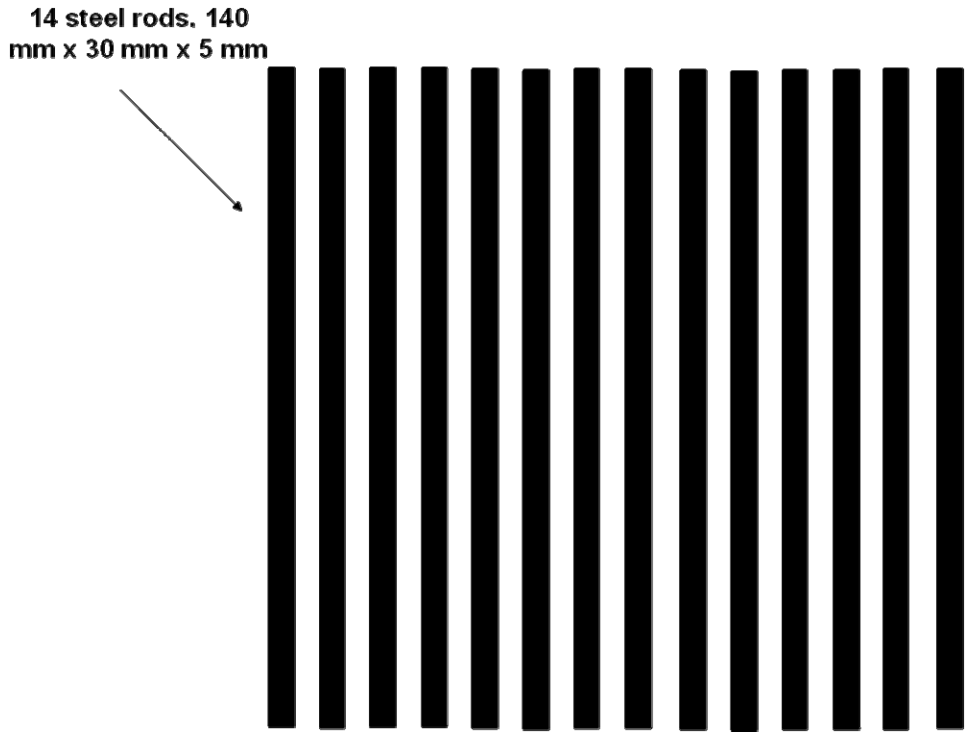


Picture 2.8: Paper-glue mock-up of the air pipes

Alternatively the assembly can be build from low grade metal sheet / pipes which will corrode away during operation leaving over the clay structure of the gasifier.

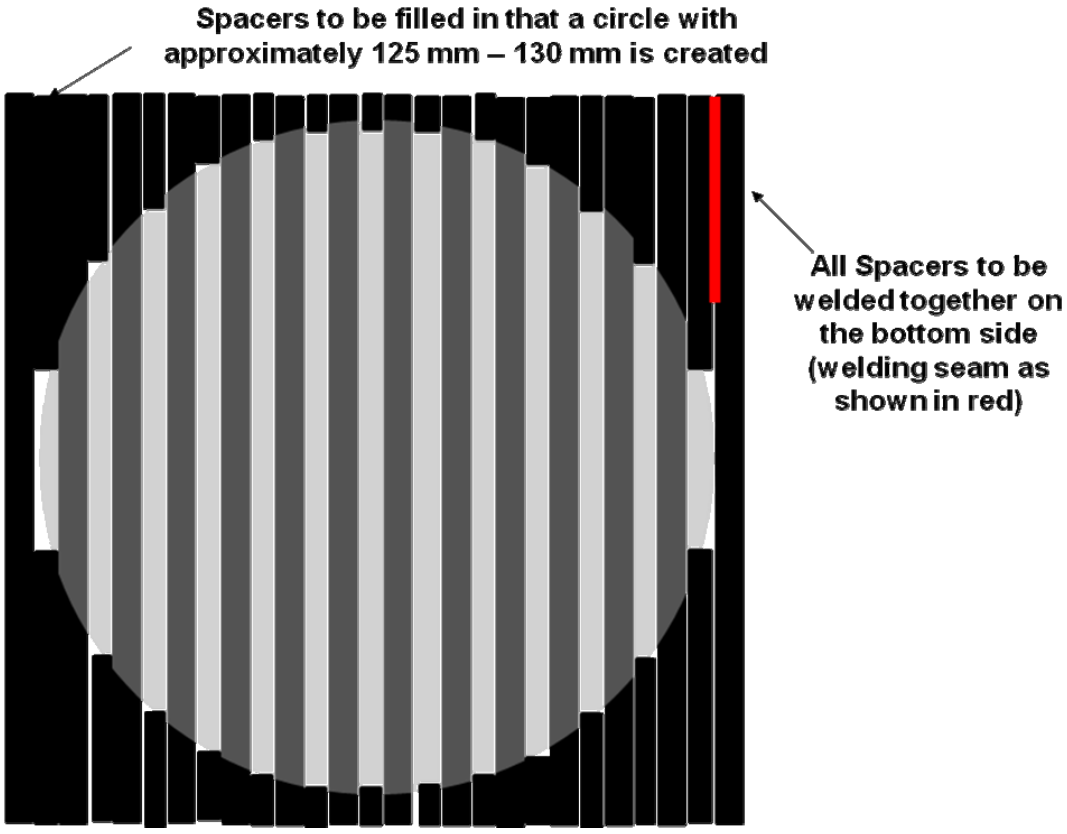
2.2.3 Grate

The grate shall be made entirely from low grade flat steel profile in the dimension 5x30 mm as shown in **picture 2.9** to **picture 2.12**.



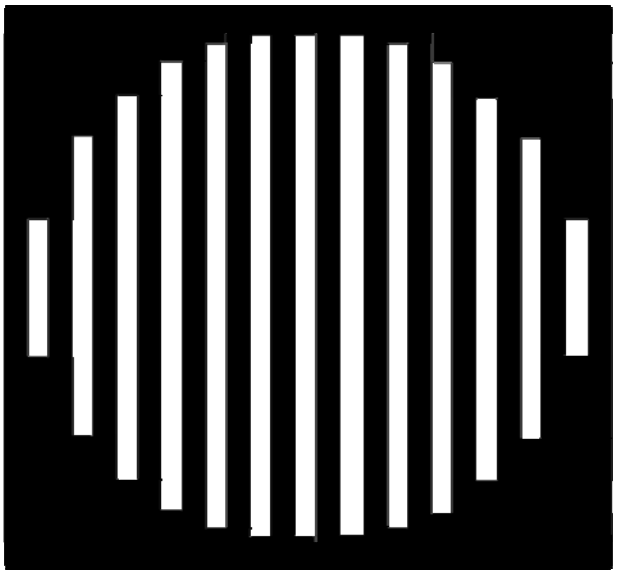
Picture 2.9: Grate base design – main rods

To achieve a circle-like shape the gaps between the main rods have to be filled with shorter rods accordingly, **picture 2.10**.



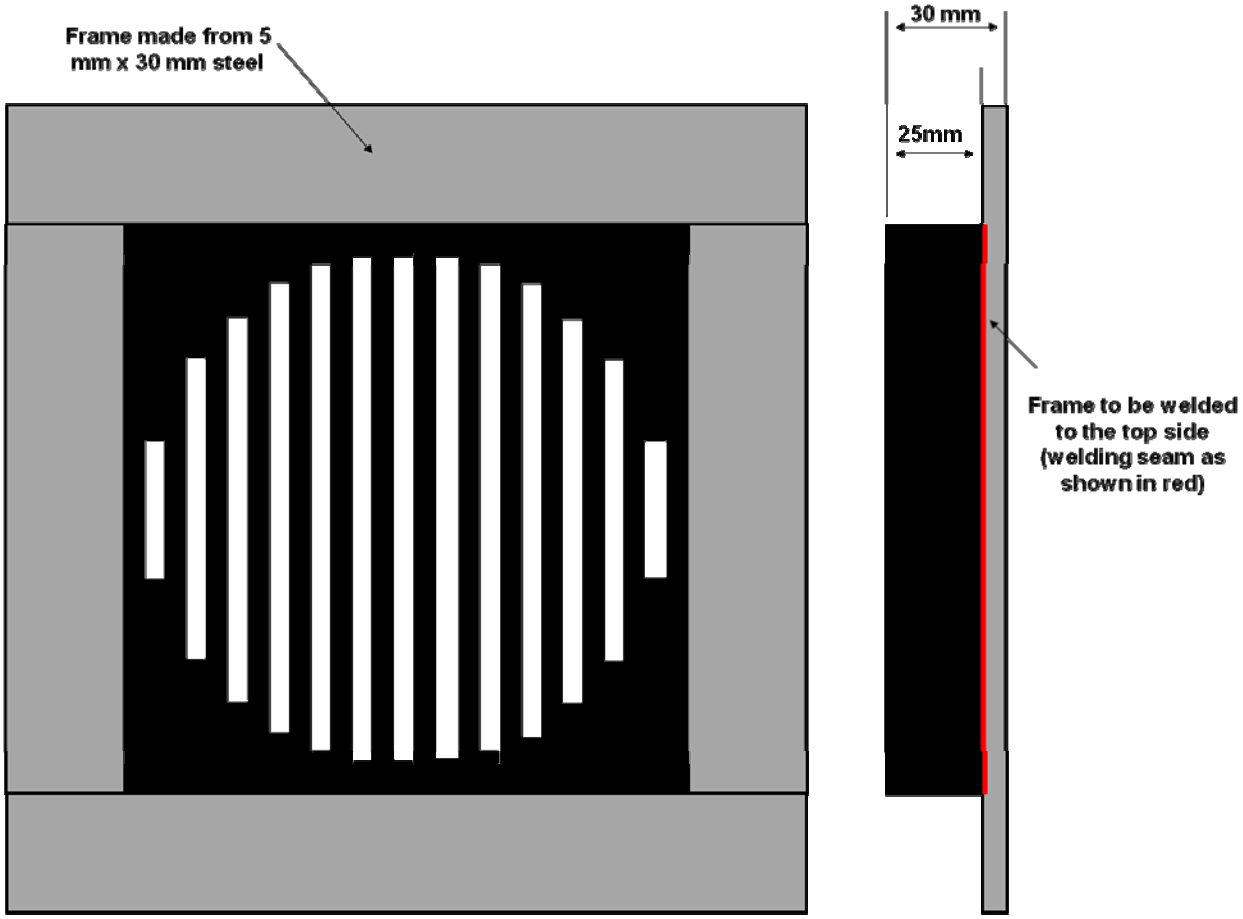
Picture 2.10: Grate base design with gap fillers introduced

Picture 2.11 shows the projected result of this production step.



Picture 2.11: Grate surface projection

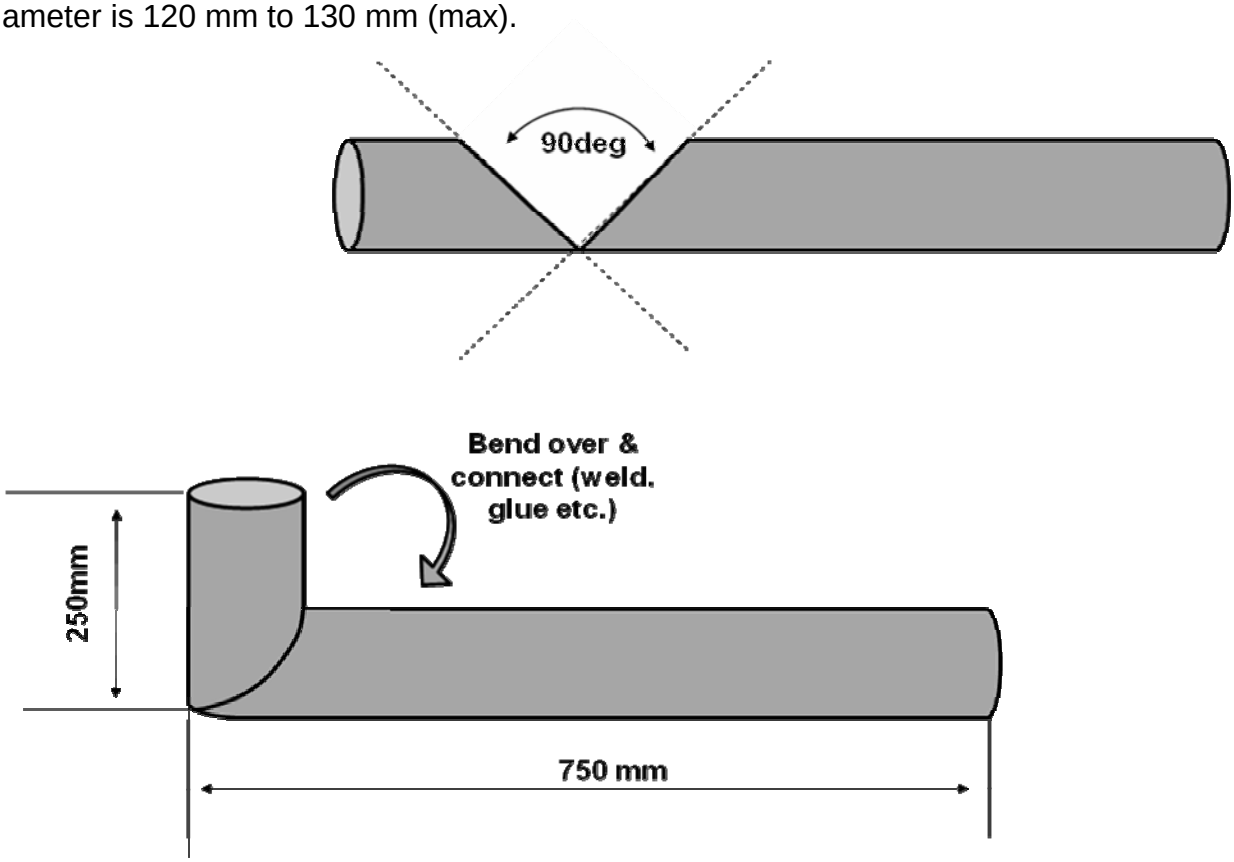
To allow for fixation in the gasifier clay/mud housing a frame is to be added to the grate likewise made from 5 mm x 30 mm steel profile, **picture 2.12**.



Picture 2.12: Grate with steel frame

2.2.4 Syn-Gas Pipe to the Ash Settling Tank

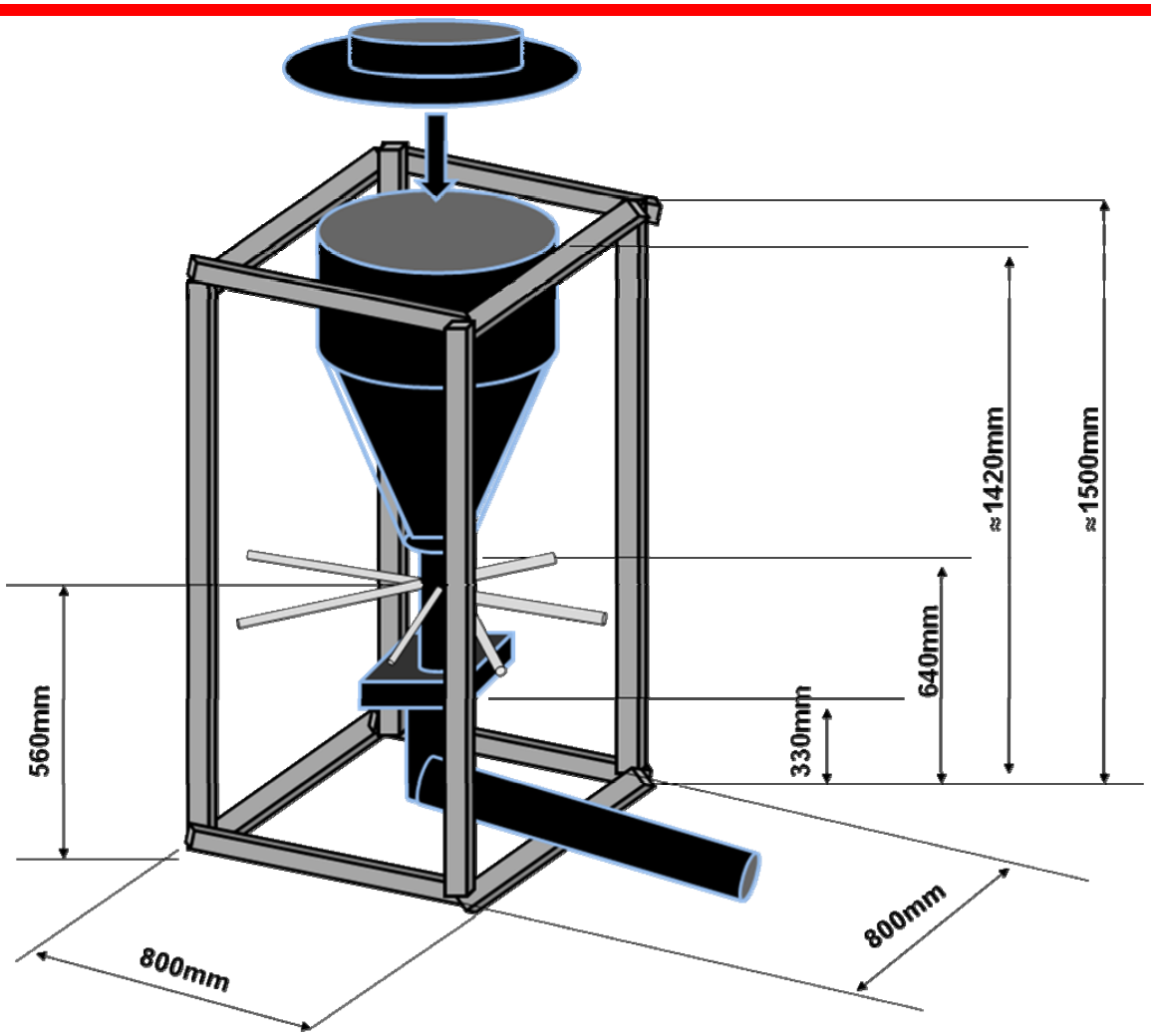
The expected thermal and chemical stress on the syn-gas pipe during operation does not allow for the employment of low grade steel material for structural purpose. The employment of high alloy steel material is not feasible for cost and supply reasons. Instead it shall be entirely made from low grade clay or mud. To build up the final structure in clay/mud the pipe is made from a compound of plastic foil, paper and glue before embedded into the clay/mud to be connected to the grate. **Picture 2.13** shows the dimensions of this pipe. Alternatively the assembly can be build from low grade metal sheet / pipes or poly-styrene which will corrode / burn away during operation leaving over the clay structure of the pipe inside the gasifier. The anticipated inner diameter is 120 mm to 130 mm (max).



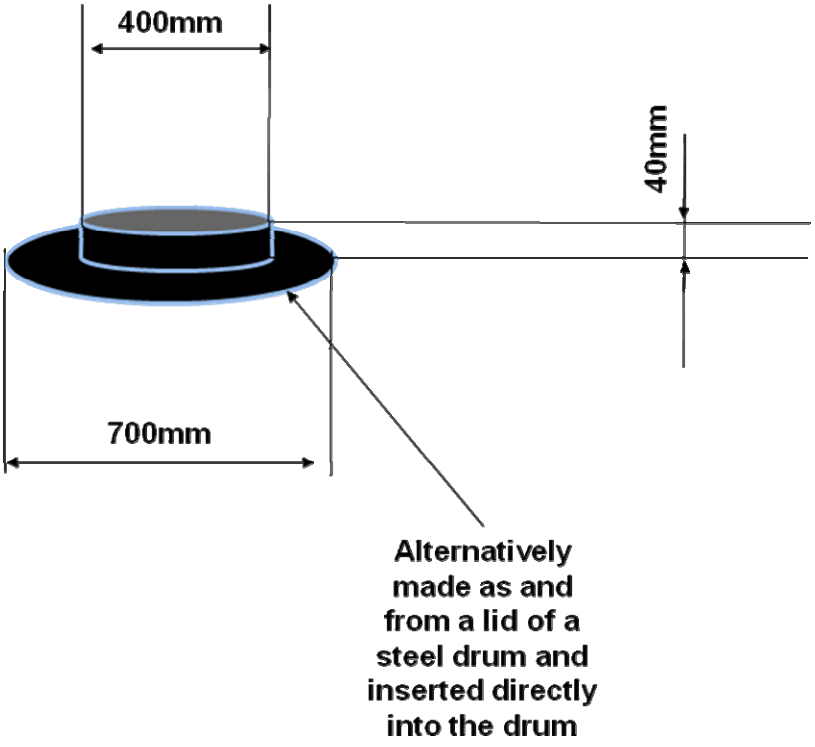
Picture 2.13: Syn-Gas pipe dimensions

2.2.5 Supporting Wooden Frame

The supporting wooden main frame for the gasifier portion is to be build from 80 mm x 80 xx slats as shown in **picture 2.14**. The main outer dimensions are: 800 mm x 800 mm x 1500 mm.



Picture 2.14: Dimensions of wooden support frame for gasifier



Picture 2.15: Dimensions of the strickle board

2.3 Clay and Mud Filler and Build of the Gasifier

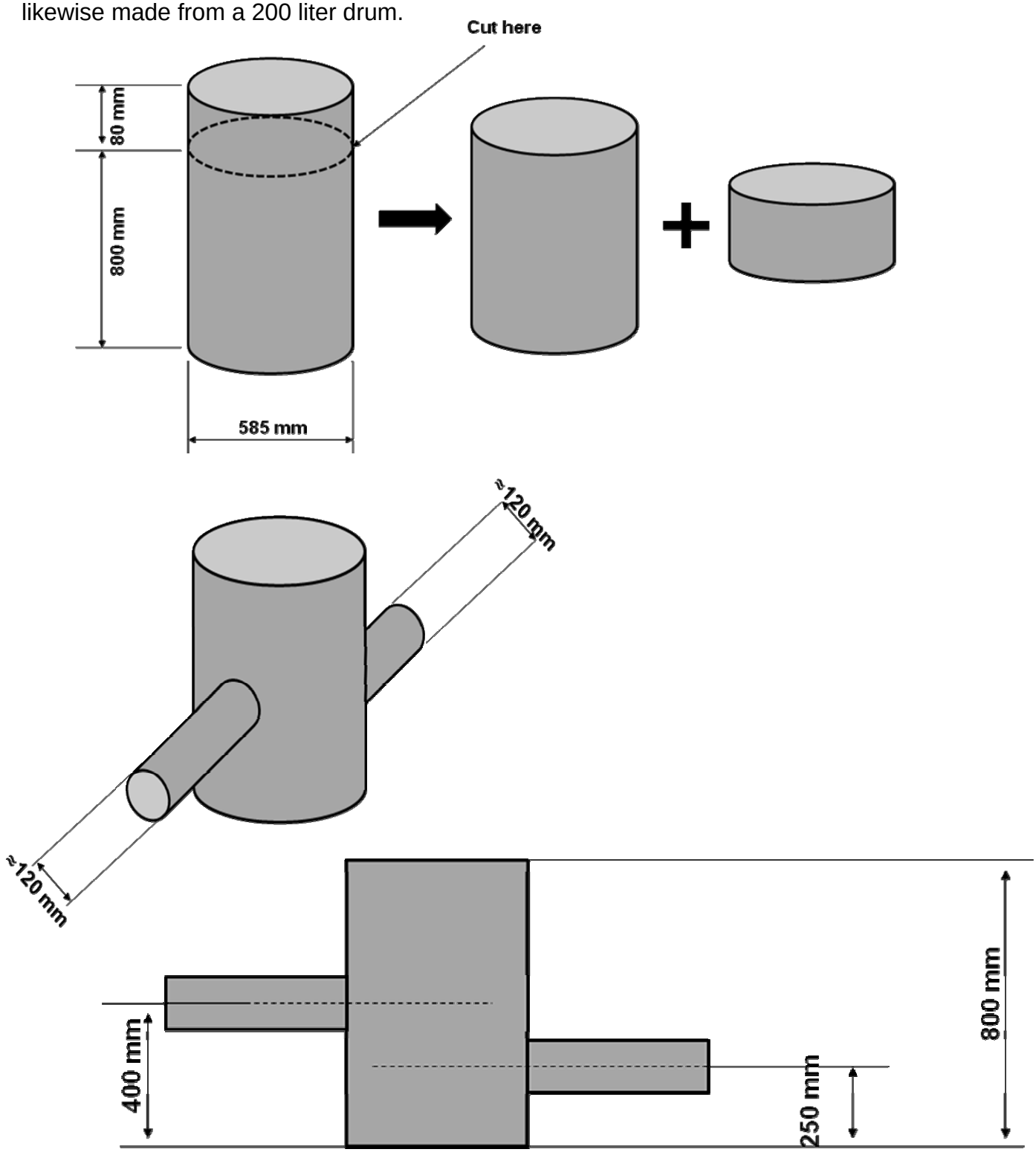
1. Erect the wooden frame
2. Fill mud to the bottom until the upper level of the lower wooden slat is reached
3. Take Syn-gas pipe and add about 1 cm clay layer to its outer surface, wait for drying
4. Attach (screw) slats as a wall to the wooden frame from the bottom to a height of approximately 300 mm, add a hole for the syn-gas pipe outlet
5. Insert Syn-gas pipe into hole and fix it upright centred (use wires, ropes etc.)
6. Fill with mud to upper level of slat wall
7. Use higher grade clay for final layer around the upper end of the syn-gas pipe in order to establish a good base for the grate
8. Fix the grate and embed it with clay in the nearer surrounding (approximately 5 cm on all sides)
9. Wait for drying out
10. Attach (screw) more slats as a wall to the wooden frame to a height of approximately 600 mm, add 8 holes for the air intake pipes (approximately 20 mm diameter)
11. Use higher grade clay for final layer of about 2 cm thickness around the thermo-chemical reaction pipe, wait for drying out
12. Use high grade clay for fixation of the thermo-chemical reaction pipe tight onto the grate, fill with mud to the level of the air intake pipes, wait for drying out
13. Insert and connect the 8 air intake pipes and fill with mud to the upper level of the wooden slats but use high grade clay around the upper end of the thermo-chemical reaction pipe to enable a good connection to the cone later on
14. Attach (screw) more slats as a wall to the wooden frame to a height of approximately 1100 mm, begin to fill in a cone from mud, slightly larger than the drum-cone but able to structural support the drum cone when inserted and to be fixed, wait for drying out
15. Carefully fix the drum-cone onto the thermo-chemical gasification pipe, use high grade clay for best sealing results, fill the remaining gaps with mud, wait for drying out
16. Attach (screw) the remaining slats as a wall to the wooden frame to its maximum height of approximately 1500 mm, fill up with mud to exactly the height of the upper level of the drum, which is approximately 1400 mm, ad the strickle board centred on the top of the drum and wait for drying out
17. Fill up to the remaining height of approximately 1500 mm with clay, turn in / abrade a groove of approximately 5 cm depths and an inner diameter of 500

mm and an outer diameter of approximately 650 mm, smoothen the surfaces, wait for drying out

18. Paint / Seal the surface of the groove

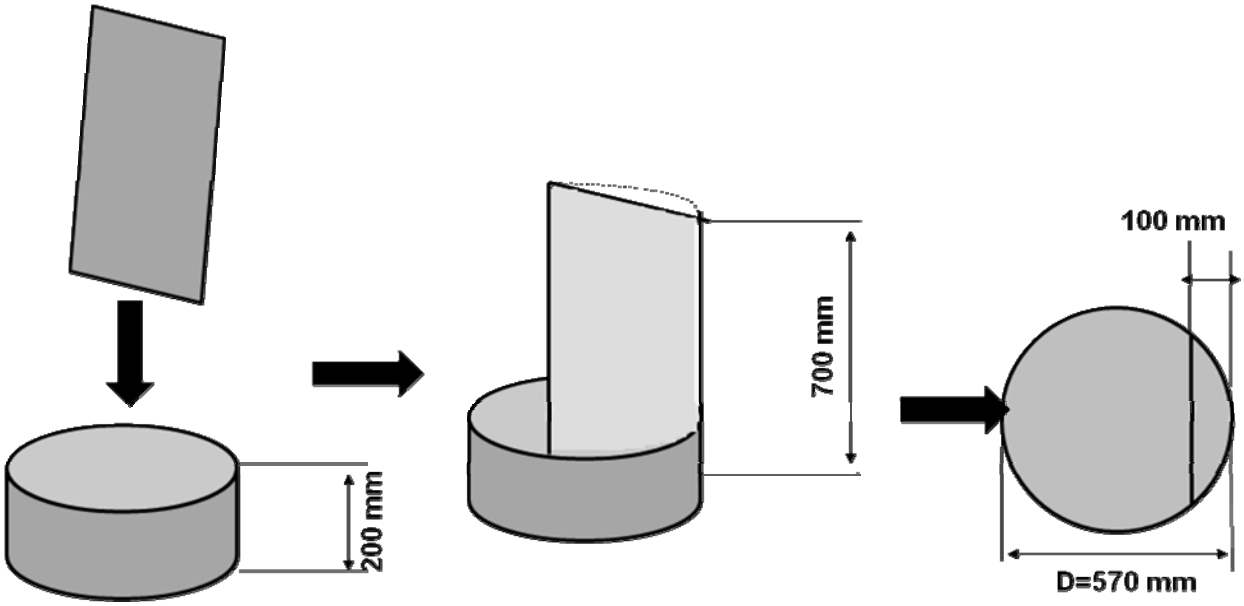
2.4 Ash Settling Tank

Picture 2.16 to **2.20** show the make and assembly of the ash settling tank. The shell is likewise made from a 200 liter drum.

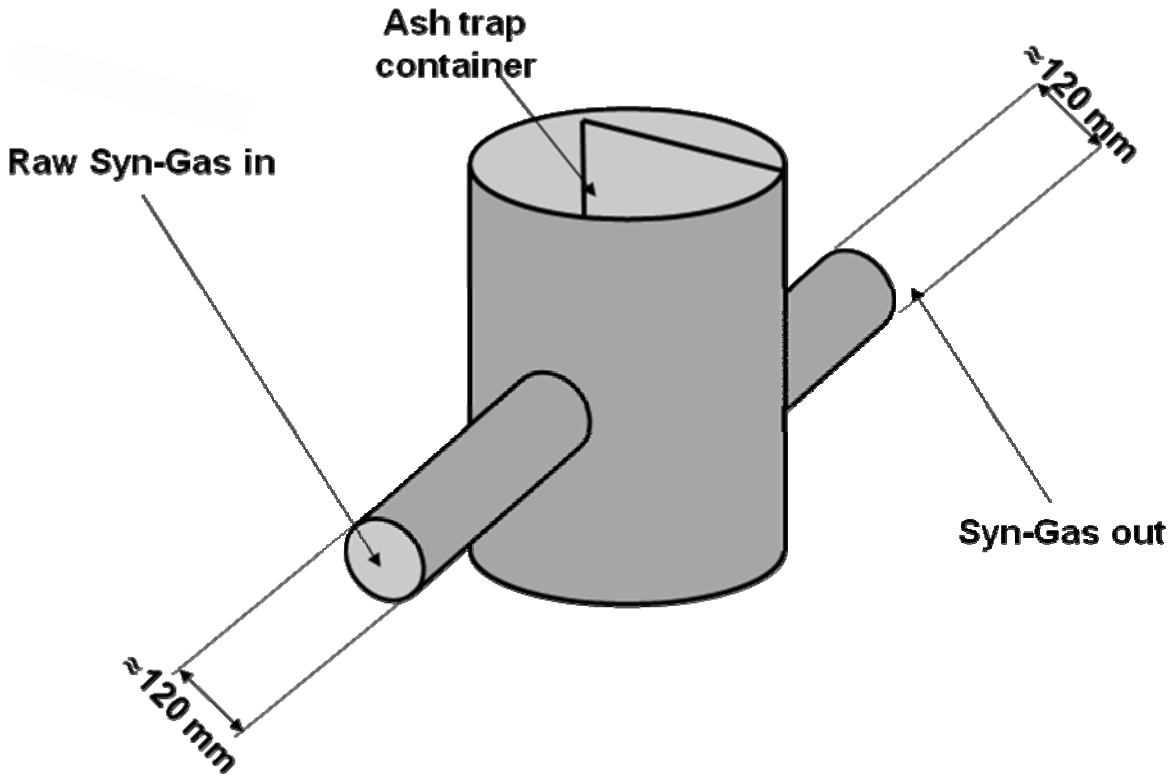


Picture 2.16: Ash Settling Tank, outer dimensions

The ash container is shown in **picture 2.17**. Its function is to act as a baffle plate with its high rear side and to collect the out falling ash in the basket below. The entire container can be removed from the tank for maintenance reasons.

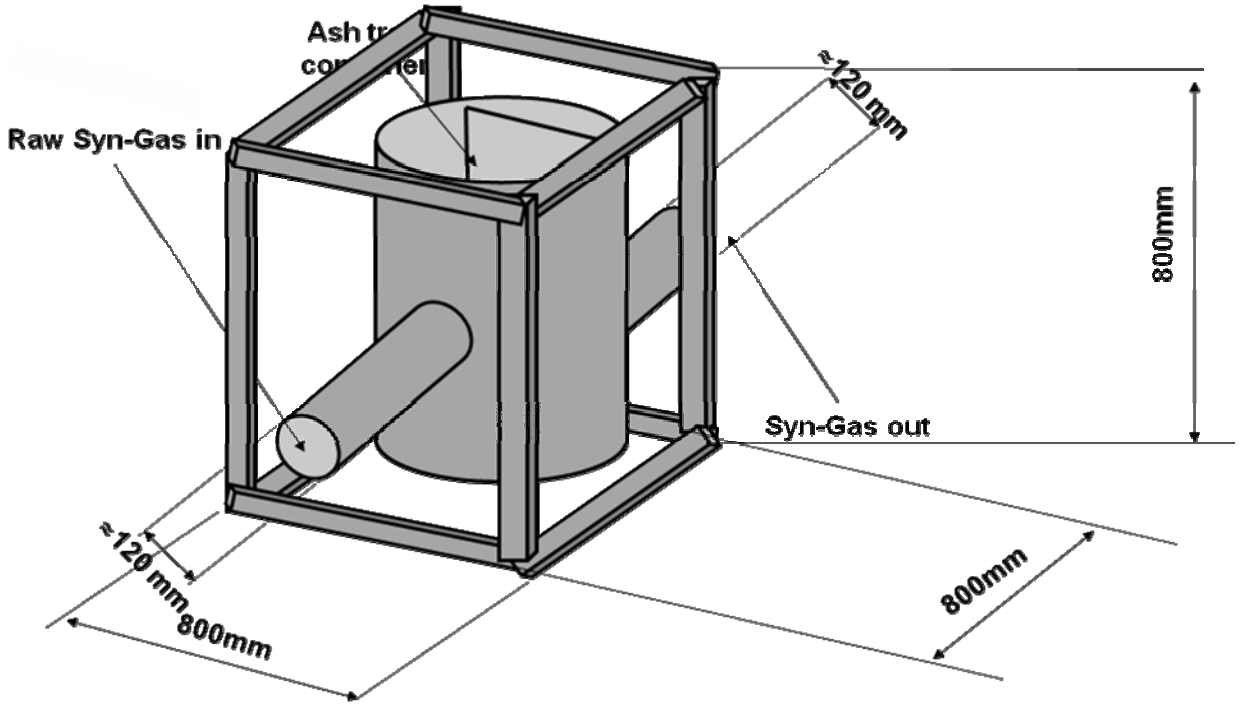


Picture 2.17: Ash container

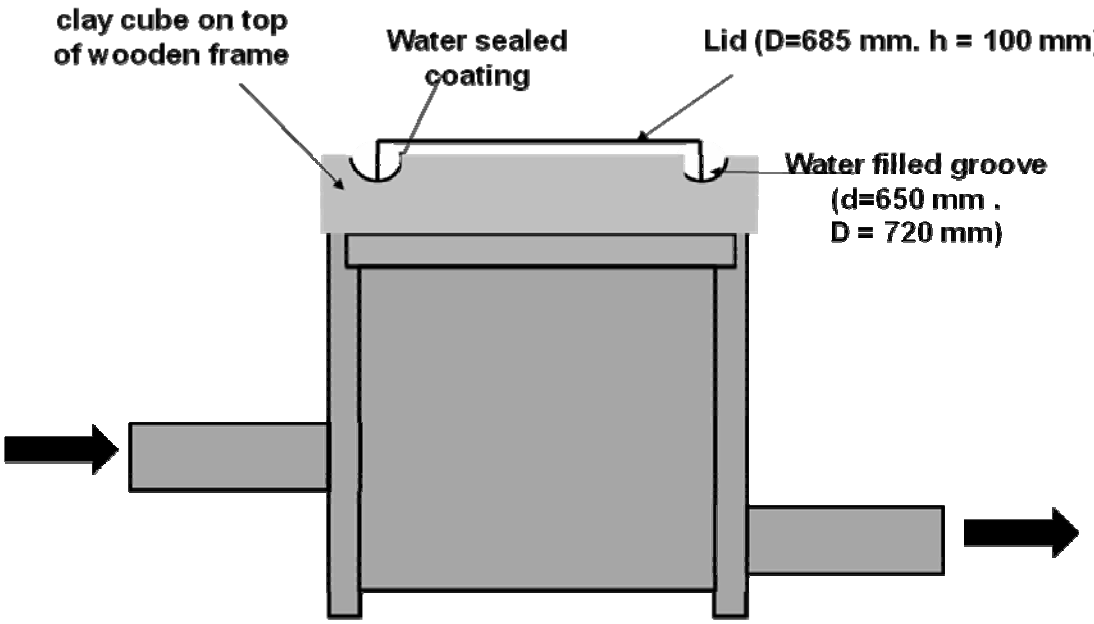


Picture 2.18: Container Assembly

The Ash settling tank is mainly made from low grade steel and metal sheet material such as 200 liter drums. It also is directly exposed to the very high Syn-Gas temperatures during operation. To protect material from corrosion and thermal deformation and humans from the threat of burning or injury the whole ash settling tank assembly is to be casted with mud into a wooden frame as the gasifier in the foregoing section. The dimensions for the wooden frame to be used are given in **picture 2.19**.



Picture 2.19: Wooden Frame Structure for Ash Tank Assembly



Picture 2.20: Gas tight sealing Lid for Ash Tank Assembly

2.4.1 Cooing

The water …, **picture 2.21**.

Picture 2.21: xx

2.4.2 Cleaning Opening

The opening …, **picture 2.22**.

Picture 2.22: xx

2.4.3 Transition to the Ash Filter Element

The transition …, **picture 2.23**.

Picture 2.19: xx

2.4.4 Supporting Wooden Frame

The frame …, **picture 2.20**.

Picture 2.20: xx

2.4.5 Clay and Mud Filler

The mud…

2.5 Ash Filter

The ash

Picture 2.21 shows

Picture 2.21: xx

2.5.1 Wet Filter Element and Cooling

The …, **picture 2.22**.

Picture 2.22: Cross section …

2.5.2 Cleaning Opening

The …, **picture 2.23**.

Picture 2.23: Cross section …

2.5.3 Gas Outlet

The …, **picture 2.24**.

Picture 2.24: Cross section …

2.5.4 Supporting Wooden Frame

The …

2.5.5 Clay and Mud Filler

The mud…

2.6 Total Assembly

As figure ….

2.7 Safety

3. Installation, and Start-up

Details …

3.1. Installation and Assembly

Details …

3.2. Start-up

Details …

4. Maintenance and Operation

Details …

5. Appendix

30 Liter Fass (Einweg)

Abmessungen:
Innendurchmesser: 270 mm
Außendurchmesser: 280 mm
Außenhöhe: 535 mm

Speziell für KBA (Kontrolliert Biologischer Anbau)
und NOP (National Organic Program) Ware

200 Liter Sickenspund-Fass (Einweg)

Abmessungen:
Innendurchmesser: 571,5 mm
Außendurchmesser: 585 mm
Außenhöhe: 882 mm