GASIFICATION

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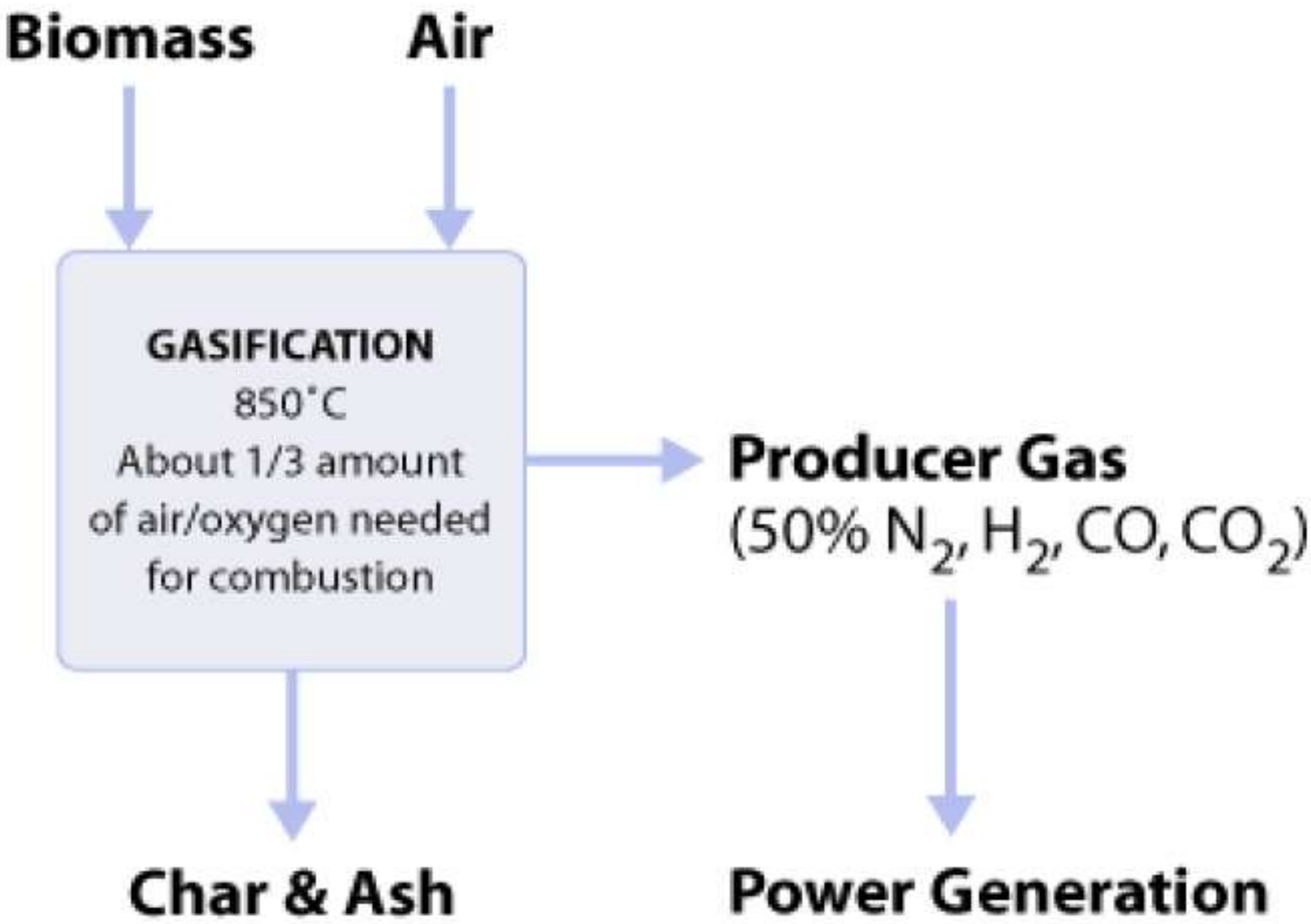
Overview the Basics of Gasification

- The process of gasification to produce combustible from organic feeds was used in blast furnaces over 180 years ago.

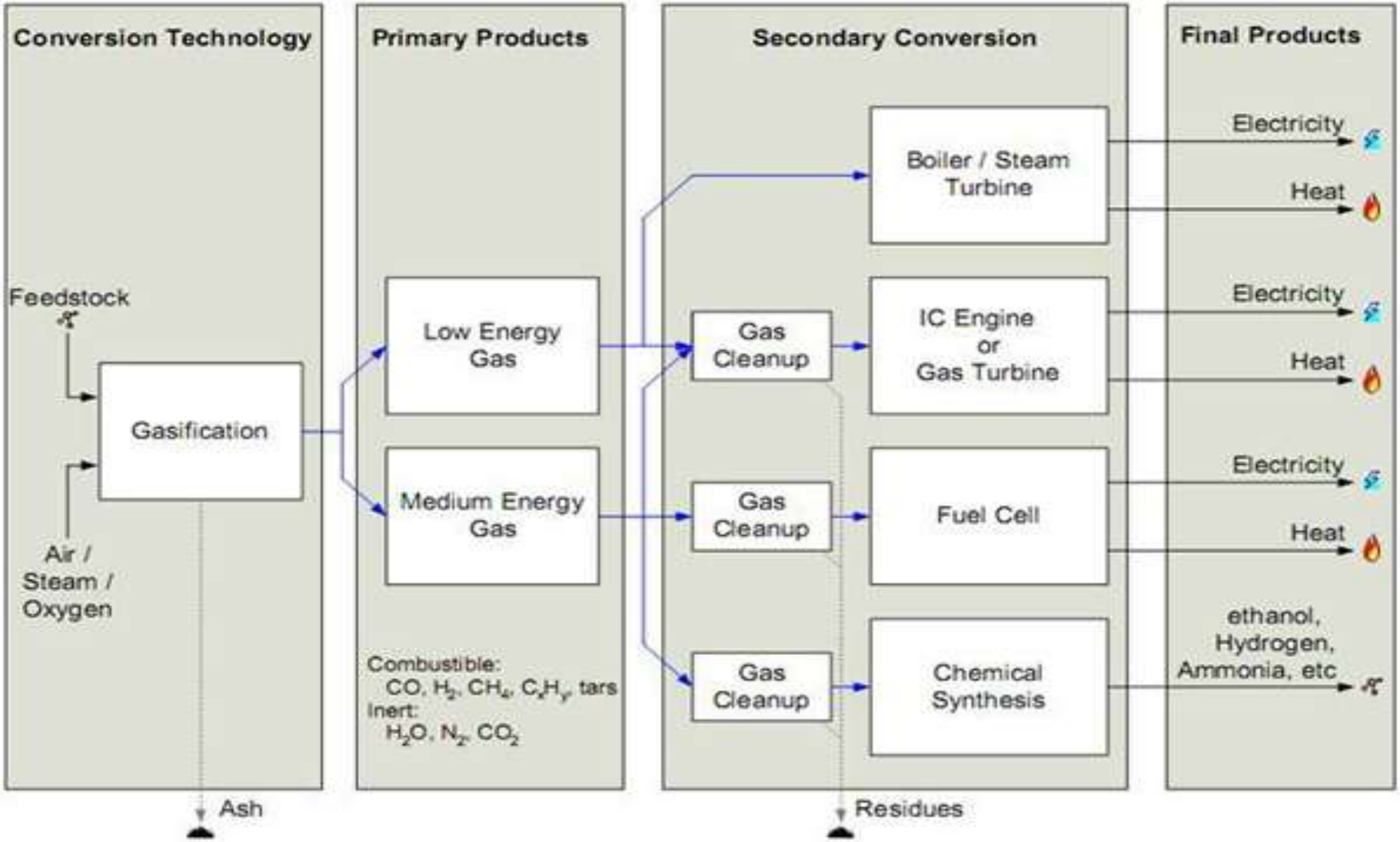
- Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H^2) and traces of Methane (CH^4). This mixture is called producer gas.

WHAT IS GASIFICATION?



Different Types of Feedstock for Gasifier

Gasifier Process Flow Options



Gasification Reactors

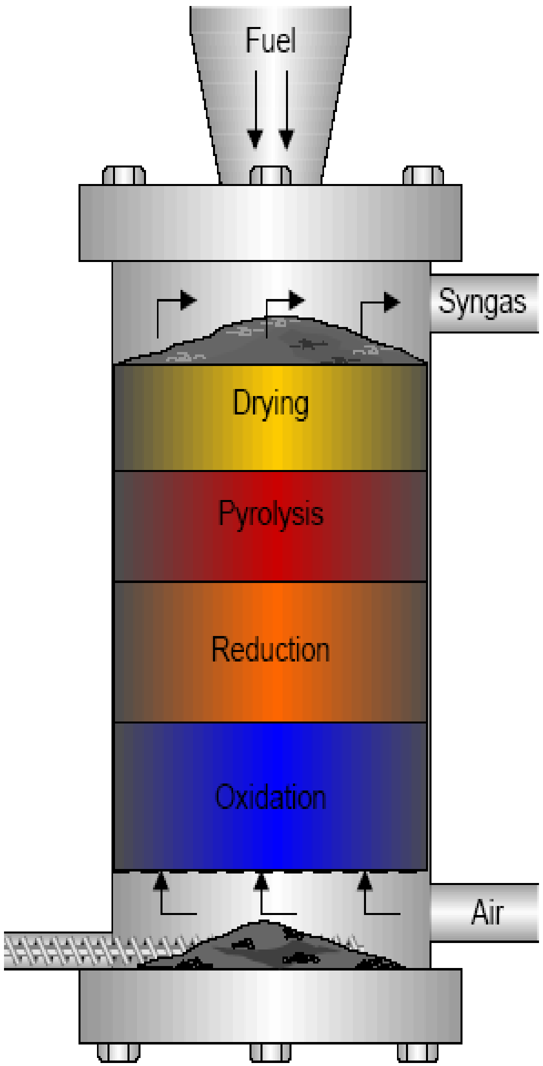
1. fixed beds

- *Up draft*
- *Down draft*
- *Cross draft*

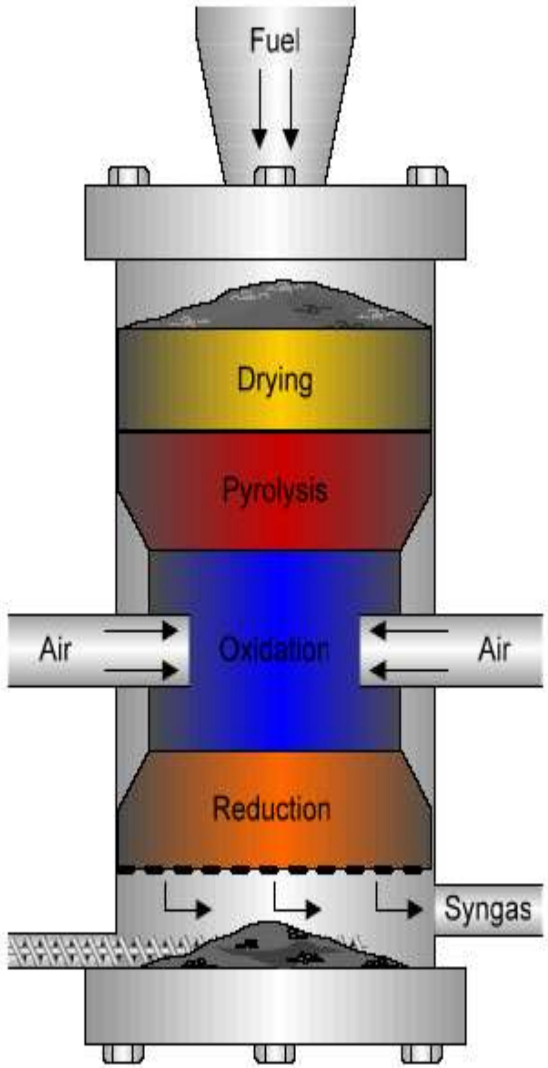
2. fluidized beds

- *Bubbling*
- *Circulating*
- *Spouted*
- *Swirling*

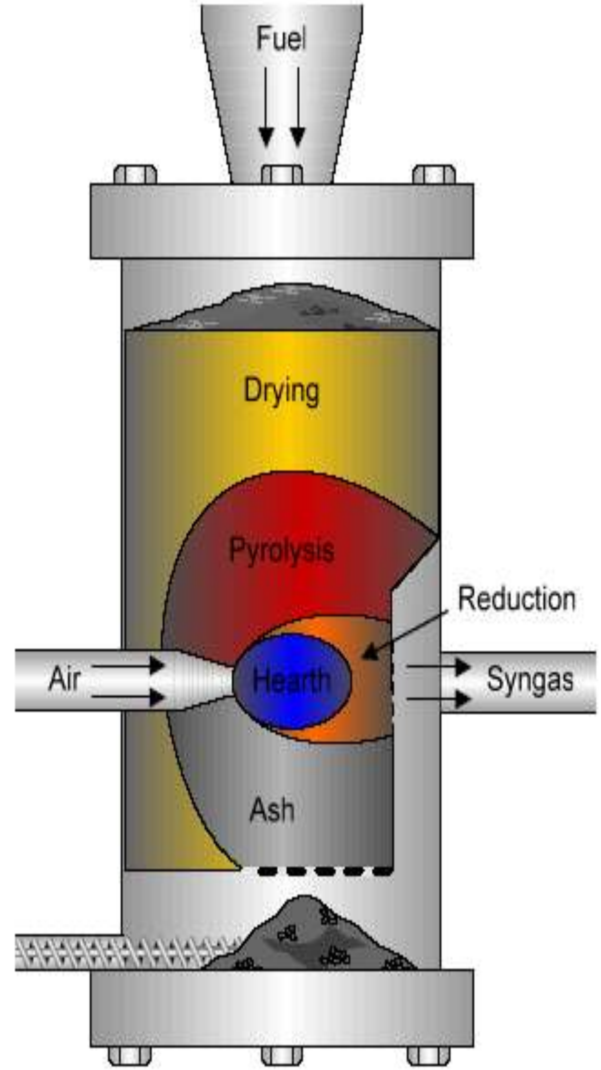
Fixed Bed Gasifiers



1. Up draft



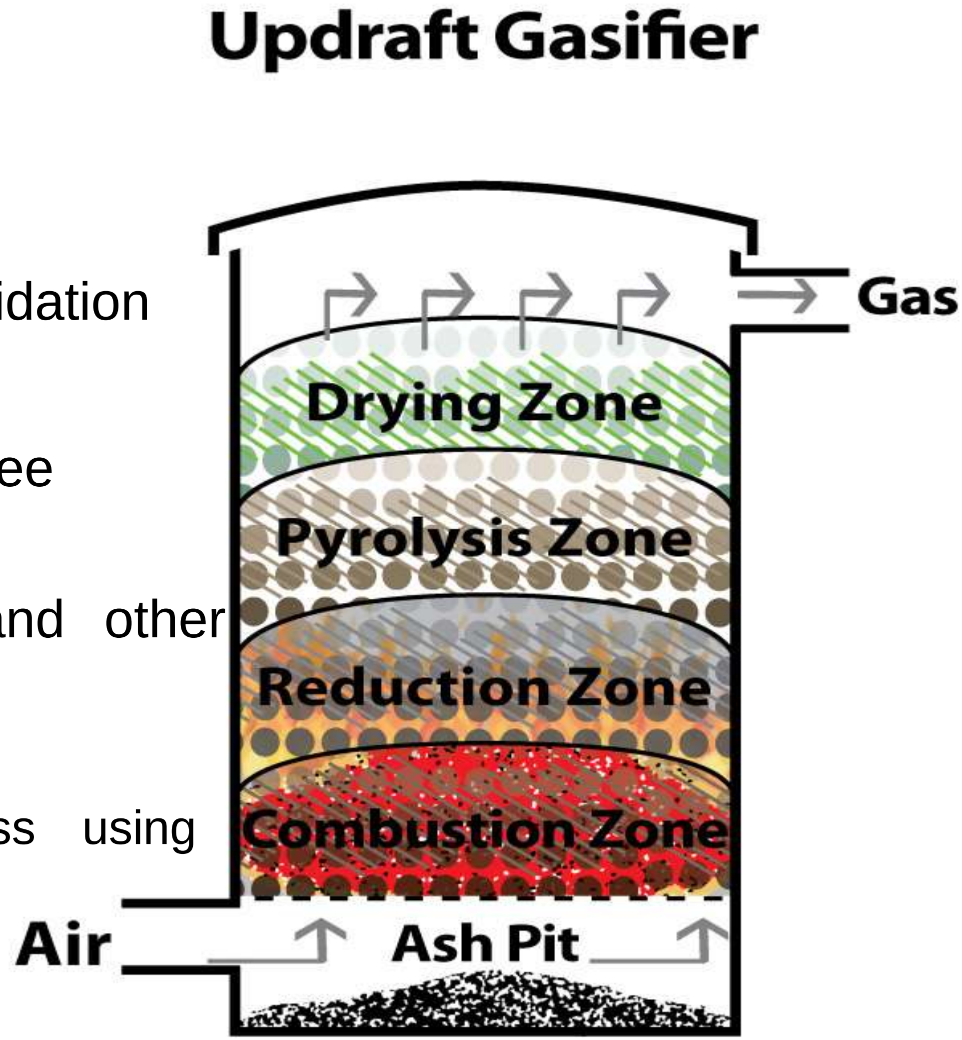
2. Down draft



3. Cross draft

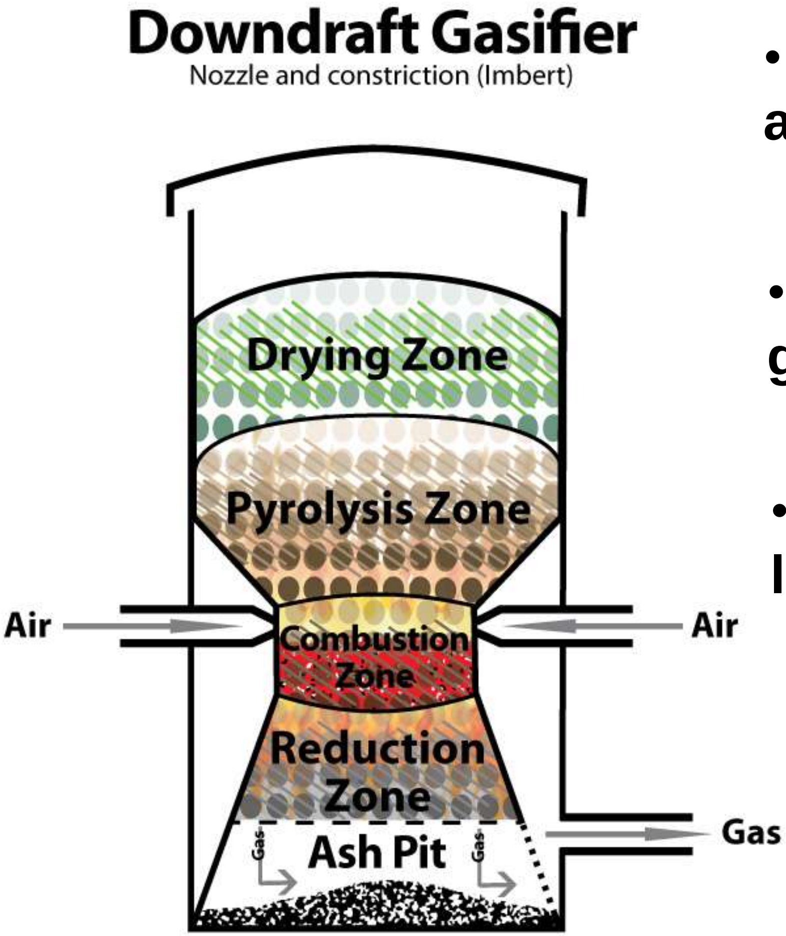
1. UPDRAFT GASIFIER:

- The gasifying agent is injected
- The high temperature oxidation zone
- The fuel descends through three
- The produced gases, tar and other volatiles disperse
- Updraft gasification of biomass using particulate fuels



Fixed Bed Gasifiers (Cont.1)

2. Downdraft Gasifier:



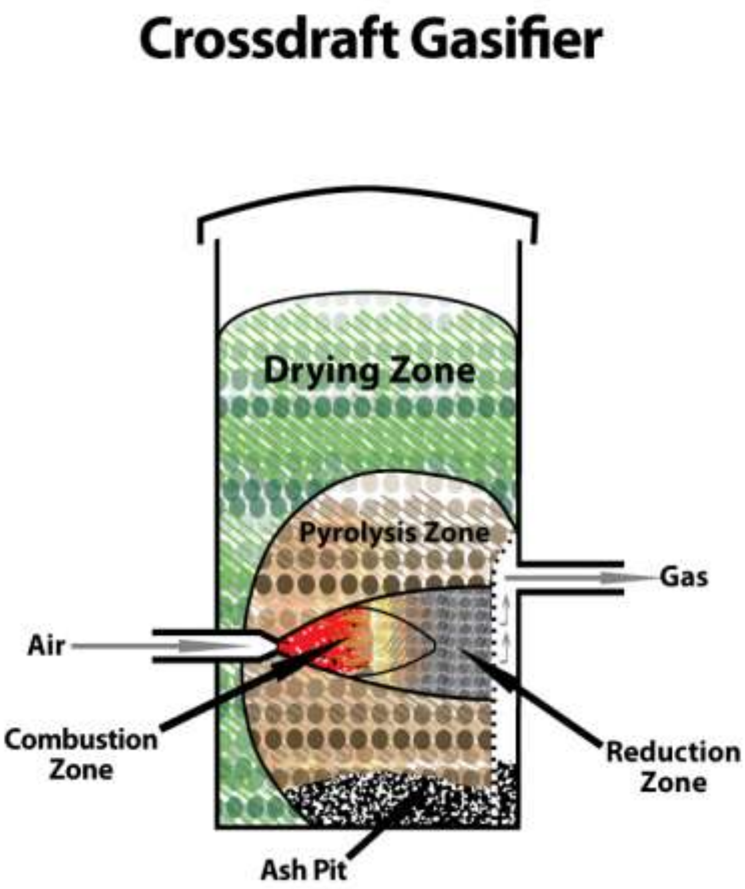
- Feedstock is introduced at the top and the gasifying agent

- Reaction zones in a downdraft gasifier

- The final product gases, which leave the gasifier

Fixed Bed Gasifiers (Cont.2)

3. Cross-draft Gasifier:



- Air or air/steam mixtures are introduced in the side of the gasifier
- Normally an inlet nozzle is used
- The velocity of the air as it enters the combustion zone
- The combustion (oxidation) and reduction zones
- Cross draft gasifier are normally simpler

Advantages and Disadvantages of various Gasifiers

No	Gasifier Type	Advantage	Disadvantages
1	Updraft	-Small pressure drop -good thermal efficiency - little tendency towards slag formation	-Great sensitivity to tar and moisture and moisture content of fuel -relatively long time required for start up of IC engine - poor reaction capability with heavy gas load
2	Downdraft	-Flexible adaptation of gas production to load - low sensitivity to charcoal dust and tar content of fuel	- Design tends to be tall - not feasible for very small particle size of fuel
3	Crossdraft	-Short design height -very fast response time to load - flexible gas production	- Very high sensitivity to slag formation - high pressure drop

FLUIDIZED BEDS

1. Bubbling fluidized bed:

- A fluidized bed gasifier consists of an inert bed material
- The bed material aid in heat transfers and may provide a catalytic or gas cleaning action
- Fluidized bed gasifiers have several advantages over other gasification reactors
- The disadvantages of fluidized bed reactors are large pressure drop, particle entrainment, and erosion of the reactor body.

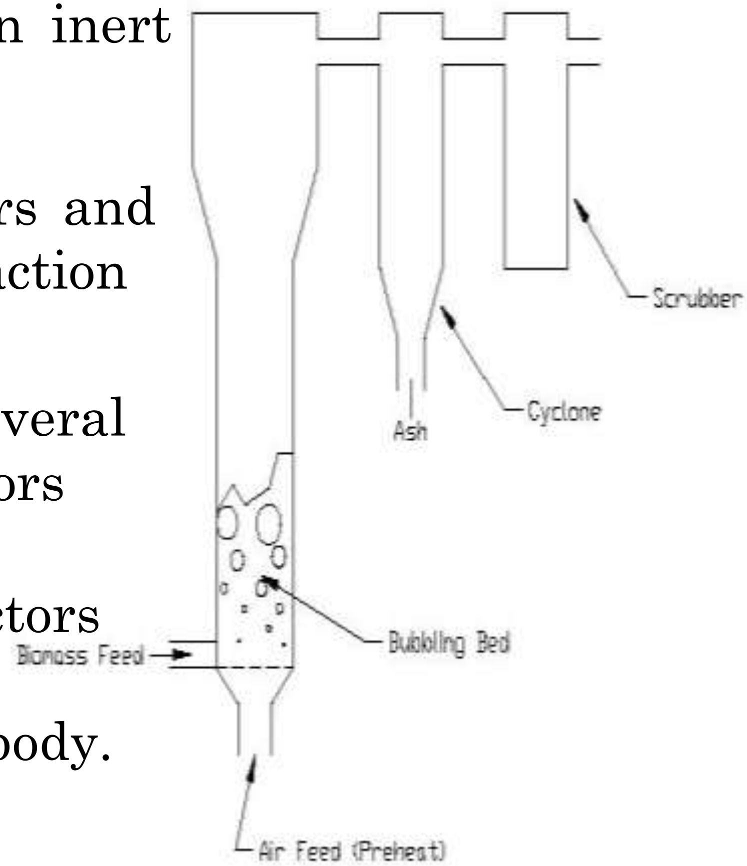


Figure 1: Bubbling fluidized bed

Bubbling fluidized beds are categorized as either a ***single fluidized bed and multi-fluidized beds.***

1.1. Single fluidized bed gasifier:

This system consists of only one bed into which the feedstock and gasifying agent enter and out of which the produced gas and char exit.

- The **advantages** of the system includes: (1) lower cost than dual and multi-fluidized beds; (2) less maintenance; and (3) the produced gas is ready for utilization.

- The **disadvantages** of the system includes : (1) heating value of the produced gas is lower than that produced by the dual bed; (2) inorganic materials in the feedstock cannot be separated; and (3) pyrolysis occurs at the bottom of the gasifier leading to a non-uniform temperature distribution.

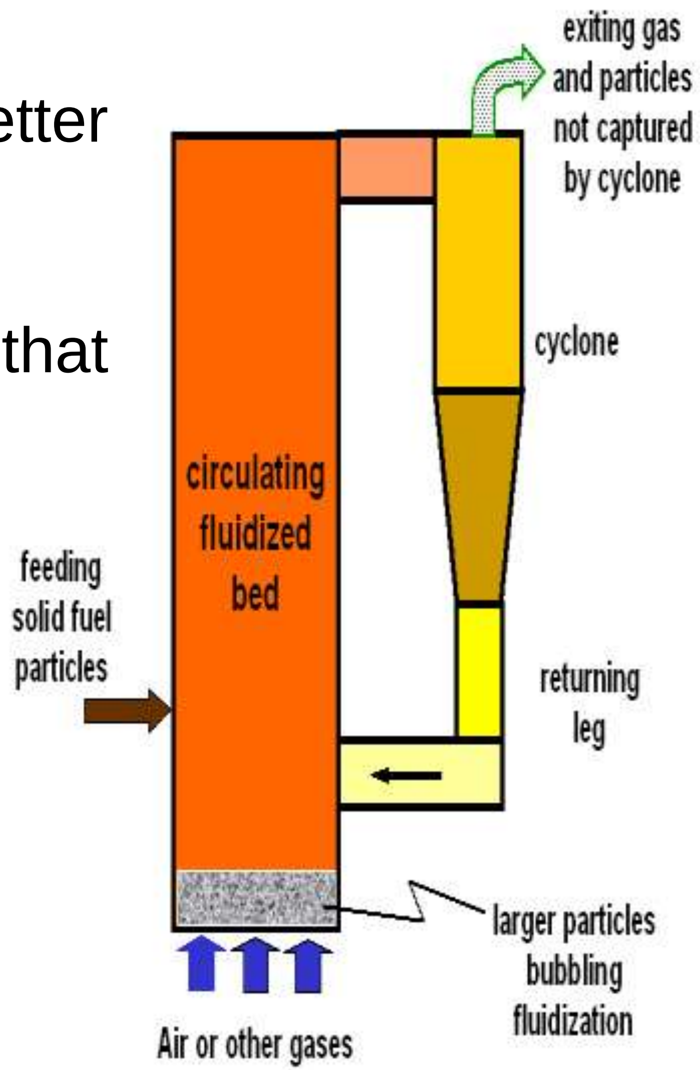
1.2. Dual and multi-fluidized beds gasifier:

- The **advantages** of the dual bed system include: (1) the gas heating value is larger because char combustion occurs in a separate reactor and hence the combustion gas does not dilute the pyrolysis gas; (2) inorganic materials in the feed can be separated.

- The disadvantages of this system are relatively uniform temperature. Higher construction costs and greater maintenance.

2. Circulating fluidized bed gasifier

- A higher processing capacity, better gas-solid contact, and the ability
- still less commonly used that bubbling models, primarily



3. Spouted fluidized bed:

- Consists of a bed of coarse particles partly filling the vessel,

- The particles in the gas...

- Spouted fluidized bed gasifiers have been used.

- The minimum particle diameter at which spouting appears to be practical is about 1 mm.

4. Swirling fluidized bed:

- A swirling fluidized bed consists of
- Primary air is introduced at the bottom
- Secondary air is introduced through one pair of openings
- The injection of secondary swirling air into the freeboard

PROPERTIES OF PRODUCER GAS

- The producer gas is affected by various processes as outlined above hence one can expect variations in the gas produced from various biomass sources.
- The gas composition is also a function of gasifier design and thus, the same fuel may give different calorific value as when used in two different gasifiers.

The average energy conversion efficiency of wood gasifiers is about 60-70% and is defined as

$$\eta\ \mathrm{Gas} = \frac{\textbf{Calorific value of gas/kg of fuel}}{\textbf{Avg. calorific value of 1 kg of fuel}}$$

Example :

1 kg of wood produces 2.5 m3 of gas with average calorific value of 5.4 MJ/m3. Average calorific value of wood (dry) is 19.8 MJ/kg18 . Hence

$$\eta\ \mathrm{Gas} = \frac{2.5\ (m3) \times 5.4\ (MJ/m3)}{19.80\ (MJ/kg) \times 1\ (kg)} = \mathbf{68\%}$$

Composition of Producer Gas from Various Fuels

Fuel	Gasification method	Volume percentage					Calorific Value MJ/m³	Ref.
		CO	H_2	CH_4	CO_2	N_2		
Charcoal	Downdraft	28-31	5-10	1-2	1-2	55-60	4.60-5.60	12
Wood with 12-20% Moisture content	Downdraft	17-22	16-20	2-3	10-15	55-50	5.00-5.86	12
Wheat straw pellets	Downdraft	14-17	17-19	-	11-14	-	4.50	15
Coconut husks	Downdraft	16-20	17-19.5	-	10-15	-	5.80	15
Coconut shells	Downdraft	19-24	10-15	-	11-15	-	7.20	15
Pressed Sugarcane	Downdraft	15-18	15-18	-	12-14	-	5.30	15
Charcoal	Updraft	30	19.7	-	3.6	46	5.98	16
Corn cobs	Downdraft	18.6	16.5	6.4	-	-	6.29	17
Rice hulls pelleted	Downdraft	16.1	9.6	0.95	-	-	3.25	17
Cotton stalks cubed	Downdraft	15.7	11.7	3.4	-	-	4.32	17

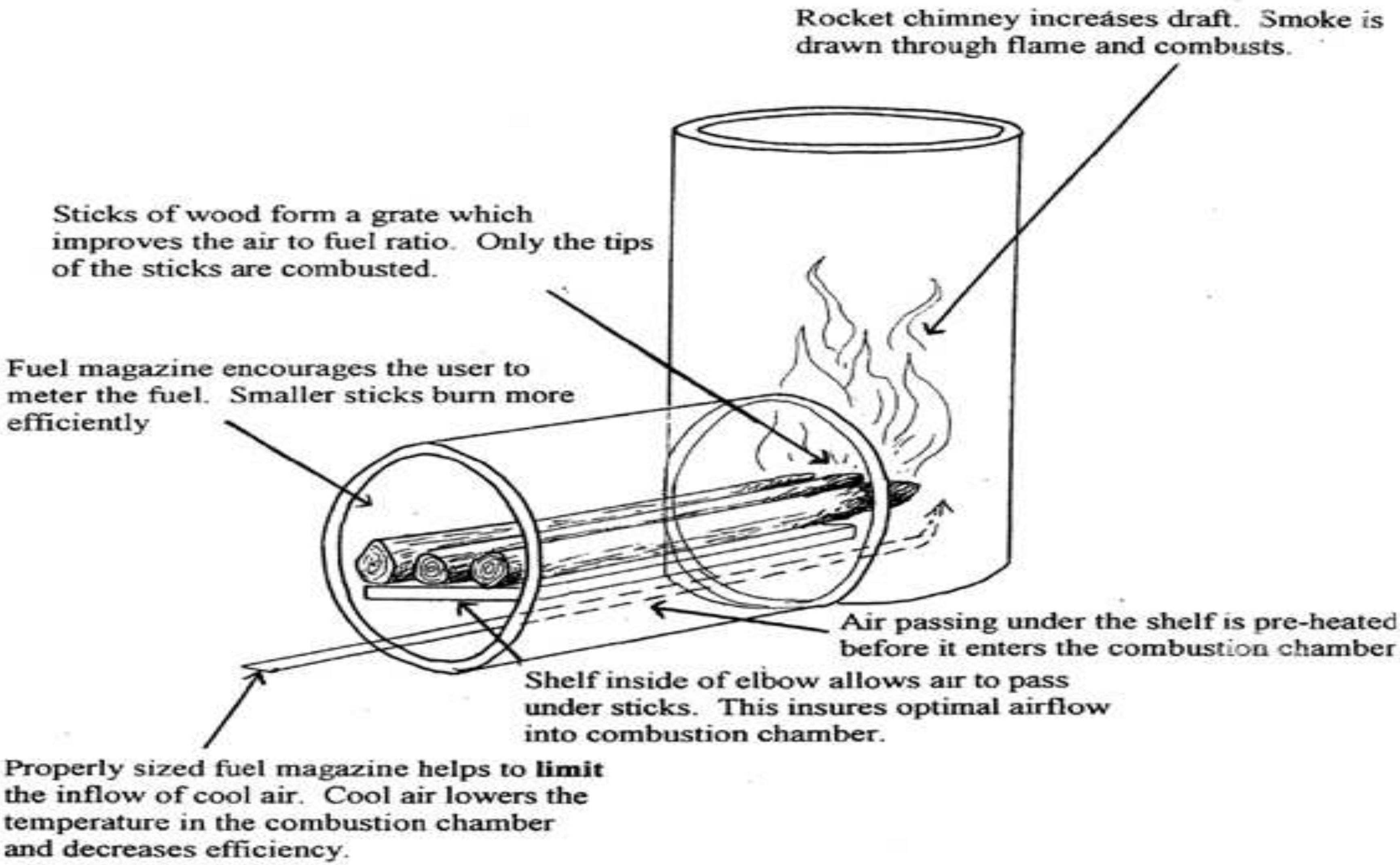
APPLICATIONS

a) Shaft power systems

b) Direct heat applications

c) Chemical production

DESIGN PRINCIPLE OF APPROVECHO ROCKET STOVE



Alternative Raw Materials

Rice husk use as organic material in brick's mixture because rice husk is usually everywhere available, even in remote rural areas.

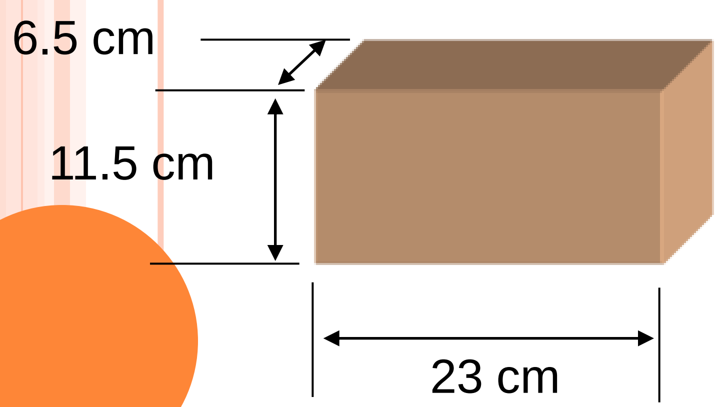
Usually rice husk can be divided into three sizes, depending on rice variety and huller ma-chine type:

- Largest size (7-12 mm) is as long as whole rice paddy (average length ~ 10 mm)
- Medium size (3-7 mm) (average ~ 5 mm)
- Small size (<3 mm), is counted as rice bran, which are rich of several useful nutritive components, and used as human food additive and animal fodder. Due to that fact, this type of rice husk was not considered as raw materials for rocket stove production.

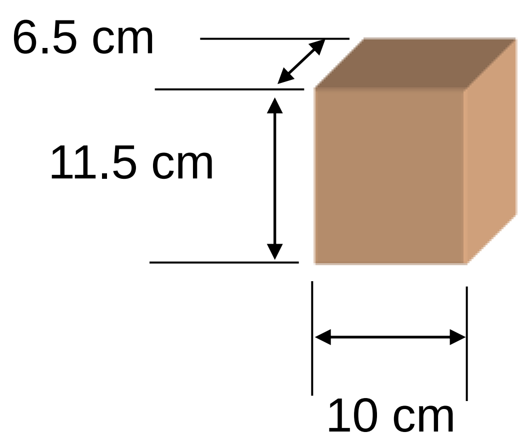
CONSTRUCTION FOR BUILDING ROCKET STOVE

Rocket Stove: Modification by NUOL Team

- Original Brick



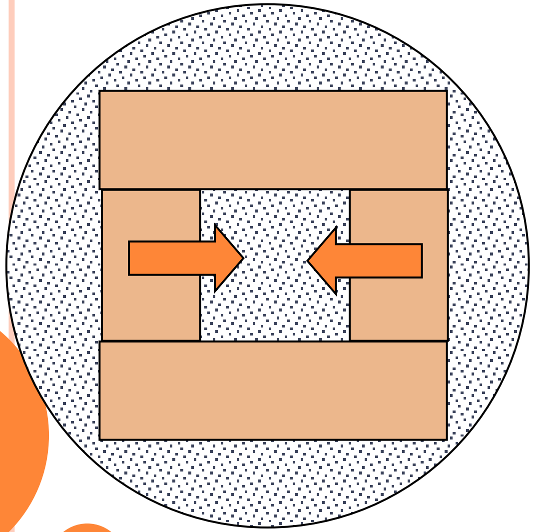
(6 pieces)



(5 pieces)

Rocket Stove: Modification by NUOL Team

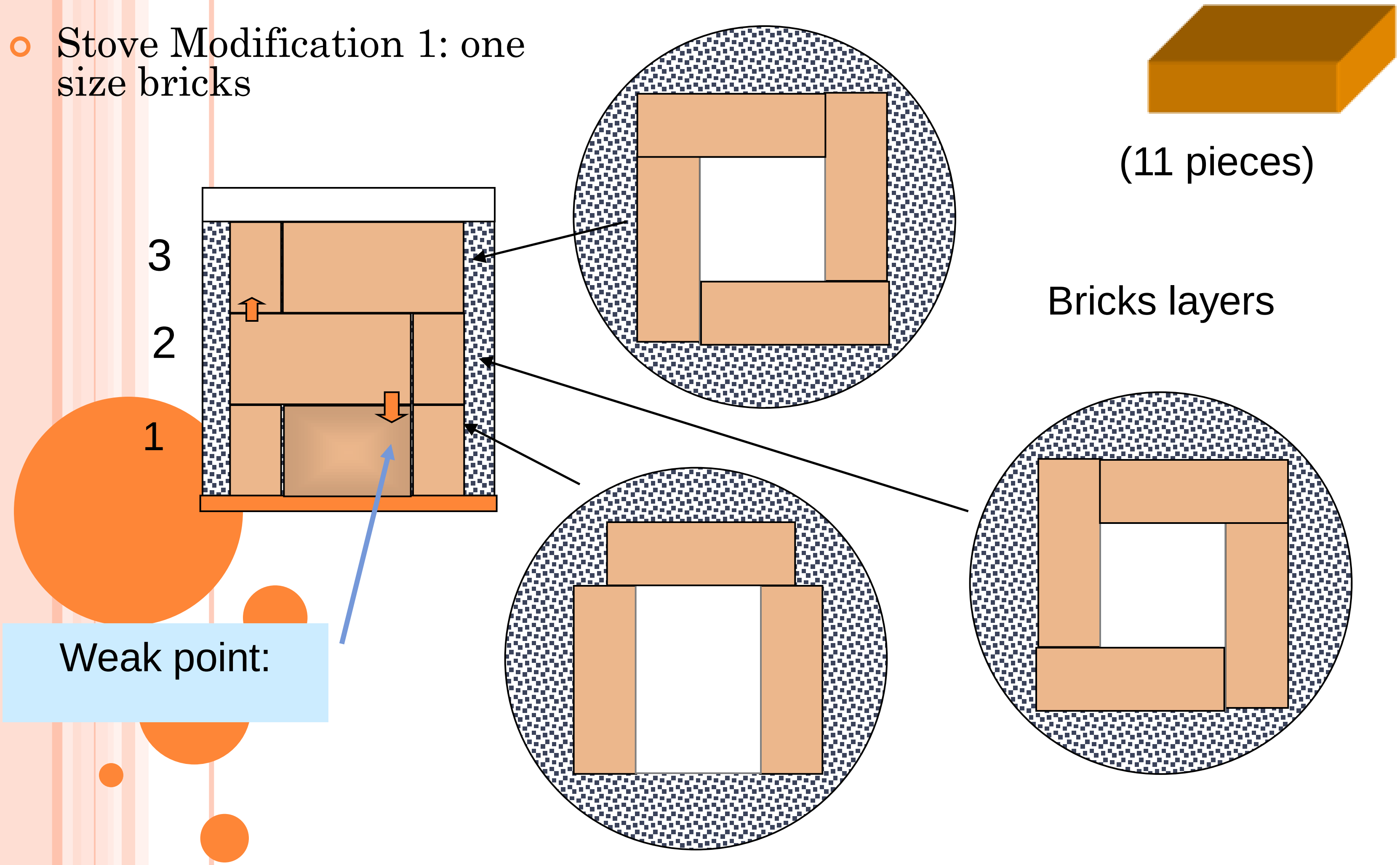
- Original Brick: weak points



- Possible movement of the short bricks
- Requires molds of two sizes

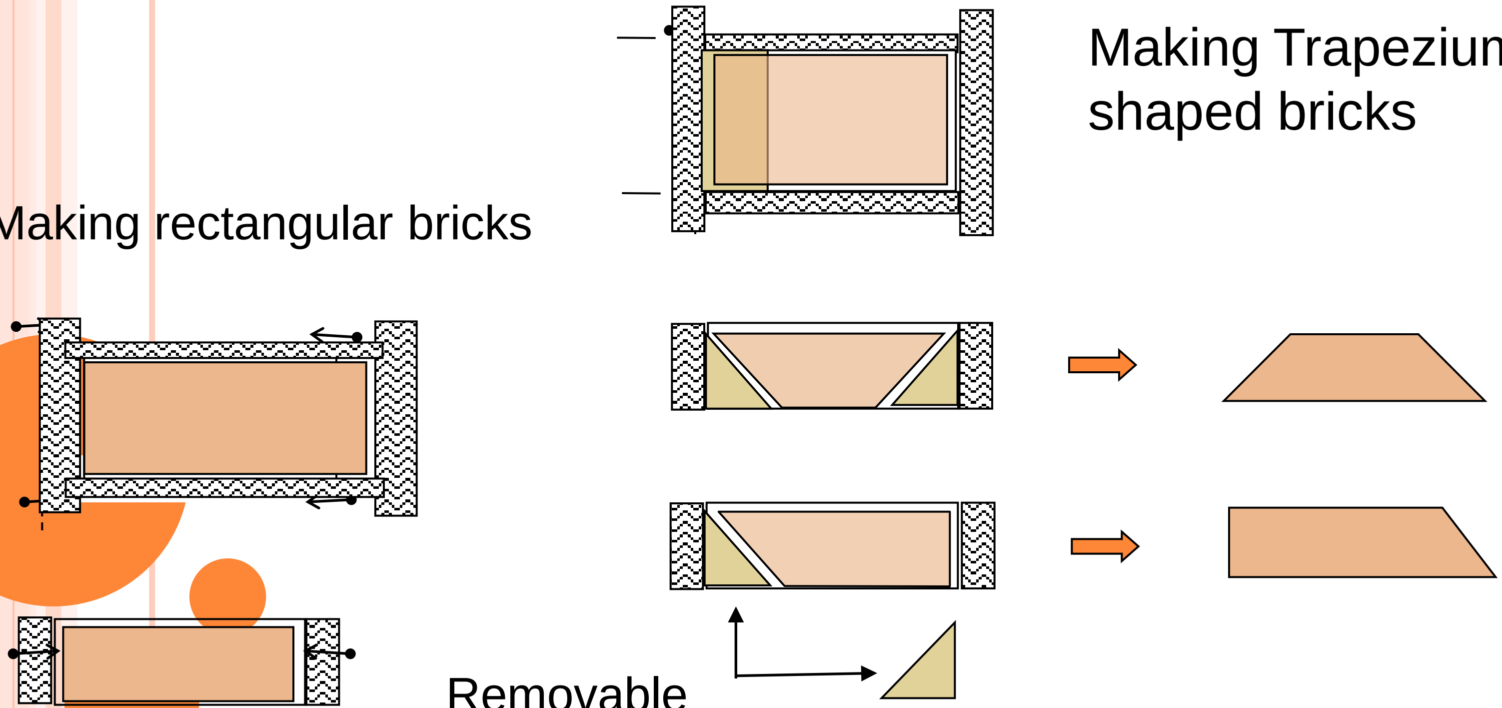
ROCKET STOVE: MODIFICATION BY NUOL TEAM

- Stove Modification 1: one size bricks



Rocket stove: modification by NUOL team

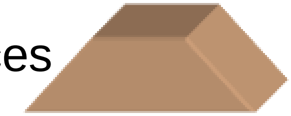
- Mold Modification



Rocket stove: modification by NUOL team

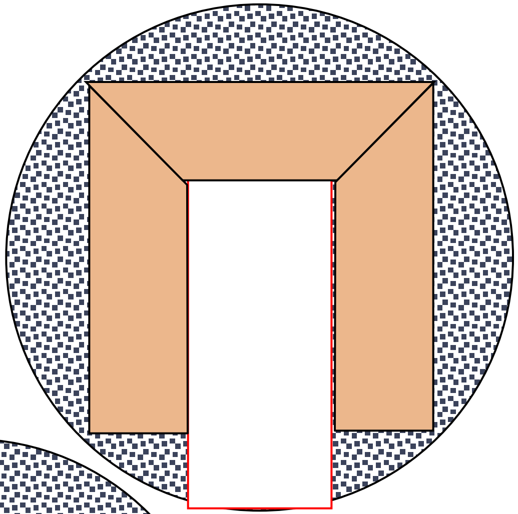
- Modification 2: Trapezium bricks

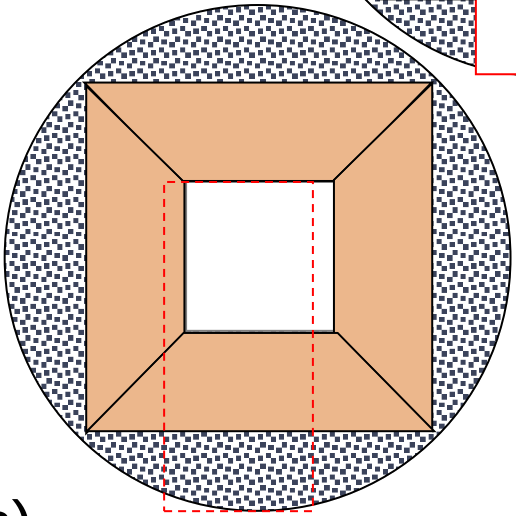
9 pieces



2 pieces

First layer:





Next layers

Strong points:

- One size of changeable mold
- Easies placement of the bricks
- Stronger structure
- Universality of the mold (rectangular or trapezium bricks)

ROCKET STOVE: MODIFICATION BY NUOL TEAM

- Pictures of modified mold

(for making Trapezium bricks)

(for making rectangular bricks)

ROCKET STOVE: MODIFICATION BY NUOL TEAM

- Pictures of the bricks

Reference

Anil K. Rajvanshi. 1986. Biomas Gasification. PHALTAN-415523, Maharashtra, India. Available online from www. nariphaltan.org/Gasifier.pdf

Sadaka, S. S., A. E. Ghaly and M. A. Sabbah. 2002. Two phase biomass air-steam gasification model for fluidized bed reactor: Part I, II, III. Biomass and Bioenergy. 22: 439-487