

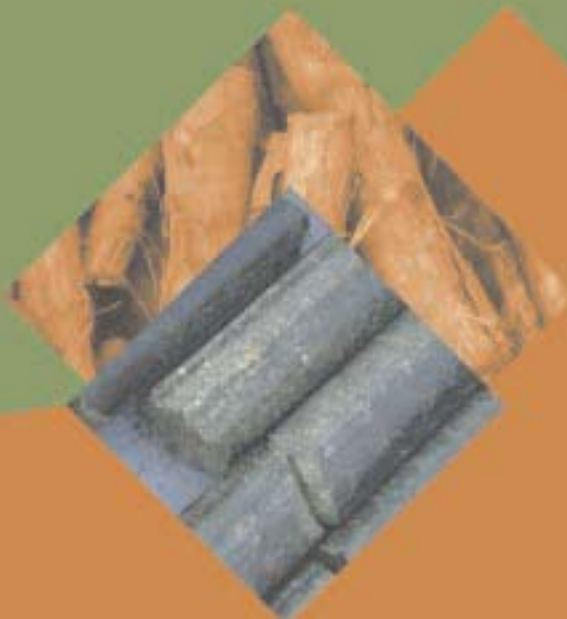


Uttam Urja Biomass Gasifier for Thermal Applications

Operation and Maintenance Manual



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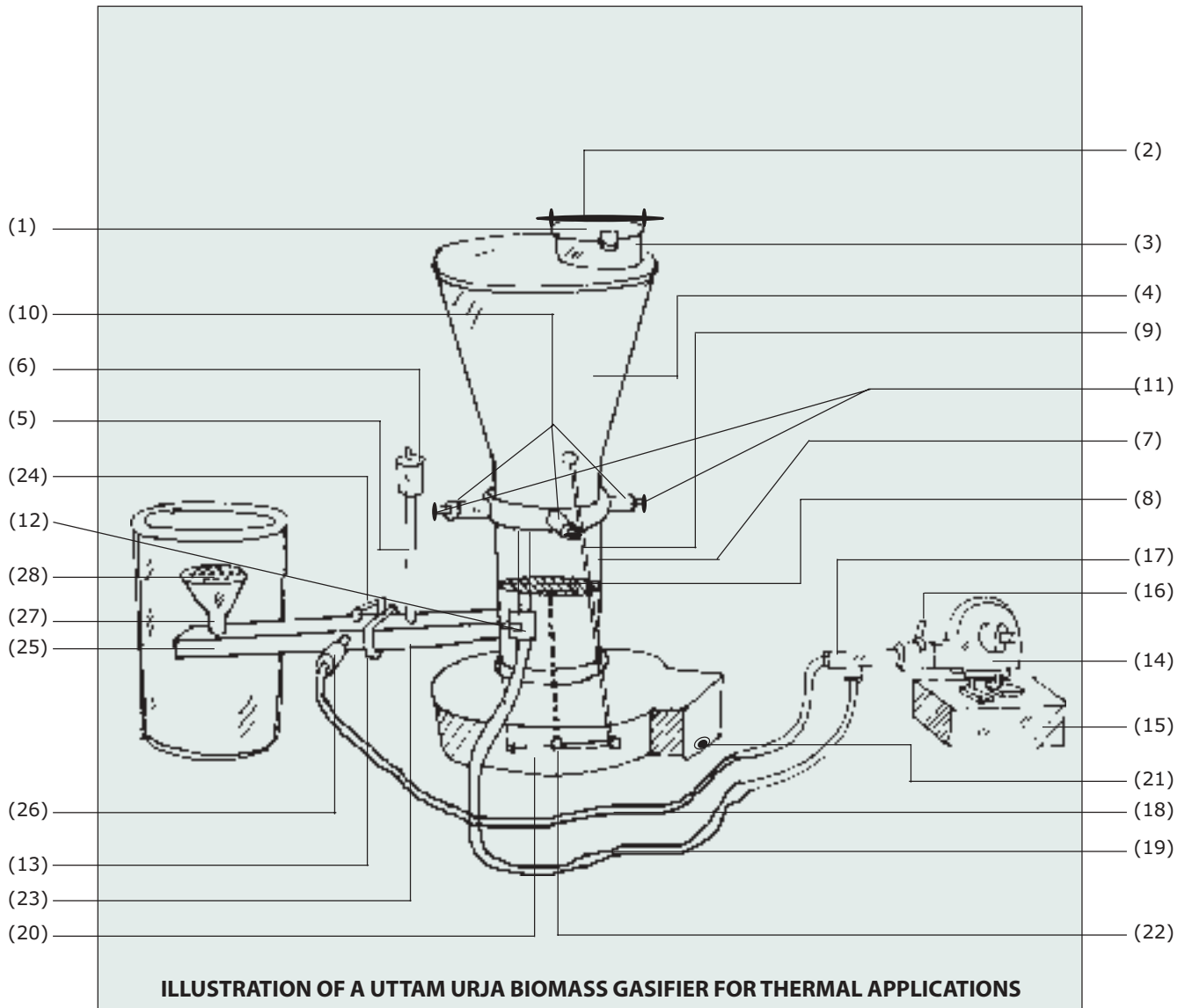
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LIST OF COMPONENTS

- | | | | |
|----|---------------------------|----|--------------------------|
| 1 | Hopper lid | 15 | Blower stand |
| 2 | Lid clamp | 16 | Valve |
| 3 | Water seal | 17 | T-joint |
| 4 | Fuel hopper | 18 | Burner air supply pipe |
| 5 | Gas flare pipe | 19 | Gasifier air supply pipe |
| 6 | Gas flare pipe lid | 20 | Ash pit tank |
| 7 | Firing box | 21 | Ash pit tank drain valve |
| 8 | Grate | 22 | Ash pit centre bush |
| 9 | Grate shaking arm | 23 | Gas outlet duct |
| 10 | Air nozzle | 24 | Damper |
| 11 | End plug | 25 | Burner duct |
| 12 | Gasifier air supply valve | 26 | Burner air supply valve |
| 13 | Flange | 27 | Burner |
| 14 | Blower | 28 | Burner port plate |

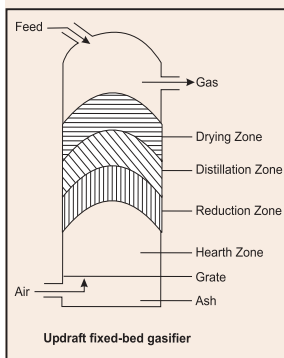
Note: There may be additional components for an Uttam Urja biomass gasifier used for specific niche applications

BIOMASS GASIFICATION

Biomass gasification is the process of conversion, through partial combustion, of a solid biomass feed material to combustible gas. The technology may be regarded as 'fuel switching'—to convert solid fuel to gaseous fuel. Gasification is achieved in the presence of heat and limited supply of O_2 (oxygen) resulting in incomplete combustion of the solid biomass material. The resultant combustible gas mixture, of which H_2 (hydrogen) and CO (carbon monoxide) comprise 15%–20% each, 2%–3% is CH_4 (methane), 7%–10% is CO_2 (carbon dioxide) and the remainder is N_2 (nitrogen), is called producer gas. The gas is a low-heating value fuel having a calorific value between 4–5 MJ/Nm³ (megajoules per normal cubic metre). Almost 2.5–3 Nm³ of gas can be obtained through the gasification of about 1 kg of air-dried biomass. The gas can be burnt in oven/burners, boilers or kilns for thermal applications, or it can be cooled, cleaned, and fed into an engine to operate either in a dual fuel mode or in a 100% producer gas mode to generate electricity.

TYPES OF BIOMASS GASIFIERS

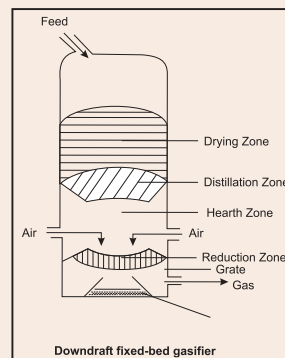
Updraft or counter-current gasifiers



The simplest type of gasifier is the fixed-bed updraft gasifier. In this, biomass is fed at the top of the reactor and moves downwards as a result of its conversion and removal of ash. Air is taken in at the bottom, and the gas leaves from the top. The advantages of an updraft gasifier are its simplicity, high

charcoal burnout, and internal heat exchange that lead to low gas-exit temperatures and high gasification efficiencies (70%–80%). Because of the internal heat exchange, the fuel is dried at the top of the gasifier, and so fuels with high moisture content (up to 40%, wet basis) can also be used. The major drawbacks are the high amount of tar and pyrolysis products that occur because pyrolysis gases do not pass the hearth zone and, therefore, are not combusted. However, this is of minor importance if the gas is used for direct heat applications in which the tar is simply burned. But if the gas is to be used for engines, it needs to be cleaned thoroughly.

Downdraft or co-current gasifiers



In a downdraft gasifier, biomass is fed at the top, and the air intake is at the top or from the sides.

The gas leaves from the bottom of the reactor and moves in the same direction. The biomass is dried in the drying zone, then pyrolysed in the distillation zone. These

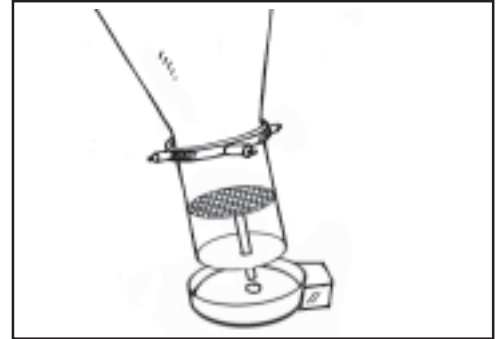
zones are heated, mainly by radiation and partly by convection, from the hearth zone, where a part of the char is burned. Pyrolysis gases also pass through this zone and are burned as well. The extent to which the pyrolysis gases are actually burned depends on design, biomass feedstock, and the skill of the operator. After the oxidation zone, the remaining char and combustion products – carbon dioxide and water vapour – pass to the reduction zone where carbon monoxide and hydrogen are formed. The main advantage of a downdraft gasifier is the production of gas with low tar content, crucial for power generation and niche thermal application.

THERMAL APPLICATIONS OF UTTAM URJA BIOMASS GASIFIERS

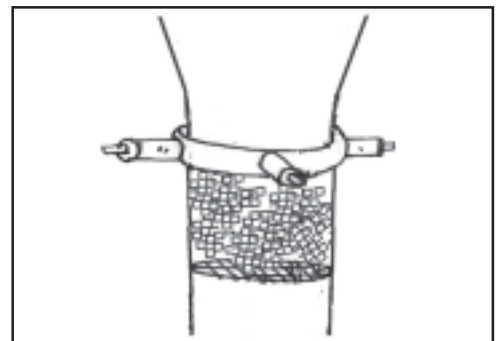
- **Dryers** Drying applications in farm products, food, and spices industry (such as areca nut, tea, coffee, tobacco, large cardamom, among others), rubber, and chemical products (temperature requirement: 60–130 °C)
- **Kilns** Baking of tiles, pottery, plaster of Paris, and lime (temperature requirement: 700–1000 °C)
- **Furnaces** For melting metals and alloys such as copper, aluminum, lead, and stainless steel, and scrap melting/recycling (temperature requirement: 650–1100 °C)
- **Process heat** Process industries requiring low-pressure steam such as large-scale cooking, textiles, tyre retreading, and food processing units such as bakeries and namkin making units
- **Water boilers** Institutional cooking, silk cocoon cooking, fabric dyeing, areca nut boiling, food processing, chemical products, and similar industries

INSTALLATION AND COMMISSIONING

1. Place the ash pit tank at a suitable location according to a well-designed layout. The extended portion of the ash pit should be located in a way that makes removal of water and char-ash easy.
2. Place the grate and assemble the grate-shaking arrangement inside the gasifier. Then, place the gasifier in the ash-pit tank so that the grate rod fits properly in the bush located at the base centre in ash-pit tank.



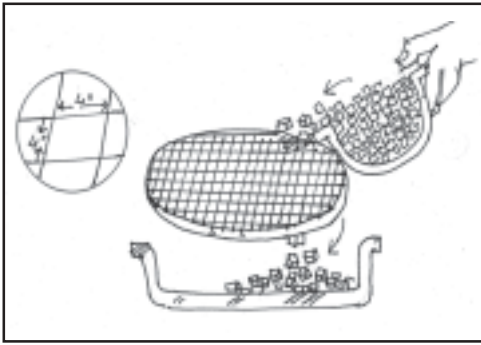
3. Place the burner in position for the given application, and connect the gas outlet duct to the burner according to the system layout.
4. Ensure that all the flanges are aligned (face-to-face) and tightened properly. Place the asbestos gasket in between to ensure leak-proof joints.
5. Place the blower at a suitable position according to the layout, and connect the blower outlet to the gasifier air nozzles and burner duct (for premixing air with gas), along with control valves.
6. Connect the blower to the plug point. The electric supply board should have a proper fuse and/or an MCB to ensure safety.
7. To check whether the joints are leak proof, prepare a soap solution and apply it liberally to all the flange joints while the air blower is operational. Soap bubbles will come out of joints that may be leaking. These must be tightened. This also applies to the air and gas duct.
8. Ensure that there is proper ventilation around the gasifier and burner system so that any unburnt gas generated (for example, gas which comes out of the burners if the flame is temporarily extinguished) is removed efficiently and speedily. Use high flow exhaust fans if the gas is burnt in a closed room. Ensure that a CO (carbon monoxide) alarm is installed if the gasifier and burner are being operated in a closed room.
9. Before charging wood, fill charcoal over the grate up to the air supply nozzles inside the gasifier reactor, and then fill the hopper with fuelwood/biomass.



FUEL PREPARATION

1. The accepted range of moisture content of the feedstock that is to be used as biomass in an Uttam Urja gasifier is ~15%. The heating value of gas deteriorates as the moisture content increases. So fuelwood should be sun dried for at least 2–3 days to reduce the moisture content to the acceptable range.
2. Cut the fuelwood into chips or use appropriately sized briquettes of agricultural residues.





3. The fuelwood chips or briquettes should be able to pass through a 3–4 inches x 3–4 inches mesh (the mesh size should not be more than 1/5th of the diameter of smallest section of the reactor). If the biomass exceeds these dimensions it could result in fuel bridging during operation.

STARTUP PROCEDURE



1. Clean the ash pit (applicable only for operational gasifiers)

Drain water, if any, from the ash pit by opening the drain valve provided at the lower end of its wall. After draining the water, shovel the residual ash and char material collected at the bottom.



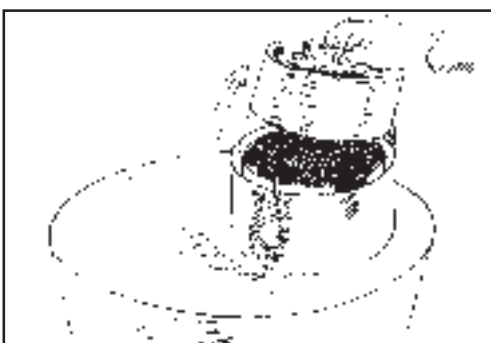
2. Fill the ash pit with makeup water

After removing the ash and char from ash pit, add fresh water. Fill water to a level so that at least 8–10 inches of water seal is maintained at the bottom edge of the gasifier inside the ashpit water tank. This is done to prevent any gas bubbling (leakage) through it. For a newly commissioned gasifier, fill water in the ash pit tank and the top water seal and ensure that there is no leakage.



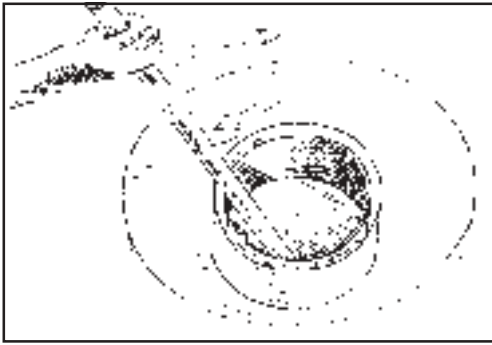
3. Open the gasifier lid

To open the gasifier hopper lid, remove the lid clamp by sliding it out horizontally through the two hooks at top edge of the water seal.



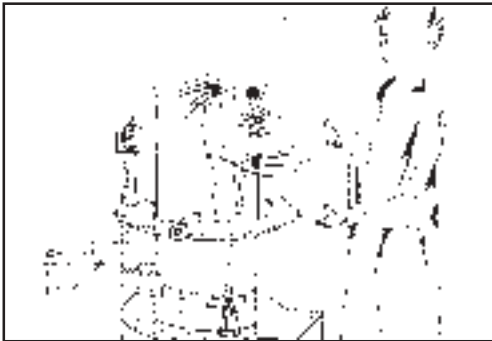
4. Open the gasifier hopper lid

Take off the lid of the gasifier hopper from the annular water seal groove provided on the top of the gasifier hopper. In case of an Uttam Urja gasifier with a bigger hopper or a larger capacity, use the chain pulley to open the hopper lid.



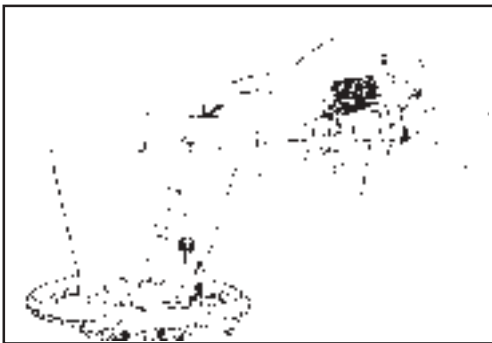
5. Level the existing fuel bed

Before adding a charge of fresh fuel into the gasifier, it is always better to level the existing fuel bed with the help of wooden or bamboo stick or iron rod (about 8–9 feet long). This helps minimize fuel bridging and makes the fuel bed more uniform and compact. But do not ram the fuelwood too much as it can lead to fuel bridging.



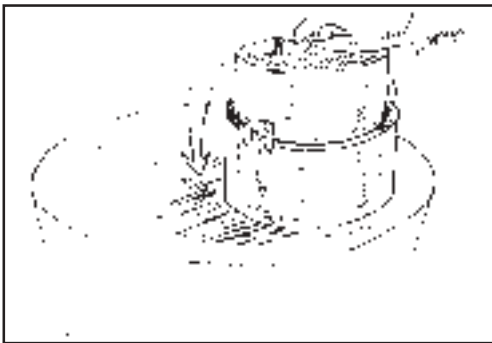
6. Shake the grate rigorously

After levelling the fuel bed, rigorously shake the grate five to six times with the help of the grate shaking rod. This will help remove the ash formed on the grate and also minimize the chances of clinker formation.



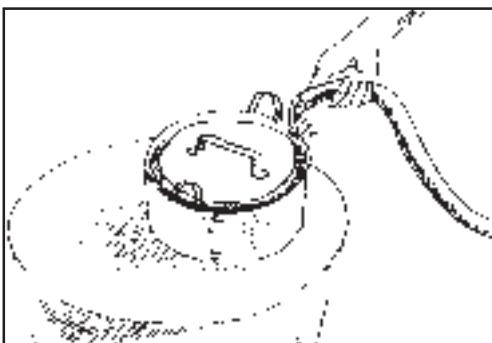
7. Fill the hopper with fresh fuel

Use baskets, buckets or bags to add fresh fuel in the hopper. Fill the fuel hopper up to the rim. Filling the hopper to same level every time can help get a more accurate estimate of the fuel consumption in between fuel charging intervals. Air-dried fuelwood pieces and twigs, coconut shells, areca nut shells or briquettes of loose biomass can be used. Never try to look into the hopper or inhale vapours/gases coming out of the hopper top. These can be dangerous. Always keep your face away from the fuel port.



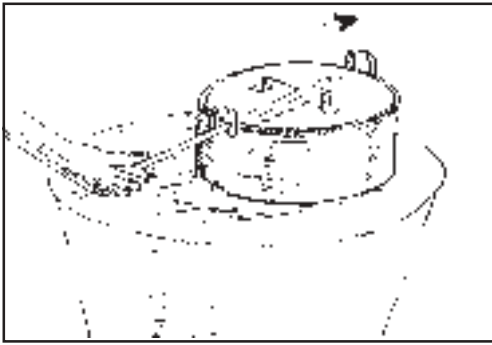
8. Close the gasifier lid

Place the hopper lid back inside the annular groove provided at the top of the hopper. Ensure that it sits properly inside the groove. Remove any fuelwood chips that have gone inside the groove hampering the placement of the lid.



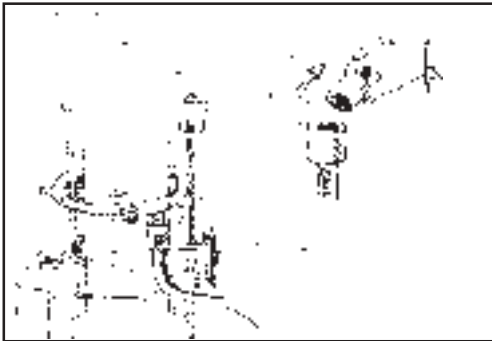
9. Fill water in the top water seal

Fill water inside the annular groove (of the water seal) provided on the gasifier hopper top. The water-seal arrangement helps in preventing any gas leak from the gasifier top. The advantage is that it makes removing and closing the hopper lid easy and quick, without having to tighten or loosen bolts, thereby minimizing the fuel charging time.



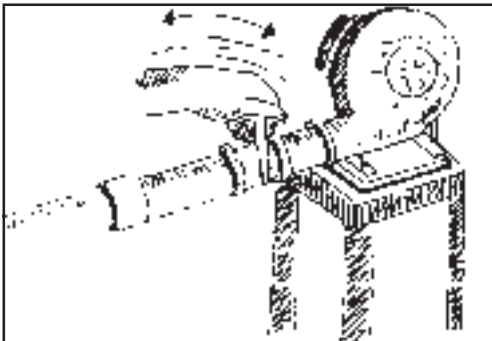
10. Lock the gasifier lid

Lock the gasifier lid by pushing the lid clamp horizontally through the hooks on the hopper lid. To prevent accidental injury, lock the lid properly to keep it from lifting due to a rise in gas pressure inside the gasifier or suddenly blowing off in the event of a backfire.



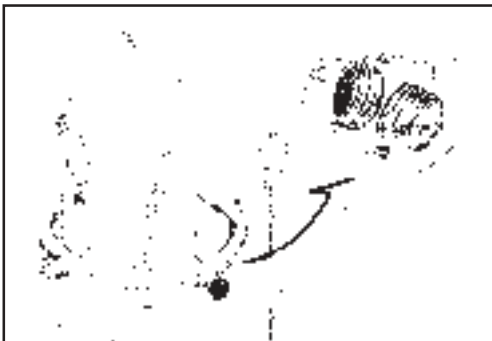
11. Open gas flare pipe

Ensure that the gas flare pipe is open at the time of igniting/starting the gasifier. This can be done by removing the lid placed at the top end of flare pipe inside the water seal annular groove. This helps avoid dirty gas flowing through the gas duct towards the burner or the drying chamber during the start-up period.



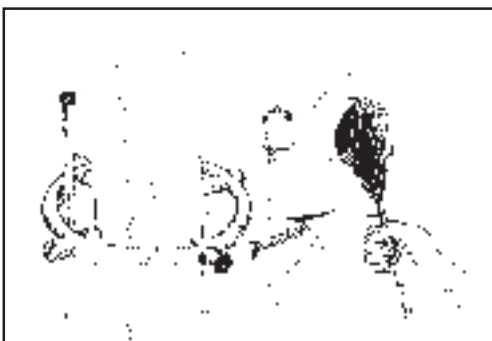
12. Switch on the blower and open the gasifier air supply valve

Switch on the electric blower. Open the valve in the blower outlet pipe and ensure that the valve supplying air to gasifier and the flare pipe is open. This is necessary to prevent pressure build-up in the gasifier and gas pipeline.



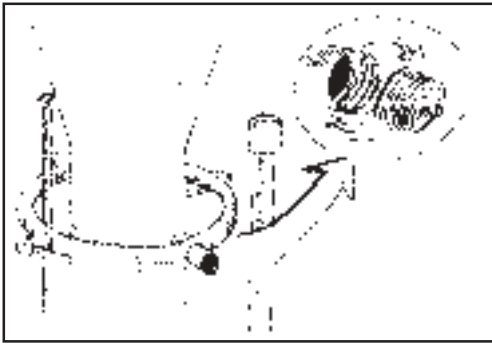
13. Remove the end plugs of the air nozzle

Remove the end plugs (with small holes) of the air nozzles. Do not misplace any end plug as it is essential to close the air nozzle opening for gasifier operation.



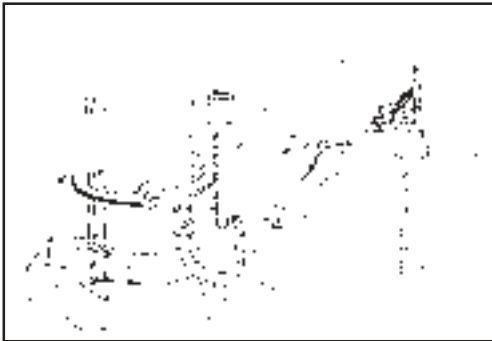
14. Ignite the gasifier through the nozzles

Light torches (made of an asbestos rope wound on a thin metal rod) dipped in diesel or kerosene. Put firing torches inside all the air nozzles through the end plugs. Tighten the end plugs to place them securely. To avoid a backdraught and to keep the torch from going out, reduce the rate of airflow while inserting the torches in the air nozzles.



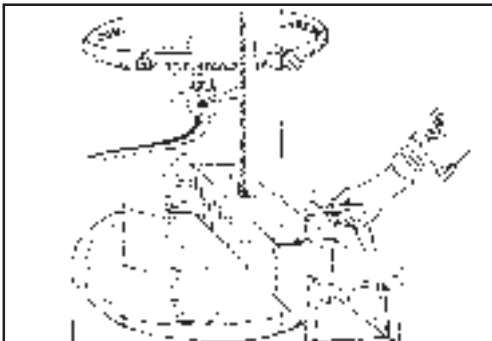
15. Remove the torch and close the air nozzles

After ensuring a flame in all the gasifier nozzles, remove the torches by unscrewing the end plugs. Close the air nozzles by tightening the different sets of end plugs, with view glass, to place it securely. The view glass is provided for monitoring the red hot fuel bed condition inside gasifier fire box during operation.



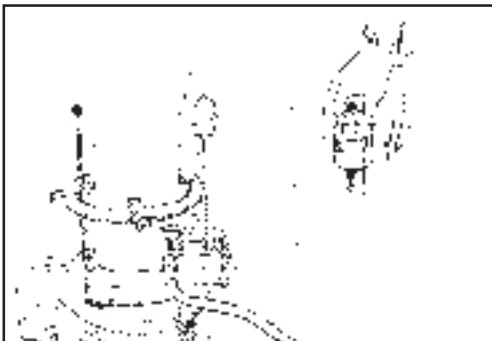
16. Check combustible gas by flaring

Within 5–15 minutes of igniting the fuel bed, combustible gas would start coming out from the gasifier through the flare pipe. The gas can be tested by burning it using a torch. If the quality of gas is good, the gas will continue to burn even after the torch is removed.



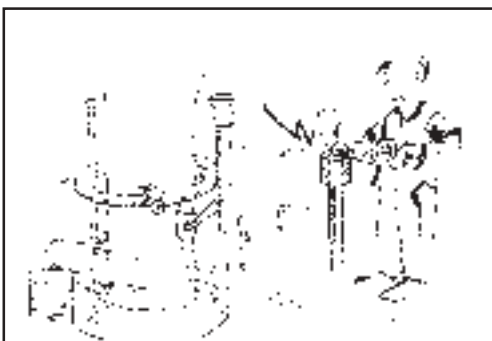
17. Open the gas outlet damper

Once the gas starts burning steadily in gas flare pipe, indicating the production of combustible gas, open the damper (flap valve) provided at gasifier gas outlet. This allows the gas to go towards the burner.



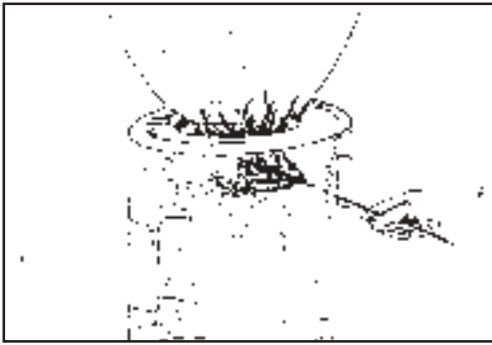
18. Close the flare pipe

After ensuring a stable flame in the flare pipe, close the flare pipe to allow gas from flowing towards the burner or the dryer. To do so, place the lid inside the water seal annular groove (filled with water) at the top end.



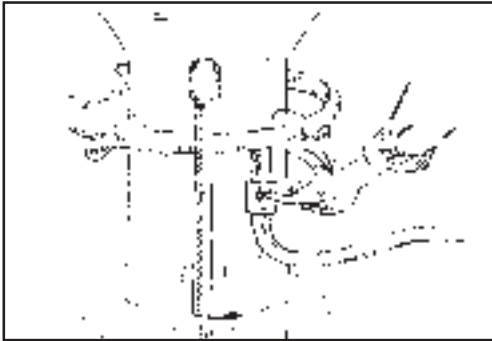
19. Add water in the flare pipe water seal

Add water in the annular groove of water seal arrangement at the top end of flare pipe. This stops gas from escaping when the gasifier is in operation.



20. Ignite gas in the burner

Once gas starts coming out through the burner port, ignite the gas with a torch. Ensure that the gas is ignited quickly to prevent it from accumulating inside the chamber, which could be harmful if the gasifier is installed in a confined or poorly ventilated space.



21. Adjust the positions of the air supply valve

Ensure that the valve at the outlet of the electric blower is open. For varying the rate of gas production (within a turn down ratio of 3:1 to 4:1) the position of the air valve in front of the gasifier nozzles can be adjusted to control the air going through them to the gasifier.



22. Adjust the gas damper as required

Adjust the position of the gas damper as required to keep the gas burning steadily inside the burner. Premixed air is supplied to ensure complete burning. The supply of airflow can be controlled to stabilize the gas burning in the burner as well as to control the gas flame in it.



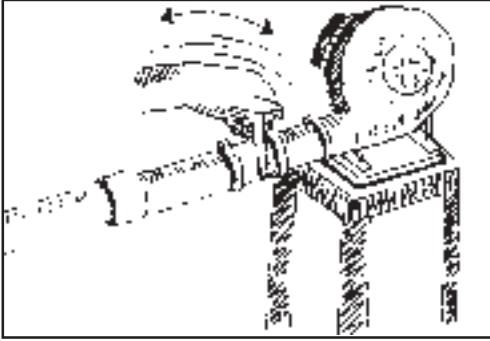
23. Shake the grate at regular intervals

In order to remove the ash formed on the grate, use the grate-shaking rod and shake the grate (four to five times) at regular intervals (every 20–30 minutes). This also minimizes the chances of any clinker formation in the gasifier bed.

Monitor the gas flame inside the burner at regular intervals. Adjust the damper in gas supplying duct and the premixed air supply to the gas burner, if required. Adjust the supply of air to gasifier air nozzle to vary the power as required. The length of the flame in the burner can be adjusted by controlling the premixed air.

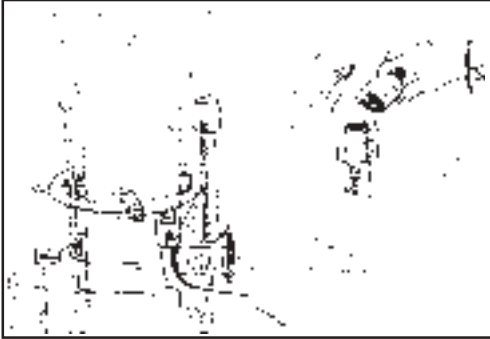
Operate the gasifier till the fuel lasts in the hopper or till the time specified by the manufacturer for replenishing the fuel.

SHUTDOWN PROCEDURE



1. Switch off the blower and close the valve

Switch off the electric blower. Close the valve of the blower outlet pipe, and ensure that the valve supplying air to gasifier is shut off completely preventing further gasification reactions inside the gasifier.



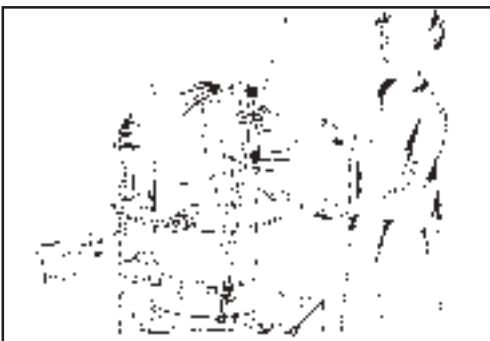
2. Open the gas flare pipe

Open the gas flare pipe by removing the lid placed inside the water seal annular groove at the top end of flare pipe. This helps in releasing the gas pressure in the gasifier and the entire gas pipeline. It also diverts the gas flow, through the gas duct, from the burner or the drying chamber towards the flare pipe.



3. Close the gas outlet damper

In order to stop the production of gas and to prevent it from going to the burner or the dryer, close the damper (flap valve) at the gas outlet. This will stop the gas from flowing towards the burner.



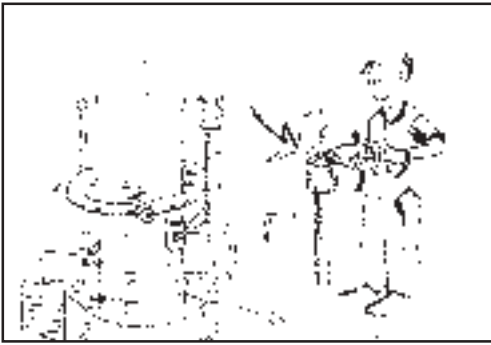
4. Shake the grate vigorously

After extinguishing the flame at the gas burner and cutting off the air supply to the gasifier, shake the grate vigorously (8–10 times) with the help of grate-shaking rod. This will help remove the ash formed on the grate and minimize the chances of any clinker formation.



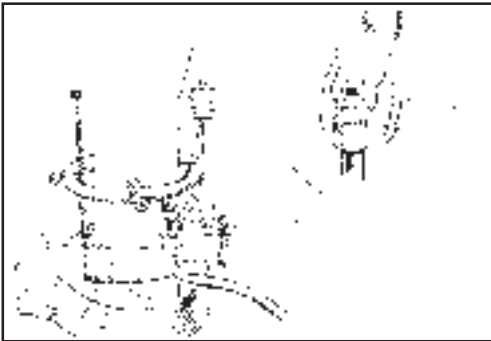
5. Fill water in the top water seal

Fill water in the annular groove of water seal arrangement at the top of the gasifier hopper. This will check any gas leakage from the gasifier and will also prevent air from entering the gasifier averting backfire or continued fuel burning inside the reactor, which could lead to fuel wastage.



6. Fill water in the flare pipe water seal

Fill water in the annular groove of the water seal arrangement of the flare pipe. This stops gas leakage and keeps any air from entering through it, preventing backfires or continued fuel burning (fuel wastage) inside the gasifier after the system has shut down.



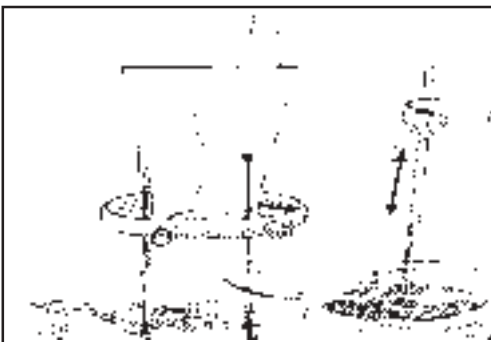
7. Close the flare pipe after five minutes

After the system has shut down, ensure that the fire inside the gas burner is extinguished and all air supply valves are closed. Allow the gas to come out through the flare pipe for about five minutes to release all residual gas from the system. Then close the flare pipe by putting the lid back inside the water seal groove to isolate the system from the ambient air.

At the end, ensure that:

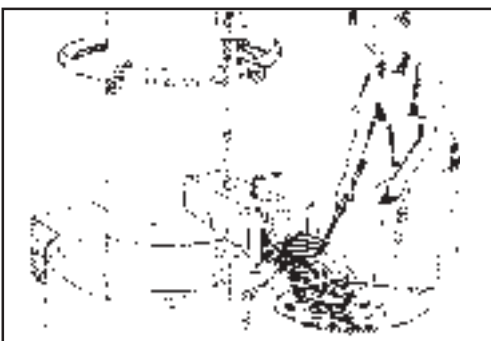
- J The blower has been switched off.
- J All the valves have been closed to prevent any air supply to the gasifier.
- J There is sufficient water in all the water seals. Add makeup water, if required.
- J There is no gas leakage from any joint or valve.

MONTHLY OR FORTNIGHTLY MAINTENANCE



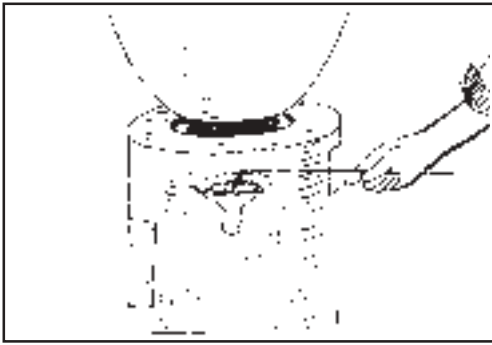
1. Remove clinker, if any

Exhaust all the fuel till the level of the grate. If there is clinker on the grate, break it into pieces with a rod and remove it. Check for any stone pieces or unwanted objects that might get jammed inside the grate rod, and remove them.



2. Clean the gasifier outlet duct

Once a month, check the gasifier outlet duct for any blockage. Open the flange that joins the gasifier and the dust settling chamber. Remove the ash accumulated inside the settling chamber. Refit the flange properly.



3. Clean the burner ports

Remove the dust/soot deposits from the burner ports. This can be done with the help of a thin L-shaped metal rod. This will reopen the burner port and allow the gas to flow freely through it.

TROUBLE SHOOTING

1. Problem in ignition of the gasifier through air nozzles.

- : Check the fuel bed for the presence of charcoal. In case there is no charcoal, add charcoal on the grate upto the air supply nozzles.
- : Check whether the size and moisture of the fuelwood is of the recommended value. If not, empty the gasifier and use fuelwood of the recommended size and moisture.
- : Initially allow a small amount of air into the reactor for catching fire, and then, gradually increase air for burning.
- : Agitate the fuel bed with the help of a wooden or bamboo stick or an iron rod to break any bridge formation in the reactor.

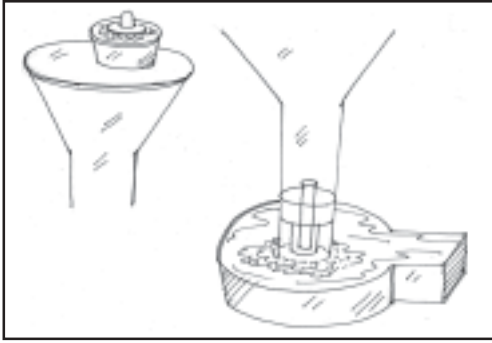
2. Flame extinguishes at burner or there is a lean flame at burner

- : Check the red glow in the gasifier reactor through view glass; ignite the biomass again. Replenish the biomass, if required. Check the moisture content of the biomass using a hand-held moisture meter, bridging in the combustion bed, and blockage in the gas outlet pipe.



- : Use the grate-shaking arm to shake the grate. If this does not produce the desired result, open the hopper lid of the gasifier and agitate the fuel bed to break any bridge formation.
- : Replenish the biomass/fuelwood, if needed.
- : Mix optimum quantity of air with the gas in gas outlet duct by adjusting the valve/damper position.
- : Check the grate for formation of any clinker, which might have choked it. Try removing clinker from above through the hopper top using a rod or by decommissioning the gasifier.
- : Check for any accumulated dust in the burner line and clean it, if necessary.

3. Bubbling at the ash pit water seal tank and at the fuel opening door



- : Check the water level in the ash pit water seal and the water seal of the hopper top. Refill the water to the recommended level.
- : Check the complete producer gas duct and clean it if there is a blockage.
- : Check for blockage around/near the opening of fuel door in the main gas duct and clean it, if required.
- : Check the condition of the fuelwood bed for choking and clean it, if required.
- : Check if there is any clinker formation on the grate, and remove it.
- : Check if the grate rod is fitted properly in the bush located at the ash pit base centre.

SAFETY PRECAUTIONS

1. Place a fire extinguisher, of appropriate size and capacity, on a wall near the gasifier. Ensure that the extinguisher is easily accessible. It is also advisable to install a CO (carbon monoxide) alarm near the gasifier system.
2. While charging fuel, do not lean and look inside the gasifier hopper through the fuel-charging door. Combustible gases can suddenly come out, catch fire and cause injuries.
3. Ensure that the blower is not connected to the electricity supply and the air supply valves are in closed position while charging fuel inside the gasifier
4. During power cuts, close all air supply valves and open the gas flare pipe. Close the gas flare pipe after releasing the accumulated gas in the gas duct.
5. Do not look at the firebox through the air nozzles with the naked eye when the end-plugs are removed from nozzles. This is because sometimes flames shoot out through them. Use a mirror to see the reflection of the firebox after having removed the end plugs of the nozzles. During regular operation, the red glow in the gasifier reactor can be monitored through the end plugs that have been provided with a view glass.
6. While igniting the burner, use a long lighting torch to keep sufficient distance from the burner to avoid any mishap due to accidental backfire. To prevent fire hazards, do not lean towards the burner.
7. Prevent gases from accumulating in the burner system. The burner enclosure should be well ventilated before inserting the lighting torch. Preferably, ignite the torch and then open the valve that supplies gas to the burner.
8. Empty the ash pit tank only after ensuring that the fire in the firebox chamber has been extinguished completely.
9. If the body of the gasifier is hot, do not sprinkle it with water to cool it because sudden cooling damages the firebox lining.
10. Do not pre-mix too much air with the gas as that can result in the gas burning within the gas burner and gas duct. This can cause overheating and may damage the duct.

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About the manual

Efficient utilization of biomass energy has been an important focus area for TERI (The Energy and Resources Institute). TERI's research on biomass gasification began as early as 1984. The Biomass Energy Technology Applications (BETA) group of the Institute handles a range of developmental activities—from basic research to disseminating tailor-made products for various thermal and power applications.

Over the last two decades, the BETA group has developed customized gasifier systems for various thermal applications such as large-scale cooking, *namkin* making, food processing, drying of species and plantation crops, rubber drying, fabric dyeing, and crematoriums among others. It has installed more than 400 gasifier systems throughout India with a cumulative installed capacity of about 15 MW_{th}.

With increasing prices and scarcity of fossil fuels, gasifier systems are being accepted widely for thermal applications to contain fuel costs. To make the use of biomass gasifiers commonplace, there is a need to build the capacity of various stakeholders, namely, users, operators, and local service providers, to avoid any technological pitfall. This manual for the Uttam Urja biomass gasifier, designed by TERI, is an effort to partially achieve this objective. This manual will help gasifier users to easily adopt this modern biomass technology.

For more information on the Uttam Urja biomass gasifier, please contact:

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