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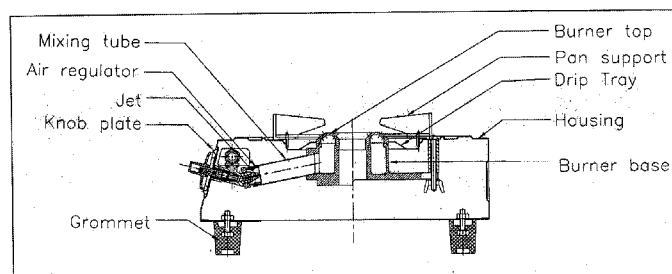


Figure 1: Bio Gas Stove – General Arrangement

(57) Abstract: Disclosed herein is an apparatus for combustion of gaseous fuel, preferably for domestic cooking with improved thermal efficiency and gas savings. The invented apparatus consists of improved designs of jet, air regulator, mixing tube, burner top, drip tray and pan support.

AN APPARATUS FOR COMBUSTION OF GASEOUS FUEL

FIELD OF THE INVENTION

[01] The present invention relates to an apparatus for combustion of gaseous fuel preferably obtained from organic wastes. This invention particularly relates to energy efficient biogas burner.

BACKGROUND OF THE INVENTION AND PRIOR ART

[02] A major percentage of population continues to depend on biogas for their cooking needs. The cooking devices used by majority of them have very poor thermal efficiency and serious health impacts due to unclean combustion. While past few decades have seen a lot of interest world over in development of better cookstoves for burning biogas, the magnitude of the problem is still a major cause of concern.

[03] For cooking used for domestic purpose, many manufacturers are supplying BIS certified biogas stoves in local market of India. BIS standard IS8749:2002 for biogas stoves specifies minimum thermal efficiency of 55%.

[04] There are many BIS certified stoves in the local market which meet the BIS requirement of minimum thermal efficiency. The applicant decided to further improve upon it to strengthen its drive for energy conservation. The salient feature of the existing burners are mentioned in the prior art below.

[05] The design of gaseous burner is normally based on Wobbe number or Wobbe index of a fuel gas. The higher the Wobbe number for a gas, the greater the heating value of the quantity of gas that will flow through a hole of a given size in a given amount of time. In almost all gas appliances, the flow of gas is regulated by making it pass through a hole or orifice. The usefulness of the Wobbe number is that for any given orifice, all gas mixtures that have the same Wobbe number will deliver the same amount of heat. LPG has Wobbe number 73.5-87.5 and natural gas which consists of methane has Wobbe number of 39-45. As a typical composition of biogas consists of fuel gas methane only 55% and rest as carbon dioxide which is a non-fuel gas,

its Woobe number is much lower than natural gas and LPG both. Therefore a burner suitable for these fuels i.e. LPG and natural gas is not suitable for biogas.

[06] In a biogas burner, there are various features such as primary air regulator, port area and size of ports, design of drip tray and fuel jet, gap between burner top and vessel which play an important role in its thermal efficiency. Presently available biogas burners have poorly designed primary air regulator along with incorrect design of fuel jet which results in inappropriate amount of primary air entering into the mixing tube along with fuel gas. Also currently available burners have non optimized port area and size of ports. Further the improper drip tray provided in currently available burners result in higher heat losses. All these aspects finally result in lower thermal efficiency.

[07] **US Patent 6,461,147** relates to a gas burner for relatively light fuel gases whereas light gases include, e.g. natural gas with the naturally occurring variations (LNG, CNG). This burner is particularly for use in ovens, incinerators etc. and therefore not related to cooking.

[08] **US Patent 6,634,881** discloses a burner assemblage for a multi burner waste gas flare where waste gas is biogas.

[09] **US Patent 6,601,543** discloses a method of utilizing a methane-containing biogas, which may be selected from the group consisting of waste dump gas and biogas originating from fermentation installations and putrefication processes of sewage treatment plants, by feeding the methane-containing biogas to a gas engine of a gas engine/generator assembly generating electricity.

[10] **US Patent 5,738,023** discloses an apparatus for burning fuel, for instance oil, gas, coal, biogas formed from organic waste, or the like in which the apparatus comprises a combustion means for burning this fuel in addition to a converting means for converting the energy becoming available during this combustion into heat, cold or into a combination of thermal energy with power. For instance, a burner which can transfer the combustion heat to a heat exchanger for heating of a heating medium, such as air, tap water, or a combustion motor, for the purpose of heat/power generation, in which the apparatus further comprises a supply conduit for combustion air and a discharge conduit for flue gases.

[11] **US Patent 6,093,018** discloses an improved gas burner, comprising: a burner head, a receiving chamber where primary air and fuel gas are mixed. Head containing circumferentially positioned lateral apertures for issuing and uniformly distributing said mixture

around said burner head to form a flame. The gas burner can provide controlled feeding and admixing of the secondary air directly to the base of the flame that enables the combustion process characterized by high-elevated temperature.

[12] **Chinese patent CN 2261568(Y)** discloses a household stove comprising a frame and a burner. The stove can adopt manufactured gas, liquefied petroleum gas and natural gas (biogas), etc., as the fuel, and can also adopt the liquid fuels, i.e., the distillate of the petrochemical industry as the fuel, such as diesel oil, heavy oil, C5, etc. It is reported that the fuel can be burnt efficiently and quickly.

[13] **Chinese patent CN 201281389(Y)** discloses a multifunctional civil cooker which can utilize various fuels such as coal, wood, weed, agricultural straw, biogas, natural gas, liquefied gas and the like, thus meeting the requirement of household cooking, heating and domestic water supplying.

[14] **Chinese patent CN 2842218** discloses an environmental protection combustion furnace which can burn inflammable exhaust gas and various kinds of inflammable waste simultaneously. The utility model can also independently burn coal or gas, such as biogas, coal gas or liquefied gas, etc. The utility model can be widely used for treating various kinds of combustible waste, such as grain stillage, bagasse, wood chips, inflammable municipal waste, etc., and is ideal environmental protection combustion processing equipment.

[15] **Chinese patent CN 2532386** discloses a gas energy saving large flame gas stove which is particularly suitable in the catering trade and its main fuel gas is natural gas but gas holder or biogas also can be used as the fuel gas.

[16] **Chinese patent CN 2083728** discloses a heating stove which can use petroleum liquid gas, biogas and coal gas as fuels and has high heat efficiency and convenient operation but this is heat exchanger type stove.

[17] **Indian patent IN 215495** discloses a multi-purpose stove useful for cooking, baking, space heating and drying. The use of the device of this invention is that this multipurpose stove is capable of conducting many heating processes, such as cooking, baking, space heating (room heating) and drying of various materials at a time or separately as per requirement. One of the main uses of this device is pollution free space heating along with cooking with minimal fuel consumption. However this patent is for burning solid fuels efficiently.

[18] **Indian patent IN 231282** discloses an LPG stove of improved thermal efficiency achieved by reducing heat losses. As it relates to LPG and therefore this stove is not going to work with biogas as clarified with the help of Wobbe number earlier.

[19] A drawback of the known method as discussed above is mainly that the efficiency achieved in those manners is limited. Therefore, a biogas burner system is needed which alleviate the problems of the prior arts.

DESCRIPTION OF THE INVENTION

[19] The aim of the present invention is to provide an apparatus for combustion of gaseous fuel from organic wastes which include biogas burner for domestic cooking purpose having improved thermal efficiency. In addition to this, other aim is to develop a burner with a potential for saving biogas and better performance.

[20] The above aims have been achieved through improved combustion and minimization of heat losses.

[21] According to the present invention there is provided an apparatus for combustion of gaseous fuel comprising:

- a conical jet for entry of primary air,
- a primary air regulator,
- a mixing tube fitted at the burner base,
- a burner top mounted over the burner base,
- a drip tray and pan support.

[22] In the apparatus, the fuel enters through conical jet into the mixing tube creating a pressure gradient around it, forcing primary air to enter into the mixing tube; wherein the air regulator controls the incoming primary air and maintains the alignment of the jet and the mixing tube; and the drip tray aligns the secondary air for combustion through the burner top.

[23] In a preferred embodiment, the invented apparatus is applicable as a biogas burner preferably for domestic cooking. The bio-gas is obtainable from organic wastes.

[24] The foregoing advantages as well as the particular construction of the improved gas burners will become more noticeable and understandable from the following detail description thereof when read in conjunction with the accompanying drawings.

[24] The invented biogas burner assembled of conical jet, primary air regulator, mixing tube, burner top, drip tray and pan support is shown in the accompanying Figure 1. The salient features of different parts of the biogas burner are mentioned below.

Jet (Fig. 2)

[25] The newly developed jet provides easier entry of primary air into mixing tube and better mixing of fuel with air. Its shape has been made conical with an included angle of about 19 ± 1 degree and length of conical part being about 9 ± 1 mm long whereas the jets being used currently are cylindrical in shape. The invented conical shape reduces turbulence at the entry zone of primary air resulting in its smooth flow and entry of sufficient quantity in the mixing tube. The sufficient quantity of primary air results in faster combustion of fuel gas and lower thermal losses. The single step hole of new design of jet as compared to two step of existing burner, ensure easier fabrication and quality control.

Primary air regulator (Fig. 3)

[26] An appropriate primary air regulator has been designed and provided at entry side of the mixing tube. This part in association with conical jet sets out the correct amount of primary air to enter the mixing tube and provides seat to mixing tube. Too little primary air will result in slow and inefficient combustion of biogas and unstable flame and excess air will result in greater heat losses along with flue gases.

Burner base and mixing tube (Fig. 4)

[27] Mixing tube fitted in the burner base has been designed to ensure smooth or resistance free movement of fuel air mixture in forward direction. The mixing tube has been made with air passages (Four number of holes of about 8 mm diameter) in its wall near the biogas entry point to facilitate primary air entry. The existing mixing tube of market available biogas burners has not been provided with air passages in the wall of mixing tube.

Burner Top (Fig. 5)

[28] Total port area and size of the ports which consist of diameter of port and its depth, provided in burner top plays a major role in optimum functioning of the burner. Improper

port area and port size can lead to flame lifting, back flash and inefficient combustion and instability in the flame. In present design, these aspects have been optimized to obtain the stabilized flame. Burner designed for vessel no 3 (BIS standard IS 8749: 2002), the total port area has been decided to be about $554 \pm 12 \text{ mm}^2$. The port diameter is about 2.8 mm and total no. of holes has been fixed about 90 ± 2 . Burner designed for vessel no 4 (BIS standard IS 8749: 2002), the total port area has been decided to be about $585 \pm 12 \text{ mm}^2$. The port diameters about 2.8 mm and total number of holes have been fixed about 95 ± 2 . Similarly, burner designed for vessel no 5 (BIS standard IS 8749: 2002), the total port area has been decided to be about $615 \pm 12 \text{ mm}^2$. The port diameter about 2.8 mm and total number of holes has been fixed about 100 ± 2 .

Drip tray (Fig. 6)

[29] The burner has been designed with proper size and shape of drip tray. The designed drip tray provides aerodynamic flow of flames and at the same time optimum supply of secondary air. Additionally it reduces the heat going unused. This results in efficient heat recovery and minimum heat losses. Drip tray internal diameter has been kept about 99 mm to ensure a gap of about $6.5 \pm 0.5 \text{ mm}$ between drip tray internal edge and the wall of burner top. This gap helps in achieving optimum performance.

Gap between burner top and vessel

[30] An optimum gap between burner top and vessel base results in proper fuel combustion and minimum waste heat. Too little or too much gap results in inefficient combustion or greater heat losses. The dimensions of the pan support have been decided to create a gap of about $22 \pm 1 \text{ mm}$ between burner top and flat bottom vessel base.

Performance of invented Biogas burner

[31] Performance evaluation for its thermal efficiency was carried out at applicant's laboratory. The results obtained are given at Table I.

[32] **Table I: Performance of invented burners as per IS: 8749: 2002**

S. No.	Burner's name	Vessel no.	Gas consumed at STP (L)	Time taken (minute)	GBR (L/h)	Thermal efficiency
1	IOC I	3	99.0	19.1	311.0	64.23
2	IOC II	4	119.6	19.0	377.8	68.20
3	IOC III	5	156.4	21.5	436.5	65.11

[33] The invented burner is found giving higher thermal efficiency as compared to locally available burners. The developed burner has resulted in giving thermal efficiency more than 64% and gas saving of the order of 10%.

CLAIMS:

1. An apparatus for combustion of gaseous fuel comprising a jet for entry of primary air, a primary air regulator, a mixing tube fitted at the burner base, a burner top mounted over the burner base, a drip tray and pan support,
characterized in that the jet is conical in shape having an included angle of about 19 ± 1 degree; and
the said apparatus has a high thermal efficiency and gas saving property.
2. An apparatus as claimed in claim 1, wherein the length of the conical part of the jet is about 9 ± 1 mm.
3. An apparatus as claimed in claim 1, wherein the primary air regulator in association with the conical jet provides a seat to the mixing tube and sets out the correct amount of primary air to enter the mixing tube.
4. An apparatus as claimed in claim 1, wherein the mixing tube has air passages by providing holes in its wall near the fuel entry point to facilitate primary air entry.
5. An apparatus as claimed in claim 4, wherein the mixing tube preferably has four holes of about 8 mm diameter in its wall.
6. An apparatus as claimed in claim 1, wherein the burner top is provided with appropriate port area and size of the ports to obtain stabilized flame.
7. An apparatus as claimed in claim 6, wherein the burner top for vessel number 3 has total port area of about 554 ± 12 mm² port diameter of about 2.8 mm and total no of holes about 90 ± 2 ; for vessel number 4 has total port area of about 585 ± 12 mm², total no of holes of about 95 ± 2 and for vessel number 5 has total port area of about 615 ± 12 mm², port diameter of about 2.8 mm and total no of holes of about 100 ± 2 .

8. An apparatus as claimed in claim 1, wherein the drip tray provides aerodynamic flow of flames, at the same time optimum supply of secondary air for efficient heat recovery and minimum heat loss.

9. An apparatus as claimed in claim 1, wherein the drip tray has internal diameter of about 99 mm to ensure a gap of about 6.5 ± 0.5 mm between drip tray internal edge and the wall of burner top.

10. An apparatus as claimed in claim 1, wherein the dimensions of the pan support is constructed to create a gap of about 22 ± 1 mm between the burner top and the flat bottom vessel base.

11. An apparatus as claimed in claim 1, having a thermal efficiency of above 64% and gas saving of about 10%.

12. An apparatus as claimed in claim 1 is a biogas based burner preferably for domestic cooking.

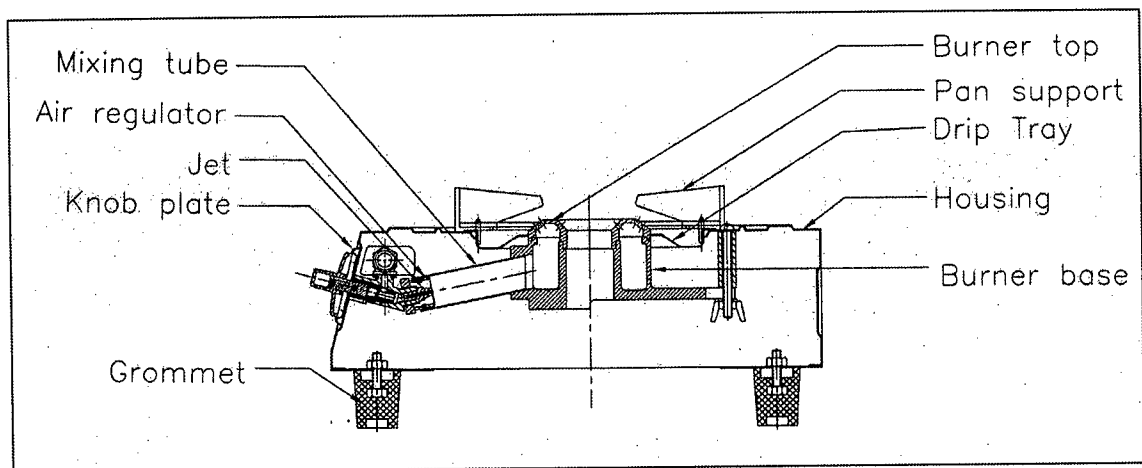


Figure 1: Bio Gas Stove – General Arrangement

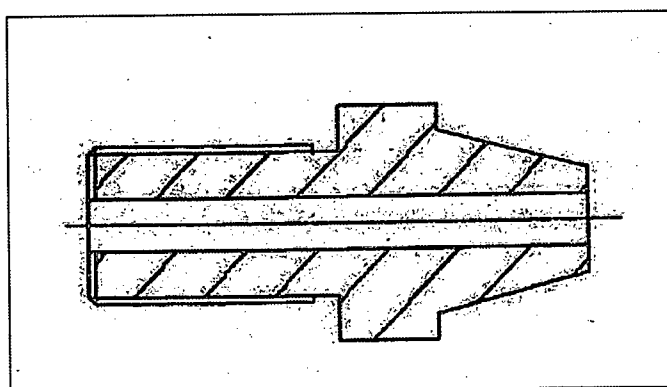


Figure 2: Jet

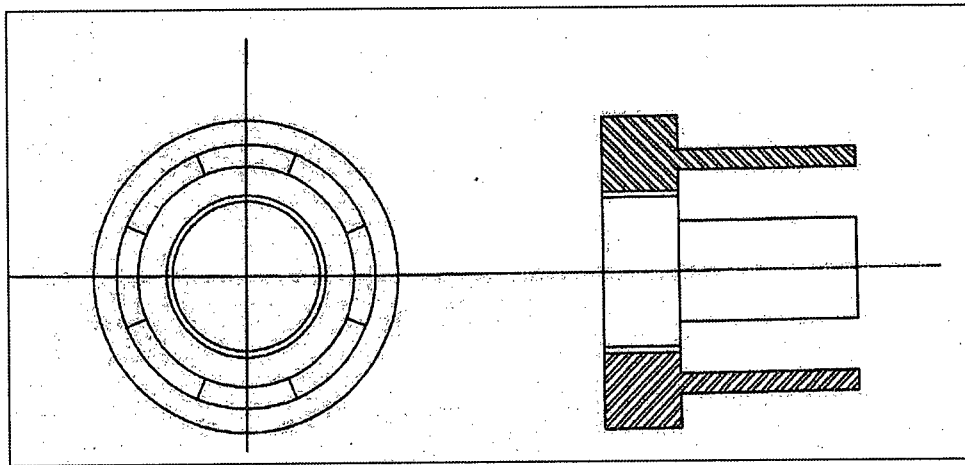


Figure 3: Primary Air Regulator

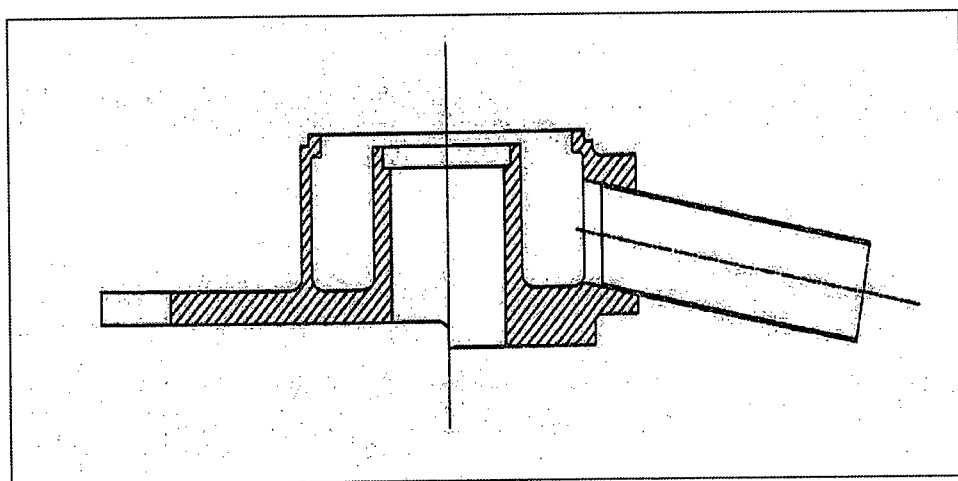


Figure 4: Burner Base & Mixing Tube

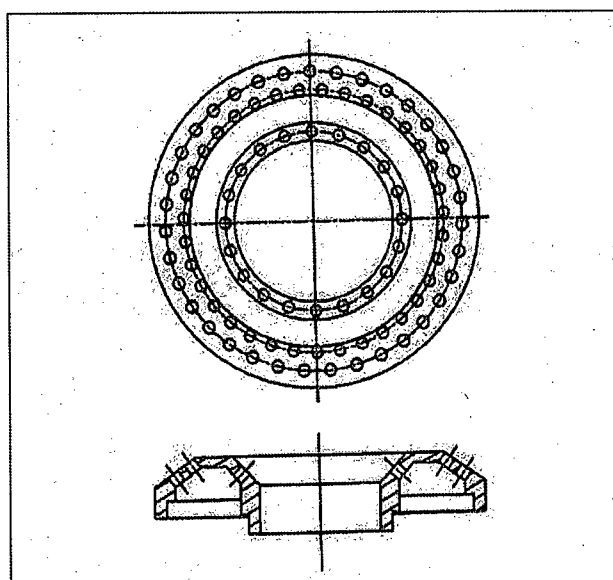


Figure 5: Burner Top

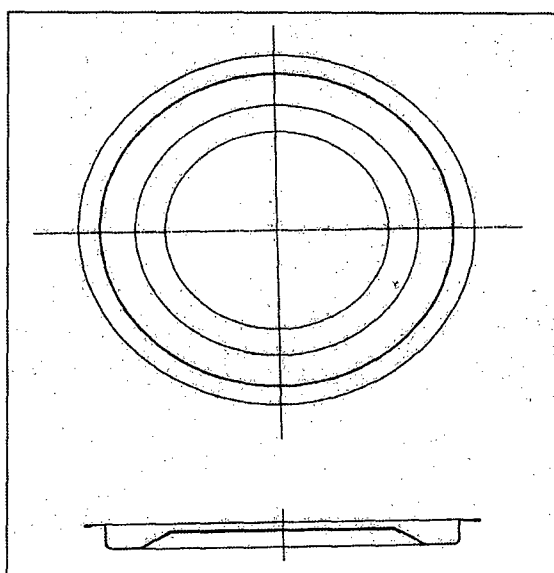


Figure 6: Dip Tray