RESEARCH ON INCREASING THE EFFICIENCY OF THE EXISTING BURNERS

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Abstract: Existing designs of most conventional domestic burners (CB) has typically relied on open combustion flame, where a large amount of energy is lost as convectional energy loss (i.e., air carries the heat away from the spot), resulting in relatively low thermal efficiency (<30%). This defect can be considerably reduced by using enclosed combustion with increased contact area of the flame (new concept not known to exist). This defect can be considerably reduced by using enclosed combustion without disturbing the escapement of combustion product and increasing the contact area of the flame reaching the vessel. The paper is a documentation on two prototype designs with increasing the overall heat transfer efficiency from the flame to the vessel as the main objective. The first prototype was mock fabricated to mimic the original design since the actual design complications of this prototype was not possible to fabricate with available fabrication methods. Experimentation of this prototype was conducted and a positive 2.03%increase in mentioned efficiency over the conventional burner was recorded. To overcome the higher degree of design constrains and to reduce the cost, a more simple and effective design was produced with the aid of CFD analysis. This design was fabricated as second prototype and an experimentation was carried out recording a positive 4.1841% increase in mentioned efficiency over the conventional burner. Moreover, with the same prototype another experimentation was carried out under open flame conditions simulating external wind draft disturbances and a phenomenal 47.7272% increase in mentioned efficiency over the conventional burner was recorded. A brief explanation of the third prototype which has several design supremacies over second prototype which is currently under development as of the publication date of this paper is also provided

Keywords: enclosed combustion, fin type external projection, reduced convection losses.

I. INTRODUCTION.

As since the invention of the gas stove (domestic) the same design of burner is manufactured and used by the industries and the domestic respectively. (Except a few changes in design to enhance the style, rather than the increasing the efficiency). The first gas stoves were developed as early as the 1820s, but these remained isolated experiments. James sharp patented a gas stove in Northampton, England in 1826 and opened a gas stove factory in 1836. At the World Fair in London in 1851, a gas stove was shown, but only in the 1880s did this technology start to become a commercial success. The losses in the domestic gas burners is high and it can be rectified by the following setup of the burner design. The following burner design consists of few manually movable parts for pre-adjustment of the vessel. This setup clearly indicates that it greatly reduces the convectional losses in the burners. Conventional gas burners is only less than 30% efficient which is undesirable. To overcome this problem following new design of the burner can be used to enhance its efficiency to a considerable rate. This is possible by this new burner design. This stove moreover, is not a complex design for the manufactures and not even a difficult operation for users too. Before seeing the structure of the burner design a small analysis is done in the existing burners in the area of losses.

II. LOSSES IN THE CONVENTIONAL BURNERS

- Convection loss (air entering the combustion region, absorbs heat and escapes the spot as hot air) which is unwanted.
- Flame rolling out of the vessel is greatly lost to the atmosphere.
- Heat is lost to the stand of the burner stove.

III. EFFICIENCY THE CONVENTIONAL BURNERS

It has been proved by experiment that the efficiency of the conventional burners is less than 30%. By numerical values in the standard tables it has been found that the energy released during the combustion of LPG is 11,900 Kcal/Kg. Therefore the availability (useful amount of work) is less than 3,570 Kcal/kg; remaining heat greater than 8,330 Kcal/kg is lost to the atmosphere which is most undesirable. Let us consider ‘a’ be the volume of air entering the combustion area with a velocity ‘u’ which nears the combustion spot and absorbs the heat from the flame by the phenomenon of Newton’s law of cooling. The out coming air is about ‘y(a-x)’

Where

x- Amount of air required for combustion

y- Factor of heat absorption

The flame temperature is reduced to certain limit due to heat absorption of air (i.e. The air flowing inside the combustion area not only supports for combustion but also for heat transfer ,but here it is unwanted and it reduces the heat transfer from the flame to the vessel. Thus efficiency is reduced. The above discussed loss is the major type of loss existing in the conventional gas burners. Other than this loss there are many minor losses among them few can’t be still be unavoidable in the new concept itself. One of the minor loss is the flame rolling out of the vessel when the flame is adjusted to the maximum limit or nearing to the maximum. This flame transfers heat to the vessel but in a minimum amount than it transfers heat to the atmosphere at the maximum rate. Here too the losses are seen. The above discussed two types of the losses is rectified by the new concept of the gas burner that I have introduced. The images given below clearly indicate the flame rolling out of the vessel. The part near the vessel heats the vessel and the part surrounded by the external atmosphere heats the air.

The proposed design is first explained in the fore coming part, Latter deals about the modified structure of the gas burner. The latter is more advantageous. This is confirmed by fabricating the both structures of the models.

IV. CONSRUCTION OF ENCLOSABLE AUTO-LEVEL TUNABLE GAS BURNER (EATB).

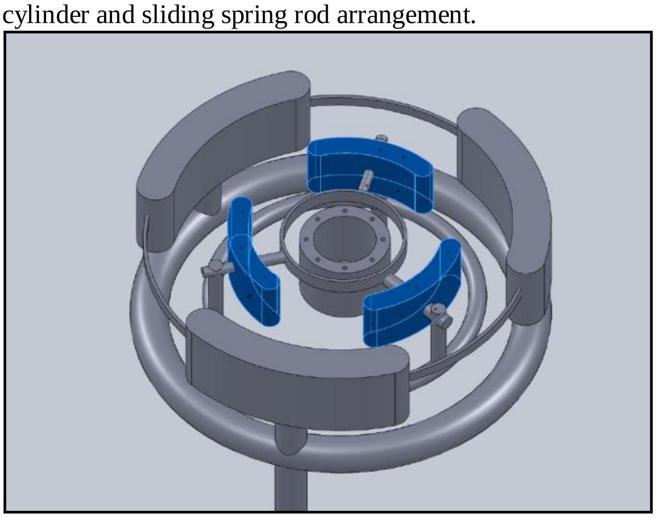
The components of enclosable auto-level tunable gas burner are listed and explained below:

COMPONENTS:

- Inner radially adjustable stand.
- Outer vertically adjustable stand.
- Lower (inner) oil reservoir.
- Lower (outer) oil reservoir.
- Hydrostatic transmission cylinder.
- Sliding spring rod arrangement.
- Auto-level tunable burner head.

A. INNER RADIALLY ADJUSTABLE STAND.

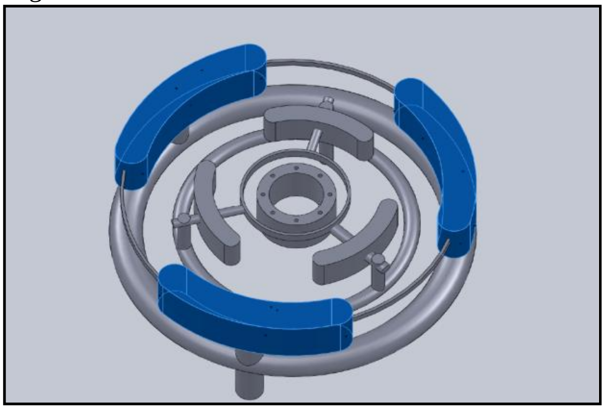
This inner stand is adjustable radially (i.e., the virtual circle formed radius can be adjusted). This is achieved by tuning the knob which internally aligned with the hydrostatic cylinder and sliding spring rod arrangement.



Inner radically adjustable stand

B. OUTER VERTICALLY ADJUSTABLE STAND.

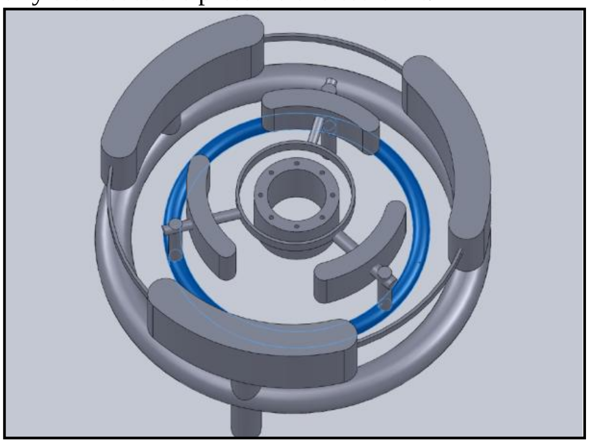
This stand is adjustable vertically (i.e., the height of the outer stand is raised /lowered form the level of inner stand and above). This is achieved by tuning the knob which internally aligned with the hydrostatic cylinder and sliding spring rod arrangement.



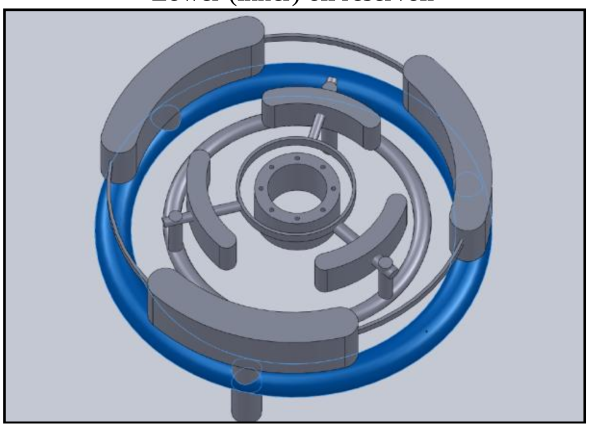
Outer vertically adjustable stand

C. INNER OIL RESERVOIR AND LOWER OUTER OIL RESERVOIR.

These are the reservoirs which are used for uniform radial expansion and contraction in the case of inner stand and uniform rising and lowering of the outer stand as the fluid equally distribute the pressure exerted on it.



Lower (inner) oil reservoir



Lower (outer) oil reservoir

D. HYDROSTATIC TRANSMISSION CYLINDER.

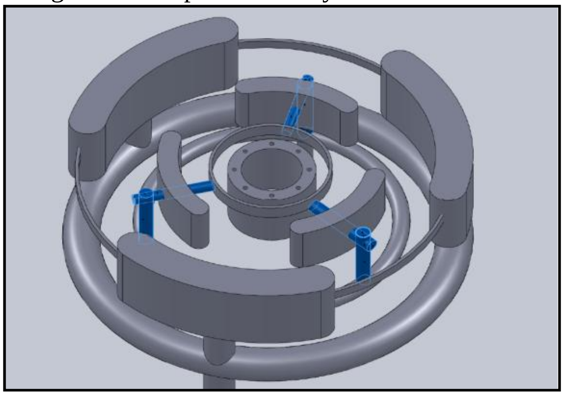
The hydrostatic transmission cylinder is used for pre-adjustment of the stands before the ignition is started. When the knob is screwed the piston pushes the oil into the lower (inner) oil reservoir in the case of inner stand and lower (outer) oil reservoir in the case of outer stand.

E. SLIDING SPRING ROD ARRANGEMENT.

Sliding spring rod arrangement helps to transfer the hydraulic energy into vertical up and down motion in the case of outer stand and radial movement in the case of inner stand. The retardation is done by fixing a spring (i.e., to regain its original position).

F. FOR INNER STAND ADJUSTMENT.

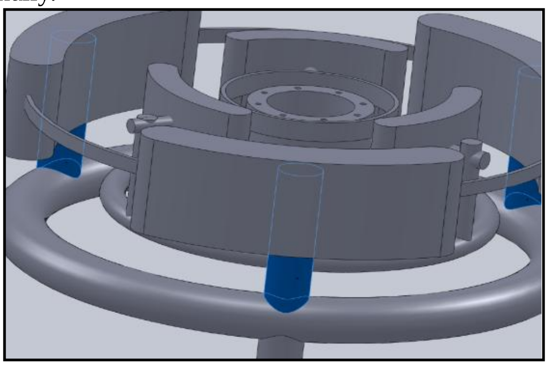
Inner stand adjustment by sliding spring rod arrangement has oil pipe fitting and piston setup. Between the inner stand and fixed inner circle the spring is enclosed within the sliding sheets of cylindrical metal. Same setup is done for all the three segment of stands. This stand can be smoothly moves by placing rail below path traced by the stand.



Overview of the sliding spring rod arrangement for inner stand adjustment

G. FOR INNER STAND ADJUSTMENT.

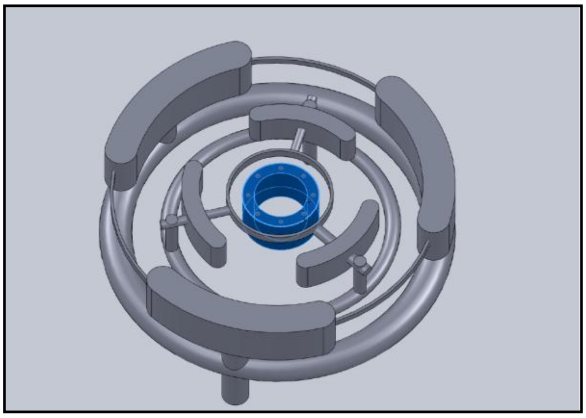
Outer stand adjustment by sliding spring rod arrangement has oil pipe fitted and piston setup. This arrangement is nearly same as that of the inner stand except that the arrangement is vertical than horizontal and spring adjustment is in the oil tank. Here the common rail is not required as it is already stable by interconnecting the segments of the stand externally.



Overview of the sliding spring rod arrangement for inner stand adjustment

H. AUTO-LEVEL TUNABLE BURNER HEAD.

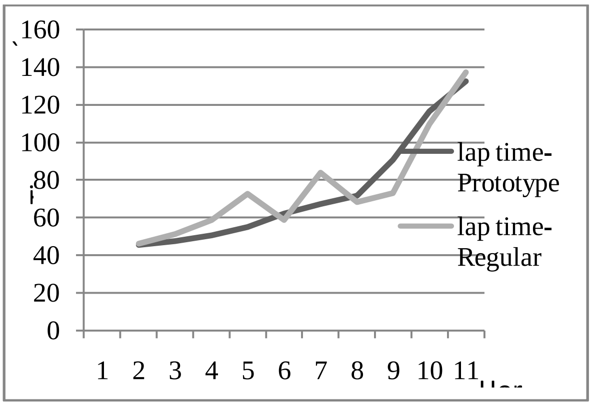
Auto-level tunable burner head is self-level tunable burner which rises during the "SIM" state (low flame) and lowers during "high" state (high flame).This level adjustment is done automatically when the flame control is done. This is greatly helpful for avoiding the flame rolling out of the vessel.



The enclosable auto level tunable burner during construction showed less expected results because the three radially adjustable stands could only provide oxygen supply between those stands that is three passages which is also slowed by the outer vertically adjustable stands. As the experiment is proceeding with a preliminary prototype without the hydraulic adjustment of the inner radially adjustable stand and outer vertically adjustable stand we found that the efficiency of the enclosed auto tunable burner when compared to normal burner in standard conditions without forced air supply (external wind /others e.g. fan,…etc.,) was 3 to 3.5 %. But during testing the prototype in outdoor conditions the efficiency was remarkable xxx to yyy %.This shows the enclosable auto level tunable burner would also be more suitable to more suitable for commercial purposes. The above mentioned prototype of the Enclosed Auto-level Tunable Burner (EATB) is found to be less advantageous than the latter (follows) design which has better overall efficiency and simplicity when compared to the EATB. We have also reduced the convection loss due to air escapement by adding fins subtended to an optimized angle to aid cyclone air flow shielding for effective atmospheric air usage, which prevails in both conventional and EATB burner heads

Temperature (0c)	Split Time (s)	Lap Time-Regular (s) ds
40	0	
45	46.1	46.1
50	97.33	51.23
55	155.91	58.58
60	228.55	72.64
65	287.3	58.75
70	371.21	83.91
75	439.38	68.17
80	512.23	72.85
85	622.09	109.86
90	759.38	137.29

Temperature (^{0}c)	Split Time (s)	Lap Time-Regular (s) *ds*
40	0	
45	48.96	45.65
50	96.61	47.65
55	147.24	50.63
60	202.47	55.23
65	264.7	62.23
70	332.21	67.51
75	403.97	71.76
80	494.8	90.83
85	611.31	116.51
90	743.91	132.6



V. EQUI-PARTIALLY VENTED GAS BURNER (EVGB)

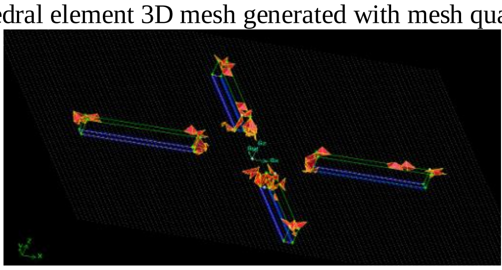
As we already know that the combustion of the domestic burner is normally supplied with excess amount of air. It is precisely not supplied but it enters as the opening provides. So we are restricting the air flow through the side vents. The advantage of the equi-partially vented burner is that the air enters the burner in all directions which is contradictory to the previous case as it makes entry through the three limited entries.

EFFECT OF WIND ON FLAME WITH THE CONVENTIONAL BURNER STAND STUDIED BY NUMERICAL METHOD:

The disturbance caused by wind drift caused on the Flame with the conventional burner stands is studied numerically with parameters of ambient air at 1.8kmph flowing continuously under steady flow conditions over the flame domain. The hydrodynamic behavior of the air over the burner is thereby studied.

Mesh Developed:

Tetrahedral element 3D mesh generated with mesh quality of,



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Applying quality criteria for tetrahedra/mixed cells.
Maximum cell squish = 7.98073e-001
Maximum cell skewness = 9.30140e-001
Maximum aspect ratio = 1.87231e+001
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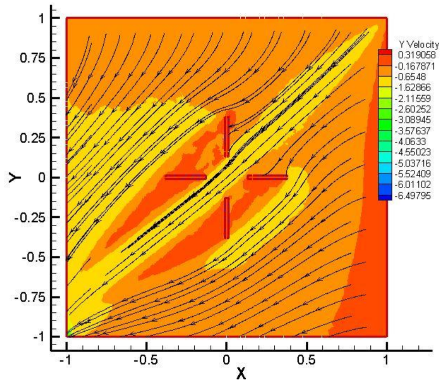
Reported by FLUENT-ANSYS V12.0.7

(b) Effect of cross wind:

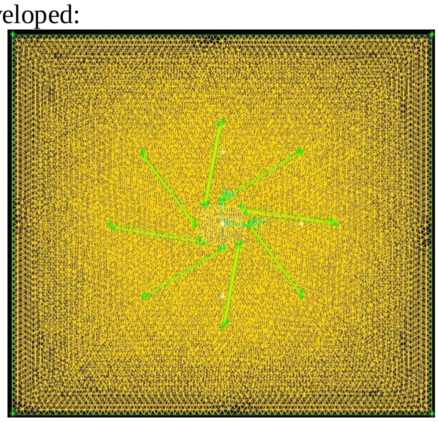


From (a) and (b) Ansys results, we find that the stream velocity of ambient under given conditions over the burner head is nearly the free stream velocity which is not satisfactory to trap the heat loss by convective heat transfer.

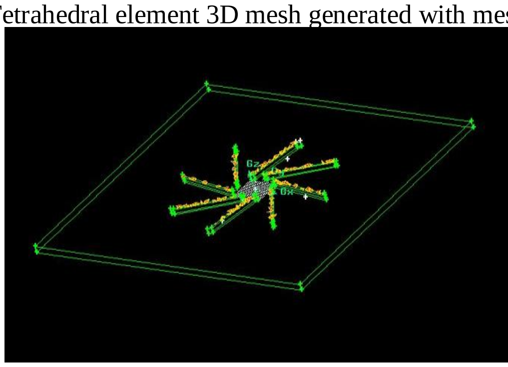
EFFECT OF WIND ON FLAME WITH PROTOTYPE II BURNER STAND STUDIED BY NUMERICAL METHOD:

The disturbance caused by wind drift caused on the Flame with Prototype II burner stand is studied numerically with parameters of ambient air at 1.8kmph flowing continuously under steady flow conditions over the flame domain. The hydrodynamic behavior of the air over the burner is thereby studied.

Mesh Developed:



Tetrahedral element 3D mesh generated with mesh quality

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Applying quality criteria for tetrahedra/mixed cells.
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Maximum cell skewness = 9.79614e-001
Maximum aspect ratio = 4.24132e+001
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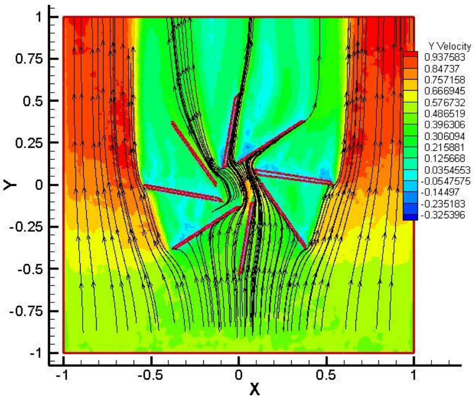
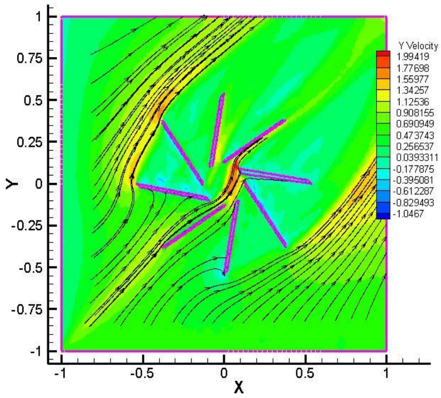
Reported by FLUENT-ANSYS V12.0.7

(c) Effect of straight wind:



(d) Effect of cross wind:



From (c) and (d) Ansys results, we find that the stream velocity of ambient air under given conditions over the burner head is a fraction of the free stream velocity which is satisfactory to trap the heat loss by convective heat transfer at the same time providing enough air breath for steady flame.

VI. MECHANISM OF CYCLONE AIR FLOW SHEILDING

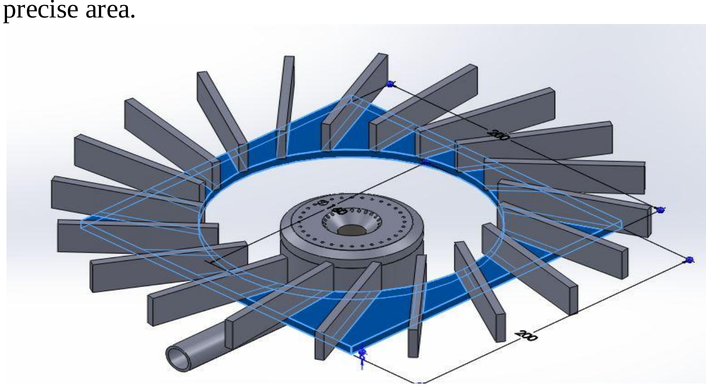
The combustible gas upon the exit from the burner head is in need of oxygen from the atmospheric air. Due to this, the flame consumes the oxygen within the local area enclosed by the subtended fins. This creates a partial vacuum within the concealed area. Due to this vacuum atmospheric air is sucked through the partial vents. During this the atmospheric air entering through this fin obtains an angular momentum due to which the air is diverted along the circumference of the inner circle of the fins. This diverted air flow along the inner circumference creates a cyclone path spiraling into the flame where oxygen is required. This phenomenon blocks any wind or external disturbing air flows which thus forms ‘Cyclone Air Flow Shielding’. This reduces the convection loss by heat escapement due to the high wind factor.

VII. CONSTRUCTION OF EQUI-PARTIALLY VENTED GAS BURNER

Since the air supply needed for complete combustion of liquefied petroleum gas used in domestic/commercial purpose ranges from 2 to a maximum of 9 %.The existing domestic burner allows air greater than 9 % which leads to conventional loss. The construction mainly focuses to reduce excess air flow in the combustion area. The Equi - Partially vented gas burner has fins that provides the above needs. The construction of this burner mainly focuses on the stand which consists of two parts 1) Base and 2) Fins.

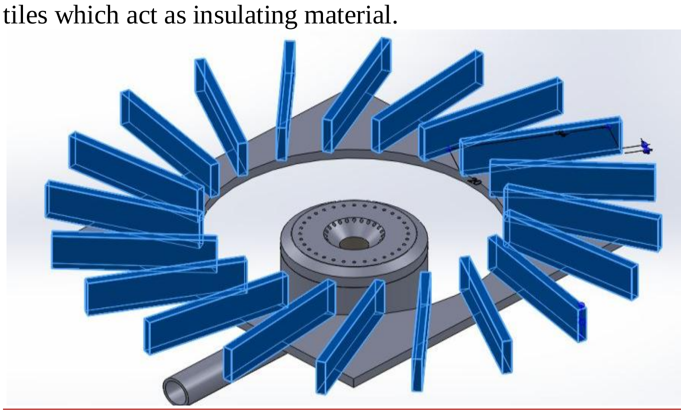
BASE

This is made up of ceramic tiles which is having high heat resistance that can resist the amount of heat entering and liberating out from combustion to a certain extent when compared with other materials. A large hole of size 180 mm diameter. This not only acts as an insulating material and it also ably supports the fins provided radially. The large area also provides support to the vessels to be held tight. It gives the passage for fuel to make contact with the vessel in a precise area.



FINS

Fins form an integral part in our design of the burner. The main functions of the fins are to regulate the air supply, to decrease the combustion area so that fuel won’t escape out very easily as that of in ordinary the conventional burners. The fins are designed in such a way that the air passage flows in specified path designed in such a way it increases the efficiency to a desirable amount. Based on the various preliminary experiments done on how many numbers of fins to be inserted, we have come to a conclusion of twenty (20) which satisfies our needs. The fins are also made of ceramic tiles which act as insulating material.



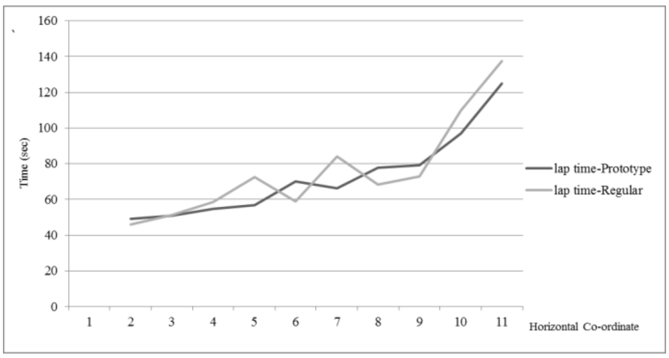
EXTRA PERIPHERALS:

Along with base and fins, many other components are required for complete construction of Equi partially vented gas burner. They are burner head and external gas vent. During testing of equi-partially vented gas burner showed increase in efficiency than the normal burner and the enclosable auto- level tunable burner (EATB).The comparison testing of normal burner and equi –partially vented gas burner is shown below: The below tabular column shows the results of temperature Vs time (represented as split time and lap time) of the constructed equi-partially vented gas burner. The below tabular column shows the results of temperature vs. time (represented as split time and lap time) of the normal gas burner

Temperature (^{O}C)	Split Time(s)	Lap Time(s)
40	0	--
45	48.96	48.96
50	99.91	50.95
55	154.6	54.69
60	211.23	56.63
65	281.23	70
70	347.52	66.29
75	425.28	77.76
80	504.4	79.12
85	601.23	96.83
90	726.18	124.95

Temperature (^{O}C)	Split Time(s)	Lap Time(s)
40	0	
45	46.1	46.1
50	97.33	51.23
55	155.91	58.58
60	228.55	72.64
65	287.3	58.75
70	371.21	83.91
75	439.38	68.17
80	512.23	72.85
85	622.09	109.86
90	759.38	137.29

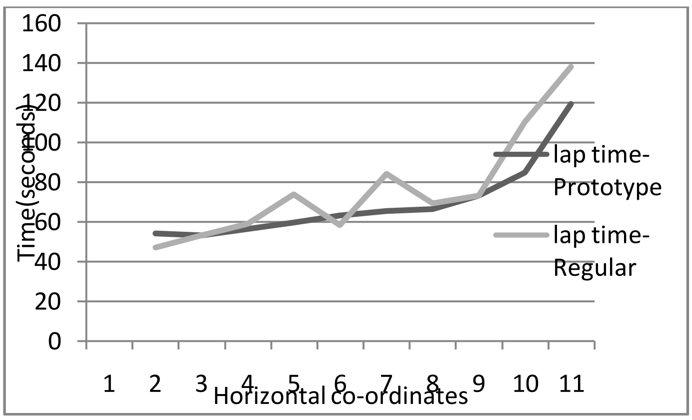
The comparison graph between both lap timings of both normal and equi-partially vented gas burner considering to the test is shown below:



During the secondary comparison study of design equi-partially vented gas burner with normal burner in outdoor conditions (irregular air supply). The comparison results are as shown below.

Temperature(^{o}C)	Split time(s)	Lap time-Prototype(s)
40	0	---
45	54.02	54.02
50	107.15	53.13
55	163.38	56.23
60	223.06	59.68
65	286.17	63.11
70	351.53	65.36
75	417.86	66.33
80	491.11	73.25
85	575.77	84.66
90	695.13	119.36

Temperature(oC)	Split time(s)	Lap time-Normal(s)
40	0	---
45	47.1	47.1
50	100.34	53.24
55	159.45	59.11
60	233.47	74.02
65	292.03	58.56
70	376.25	84.22
75	445.49	69.24
80	518.85	73.36
85	629.07	110.22
90	767.21	138.14



N.B. The diagrams inserted in the paper are not taken from the web. They are all drawn manually by the author himself. Used software: Solid works 2010 premium edition

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