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AN EXPERIMENTAL STUDY ON PREMIXED TYPE PRODUCER GAS BURNER

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ABSTRACT

Energy is an important issue in the present scenario of the world and there is always a need in the renewable energy for sustainable growth. The rapid increase in population leads to the increases of energy consumption. But, the existing supplying systems are limited by fossil fuel stock. Majority of households use appliances powered by electric power or fossil power for the daily applications such as cooking, heating processes, etc. Energy crisis and environmental damage are concerned. The researchers are recommending an alternative fuel and efficient conversion techniques to overcome those problems. Producer gas burner can act as a simple and very important device for an energy sector which can improve cooking and kitchen environment. It would be more worthy if it is used for roadside hotels, hostels, schools, etc. where cooking is used for a large number of people. This Experimental work deals with the design and fabrication of a burner system, operating on producer gas, for domestic cooking purpose and the burner is designed focusing on characteristics such as simplicity, cost effectiveness, efficiency and safety. Also concentrated on the modifications necessary to meet the requirements of stable flame for the burner and the testing is involved in determining the performance of the burner system.

It is found that efficiency of premixed type of burner is better as compared to diffusion type of burner since there is increase of burner efficiency of 5% for premixed type. Hence mixing chamber is provided for the Premixed Type. For the analysis of the efficiency of burner water boiling test is conducted. It is also experimentally determined that the efficiency of fabricated Producer Gas Burner is 20% and uniform temperature profile is obtained. The time required for heating water from 25^0C to 80^0C is nearly same compared to LPG for same temperature conditions.

INTRODUCTION

India ranks fifth in the world in total energy consumption, whereas more than 70 % of its primary energy needs are being met through imports, mainly in the form of crude oil and natural gas. Coming to the power generation, India has increased installed power capacity from 1,362 MW to over 1,12,058 MW since independence and electric field more than 5,00,000 villages. This achievement is impressive but not sufficient. It is a matter of concern that 44 % of households do not have access to the electricity. The electricity supply is not even sufficient for those who have been connected. India is facing an energy shortage of 2.1%, or 24,077 million units (MUs) and a peak shortage of 2.6 %, of 4,208 MW (2015-16).

The annual per capacity consumption of 1,010 KWh is amongst the lowest in the world. Around 280 million people in the country do not have access to electricity. In comparison, China has a per capita consumption of 4,000 kWh, with developed nations averaging around 15,000 kWh per capita. India needs as much as 13,397.39 billion to meet its target of installing 1,00,000 MW of solar power capacity and around 60,000 MW of wind power capacity by 2022. Energy is an important issue in the present scenario of the world and there is always a need in the renewable energy for sustainable growth. The rapid increase in population leads to the increases of energy consumption. But, the existing supplying systems are limited by fossil fuel stock. Majority of households use appliances powered by electric power or fossil power for the daily applications such as cooking, heating processes, etc. Energy crisis and environmental damage are concerned. Most of the houses use LPG as fuel for cooking. An average, a household uses about 8 to 10 LPG cylinders per year for cooking. The LPG consumption has increased by 16% in six months from April to September 2015. Keeping in view problems related to availability, price of LPG fuel, research centers and institutions are challenged to develop a technology for cooking based on alternative energy sources other than LPG.

Producer gas is the mixture of gases produced by the gasification of organic material such as biomass at relatively low temperatures (700º to 1000º C). Producer gas is composed of carbon monoxide (CO), hydrogen (H_2), carbon dioxide (CO_2) and typically a range of hydrocarbons such as methane (CH_4) with nitrogen from the air. Producer gas can be burned as a fuel gas such as in a boiler for heat or in an internal combustion gas engine for electricity generation or combined heat and power. Producer gas has a lower calorific value (4500 to 5500 kJ/m^3) compared to liquefied petroleum gas (41,000 kJ/m^3), but can be burnt with high efficiency and good degree of control without emitting smoke. Density of Producer gas is about 0.729 kg/m^3. Producer gas consists of 27% of Carbon Monoxide, 4.5% of Carbon Dioxide, 14% of Hydrogen, 3% of Methane, 50.9% of Nitrogen and 0.6% of Oxygen

The burner is designed for producer gas. The main components of the burner are the injector, the air/gas mixing chamber and the burner ports. The injector tapers into a nozzle which enters into the air/gas mixing chamber. The air/gas mixing chamber opens into the burner head. The burner head has number of ports from which the gas can be ignited. The combustion of gas is regulated by moving the injector into and out of the air/gas chamber, which regulates the amount of air that enters the chamber. If the injector is moved deeper into the air/gas mixing chamber, the drift of oxygen into the burner is reduced thus reducing combustion. On the contrary, when the injector is moved out of the air/gas mixing chamber, more oxygen enters into the burner thereby increasing combustion. The frames and the stands are made from angle bars. A wall made from metal sheet welded round the frame serves as wind breaker. The stove is connected to the gas holding unit of the gas plant by a rubber hose which convey gas from the gas holder of the plant to the burner.

The objectives of this work are, To get faster burning rate, reduce the pressure drop, design high efficient burner., obtain better combustion by proper mixing of air with producer gas, design and fabricate and modify a commercial gasifier burner using locally available materials such as wood, agricultural waste, coconut shells etc. To study and analyse the performance of the fabricated gas burner using the Water Boiling Test, create a continuous fuel supply system, design and fabricate mixing chamber for mixing of Air and Producer Gas.

LITERATURE SURVEY

A detailed study is done in understanding the system, it is suggested by J J Hernandez that premixed flames from the combustion of producer gas obtained from biomass gasification using air and steam as gasifying agent have been analyzed. The main advantages of using steam instead of air as gasifying agent from the combustion point of view are the following, larger flame stability region, higher blow off limit for a given relative producer gas/air ratio. Therefore, more power can be achieved. Results related to chemi-luminescence are the following; the maximum amount of OH and CH radicals generated in the combustion of the producer gas obtained has been obtained for a relative producer gas/air ratio about 1.1 and 1 for steam gasification and air gasification respectively. These values are consistent with the maximum adiabatic flame temperature of the fuels. By using lean mixtures while keeping the combustion stability, It is possible to reduce the nitrogen oxides emissions up to 18.6 % using producer gas from steam gasification (corresponding to a relative fuel/air ratio of 0.82), whereas using air gasification producer gas the reduction of NOx is 15.2 % (corresponding to a fuel/air ratio of 1.437).

Anthony I Obi fabricated a burner and concluded that it boiled 0.10 liters of water in one minute while 1.73g of rice was cooked in a minute. The gas consumption for water boiling and rice cooking were 0.47m^3/min and 2.87m^3/min respectively. The efficiencies of the burner in the above processes were 21% and 60% respectively. The re-igniting of the burner resulting from the flame dying off may have been responsible for the comparatively low cooking and high gas consumption rates. The water boiling test result shows that the improved burner helps has a better gas consumption rate compared to the prototype burner.

Nelson A Bajet modified the LPG burner and suggested that the preliminary trials of the design of the biogas burner were the performance of little flame heat efficiency were not suitable for cooking because of an excessive carbon black due to incomplete combustion. The third designed and developed biogas burner composed of four parts, namely the nozzle, air regulation parts, injector and head. A liquefied petroleum gas cooking burner was used, but it was modified in some parts like in the nozzle, air regulation parts and in the injector. This design was found effective for biogas as substitute for LPG. Payback computation showed that, 4.87 years payback period was computed to recover the cost of biogas technology if utilized for household consumption only. Stove design for biogas is cost effective, an alternative fuel source, and saves forest by not using firewood or charcoal for cooking. The technology is health and environment friendly.

According to Narendra Rathore **,** producer gas burner type has the potential to save fuel wood because it can work on a great variety of non-wood or waste-wood fuels. The combustion efficiency and heat-capture efficiency of burners are better than efficiencies of open fires and burner currently in use, resulting in the need for less fuel. Traditional cook stoves, because of their very low efficiency, emit more than 10% of their carbon as products of incomplete combustion, comprising varying amounts of tar. In addition, about 100–180 g of carbon monoxide and 7.7 g of particulate matter are also emitted per kg of wood. There are millions of small and inefficient cooking fires needed to feed economically poor people. Society needs an efficient burner that does not pollute, and the small wood gas burner is one of these, and quite possibly the best of these.

BURNER CHARACTERISTICS

Following are the characteristics of a good burner:

1. The burner should be capable of operating with a high air gas ratio, since an air gas ratio that approaches a theoretical mixture produces a small flame of high temperature.
2. The flame should be of uniform height in all parts of the burner, so that the distribution of heat will be uniform.
3. The burner must stand considerable variations in the gas pressure, or gas rate without giving trouble.
4. The flame must not flash back into the burner.
5. The flame must not blow off.
6. Stable and proper operation in the range of design parameters
7. Low pollution
8. Longer life time
9.

PRODUCER GAS COMPOSITION AND USES

Producer gas is a low calorific value fuel (4,500 kJ/kg to 5,500 kJ/kg) gas comprising of mainly carbon monoxide and nitrogen. It is produced by passing air or a mixture of air and

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steam through a burning bed of solid fuel such as, coal, coke, wood or biomass. Hydrogen is also present in a significant amount in the producer gas if air-steam blast is used. The exact composition of producer gas depends on the type of fuel, composition of the blast and operating condition. The composition of Producer gas is shown in Table 1.

Table 1: Composition of Producer Gas

Carbon Monoxide	27 %
Carbon Dioxide	4.5 %
Hydrogen	14 %
Methane	3 %
Nitrogen	50.9 %
Oxygen	0.6%

Energy values of different biomass was studied and it was observed that coconut shells energy value is better as compared to other biomass. Hence in experiment Coconut shell was used as biomass. The detailed composition and Heating values of different biomass is shown in Table 2.

Table 2: Heating Value of Different Biomass

Fuel	**Composition by volume (%)**					**Heating Value in MJ/m^3**
	CO	**H_2**	**CH_4**	**CO_2**	**N_2**	
Charcoal	28-31	5-10	1-2	1-2	55	4.6-5.65
Coconut husks	16-20	17-9.5	-	10-15	-	5.80
Coconut Shells	19-24	10-15	-	11-15	-	7.20
Corncobs	18.6	16.5	6.4	-	-	6.29
Cotton stalks	15.7	11.7	3.4	-	-	4.32

Using the combustion equation of producer gas (wood as biomass), Enthalpy of formation, Air fuel ratio and adiabatic flame temperature are calculated.

PROCEDURE FOR FABRICATION OF BURNER

The following operation sequence is followed for the design of parts, process and the construction of Burner for producer gas. These procedures include;

1. Selecting the gasifier to evaluate the burner performance: There are mainly four types of gasifiers, in that we are dealing with downdraft gasifier.
2. Obtain information on the maximum gas velocity available in the gasifier selected: Maximum gas velocity obtained from the gasifier is approximated to be 12 m/s.
3. Computing the parts sizes (main design): This part includes the design calculations regarding the area, port sizes etc of burner.
4. Producing the working diagrams: This includes the design sketch.
5. Selecting the materials for the parts: Here we have selected Cast Iron as the material for the parts, because of its easy availability, good conductivity and machinability.
6. Selecting manufacturing methods: We have selected casting process and then drilling is done.

Fabrication, assembly and performance evaluation: Fabrication includes pattern making, mould preparation and casting. Then the casted product is sent for finishing in a lathe machine and then drilling is done as per the port size and number

For every design study, a few parameters are significant to ensure a proper fit of parts during assembly. It is important to note that the gas inlet pipe should be smooth and subsequently the determination of the following important dimensions

1. Diameter of the burner head and reference area
2. Length of the mixing pipe
3. Number and diameter of flame port holes
4. Height of the burner head.

EXPERIMENTAL SETUP

Fabrication of any part of burner includes, Pattern making, Mould making, Core making, Melting of metal and Pouring, Cooling and solidification, cleaning of casting and inspection.

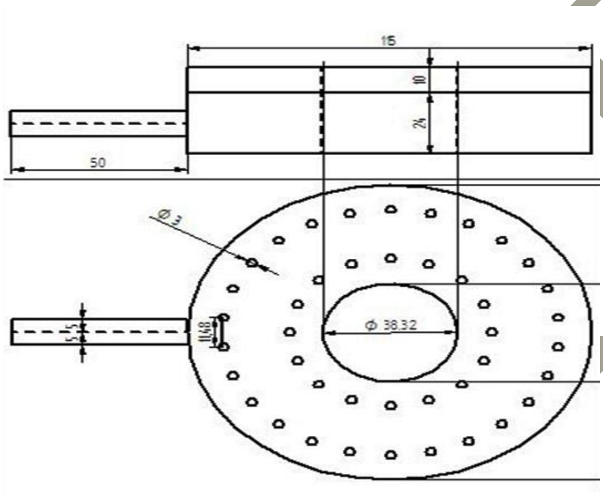


Figure1: Producer Gas Burner Dimensions

Figure 2: Fabricated Producer Gas Burner

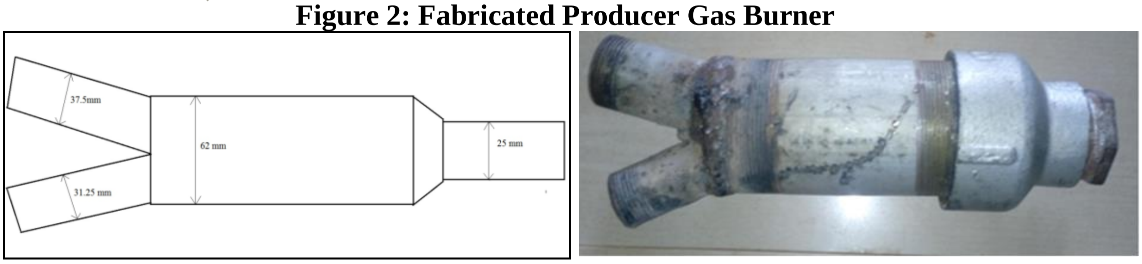


Figure 3: Fabrication of Combustion Chamber

Based on the design calculations a burner of 5 kW was designed and fabricated with reference diameter of 160 mm and burner holes of 3 mm. As per design only 40 holes are required, based on pitch of 11.4 mm 42 holes were selected. The detailed dimensions is shown in Figure 1. The finished product is shown in Figure 2. A combustion chamber for pre mixing of air and fuel was fabricated. The details and final product is shown in Figure 3

Stand and Frame are very essential for placing any type of vessel on the burner for heating purpose. MS rods are welded as per the height and structure required. We have tried the experimental work for vessel with flat bottom so that maximum surface is exposed to burner.

Excess air increases the amount of oxygen to the combustion and the combustion of fuel. The combustion efficiency increases with increased excess air, until the heat loss in the excess air is larger than the heat provided by the more efficient combustion. To supply the excess air two separate ball valves are provided at the exit of blower: one valve to control air supply to the gasifier and another to control excess air supply. The arrangement is shown in Figure 4. To supply the air 600W, 240V air blower is used.

Figure 4: Inlet and Bypass Pipe Set up

The details of the overall fabrication details are included in Table 3

Table 3: Overall fabrication details

Pattern material	Thermocol
Sand used for mould	Black sand
Metal used	Cast Iron
Melting temperature of CI	1200 ^{0}C
Drilling Machine	Vertical type
Drill bit size used for drilling	3 mm
Material of mixing chamber	Galvanized Iron
Stand to place vessel	Material: Mild Steel
	Width: 30 mm
	Length: 30 mm
	Height: 52 mm

A Producer gas burner is a device to generate flame to heat up products using producer gas as fuel. Figure 5 shows the complete setup of downdraft gasifier connected to the burner and the flame produced by burner. In between gasifier and the burner, mixing chamber is placed.

The mixing chamber and the pipe and fittings are made up of Galvanized Iron. Excess air is supplied to the mixing chamber through valve and pipes provided.

Figure 4: Experimental Setup

RESULTS AND ANALYSIS

The efficiency of gasifier with respect to time is plotted in Figure 4 and was found that the average efficiency is 72 %. The efficiency is calculated for Coconut Shell Biomass.

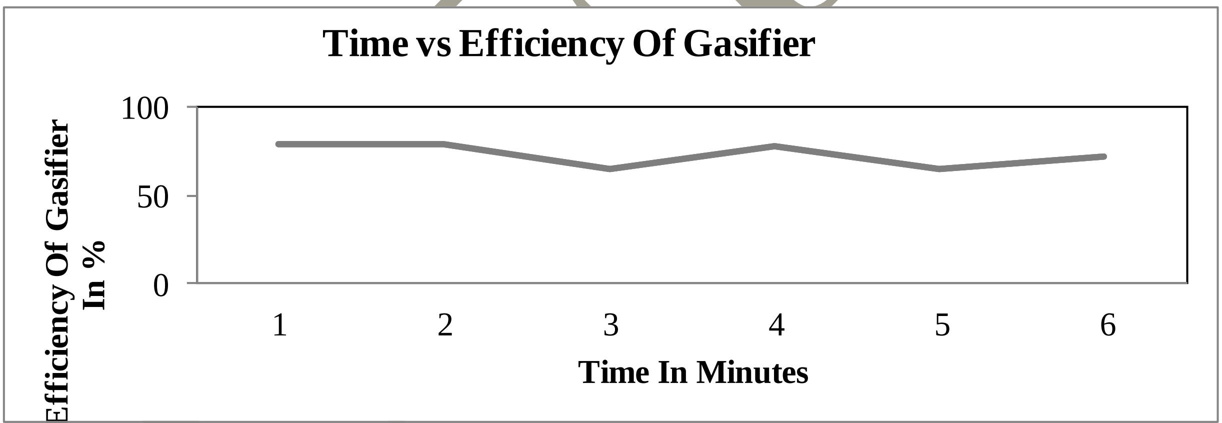


Figure 5: Gasifier Efficiency

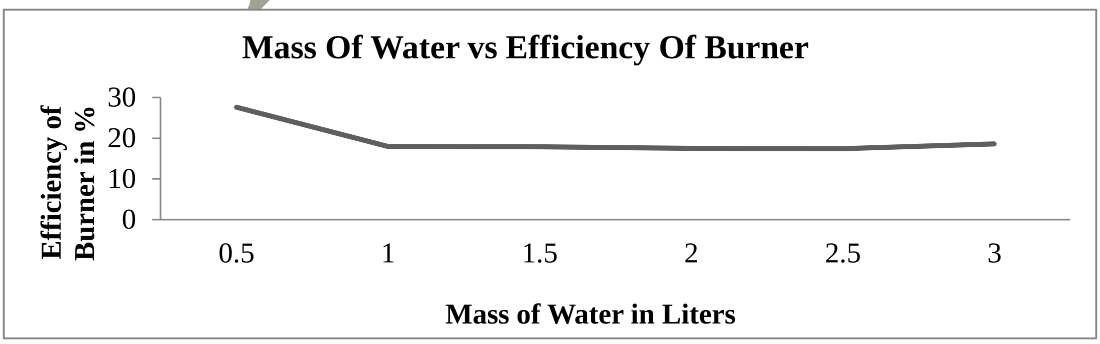


Figure 6: Burner Efficiency

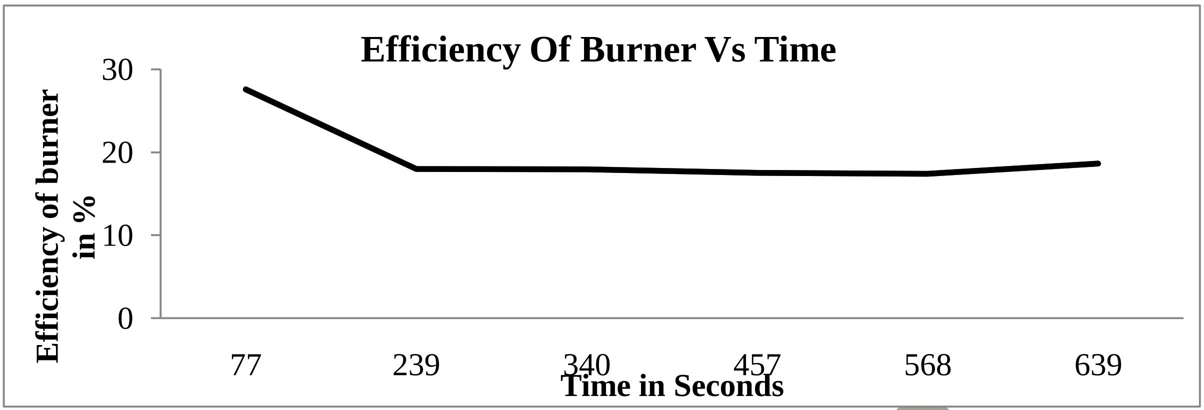
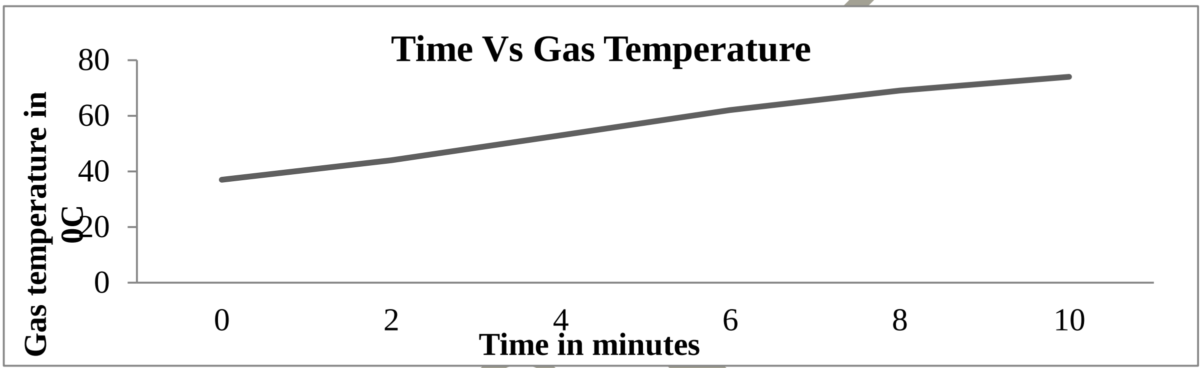


Figure 7: Burner Efficiency Vs Time



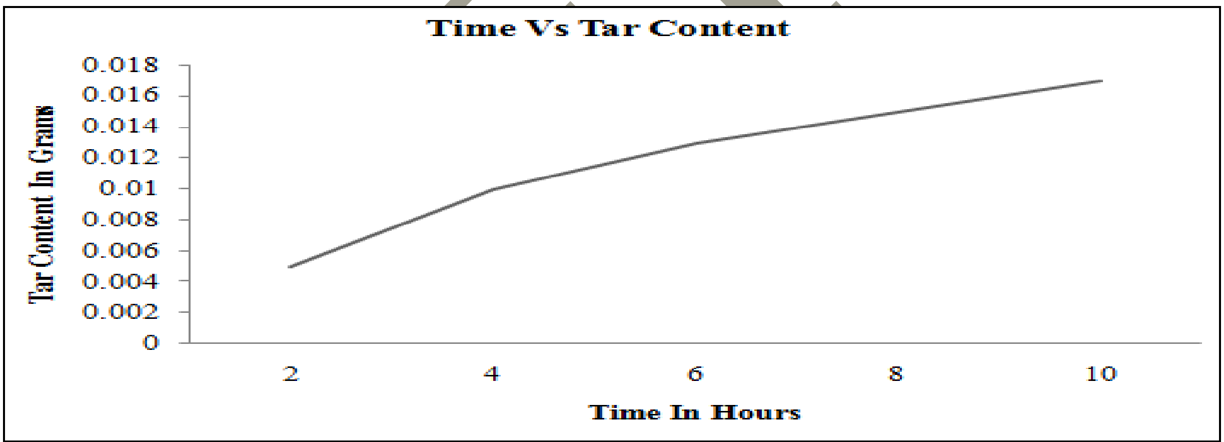


Figure 9: Tar Content

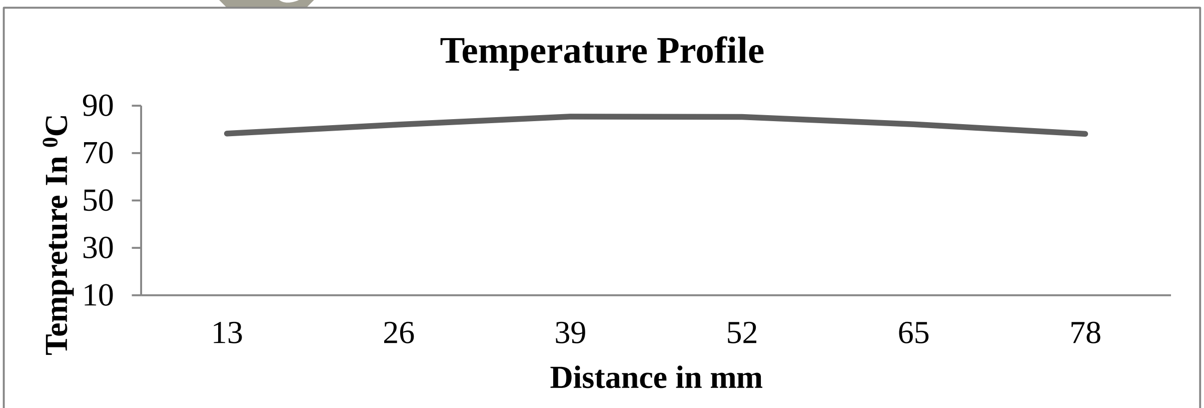


Figure 10: Temeperature profile

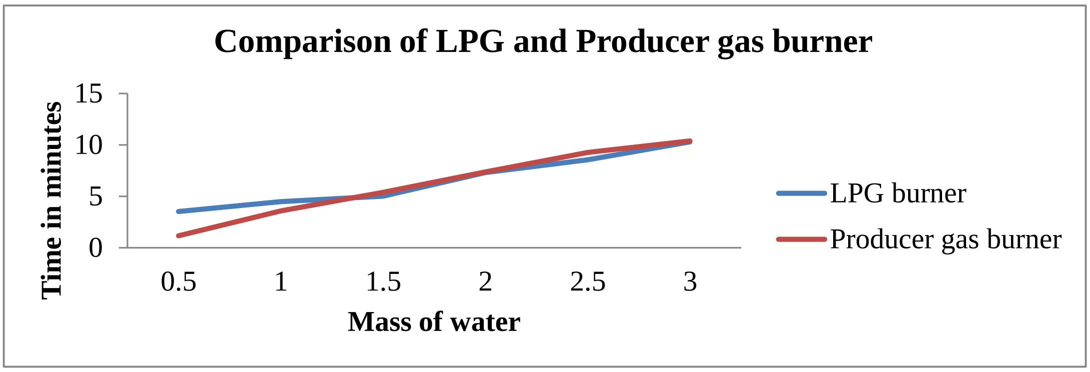


Figure 11: Comparision of LPG and PG

The burner is tested for long hours and increasing the water quantity, it is found that average efficiency of burner is 20 %. The burner efficiency with respect to time is shown in Figure 6. Similarly Figure 7 , 8, 9 and 10 shows experimental values of Burner efficiency with time, gas temperature profile, tar content in burner, Temperature profile of burner. Figure 11 shows the comparison of LPG and Producer gas Burner. It is found that the time taken for heating water from 25^0C to 80^0C is nearly same.

CONCLUSIONS

These are the conclusions after carrying out the experiment on Producer Gas Burner. The Premixed type burner is more efficient, than diffusion type and burner efficiency of nearly 5% is increased for premixed type. The flame obtained from the premixed burner is more stable than the diffusion type. The average efficiency of the gasifier is 72 %. It can be increased if low moisture wood is used as Biomass since the experiment was carried out at winter condition. From the Water boiling test, the average efficiency of burner is nearly 20 %. To increase the efficiency tar has to be removed by filtration method. It is observed that the producer gas temperature increases with an average rate of 5.65 ^{0}C/ min. Hence the burner gas temperature is also increased; this can be worked out by cooling the Producer Gas. Tar content deposit on the burner increases with each operation at an average rate of 1.5 gm/hr. Lesser the tar content better the system. From the temperature profile maximum temperature is found at center of burner surface which is 85.4 ^{0}C and we have observed that temperature is uniformly distributed. Hence thermal stress developed in burner is less. The time required for Producer gas burner to heat water from 25 ^{0}C to 80 ^{0}C is nearly same as compared to LPG for same temperature conditions.

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