Review on Design and Development of Advanced Chulha

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Abstract— Now days, the world is upgrading with innovative techniques which provide the ease for performing required task to get complete. For each kind of work, energy is essential & the consumption of energy is most considerable fact which plays an important role for any equipment. On the basis of this we are trying to develop an appliance which will utilize the heat energy at its maximum extent than the conventional methods. This appliance will be more utilizable where the energy recourses like coal & farm wastage are used. By designing it in the proper manner, we can reduce the pollutant particles at maximum level & can make it environment & user friendly.

Key words: Chulha, Advanced Chulha

I. Introduction

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then "dumped" into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its "value". The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved. Large quantity of hot flue gases is generated from Boilers, Kilns, Ovens and Furnaces. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered.

Depending upon the type of process, waste heat can be rejected at virtually any temperature from that of chilled cooling water to high temperature waste gases from an industrial furnace or kiln. Usually higher the temperature, higher the quality and more cost effective is the heat recovery. In any study of waste heat recovery, it is absolutely necessary that there should be some use for the recovered heat. Typical examples of use would be preheating of combustion air, space heating, or pre-heating boiler feed water or process water. With high temperature heat recovery, a cascade system of waste heat recovery may be practiced to ensure that the maximum amount of heat is recovered at the highest potential. An example of this technique of waste heat recovery would be where the high temperature stage was used for air pre-heating and the low temperature stage used for process feed water heating or steam raising.

Wood and biomass are used as domestic fuel even today in a majority of households in India. With its wide cultural diversity, a vast range of traditional cooking devices and practices are prevalent in different parts of the country. These include the three-stone fire, horseshoe-shaped chulhas with one or more pot-holes, sawdust stoves, special stoves for burning coal or charcoal, etc.

Recovery of waste heat has a direct effect on the efficiency of the process. This is reflected by reduction in the utility consumption & costs, and process cost. A number of toxic combustible waste such as carbon monoxide gas, sour gas, carbon black off gases, oil sludge, Acrylonitrile and other plastic chemicals etc, releasing to atmosphere if/when burnt in the incinerators serves dual purpose i.e. recovers heat and reduces the environmental pollution levels. Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes of all flue gas handling equipment such as fans, stacks, ducts, burners, etc. Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption like electricity for fans, pumps etc.

We are trying to develop an appliance which will utilize the heat energy at its maximum extent than the conventional methods. This appliance will be more utilizable where the energy recourses like coal & farm wastage are used. By designing it in the proper manner, we can reduce the pollutant particles at maximum level & can make it environment & user friendly.

II. Problem Statement

Heat energy is the energy which is used in the conventional chulha for completing the required task such as cooking and boiling of water and etc. this method of using of chulha produces hazards impact on environment and the user. The following main parameters will describe the exact problem statement while using the conventional chulha.

1) Fuel consumption: Using the conventional chulha there are heat losses which cannot be reuse the heat energy to the performing operation. While we burn the coal or the farm wastage in the chulha, complete heat energy producing from it is not given or supplied to the requirement, due to heat losses occurring because of open structure design of chulhas. Considering all this reasons we can conclude that even maximum amount of fuel using in the conventional chulha will not provide the complete amount of energy to the cooking or boiling of water and etc.
2) Location: conventional chulha are must be placed at the outside of the home since because of hazardous impact of the pollutant on human beings and domestic equipments and food stuff. Also in the rainy season it is not easy to work with the conventional chulha since atmosphere is wet and humid. As the location of conventional chulha is placed at outside the home there is problem of ignition of coal or biomass due to wind.
3) Design: Design is most important factor about any equipment which consume the heat energy. In the conventional chulha, its open design structure causes the high amount of heat losses which reduces efficiency of the appliance. Conventional chulha are generally made up mixture of soil and cow dung, hence if the

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chulha get wet in the rainy season or due to any another reason, it arises problem for ignition.

4) Cooking and the boiling of water is main purpose of conventional chulha but these two purposes uses fuel separately. This disadvantage of Chulha facilitates the more and more consumption of energy sources. Hence requirement of coal or biomass is increases day by day.

III. Design Development

Development of the project is motivated by following factors

A. Energy Losses in Stoves

- Incomplete combustion. Some of the volatile gases and char- coal produced during the burning process do not react with the incoming oxygen; thus, the heat that would be generated by these reactions is lost. Incomplete combustion leads to the formation of soot and tar particles in the gas stream leaving the combustion zone. It can also lead to the formation of carbon monoxide, which may accumulate to a dangerous level in the living quarters.
- Heat carried away by the gases produced by combustion. The gases leaving the combustion zone are hot. Unless the pot can capture this heat, it is lost to the atmosphere. These gases also contain air. The greater the percentage of excess air (that is, the amount of air beyond that required to burn the wood completely), the greater the heat loss to the gas stream will be. Some heat energy is needed to exhaust flue gases and draw in combustion air.
- Losses due to heating a stove. The stove absorbs heat from the fire. Some of this heat will be transferred to the pot, but some is lost.
- Losses to the atmosphere from the stove walls and the cooking pot. Any hot object will radiate and conduct- heat to anything cooler around it. Energy used in evaporating excess water from wood with high moisture content.
- Inefficient operation of the stove for intended purpose, ex. Having a high draft to allow faster cooking. Not using pot covers while cooking. Using wood pieces that are too large or too small.
- The first four losses can be minimized through proper stove design.

B. Improving Combustion Efficiency

- Insulating the fire box (combustion chamber)
- Reflecting part of the heat absorbed by the walls back onto the wood surface
- Placing the pot away from the seat of the fire. The most efficient position for the pot is where the flame is not cooled by the pot's cold surface, but where the bottom of the pot still receives a large proportion of the radiant energy released from the fire.
- Controlling the flow of cold air to the fire.

Air can be channeled around the wood by the use of grates or baffles. There are multiple ways that the air can be forced to flow through the wood the walls of the combustion chamber must slope in toward the grate and that the areas of the grate open to the passage of air must be approximately 25 to 30 percent of the total grate area.

More sophisticated methods of improving combustion efficiency are:

- Re-circulating the flue gases
- Reheating the primary air
- Adding secondary air at the end of the flame zone

C. Minimizing Heat Loss from Heating the Stove

The heat required to heat a stove can be minimized in two ways. If food is to be cooked quickly, or once or twice a day, or of a material the stove should be designed with thin walls absorb much heat. If cooking is done that does not readily frequently throughout the day, a stove that has a thick wall well should be constructed. This stove will and holds heat from the fire always remain hot. When cooking much less will be absorbed by these hot walls.

1) Challenges:

To design and test the most appropriate solutions for specific local cooking habits in rural/semi- urban contexts where the cooking is still done on firewood/ biomass. Adaptability to different fuels (availability in different seasons and regions) Adaptability to different culinary habits (ways of cooking, vessel shapes, food type e.g. In south steamed rice is cooked and in the north Chapatti (breads) is preferred. Energy is released in the combustion chamber when fuel is burnt in presence of air.

- Major part of energy released is utilized by cooking pot for cooking purpose.
- To avoid heat losses due to absorption of heat by combustion chamber walls, we have installed aluminum tubes carrying water which will produce hot water while cooking.
- To avoid heat losses carried out exhaust gases we have incorporated a heating chamber which absorbs heat carried away by exhaust gases and provide heating effect.

IV. Proposed Design

In order to avoid all problems which are majorly get faced as wastage of heat, excessive consumption of fuel and increasing rate of pollutant, we developed a design of advanced Chulha to overcome all this problems and to facilitate better efficiency and proper use of waste heat.

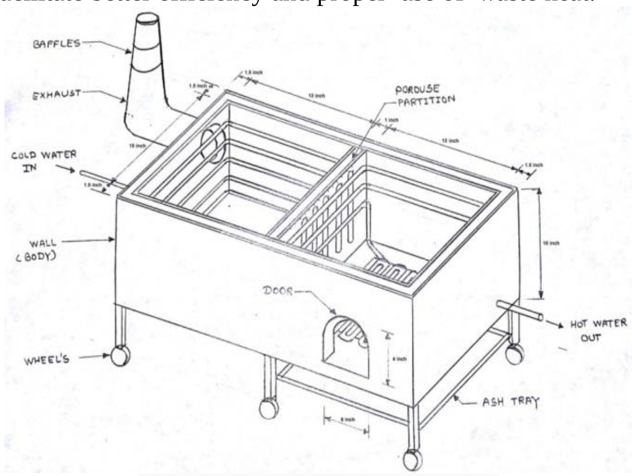

Fig. 1: Proposed Designed Model

V. Constructional Features

Advanced Chulha mainly consist of following components,

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- Insulating box – The insulating box (30×18×10 inches) is made up by Plaster Of Paris (Gypsum) having very low thermal conductivity. Thermal conductivity of the gypsum is 0.1185 W/m-K. This insulating box is covered with thin metal sheet from outside of the Chulha made by the mild steel. This box is completely closed but some ports are provided for specific use. A porous partition is introduced in insulating box. Insulating walls are made up of gypsum having thickness 1-1.5 inches.
- Water Tubing – Water tubing are used to heat the water simultaneously with the cooking. We have selected copper material for the water tubing since it has high thermal conductivity up to 410 W/m^{0}K.Water tubing is wounded reactangularly in both chambers and placed closer to insulated wall. Tubing initiate from low heat chamber and then passed towards the high heat chamber. A specific distance is provided between two wounds of tubing.
- Blower – Blower is attached on the side of high heat chamber for air circulation and blower is operated manually.
- Exhaust system – It is connected on the side of low heat chamber. Exhaust system is conical shaped pipe such as chimney to increase velocity of exhaust gases. A thin metal mesh is provided in the exhaust system to collect soot arrived from combustion of fuel.
- Cooking pots – we are using pots which are made up of aluminum material and placed inside the ports hanged on upper case.
- Other components – Remaining components of advanced Chulha are door, ash drawer and portable wheels. Door of size 4X6 inches is placed on the front side of combustion chamber which is utilized for feeding the fuel. Ash drawer is concerned to collect the ash from burnt coal. It is with sliding motion to take out the ash. For making the advanced Chulha movable, portable wheels are joined at the lower base.

VI. Principle

Wasted heat is trapped within insulated box and utilized for simultaneous work purpose with major concerns of heat recovery and minimum consumption of fuel.

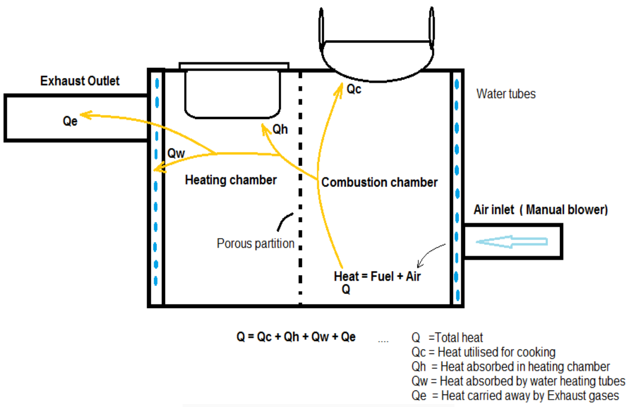

Fig. 3: Working Diagram

VII. Work Simulation

Coal is a fuel available with calorific value 5000 KJ/Kg (As per Indian coal) and cheaper than other fuels hence this fuel is considerable for advanced Chulha. Since we need to trap the heat, we use the insulating box as a structural base. When we ignite the coal fuel inside the combustion chamber, door must be closed and at the same time blower must be working manually. As the coal start burning, heat energy emits from it. Now partial heat energy is mainly used for cooking purpose and remained heat energy is trapped in this insulating box. But as the coal is burning continuously, heat is emitting from it in major extent, to recover this heat we had introduced water tubing inside the high heat chamber and low heat chamber. These water tubing are made up of copper material which absorbs the heat and this absorbed heat is utilized for heating the water. In this way we utilized the trapped heat for heating the water simultaneously with cooking. Also we introduced second section of low heat chamber with porous partition where the heat energy is stored; this section is used for heating effect. Now these burnt gases from coal get outside from the exhaust system provided on the side of low heat chamber. Exhaust system is specifically designed so that there will no back pressure of exhaust gases.

In the above manner we achieved the simultaneous completion of different work purposes with the same consumption of fuel.

VIII. Future Scope

Earlier days the fuel for cooking and the regarding works using widely which results the extreme consumption of gas cylinders, coal, electricity and etc. this provides the highly decreasing rate of such energy sources to prevent this decreasing rate of energy sources we are constructing an equipment with modification of conventional chulha.

1) Saving of fuel & energy: Energy source is important consideration for the product which will give the heat energy, if utilisation of the energy sources is minimum with required heat energy then efficiency of the product is better than conventional, our project will utilize the minimum possible amount of fuel but will provide the required amount of heat energy required for the operation consisting reuse of waste heat.
2) Reducing of hard work: Work is to be done to perform any operation or for performing any task but level of hardness of work can be reduced by concentrating on technical effect of each parameter. We provide design with compatibility which will reduce the hard work for ignition, blower and maintenance.
3) Multi-Tasking: Cooking and the boiling of water is possible at the same time with the same fuel which will reduces the time consumed for two separate works and gives us the less consumption of fuel due to reutilisation of waste heat.
4) Food stuff prevention and heating action: we are providing heating action at the 2nd chamber which will use the heat which comes from combustion chamber .This will facilitate the provision of slightly heating and the prevention of food stuff at a time of cooking and boiling of water.
5) Cost reduction: As the less amount of fuel is required for the operation with more efficiency and recovery of heat is there, we introduce with the less cost than the conventional chulha.

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6) Low maintenance: As compare to conventional chulha the maintenance of our project are very negligible. The ash of the fuel sources is directly collected at the ash tray. Further any maintenance of the project is not considerable.

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