Design of Micro Power Station with Biomass as Fuel

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Abstract— Energy conservation and regeneration is a very important topic these days. It has become a necessity to fetch for an alternate method of power production to overcome the problem of energy crisis. Looking at significant research papers most fossil fuels are expected to last up to the year 2050, whereas considering the present coal consumption rate, it is estimated that all the coal reserves might be completely exhausted by the year 2030. A lot of energy is wasted in the environment just by the ignorance of the potential of most renewable energy resources like biomass, wind, solar energy, etc. Researchers are fetching new and more economical methods to extract every unit of energy available from these renewable resources to help reduce the effect of global warming by controlling pollution.
Key words: Biomass, Renewable Energy, Fossil Fuel, Global Warming

I. INTRODUCTION

Biomass which is purely a byproduct of vegetation present all around us has hydrocarbons as its major constituent. This biomass can burn very efficiently to produce large amount of heat. Calorific value of dry biomass ranges between 18 and 21 MJ per kg. In this research paper the procedure of producing useful energy from biomass by construction of a micro thermal power station is systematically formulated. The research significantly features a better design of the power house which can produce renewable energy (more generally electricity) for local use at personal level. This setup will not only provide electric energy but also help keep the environment clean and pollution free which was supposed to happen if the biomass was burnt for no purpose as a traditional method of waste disposal.

II. TECHNOLOGY

Biomass is burnt in the combustion region of the boiler. Larger lumps of the biomass must be cut into small pieces so that the burning surface area is increased and more heat is generated. It is not advisable to make the pieces very small as it may lead to quick combustion and most heat energy will be released in too short period for the tubes to absorb it and transfer to the water. The heat produced by this combustion is used to boil the water present in the boiler tubes. Water is quickly evaporated by absorbing the heat from hot gases. Copper has great thermal conductivity as compared to most other metals, hence the tubes used for transferring heat energy are made of copper. It then flows to the steam engine via compressor tank. Engine shaft is coupled to a generator. This stage of power production is called primary stage. At the end of this stage the steam from exhaust of the engine is sent for reheating and a part of it which is condensed to form water is sent to the main water reservoir to again undergo the same procedure. This reheated steam is low pressure high temperature steam and can effectively rotate the turbine which is also coupled to the same generator and assists the engine shaft to turn with more power and produce electricity. After the whole process the steam is no longer able to retain its vapor phase and is condensed into water. The water goes through same cycle beginning from evaporating due to combustion of biomass. Assembly of all the components is shown in the fig.1.

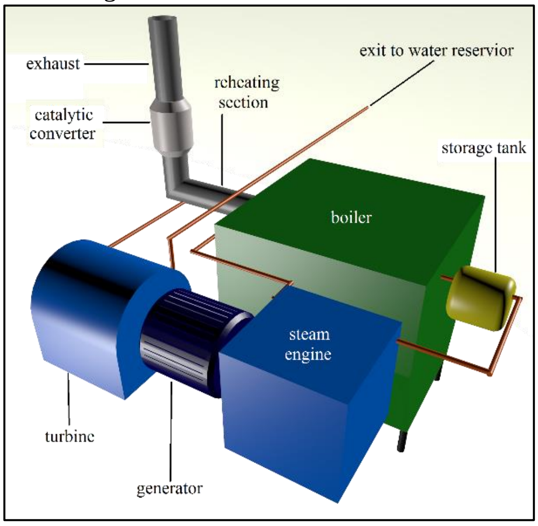

Fig. 1: Assembly of system

III. COMPONENTS OF THE SYSTEM AND THEIR FUNCTION

A. *Boiler:*

A boiler has three main regions namely, combustion region, primary heating tube, reheat tube. As shown in the figure biomass is stored in the walls of the boiler which are tapered inward near the bottom. This is an automatic biomass feeding mechanism. Storage and flow of biomass (fuel) is represented in fig. 2. After burning the fuel it is turned into ash which can easily flow down the gaps and holes in bottom mesh that serves as a holding platform for the burning fuel. Keeping the biomass in the boiler walls also prevents leakage of heat from the boiler by acting as an insulating material. The biomass near the bottom is preheated and the retained moisture is also removed from it to make it completely dry so it burns more quickly. All the sections are shown in the fig. 3

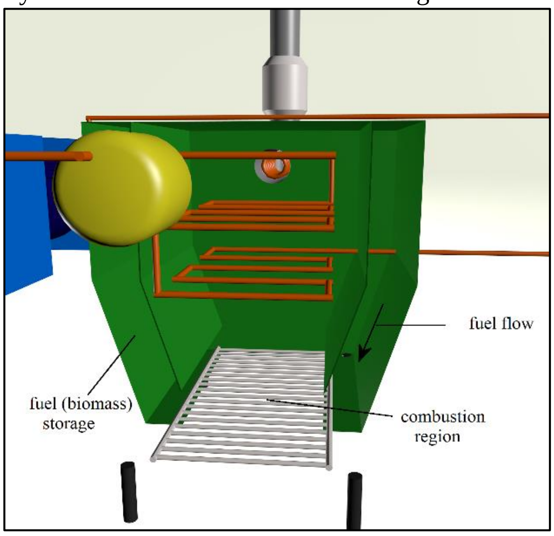

Fig. 2: Biomass storage and flow

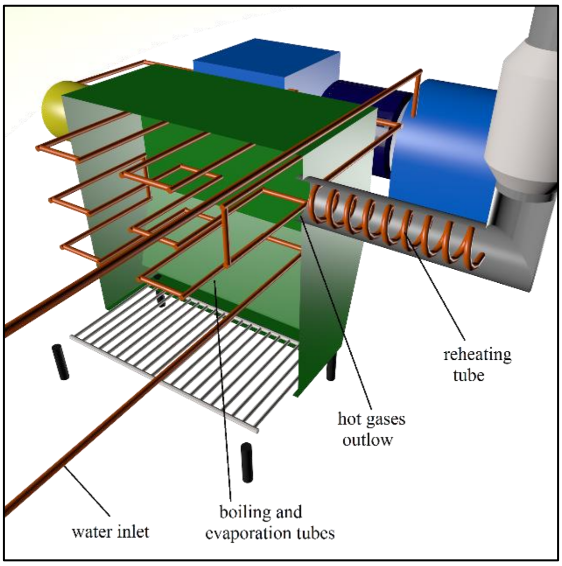

Fig. 3: Boiler section view

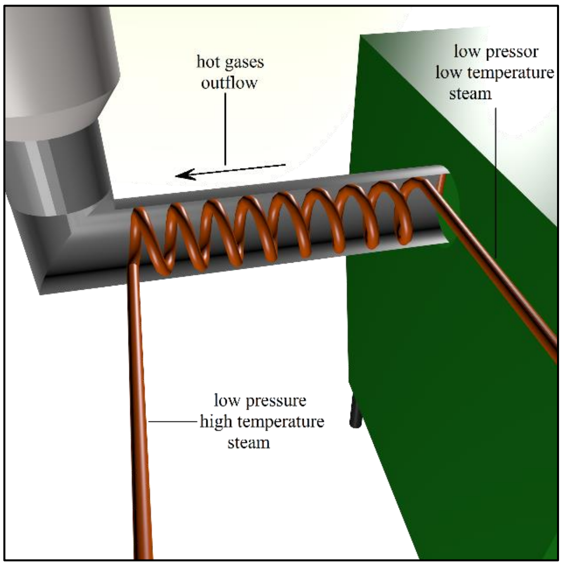

Fig. 4: Reheat process

B. Steam compressor and storage tank

As the water is boiled it is continuously evaporated and it is required be used quickly before the temperature is deceased. Since steam at lower pressure can't run a steam engine, it has to be first pressurized by keeping the volume less or same and increasing the steam particles (vapors). This can be done using a temporary storage tank. This tank will act as a steam regulator by keeping the flow constant. Even though the biomass combustion momentarily decreases which eventually reduces the evaporation of water, the tank provides excess steam required, and if ever the rate of evaporation increases the tank temporarily stores the excess steam and the flow is maintained. The tank is associated with a safety relief valve with doesn't allow the internal pressure to rise beyond its limit.

C. Steam engine

Steam engine is a device which is used to convert thermal energy from steam into mechanical motion where the shaft rotates. The rotation shaft is coupled with the shaft of a generator. The steam engine in this power house is a primary power producer. Size and capacity of the steam engine may vary according to the need to the user and their potential of feeding biomass quantity.

D. Steam turbine

Steam turbine used here is a low pressure turbine. The pressure energy is already used in steam engine, also the temperature of steam is decreased after leaving the engine's exhaust. Some part of the steam is condensed into water and is drained towards the water reservoir. Remaining steam is sent to reheat tubes where its temperature is again increased so enough energy is contained in it for steam turbine to work. Steam turbine solely works due to the reheating process. Reheating processes is shown in the fig. 4. Flue gases released due to the combustion of the biomass moves towards the exhaust of the boiler to exit with still some usable heat in it. Reheat tube is coiled and placed in the exit path of these hot flue gases. Turbine shaft is coupled to the generator shaft via a positive clutch.

E. Generator

A generator can be a synchronous alternator to produce AC electricity or a dynamo to produce DC electricity. Either type of generator can be used according to the requirement of the user.

F. Catalytic converter

A catalytic converter is not a part of the power production but it absorbs the pollutants from the exhaust gases and let only harmless particles into the atmosphere. The catalytic converter is the same one that is generally used in automobile's exhaust systems. As the exhaust gas moves forward it is completely cooled since most of the heat energy is already consumed for steam production and reheating, and free from harmful pollutants due to the catalytic converter.

IV. ADVANTAGES OF THE MICRO POWER STATION

- Doesn't require expensive fuel to produce energy.
- Not much servicing and maintenance is needed.
- The plant can work without any active supervision.
- The system works without any noise.
- Due to use of reheating method and catalytic converter, the system is almost non-polluting
- This plant can be used in industrial and residential areas as well.

V. DISADVANTAGES OF MICRO POWER STATION

- Inconvenient to transport it from one place to another.
- Copper tubes may face leakage problems due to timely changes in temperature and excessive heating.
- Electricity is not quickly generated as the combustion starts. The water first needs to evaporate to generate sufficient steam for the engine to work.

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