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RESEARCH ARTICLE

Bio-Mass Utilization for Power Generation

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Abstract

Energy crisis has severely hit Pakistan's Economy to an unbearable extent. The acute shortage of conventional energy has not only made the life miserable of a common man but the business from Pakistan is also shifting towards more developing countries which in turn pose a serious question towards the effort of the government in resolving the energy crisis as Pakistan is facing approx 10,000 MW shortage of electricity. Pakistan has got the biggest natural resource reservoirs of renewable energy which includes but not limited to coal, natural gas etc. Therefore efforts are being made to utilize the renewable energy resources in order to reduce the demand and supply gap. The renewable resource if not utilized will lead towards the destruction at a huge scale , Pakistan is God gifted in terms of available natural resource which can be utilized in the number of ways in order to overcome the needs of a common man. There are various ways to overcome the current issue of energy crisis. The key areas are coal mine, agricultural residues and wind energy, all of these can play a major role in providing an uninterruptable power supply to the national grid. This paper presents a solution for the above mentioned problem by generating biogas through the waste material. Initially the gas is produced from the waste material which is then compressed and formulized to produce methane gas, the gas then treated with few enzymes to produce steam which will be used to produce electricity at an affordable cost.

Introduction

In this fast developing country with scientific and modern technical skills there is a strong requirement of mitigation in electricity system deficits. Pakistan for the last 10 years is facing the worst shortfall of energy in the history (Haq and Khalid *et al.*, 2008), the unexpected load shedding, major transmission line losses has created a chaos among the common people for the basic necessities of life as the load shedding in urban and rural areas has reached to the peak of average 10 hrs every day. This has got a negative impact on the national and international forum as the economy has seen the worst decline of the century. Government is taking into serious account for resolving this issue by means of utilizing renewable energy resources.

Biomass has been used as a traditional source of energy in Asia and other pacific Sub-continents for a long time (Chatterjee, Saikia, Hillring, Bengt and Brunckhorst *et al.*, 2006). Moreover the Bio-Mass in near future will gain the major share in the energy market due to its cost, low complexity and due to its availability in abundance amount. It has already penetrated in the market and is already in the implementation phase and is considered as an important contributor to the future energy systems in the developed countries (D.O. Hall *et al.,* 1997).

Many studies and research have been undertaken to analyze contribution of the Bio mass energy as an alternate source of energy in Pakistan. There are various sources of Biomass which include but are not limited to wood obtained from natural forests, forestry plantations, the forestry residues, and residues from agriculture which are not

limited to straw, Stover, and cane trash etc. Furthermore the waste obtained from agro-industrial such as sugarcane and rice husk are also considered as biomass sources.

If biomass is unused for a long period of time then it will emit carbon dioxide and other gases. The useful energy can be released easily by simply burning the biomass with a faster rate. The clean energy can be obtained by using biomass through variety of technologies, which are ranging from the conventional combustion process to emerging bio fuels technology. Besides the recovery of this substantial energy, the mentioned technologies can lead towards a substantial reduction in the overall waste quantities which requires the final disposal, and it can be better managed for safe disposal within certain defined boundaries keeping the pollution control standards.

In biomass the waste-to-energy conversion process reduces the greenhouse gas emissions effects. The energy (electrical and heat etc) generated, reduces the dependency on the power plants which are based on fossil fuels. Furthermore, the biomass energy plants can harness the untapped sources of energy obtained from biomass resources. The sources of bio mass are shown in figure 1 below.

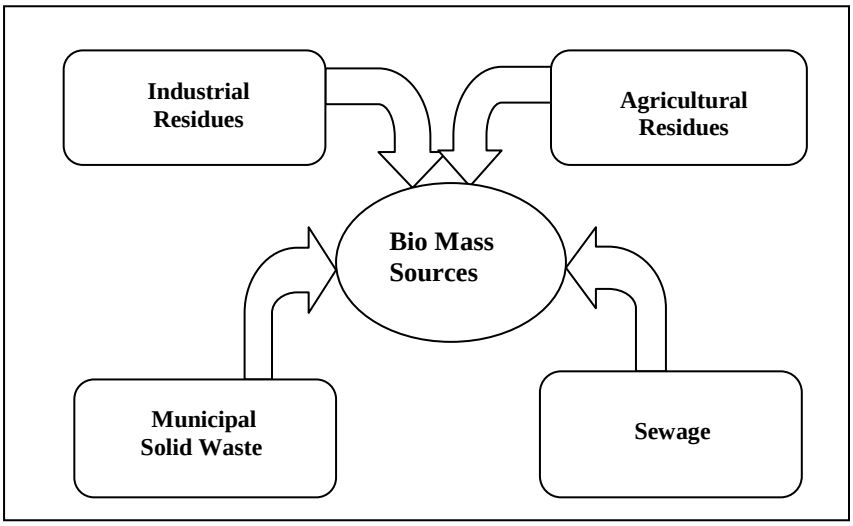

Figure 1 Sources of Bio Mass Energy

This research presents the production of bio gas which is an efficient and cost effective solution for the generation of electricity. The first step is to produce the gas by the help of waste material which will be compressed at the second stage, the third stage comprises of production of steam by the help of gas, the steam then produced will be used to generate the electricity by the detailed process mentioned in Section II.

System Model

The work is divided into 3 parts. The first part is the generation of methane gas from the waste material. The second part is the conversion of methane gas into steam and the third part is the generation of electricity from steam. The overall block diagram of the proposed system is illustrated in figure 2 below.

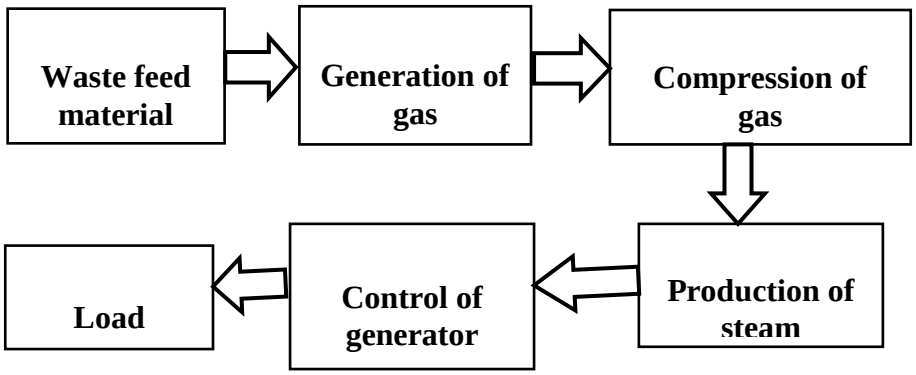

Figure 2 Block Diagram of proposed Model

Generation of methane from waste material

The first stage of the work is to produce methane gas from the waste material. For this purpose, the mixture of water and waste material is introduced in the biogas digester (shown in Figure 3) to breakdown the organic waste anaerobically and then enzymes like mizophiles were added in order to speed up the process .The digester used is of cylindrical pit design, due to its simple construction. The digester consists of a slurry tank which is covered by a gas cap so that the gas discharged from the tank can be confined in the gas drum. When the digester is emptied, waste matter is dried out for later reuse as a fertilizer.

Figure 3 Digester with biomass

The organic waste is then transferred into the bigger slurry tank and then the water is mixed with it, Afterwards another gas drum will be placed over the manure. After a certain period of time the drum rises as the biogas enters the drum and when the entire drum is filled with the biogas, it is then transferred into the storage container through outlet from the gas drum. The reason for using storage container is to make it more reliable, less expensive and more energy proficient as compared to high pressure cylinders and regulators.

Finally the gas is entered inside the compressor by using the PVC pipe, now the compressed gas travel to the cylinder through pipe and can be used for burning as a fuel for electricity generation as well as for domestic purposes. In this process methane sensor is also used to measure the concentration of natural gas. The above process is illustrated the figures below.

Figure 4 Digester with biogas

Figure 5 Gas cylinder and compressor

The anaerobic digestion process consists of three main stages which depend on the particular group of micro-organisms.are shown in the figure below.

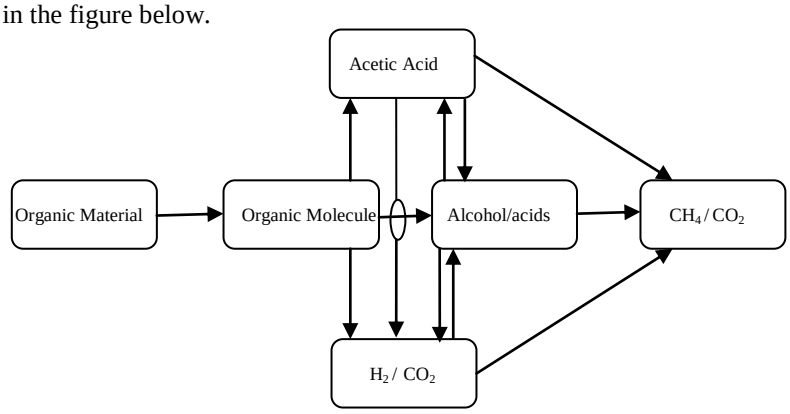

Figure 6 Digestion Process

The conversion process of organic material into methane (and carbon dioxide) under the anaerobic condition can be understood by the following stages. The first stage is the Hydrolysis and Fermentation, where extra cellular enzymes break down the insoluble organic compounds like cellulose through hydrolysis. Acetic acid and formic acid which are short chain fatty acids formed by enzymes, the by-products further undergoes the fermentation process to produce alcohols, $C0_2$, and H_2. The second phase is of Acidogenesis where formic acid, acetic acid and H_2 are produced when short chain fatty acids are oxidized by the acidogenic bacteria. The last stage is based on the reaction of different groups in order to increase the performance of the system. In this step Oxidation group which comprises of Acetic acid, H_2/CO_2/Alcoholic acids oxidizes the short chain fatty acids to produce H_2 and CO_2, whereas Fermentation group (which comprises of Organic Molecules/ Alcohol Acids) can either produce or break down the fermentation group if the concentration level is kept too high. Among these groups methanogenic bacteria is considered as the most unstable. It converts the acetic acid and H_2 to carbon dioxide and methane. None of the group is central to the anaerobic digestion process. Figure 7 summarizes the main processes in a simplified flowchart.

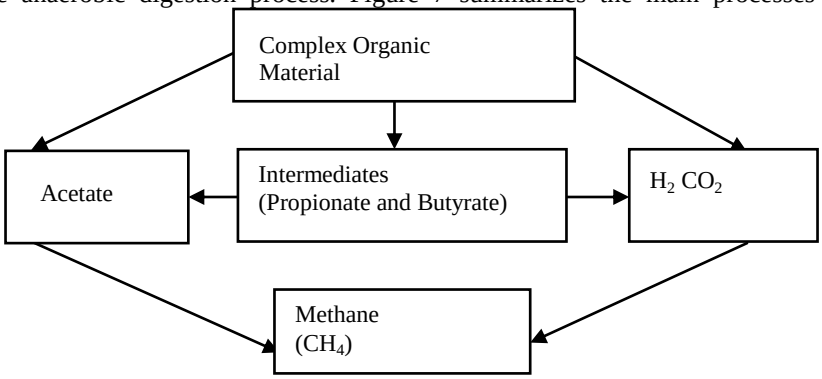

Figure 7 The Carbon flow in anaerobic environments within active methanogens

Conversion of gas into steam

At secondary stage the process for conversion of methane into steam has also been executed. A boiler or steam generator is used as a major equipment to generate steam. The methane is used as a fuel for boiling water to make steam.

In the fire tube boiler, the fuel (biogas) is burnt in blower. A boiler barrel partially filled with water and surrounded by the fire tubes. When the hot gasses are travelled through the fire tubes, the heat energy released by the process is transferred into the water. The resultant steam produced, is accommodated above the water in the same vessel. The flow of stored steam can be controlled with the valve device. Now the steam is then drained out from the outlet for utilizing for required purpose. Fire tube boilers are easy to clean and relatively inexpensive. These boilers can be used for low rate production and high storage capacity. Maximum capacity of fire tube boiler is keep at the level of 17.5 bars with a generation capacity of 9 Metric ton of steam in one hour. The main vessel if kept under pressure, may lead to worst failure which include but are not limited to the excessive pressure of the boiler, inadequate amount of water in the boiler causing overheating and vessel failure and the Pressure vessel failure due to poor construction or maintenance. To reduce or prevent such incidents testing, training certification and strict regulation is applied due to variations in standards of different boilers and plants.

Generation of electricity from steam

At final stage the electricity is generated from steam. For this generation to be achieved, two components namely Steam Engine and Dynamo play a major role. Steam Engine is a heat engine which performs mechanical work and use steam as its fluid medium (Cheng, Dah *et al.,* 1976). In our work we designed a reciprocating steam engine. It consists of five major components: a boiler, a cylinder, a piston, a flywheel and a rotating shaft.

The process started while steam entered from the boiler's outlet inside the cylinder, moving the piston back and forth and produced the reciprocating motion. When the steam entered, four events occurred in the cylinder; admission, expansion, exhaust and compression. Two ports are located on the top of the cylinder for entering and exhausting of steam. The reciprocating action of piston moved the driving rod, which is also attached to the flywheel and thereby causing the wheel to move round and round. Mechanical energy is produced simultaneously due to the conversion of linear motion into rotational.

The second most important component is the Dynamo which is an electric generator that converts mechanical energy to electrical energy. The dynamo provides pulsed dc output. It works on electromagnetic principle. The stator of dynamo provides constant magnetic field by utilizing one or more permanent magnets. The rotor windings energizes by the constant magnetic field. Large dynamos have stationary part which produce constant field provided by one or more than one electromagnets.

Now the mechanical energy produced by the steam engine is then coupled into the electric generator (dynamo) by the means of secondary drive shaft attached on the other side of the wheel. Finally the mechanical work is converted into electric energy. This electric energy now is utilized to drive the desired load.

Working of the System

Throughout the years, the anaerobic digestion is used in farms across the globe (Demirbaş and Ayhan *et al.,* 2001). It has been calculated that approximately 9 million digesters are in service within the premises of China and India, keeping in view that most of them are low budget and are of family sized. The main use of bio gas in these countries is for the purpose of cooking and lighting. Multiple outputs can be obtained through a digester, as it is capable of extracting electricity and can also be utilized as a bedding or fertilizer. In addition to this, it also eliminates the odor which results from the farming operation/ process. Such odor reduction, waste heat etc are non market goods and are indeed difficult to price which is why this research is done to examine the highly demand production and usage of biogas as a source for the production of cheap electricity. The first stage consist of adding a manure to the drum along with the water to make them wet before adding the enzymes, the later should be stir properly (whilst another drum with an outer valve will be kept and pressed over the previous so that the air would be evacuated). After keeping this stage for four weeks the drum height will be increased this proves the availability of bio gas in the drum. The PVC pipe will be attached to the out let and will be left open for while so that other lighter gases collected over methane would released. Later on the methane gas will be collected into the cylinder by the help of compressor. The gas produced will be used as a fuel to generate steam by boiling water in conventional boilers. The high pressure steam is processed in steam engine will be used to produce mechanical work. Using dynamo this mechanical energy is then finally converted into electric energy to produce electricity.

Result and Discussion

In the upcoming years, most of the developed nations are going to transit towards the alternative energy source as the current rate of fossil fuel usage has reached towards crisis level, whilst the rate of development is slow, mainstream awareness and government pressures are growing to eradicate the problem of energy crisis.

The aim of the work is to design a system that produces energy at cheaper rates. Since the future is of renewable energy, developed countries have already started there switching towards this arena quiet long ago, as cheap and uninterrupted power lines are required to accommodate the basic necessity. This transition from the conventional source to the renewable source requires much less infra structure to build and in turn shows a rapid and sustainable development towards the area. Biomass can play a key role in reducing the dependence on fossil fuels. This method will be helpful in safeguarding environment and development in rural areas. The overall system becomes cost effective due to the utilization of biomass. A maintenance cost of biomass energy system is mainly the cost of labor. The project is based on the pattern regarding comfort and safety as well. For future development, one use this design as a closed loop feed-back system which means when the load demand increases, the voltage error increases.

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