Maintaining efficiency of Biogas Energy Plant of Hybrid Model byUsing Solar Energy

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***Abstract*—This study proposes a use of a solar photovoltaic cell and biogas plant hybridization which subsequently used for electricity generation or some other domestic or industrial purposes. it proves to be very economic, environment friendly and improves the quality of life in small towns. Household biogas system has become an important part of energy source for rural areas in India. However, production efficiency of small household biogas plant is quite poor since its operation is seriously influenced by environment temperature**

Keywords—Biogas; hybrid; solar; photovoltic; environment.

I. INTRODUCTION

Almost all existing household biogas plants incorporate medium-temperature fermentation and no auxiliary heating were equipped.Thus hybrid power system that aims to increase system efficiency and increase use of renewable energy based hybrid powersystem.it provides sustained load despite natural conditions goes on changing. Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by- products from the timber industry, agricultural crops, raw material from the forest, major parts of household waste and wood. It is a biological material derived from living, or recently living organisms. It most often refers to plants or plant-based materials which are specifically called lignocelluloses biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods. Wood remains the largest biomass energy source to date; examples include forest residues (such as dead trees, branches and tree stumps), yard clippings, wood chips and even municipal solid waste. In the second sense, biomass includes plant or animal matter that can be converted into fibers or other industrial chemicals, including biofuels. Industrial biomass can be grown from numerous types of plants, including switch grass, hemp, corn, willow, sorghum, sugarcane, bamboo, and a variety of tree species. Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas also called "landfill gas" or "biogas". Crops, such as corn and sugar cane, can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats. The biomass used for electricity generation varies by region. Agricultural waste, animal husbandry residues, such as poultry litter,cow dung, are common in India.

A. Solar Energy

Solar energy is radiant light and heat from the sun harnessed using a range of ever- evolving technologies such as solar heating, solar photovoltaics’, solar thermal energy, solar architecture and artificial photosynthesis. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the way they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. The development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It is inexhaustible and independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. The Earth receives 174 pet watts (PW) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. The total solar energy absorbed by the Earth's atmosphere, oceans and land masses is approximately 3,850,000 oxyjoules per year. Solar energy refers primarily to the use of solar radiation for practical ends. However, all renewable energies, other than geothermal and tidal, derive their energy from the sun. Solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

B. Thermal storage

There are three basic approaches to storing thermal energy:

• Heating a liquid or solid which does not melt or otherwise change state during heating. (This is called "sensible-heat" storage, and the amount of energy stored is proportional to the system's temperature.)

•Heating a material which melts, vaporizes, or undergoes some other change of state at a constant temperature. (This is called "latent-heat" storage.)

•Using heat to produce a chemical reaction which will then release this heat when the reaction is reversed. Sensible heat storage is most commonly used in current parabolic trough and central receiver STHPP systems where hot heat transfer fluids such as water, oils or molten salts are stored in tanks or underground caverns. The thermal storage system of STHPP consists of two distinct tanks. The first tank contains the working fluids leaving the solar reflector field during normal working conditions of STHPP, where the second tank contains the cooled working fluids leaving from the steam generator after performing their job. The capacity of both tanks must be sized so as to hold the entire quantity of working fluids present in STHPP; in case of unavoidable disturbance of one tank it must be fed the contents to the other tank. So, the specification of both tanks must be identical to work alternate. Working fluids with high temperature are collected from receiver and then passed through the heat exchanger to the thermal storage container. Under running condition of STHPP, thermal energy is passed to storage if the temperature of heat source higher than heat loads and thermal energy from the storage will be passed to heat loads if the temperature of heat source lowers than heat loads. The present capacity factor for biomass plant is approximately 90% and efficiency 32-34% and with solar thermal storage system, capacity factor is 65% and efficiency 30%.

C. Biomass for STPP

In biomass plant the main component is the boiler, which is where biomass is burnt to generate superheated steam. Energy generated in the combustion process is used to heat the feed water (economizer), generate steam (evaporator) and superheat the steam to its final temperature and pressure (super heater). Each biomass plant consists from the same principle and refers to renewable energy coming from biological material such as plants, trees, manure, biogases, wastes, sewage gas, landfill gas etc. The effectiveness power generation requires availability of biological materials and their transportation. It is important decision to integrate the correct sources of energy for optimal power supply to the region. Practically, the integration of alternative sources, such as biomass into the other regional energy planning depends on the geographical characters of the region, the transportation, and transmission and distribution lines. The optimal sites and sizes of biomass plant will depend on availability of biomass materials and their storage, and transportation of materials. The biomass fuel is transported from the fuel storage to the boiler within the fuel system. The fuel is burned in the auxiliary boiler and steam is generated. The combustion gases from the auxiliary boiler are conveyed to the flue gas cleaning system and then cleaned gases are released to the atmosphere. The steam flows to the steam turbine produces mechanical energy. The shaft of the steam turbine and the alternator are coupled, so the alternator converts electrical energy from mechanical energy.

In sunny day, solar thermal power plant generates reasonable amount of energy by using the solar radiation. During sunny day there is no need of biomass. In sunny day solar radiations are absorbed by the solar collectors and the absorbed radiation is used to generate rated steam. This steam is used to run the turbines. But when the parameters of steam cannot reach the rated value in insufficient solar radiation, then biomass plant starts to operate. During this period the steam generated from biomass is mixed with steam from the receiver so the mixed steam reaches to the rated value. After sunset STHPP starts to use the storage energy to generate steam and in the case of deficiency of storage energy, the auxiliary boiler of biomass plant reheats the steam to maintain the rated value of steam parameter. In the absent of solar radiation or depletion of storage energy, the biomass plant starts to operate independently to generate electricity stably and continuously. The main advantage is that auxiliary boiler usebiomass fuel, producing steam for continuous and stable operation of STHPP and ensures 100% uses of renewable sources to generate electricity. So, no consumption of fossil fuel is needed in electricity generation that will contribute to reduce the environmental pollution and increase the efficiency of the STHPP.

D. Hybrid System

Hybrid power system has a great future due to its more flexibility in operation. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources [6]. Hybrid power systems can also be designed for power, heat and hydrogen generation [7]. Hybrid plants will become an increasingly attractive option as the cost of solar thermal falls and feedstock, fossil fuel and land prices continue to rise. Reich ling and Kulacki [8] solved the economic factors for wind–solar hybrid power plant and showed the cost effectiveness of the total plant. Perez-Navarro et al. [9] proposed a hybrid system, combining biomass gasification and a wind generation plants to compensate the deviations in the wind generation to 24 h. Astolfi et al. [10] evaluated the potential of a hybrid solar–geothermal plant based on an organic Rankine cycle (ORC). Nixon et al. [11]compared to biomass only, hybrid operation and showed a 29% of biomass savings. Michael Hart et al. [12] studied about the hybrid biomass–solar thermal system for heating and domestic hot water preparation for small residential applications. The literature survey shows that not much focus has been given in the area of hybridization of solar and biomass energies. The flow variations with variable solar participation have a key role on operation. The main objective of current work is the study of performance levels of biomass–solar hybrid plant under variable solar radiation and plant conditions. The flow rates, energy levels and performance variations are studied from sunrise to sunset time to understand the minimum and maximum levels.

II. Methodology

Fig. 1 shows the schematic layout for the hybrid power plant with water/steam, air and gas circuits. It is operated on a simple regenerative steam Rankine cycle. The heat source is separated and arranged in parallel for solar and biomass systems. The steam is generated from two sources in day limelight steam can be generated only from biomass energy source without stopping. Biomass and preheated air are supplied to combustion chamber for complete combustion.

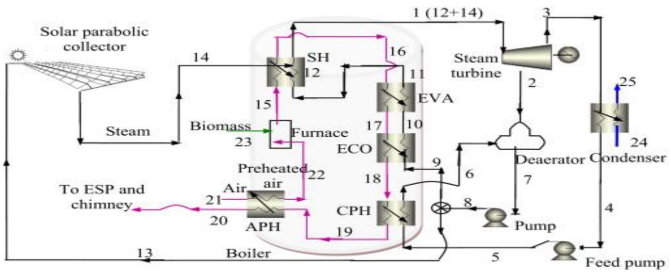

Figure: 1

The hot flue gasses coming from the furnace flows over water/steam coils to generate steam from the feed water. The heat exchangers in the direction of flue gas are super heater, evaporator, economizer, condensate preheater and air preheater and arranged to match the temperature glide. The biomass power plant is designed to operate from half load to full load condition. The condition of equal sharing occurs in day time at maximum available solar radiation in solar noon time. The full load condition for biomass plant will be reached in the night, sunrise and sunset timings. The biomass power plant will be operated at part load conditions from 50% to 100% load capacity between sunrise to noon and noon to sunset. An open feed water heater known as deaerator is located in between condenser pressure and boiler pressure. It is an inevitable component in a steam power plant [13]. Its location is defined in temperature ratio to analyze the deaerator pressure or temperature. The collector's efficiency decreases with an increase in working fluid temperature. Therefore, the steam temperature from collectors is limited to 350 °C to control the heat losses. The following are the assumptions used in the proposed hybrid power plant. Atmospheric condition is taken as 1.01325 bar and 25 °C. The global solar radiation is considered as 960 W/m2 with a beam component of 700 W/m2. The solid fuel used in combustion is rice husk. For biomass combustion, the ultimate analysis of rice husk sample considered as C: 36.74%, H: 5.51%, O: 42.55%, N: 0.28%, S: 0.55 and ash 14.37% [14]. The moisture content in the rice husk is taken at 11.7%. The combustion chamber temperature is 850 °C which is maintained below the adiabatic flame temperature. The steam turbine inlet temperature and steam temperature in furnace is considered as 450 °C at 30 bar. The steam temperature from solar collectors is taken as 350 °C. Feed water heater is located in between the boiler saturation temperature and condenser temperature i.e. at 0.2 temperature ratio. The flue gas temperature at exit of economizer is 300 °C. The isentropic efficiency for the pump and turbine is taken at 75%. Electrical generator efficiency (ηeg) is taken as 98%. The mechanical efficiency for pump and turbine is considered as 96%. There are no heat losses in components and pipe lines. Following is the formula use for thermodynamic evaluation of hybrid plant.

$$SESR = \frac{Solar \quad Energy \quad Usage}{Solar \quad Energy \quad Usage \; + \; Biomass \quad Energy \quad Usage}$$

$$SESR = \frac{m_{13}(h_{14} - h_{13})}{m_{13}(h_{14} - h_{13}) + m_5(h_6 - h_5) + (1 - m_{13})(h_1 - h_9) + m_{13}(h_1 - h_{14})}$$

$$F_{biogass} = \frac{W_{net}}{m_{biomass} \; HHV \; + I_g A_{total}} \times 100$$

III. Observations

The hybrid plants thermal efficiency decreases with an increase in steam temperature in boiler. It is because of increased solar collector's heat losses. The plant fuel efficiency is independent of solar radiation and is increasing with an increase in steam pressure and temperature. Therefore, the hybrid plant demands low steam temperature with high boiler pressure.

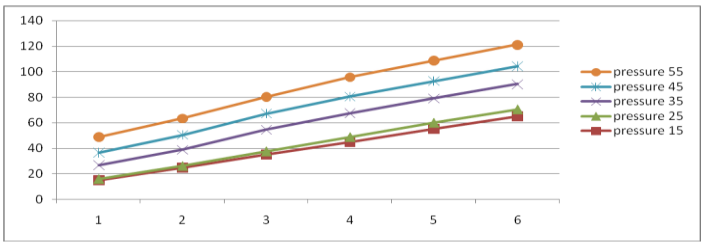

Figure-2

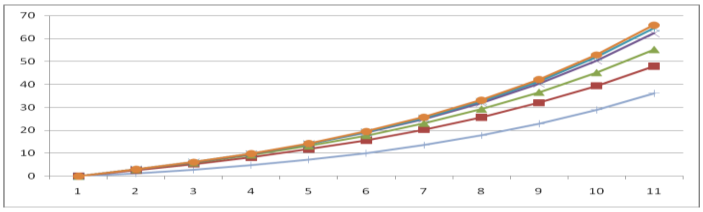

Figure-3

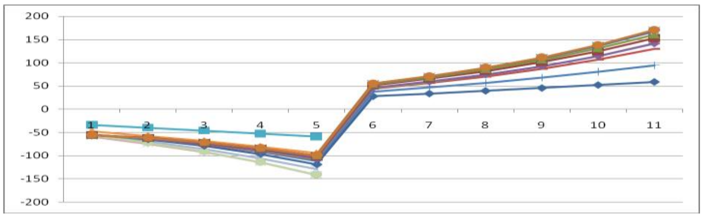

Figure-4

The plant fuel efficiency is independent of solar radiation and is increasing with an increase in steam pressure and temperature. The hybrid plant thermal efficiency is increasing with an increase in boiler pressure.
Similarly, the variations in plant fuel efficiency and hybrid plant thermal efficiency are 27 –34% and 10–12.3%respectively. Results show that the Plant fuel efficiency increases from 15-25% with the increase in solar participation from 15-50% at the boiler pressure of 25 bar approximately.
Figures show the variations in plant fuel efficiency and hybrid plant thermal efficiency with a change in pressure and temperature. As expected, the cycle thermal efficiency and specific power are increased with increase in boiler pressure and temperature. It is because of increased solar collector's heat losses. The plant fuel efficiency is independent of solar radiation.
The resulted variations in specific power and cycle thermal efficiency are 0.62–0.82 Kw/kg steam and 24–29% respectively with a change in boiler pressure (10–60 bar) and turbine inlet temperature.

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