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EXPERIMENTAL STUDY ON POWER GENERATION USING BIOMASS BASED AND SOLAR BASED BRAYTON CYCLES

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ABSTRACT

Electric power is one among the basic need in day to day life of human being. Electric power generation using conventional source of energy leads to environmental degradation and pollution. In the present work experimental comparison between power generations using solar based Brayton cycle and biomass based Brayton cycle. Brayton cycle is one which uses hot compressed air to generated power by expanding it in a turbine. In this work compressed air is varied at a flow rate of 20-50 m^3/hr, and heating is carried out using solar scheffler reflector and biomass.

Keyword: solar, biomass, compressed air, scheffler reflector, radial turbine.

1. INTRODUCTION

Current industrial society all over the world depends on conventional source of energy like coal, natural gas, oil and uranium. This leads to a wide environmental problem such as pollutions, global warming, deforestation etc. In order to reduce these harmful effects the conventional sources should be replaced by non conventional, renewable source of energy such as solar, wind & tidal etc. In the present work an experimental comparison is made between solar and coal based energy source in power generation. Brayton cycle is the basic of this experimental comparison, atmospheric air is compressed in compressor; air is heated using solar scheffler reflector which forms the renewable source of Brayton cycle. In the later air is heated using coal which is a biomass based non renewable source of Brayton cycle. The hot air is expanded in a radial turbine which is coupled to generator to generate power. Many works has been carried out in the field of solar energy for power generation, and few important works are highlighted. Sambeet Mishra and Pratyasha Tripathy [1] highlighted the major types of solar thermal system to generate electricity which include Parabolic Trough Solar Electric Generating System, Central Receiver power plant, Dish sterling system, Solar chimney power plant and Solar pond power plant. In all these power the solar radiation is concentrated on the liquid pipe line which generates steam which is expanded in a turbine for electricity generation. Valerio Marinelli *et al* [2] later made a improvement model in which the effect of the incident angle modifier was included and the effect of the reheating of the fluid was worked and concluded that the constant flow with variable inlet temperature with reheating showed better efficiency due to addition of the input heat source with reheating. Werner Platzer [3] investigated a combined PV-enhanced solar thermal power plant for reducing the cost of power produced. Solar electricity generation using concentrating solar thermal collector faces the challenge of strongly decreased levelized electricity costs by photovoltaic power plant. Adopting this method of photovoltaic generation and solar thermal power generation via thermal energy storage produced high annual capacity factor above 50% due to dispatchable solar power from thermal storage. Omar Z. Sharaf, Mehmet F. Orhan [4] has carried a study on concentrated photovoltaic thermal solar collectors. They studied the characteristics, design, principal and technological advances in solar component and elaborated the power generation process using concentrated photovoltaic thermal solar collector. Emilie Sauret and Yuantong Gu [5] presented a complete numerical simulation of a high density working fluid which could be expanded in a inward radial flow turbine at geothermal condition with 400 kW energy generation. This led to the optimization of organic Rankine cycle which has a major role in determining the competitiveness of low to moderate renewable sources. The nominal condition is well suited to handle variations of rotational speed, inlet temperature and pressure ratio while maintaining a relative efficiency. Pia Piroschka Otte [6] has made a cultural study for cooking using solar energy in Burkina Faso and India, and depicted the use of Solar Scheffler Reflector which performed economically for cooking purpose. Even today many bakeries, hotel adopts cooking by use of Solar Scheffler Reflector. Emilie Sauret and Yuantong Gu [7] presented a complete numerical simulation of a high density working fluid which could be expanded in a inward radial flow turbine at geothermal condition with 400 kW energy generation. This led to the optimization of organic Rankine cycle which has a major role in determining the competitiveness of low to moderate renewable sources. Three dimensional viscous simulations were presented and discussed at the nominal and off design condition. The nominal condition is well suited to handle variations of rotational speed, inlet temperature and pressure ratio while maintaining a relative efficiency. Solar Scheffler Reflector is not used for compressed air heating and power generation. Thus this paper focuses on non conventional source of energy conversion using Solar Scheffler Reflector.

2. METHODOLOGY AND EXPERIMENTAL SETUP

In this work, an experimental comparison is made between solar based Brayton cycle and biomass based Brayton cycle. Atmospheric air is compressed in a screw compressor and is heated using a solar scheffler reflector which form the non conventional source of energy. The hot compressed air is expanded in the radial turbine which is coupled to a generator to generate power. In the later case coal is used as a biomass which form the conventional source of energy, the hot compressed air is heated in a combustion chamber using coal and expanded in the radial turbine which is coupled to a generator to generate power. The power generated in the radial air turbine is analyzed with flow rate of 20-50 m^3/hr of air with 2-6 bar pressure. Experiment is carried with load condition and without load condition for solar based and biomass based Brayton cycles. The capacity of compressor is 1.10 m^3/sec, alternator used is 650 watt capacity, turbine is designed as per power requirement, area of solar scheffler reflector is 11 m^2, and the load is provided by two number of 100 watt bulb. Figure-1 shows the experimental set up for solar based Brayton cycle and Figure-2 shows the experimental set up for biomass based Brayton cycle

3. RESULT AND DISCUSSION

Power generation technique using renewable source of energy would contribute to a green environment. The Figure-1 is the experimental setup of the current work; experiment is carried with heating of compressed air using solar in the foremost case, secondly the experiment is carried with heating of compressed air using biomass, expanded in radial turbine and performance characteristic is drawn. Both the cases are

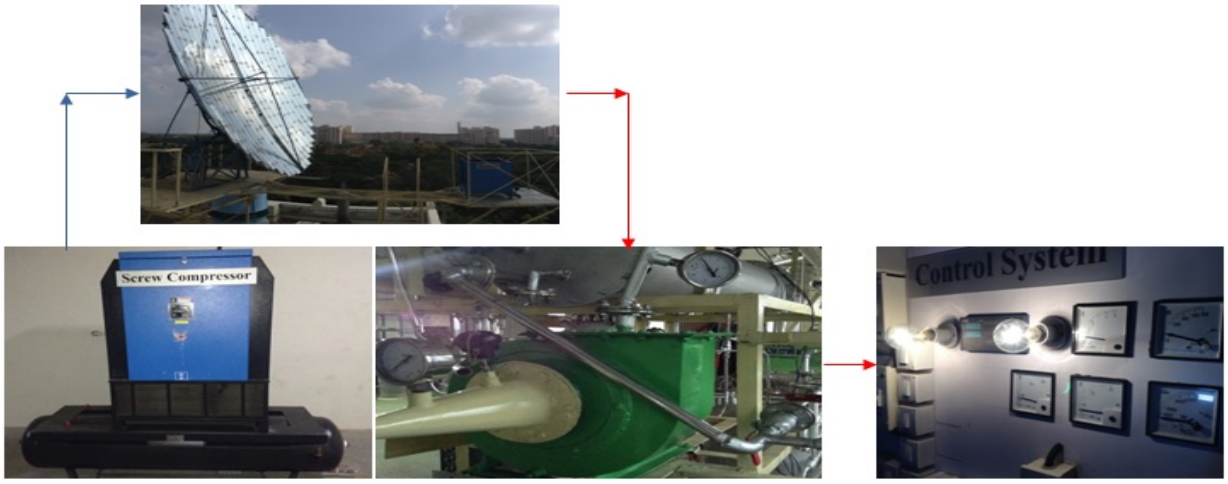

Figure-1. Experimental setup of Solar Power plant.

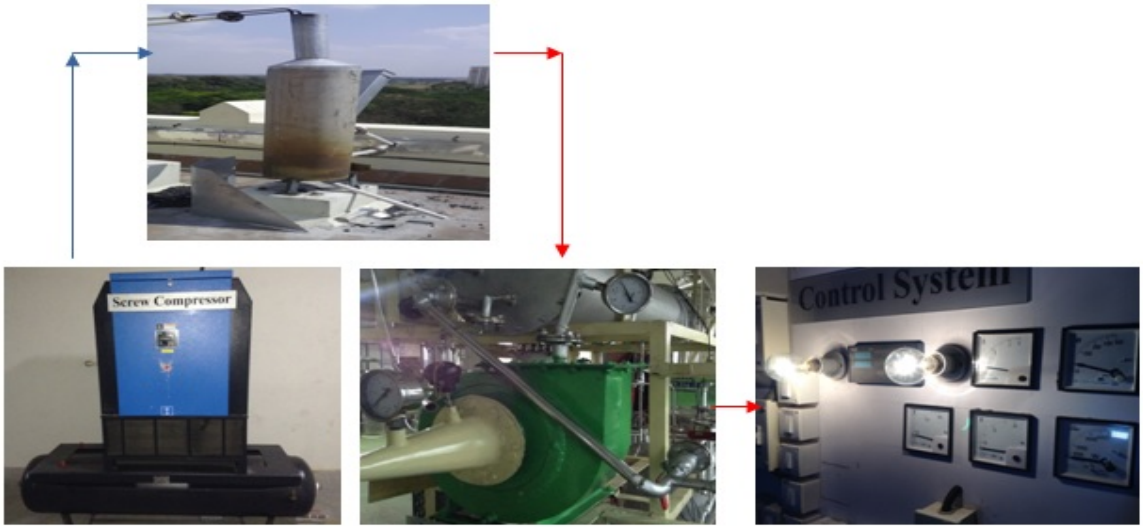

Figure-2. Experimental setup of Biomass Power plant.

performed in no load condition and with load condition. In both the case the input power supplied for heating is made constant by supplying a measured amount of heat. For heating using solar a radiation of 700 W/m^2 is concentrated using 11 m^2 scheffler, thus the input is about 7500 W. Similarly for heating using biomass coal with measured mass and calorific value are heated such that the total heat supplied is 7500 W.

Figure-3 shows the performance characteristic curve for solar and biomass based heating between mass flow rate and RPM, inlet pressure, voltage and ampere for load and no load condition. It is observed from Figure-3(a) that with increase in mass flow rate the RPM increases since higher the flow rate the twisting force developed in turning the turbine increases which is coupled to the alternator; when compared with no load condition with load case shows low RPM since the load tends to decrease the speed of the alternator than its no load speed. Since in the case of biomass heating the heating is very constant and there is no natural disturbance for same input of heat supplied, the case with biomass heating produces a slight higher RPM when compared with solar. From Figure-3(b) its clear that with increase in RPM, due to increase in flow rate, voltage starts to generate. Comparing the voltage between load and no load condition, there is a low voltage in the case of load that is obtained in the analog meter since the load is operated. Similar to voltage, ampere increase with increase in mass flow rate due to development of torque in the alternator. Since ampere can be obtained only in the presence of load, no load condition ampere is zero. With load the two 100 watt bulb starts glowing at 40 m^3/hr mass flow rates. Figure-3(d) shows the performance characteristic curve between mass flow rate and watt produced in both the solar and biomass based power generated value. For same input supplied the biomass based power plant generates a slight higher or equivalent amount of power as compared with solar.

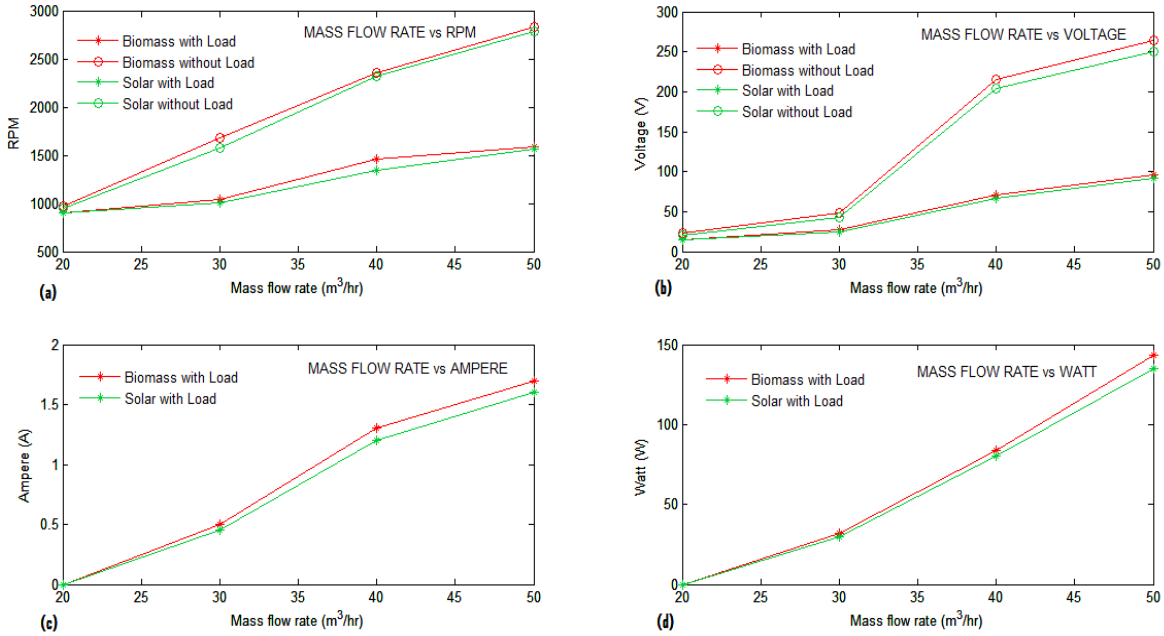

Figure-3. Performance characteristic curve.

4. CONCLUSIONS

In this work, experimental performance characteristic of power generated by single stage radial axis turbine in using solar scheffler reflector and biomass is depicted. The result highlight that the power produced by biomass generates a slight high value of power when compared to solar scheffler reflector with same input supply, due to natural disturbance and heat loss. Heating of compressed air using solar scheffler reflector increases the level of power generation using solar energy. Though the value of power generated is slightly less, the use of solar energy would ultimately reduce other conventional sources usage for power generation which would lead for green environment.

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