Prospect of Combined Cycle Power Plant over Conventional Single Cycle Power Plants in Bangladesh: A Case Study

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***Abstract*— In Bangladesh, the rising demand for electrical energy is a notable feature. Most of this energy is needed for domestic and industrial appliance electrical machineries and electric traction. Bangladesh has a huge population with increasing demand for electricity. The importance of electricity in everyday life in Bangladesh has reached such a stage that it is required to protect the power system from harm during fault conditions and to ensure maximum continuity of electricity supply. The power system of Bangladesh is facing several problems which are causing deficiency of electricity generation. The problems are such as: low production of electricity than the actual demand, faulty power system, lacking of natural resources required for electricity generation etc. This paper gives a brief description about the efficiency of combined cycle and single cycle power stations and shows the comparison between them to analyze that whether combined cycle power plants are more efficient for Bangladesh or not. This paper also discusses about the problems in electricity generation in Bangladesh and how to mitigate the desired electricity production by solving these problems. Using combined cycle is a wise choice as the heat energy which is produced in the gas turbine is re-used to boil the water into steam and supply the steam into the steam turbine to produce additional electricity. So, the combined cycle power station is the better option for electricity generation in Bangladesh. The main objective of this paper is to discuss the development, importance, challenges, progress and prospects of combined cycle power plants in Bangladesh.**

Keywords—Electricity, combined cycle, single cycle, power station, energy, efficiency, development, gas turbine, steam turbine,deficiency,mitigate.

I. INTRODUCTION

The power system in Bangladesh is very complex and quite aged with lots of lackings. Most of the power plants in Bangladesh use single cycle as power cycle for the generation of electricity. However, this method is not very efficient. Because, this method uses only a gas turbine for producing electricity and lots of heat energy is lost as exhaust gases are released in the environment. So it is high time to initiate the plans to combat the electricity problem in Bangladesh.Using combined cycle as power cycle in power stations is a better solution. The power plant which adopts LNG as fuel and employs gas-steam combine circulation technology is called the gas-steam combined circulating power plant. The advantages of this technology are as follows: reduce the environmental pollution, the power generation efficiency reach up to 57%, while in the single cycle power plant it is almost 40%; the CO2 emission of the gas-fired power plant is only 40% of the coal-fired power plant [1].

The principal ingredient of the natural gas is methane (CH4), and its molecule is composed of one carbon atom (C) and four hydrogen atoms (H). The natural gas is colorless, tasteless, and noncorrosive, the H_2O and CO_2 are formed and emitted from combustion of natural gas without producing ashes, slag, sulfur dioxide and other harmful substance. Natural gas is the well-known clean energy. LNG stands for liquid natural gas; the volume of LNG is 1/600 of the natural gas, which is convenient for storage and long-distance transportation. The efficiency of a heat engine, the fraction of input heat energy that can be converted to useful work, is limited by the temperature difference between the heat entering the engine and the exhaust heat leaving the engine.

In a thermal power station, water is the working medium. High pressure steam requires strong, bulky components. High temperatures require expensive alloys made from nickel or cobalt, rather than inexpensive steel. These alloys limit practical steam temperatures to 655 °C while the lower temperature of a steam plant is fixed by the boiling point of water. With these limits, a steam plant has a fixed upper efficiency of 35 to 42% [1].

An open circuit gas turbine cycle has a compressor, a combustor and a turbine. For gas turbines the amount of metal that must withstand the high temperatures and pressures is small, and lower quantities of expensive materials can be used. In this type of cycle, the input temperature to the turbine (the firing temperature), is relatively high (900 to 1,400 °C). The output temperature of the flue gas is also high (450 to 650 °C). This is therefore high enough to provide heat for a second cycle which uses steam as the working fluid (a Ranking cycle).

In a combined cycle power plant, the heat of the gas turbine's exhaust is used to generate steam by passing it through a heat recovery steam generator (HRSG) with a live steam temperature between 420 and 580 °C. The condenser of the Rankine cycle is usually cooled by water from a lake, river, sea or cooling towers. This temperature can be as low as 15 °C.

II. PROSPECT OF COMBINED CYCLE POWER PLANT FOR BANGLADESH

In Bangladesh, most of the power plants follow the method of single cycle. As we know that, the latest power generation installed capacity in Bangladesh is more than 10,000 MW and it will be increased if the single cycle power plants can be converted into the combine cycle power plants. The process for converting the energy in a fuel into electric power involves

the creation of mechanical work, which is then transformed into electric power by a generator. Depending on the fuel type and thermodynamic process, the overall efficiency of this conversion can be as low as 30% for the single cycle. This means that two-thirds of the latent energy of the fuel ends up wasted. A Combined Cycle Power Plant produces high power outputs at high efficiencies (up to 55%) and with low emission. In a Conventional single cycle power plant we are getting 33% of the input energy into electrical energy only and the remaining 67% is wasted. By using combined cycle power plant this 33% is improved upto 68%. [2]

For analyzing the power plant of combined cycle and single cycle, we need some preplanning. The following flow chart and curve demonstrates the working method of this research.

The simulation is completed with the help of "RETScreen" software. All the data's were collected from trusted resources. Then the simulator simulates the data and the output is generated. Combined cycle and single cycle data and formula of efficiency calculation was collected from the a Power Plant of Bangladesh.

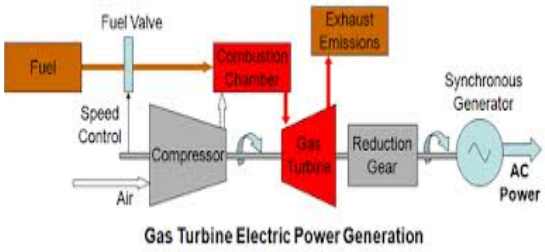

Fig 1. Single cycle

The gas turbine has a second turbine acting as an air compressor mounted on the same shaft. The air turbine (compressor) draws in air, compresses it and feeds it at high pressure into the combustion chamber increasing the intensity of the burning flame.

It is a positive feedback mechanism. As the gas turbine speeds up, it also causes the compressor to speed up forcing more air through the combustion chamber which in turn increases the burn rate of the fuel sending more high pressure hot gases into the gas turbine increasing its speed even more. Uncontrolled runaway is prevented by controls on the fuel supply line which limit the amount of fuel fed to the turbine thus limiting its speed.

The thermodynamic process used by the gas turbine is known as the Brayton cycle. Analogous to the Carnot cycle in which the efficiency is maximized by increasing the temperature difference of the working fluid between the input and output of the machine, the Brayton cycle efficiency is maximized by increasing the pressure difference across the machine. The gas turbine is comprised of three main components: a compressor, a combustor, and a turbine. The working fluid, air, is compressed in the compressor (adiabatic compression - no heat gain or loss), then mixed with fuel and burned by the combustor under constant pressure conditions in the combustion chamber (constant pressure heat addition). The resulting hot gas expands through the turbine to perform work (adiabatic expansion) [4].

In the conventional power plants air inlet to the compressor and compressed air goes to the combustion system. Then fuel has been mixed with air in the combustion chamber. It passes hot gas with huge speed to the gas turbine. Then turbine starts rotating and electricity has been produced.

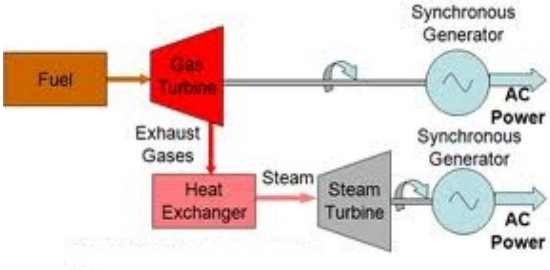

Fig 2. Combined cycle

The combined cycle power plant or combined cycle gas turbine, a gas turbine generator generates electricity and waste heat is used to make steam ti generate additional electricity via steam turbine. The gas turbine is one of the most efficient one for the convertion of gas fuels to mechanical power of electricity. The use of distillate liquid fuels usually diesel, is also common as alternate fuel. More recently, as simple cycle efficiencies have improved and as natural gas prices have fallen, gas turbines have been more widely adopted for base load power generation, especially in combined cycle mode, where waste heat is recovered in waste heat boilers, and the steam used to produce additional electricity [3].

By using the exhaust gas that released by the single cycle with approximately 593 Degree Celsius Temperature, steam has been produced in the Heat Recovery Steam Generator(HRSG). This steam passes to the turbine to produce electricity.

III. CASE STUDY: CHANDPUR 163 MW POWER STATION

Chandpur 163MW Combined Cycle Power Plant (CCPP) project under BPDB is one of the priority projects of Bangladesh Govt. The main objective of the project is to compensate the power deficit of the country particularly in comilla zone and improved problem of low voltage in the said region viz. comilla, Chandpur and adjoining areas. The other aspects of the project are to cope with the expending power demand of the country reduced transmission loss and increase the stability of national grid system. The Chandpur 163MW CCPP is situated beside the grid substation at balurmath new truck road on the Dakatia River bank of Chandpur. The data has been collected from Chandpur 163 MW power station. Data of monthly electricity generation for Single Cycle and Combined Cycle Power Plant are respectively shown in table.1 and table.2 [5] [6].

IV. SIMULATION AND RESULTS

Simulation has been done by using "RETScreen" software on the given data to analyze the load generation curve of Single Cycle and Combined Cycle Power Plant of Bangladesh. In the month of December'2013 electricity generation was stopped for repairing the generation unit of the power plant.

Table 1
Monthly Electricity Generation for Single Cycle

Month	Generation of Electricity(KW)
January	38587.5
February	67734.722
March	55537.5
April	68123.61
May	68123.61
June	80124.2
July	70122.22
August	72734.7
September	100932.876
October	93796.528
November	80124.2
December	0

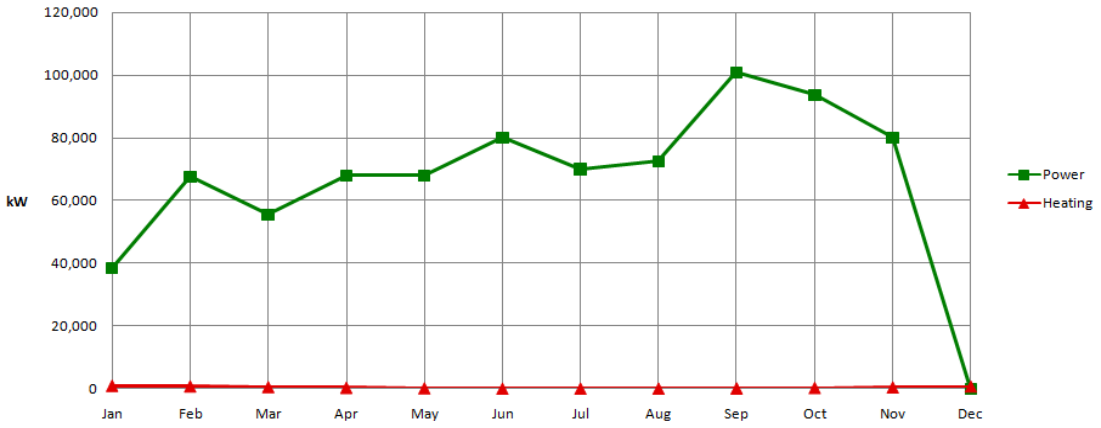

Fig 3. Load characteristic curve of single cycle

This is the load generation data of single cycle in the year of 2013.Theses data were collected from the Power Plant of Bangladesh. The net peak electricity load of single cycle is 100,933 KW and net electricity is 584,350 MWh.

Table 2
Monthly Electricity Generation for Combined Cycle

Month	Generation of Electricity(KW)
January	52363.66
February	104212.88
March	92952
April	106904.44
May	106904.44
June	90000
July	99846.81
August	130000
September	152571.73
October	139329.84
November	90000
December	0

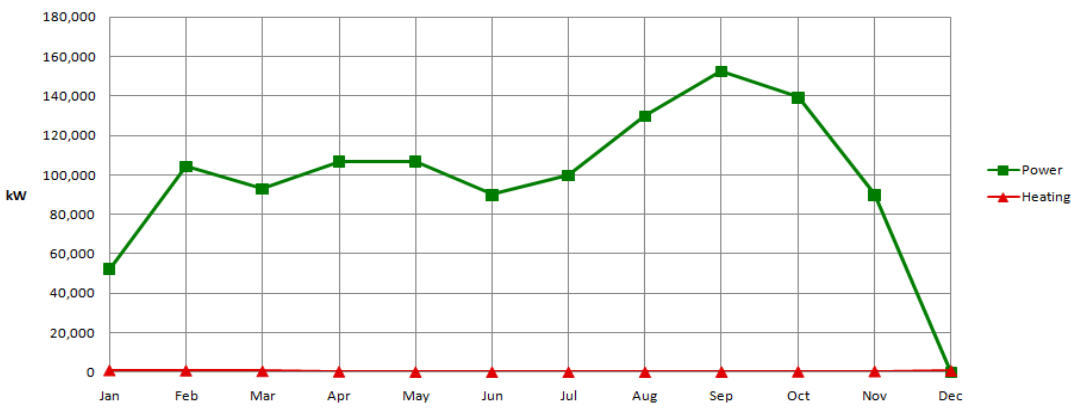

Fig 4. Load characteristic curve of combined cycle

In the combined cycle, the net peak electricity load is 152,572 KW and net electricity is 856,714 MWh.

From the load curve it is clearly seen that the production is more using combined cycle compared to the single cycle by consuming the same amount of gas that is used in the single cycle. All the input energy has been converted to produce electricity; hence heat energy production is zero.

V. EFFICIENCY CALCULATION

Thermal efficiency =

(Total Generation in kWh*3599 kcal) / (Total Gas consumption in scm*34908 kcal)

For Example, October' 2013, (for Combined Cycle)

Thermal efficiency

= (139329.84*24*30*3599) / (22380882*34908)

=.46212

= 46.212%

In the Figure.1 and Figure.2 the efficiency of Single Cycle and Combined Cycle Power Plant are shown respectively.

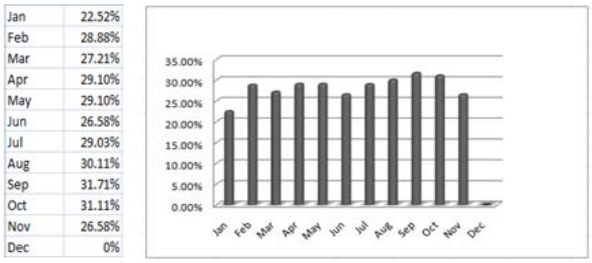

Fig 5. Efficiency of single cycle

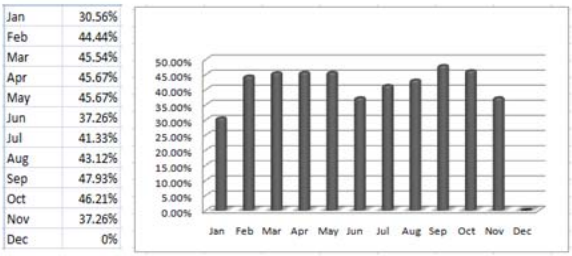

Fig 6. Efficiency of combined cycle

From efficiency calculation of single and combined cycle, it is found that average efficiency of single cycle is about 25-35% whereas the average efficiency of combined cycle is about 40-50%. Consuming the same amount of gas, the power generation from combined cycle is more than that of the single cycle. For our country, natural gas reserve is getting lower day by day, so running the combined cycle using the exhaust gases coming out from the single cycle it would be possible to produce much electricity. This will minimize the cost as well as the gas consumption and will increase the power production.

VI. CONCLUSION

The simulation outputs show that if combined cycle power plant could be introduced in Bangladesh there would be huge rise in the power production. As the natural gas reserve is getting lower in our country, it will be more beneficial for us if we use combined cycle in power generation. The gas turbine power plants require availability of natural gas with proper pressure at all times. But in Bangladesh, it is difficult to fulfill all these conditions at the same time. Through combined cycle, we can increase the efficiency by consuming the same amount of gas that we use in the single cycle and can produce more power which can minimize our electricity problem.

ACKNOWLEDGEMENT

This work is a part of the final year thesis for the partial fulfillment of the requirements for the degree of B.Sc. in EEE. The authors would like to acknowledge the facilities provided by the Faculty of Engineering, AIUB, Dhaka, Bangladesh. Special gratitude is due to the Engineers of the Chandpur 163MW Combined Cycle Power Station, Bangladesh.

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