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Improving gas turbine efficiency by chilled water system

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Abstract-Today many developed countries, energy conservation and environment effect are the most important process in the development of power generation policy in India. There are two main methods for increasing the efficiency of GAS Turbine plant is to raise the GAS temperature Before inlet to the turbine and decreasing ambient air temperature to increase the efficiency of gas turbine plants is quite simple compare to first one. A High ambient temperature of air is hot ambient weather condition. After referring literature we observe many well established technologies can be used to enhance the power output and thermal efficiency of gas turbine. In our case we are trying to reduce the ambient air by tube type heat ex changer with the chilled water system.

Keyword-Gas turbine, Compressor, Combustion chamber, Heat exchanger, Water cool, Ignition system

I. INTRODUCTION

Gas turbine is the most satisfactory way of producing large power in compact unit. In gas turbine power plant, a gas turbine is used as the prime mover to produce a mechanical energy. In the gas turbine power plant, the working medium is either a mixture of combustion product (air and fuel) or heated air at a certain pressure and a higher initial temperature. The gas turbine obtains its power by utilizing the energy of burnt gases and air which are at a high temperature pressure by expanding through the several rings of fixed and moving blades. The simple gas turbine plant consists of (!) a compressor (!!) a combustion chamber and (!!!) a gas turbine.

The basic principle on which a gas turbine works is similar to internal combustion engine. In both the cases air is made to enter the prime mover which compresses and the heated by combustion process. Hence pressure and temperature of working fluid is increased. This high pressure and temperature working fluid is then expected in the prime mover. The expanded products are discharge through the exhaust. However in this case of internal combustion engine is reciprocating machine in which charge induce into the engine cylinder intermittently. In case of gas turbine, flow of working fluid through the rotary machine (gas turbine) is continuous and smooth. With respect to design, a gas turbine is quite similar to a steam turbine. In this turbine blading working gas expands and the heat energy is converted first into the kinetic energy and then to the rotary motion of the turbine shaft. However, in steam power plant the products of combustion do not form the working medium. These are utilized to produce an intermediate fluid (steam) which is expanded in the steam turbine.

CLASSIFICATION OF GAS TURBINE

1) According to types of combustion process:
    i. Constant volume or explosion type gas turbine: This type of gas turbine works on Atkinson cycle in which combustion of air fuel mixture is takes place at constant volume. In the constant volume combustion process, the fixed volume of air and fuel burns at constant volume, hence air fuel mixture should be isolated from compressor. This is possible by valve in the combustion chamber, resulting in an intermittent combustion which inherently impairs smooth running of machine. These types of turbine have better thermal efficiency than a constant pressure cycle gas turbine. The main disadvantage of

this type of gas turbine is that complexity in mechanical system and pressure difference and velocities of hot gases are not constant, so turbine speed fluctuates. The constant volume combustion type gas turbine is not popular in practical use.
The constant volume gas turbine is absolute in use. Therefore, in this chapter we will discuss only constant pressure gas turbine.

ii. Constant pressure or continuous combustion type gas turbine: This type of gas turbine works on brayton cycle in which combustion of air fuel mixture is take place at constant pressure.

2) According of direction of flow
   i. Axial flow gas turbine
   ii. Radial flow gas turbine
3) According to action of expanding gases
   i. Impulse gas turbine
   ii. Impulse reaction gas turbine
4) According to path of working substance
   i. Open cycle gas turbine: In the open cycle gas turbine, ambient air enters at the compressor and after the compression of air, fuel is burned in the air itself to rise it to a high temperature and then product of combustion are passed on to the turbine for expansion and which after delivering the work are finally rejected to atmosphere. In the open cycle the working medium is continuously replaced by fresh air and fuel.
   ii. Closed cycle gas turbine plants: In the closed cycle gas turbine power plant, the same air or the working fluid is circulated over and over again. The working medium is not mixed with the fuel, but it is heated by the burning of fuel in a separate supply of air in the combustion chamber and transferring this heat to the working fluid which passes through tubes fitted in the combustion chamber. The working fluid does not come into direct contact with products of combustion.
   iii. Semi-closed cycle gas turbine plants: Semi-closed cycle gas turbine plant is combination of open and closed cycles, in which some part of working fluid is recirculated to the plant and another part of working fluid flows into and from the atmosphere air.
5) According to thermodynamic cycle:
   i. Simple cycle
   ii. Simple cycle with intercooling: In which the air is cooled between stages of compression.
   iii. Simple cycle with regeneration: In which the air after compression is heated with help of exhaust gases coming from turbine.
   iv. Simple cycle with reheating: In which combustion product after part of expansion in high pressure turbine is reheated in second combustion chamber and then it is expanded in the low pressure turbine.
   v. Simple cycle with intercooling, regeneration and reheating
6) According to shaft configuration
   i. Single shaft engine: example: turbojet engine, turbo shaft engine
   ii. Multi-shaft engine: example: two shaft engine with power turbine, turbojet engine, industrial slit shaft engine, twin-spool engine
7) According to application
   i. Power or industrial gas turbines
   ii. Aviation or aircraft turbines

II. COMPONANT OF PROJECT

1) Gas turbine
2) Compressor
3) Combustion chamber
4) heat exchanger
5) Chilled water system

GAS TURBINE

Fig. gas turbine

Gas turbine is mechanical device. It is used in power generation in gas turbine power plant. Which convert kinetic energy into mechanical energy?

COMPRESSOR

Fig. compressor

gas turbine compressor should be able to handle a relatively large volume of air or working media and delivering it at able 4 to 30 atmospheric pressure with the highest possible efficiencies. Moreover, the compressor should be such as can be coupled to the turbine shaft which runs at very high speed ranging from about 3,000 rpm to 40,000 rpm.

On the above basis requirement, only a centrifugal or axial compressor can be employed. Centrifugal compressors are used in small and compact unit. In centrifugal and axial flow compressor, the absolute velocities are appreciable high, so the analysis should be based on stagnation or total values. Reciprocating compressor cannot be used in a gas turbine. This chapter deals with the theory and design aspect of centrifugal and axial flow compressor.

COMBUSTION CHAMBER

Fig. combustion chamber

The combustion chamber is device which is used to produce combustion gases by mixing of fuel and air at the constant pressure.

The combustion gases expand in the gas turbine and produce the mechanical work.

HEAT EXCHAGER

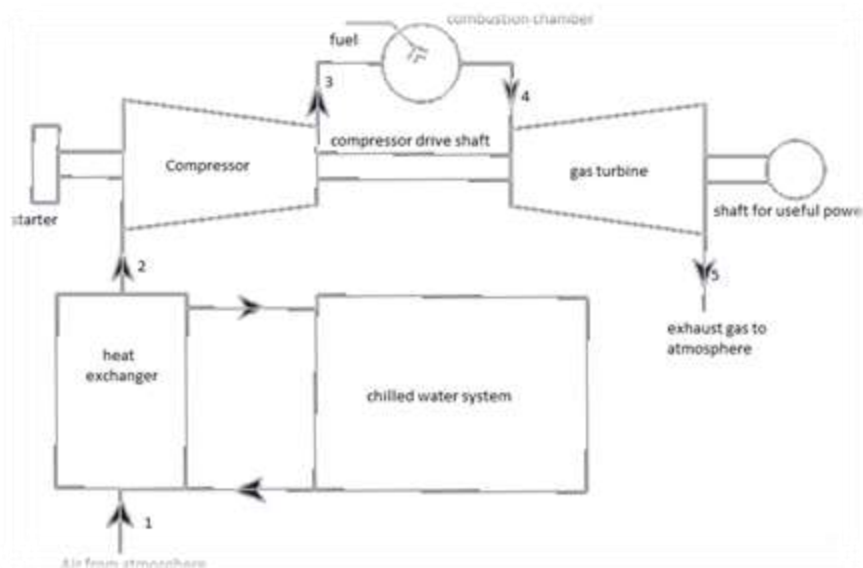
A heat exchanger is a device used for transfer to heat form high temperature to a low temperature fluid, with both the fluid moving through the same device.

There are many type of heat exchanger which are widely used in industry and application of power generation.

Some of the application are heating of air by heater at home, radiator in automobiles, domestic water heater, evaporator and condenser in refrigeration and air-conditioning, boilers, condensers cooling tower in steam power plants, gas power plants etc.

Some of the Indian manufacturers of heat exchanger are thermax, forbes marshall, tata, behr, alfa laval, paharpur of Kolkata etc.

III. WORKING PROCESS

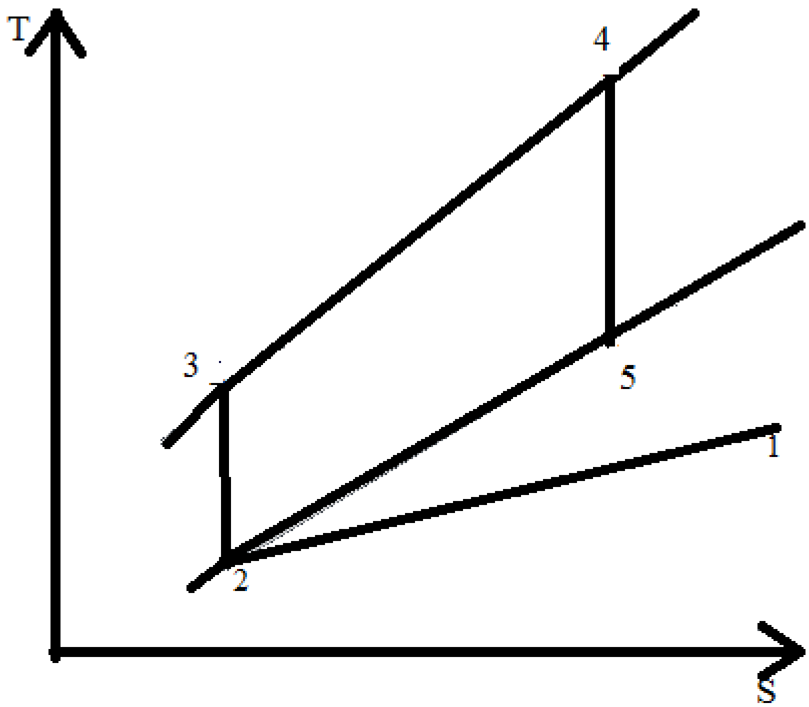


The process is start from the ambient air is coming from atmosphere through F.D fan. Where the ambient air temperature is about 25` to 35` C is to be entered into the tube type heat exchanger in a heat exchanger a chilled water cooling system is connected to chilled the ambient air from cooling water system the chilled water is supply about 7` C to the heat exchanger and it absorb the latent heat of atmospheric air and is to be cooled the chilled water is out from heat exchanger is about 15` C.

Heat exchanger out ambient air about 21` C continuously and is move into compressor where the chilled air is compressed and is moving to combustion chamber.

Decreasing the ambient air temperature to increase the gas turbine plant, as decrease of 1` C ambient temperature to increase the 1% output of the gas turbine.

IV. **Methodology**



Representing of ideal brayton cycle on T-S diagram are shown in fig. all the assumption are valid here for air standard cycle.

Process 1-2 is the heat exchange in the heat exchanger.

For heat exchanger

$$Q = mC_p\Delta T$$

WITH HEAT EXCHANGER:

$$T_1 = 21`C$$
$$T_1 = 294\ k$$
$$P_1 = 1.03\ bar$$
$$P_2 = 1.7237\ bar$$
$$T_3 = 1300`C = 1573$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{(\gamma-1)/\gamma}$$

$$T_2 = 294 \times (1.776)$$

$$T_2 = 346.428\ K$$

$$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T_2}{T_1} = (1.776)^{(0.2857)}$$

$$T_4 = 1573/1.1783$$

$$T_4 = 1334.97$$

$$W_t = C_{pg}(T_3 - T_4)$$

$$W_t = 1.63\ (1573 - 1334.97)$$

$$W_t = 387.98\ KJ/Kg$$

$$W_c = C_{pa}(T_2 - T_1)$$

$$W_c = 1.005\ (346.428 - 294)$$

$$W_c = 52.69014$$

$$W_{net} = W_t - W_c$$

$$W_{net} = 387.98 - 52.69014$$

$$W_{net} = 335.2898\ KJ/Kg$$

$$\text{heat supplied } Q = qg\ (T_3 - T_2)$$

$$= 1.63\ (1573 - 346.428)$$

$$Q = 1999\ KJ/Kg$$

$$n_{th} = \frac{W_{net}}{Q}$$

$$= \frac{335.2898}{1999}$$

$$= 16.77\%$$

V. OBJECTIVE

The main objective of this project is to increase the gas turbine efficiency by decreasing ambient air temperature.

VI. RESULTS

		RESULT
T_1	21`C	n_{th} == 16.77%
T_3	1300`C	
P_1	1.013 bar	
P_2	1.7237	