PERFORMANCE OF GAS TURBINE FOR POWER GENERATION

NISHAD DHARAM RAJ
Under Graduate, Student, B.E
Methodist College of Engineering,
E-Mail:dharam09797@gmail.com

ANUP PATHI
Under Graduate, Student, B.TECH
AVN College of Engineering,
E-Mail: anuppathi55@gmail.com

ABSTRACT:

Gas turbines are now a day's commonly used in today's world. This article explains the important components in the turbine. In spite of that it also tells the working principle involved and cycle involved in the gas turbine. It also shows the calculation part of gas turbine. This article gives the improvement of gas turbine. This discussion shows the applications of gas turbine. The article is ended with the conclusion part.

INTRODUCTION:

Fossil fuels are the major component of energy production. Almost one third of the electricity is produced by coals. As the demand of fossil fuels goes on increasing and the availability of fossil fuels decreasing. John Barber was granted the world's first gas turbine patent, in 1791 in England, for his design that used the thermodynamic cycle of the modern gas turbine but obviously not the similar components. His design consisted of a chain driven reciprocating compressor, a combustion chamber and a turbine. From then the evaluation of gas turbines takes place.

Gas turbine is a heat engine which produces mechanical shaft work at the end of the process. Gas turbine is also called a combustible turbine, is an internal combustion engine.

COMPONENTS OF GAS TURBINE

Gas turbine consists of three main components as shown in Fig 1.

a. Compressor

b. Combustion chamber

c. Turbine

Gas turbine is also called a combustion turbine, is an internal combustion engine. The gas turbine is arranged in compact geometry. Firstly the air compressor with axial flow mechanically connected with turbine and combustion chamber is arranged in between them.

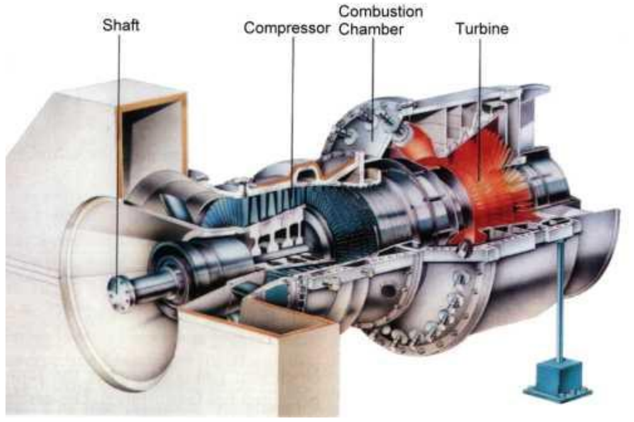

Fig 1: Component of gas turbine

WORKING PRINCIPLE OF GAS TURBINE IN OPEN CYCLE MODE

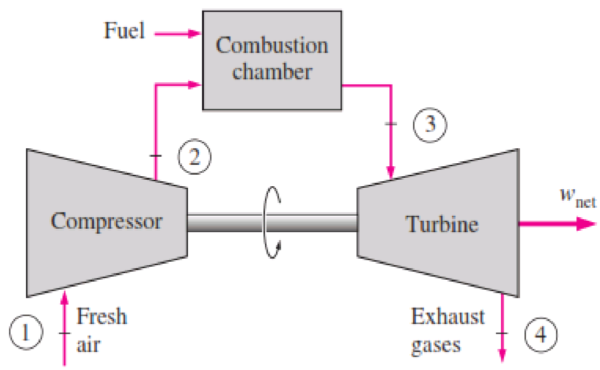

Fig 2: Gas turbine in open cycle mode

Working of gas turbine is similar to steam power plant except that air is used instead of water. Most of the gas turbine works in open cycle mode, fresh air is allowed to pass into the compressor, in this the air is compressed and the pressure of the air is bought as required. The increased air pressure moves towards the combustion chamber, in this ignition takes place when air is mixed with the fuel injected in combustion chamber and energy is released. The released energy moves over the turbine blades, spinning the turbine and mechanically powering the compressor. At last the gases are passed through nozzle generates thrust when accelerating hot gases by expansion back to atmospheric pressure. Energy is converted into shaft work, compressed air and the thrust in any combination are used to power air craft, trains, ships, electrical generators and even tanks. Gas turbine parameters runes in a order, first air pressure is increased an then temperature is varied, If suppose in case if temperature is increased first then it requires more energy to increase the temperature. Gas turbine runs on high power density, low weight and it has quick starting.

GAS TURBINE IN CLOSED CYCLE MODE

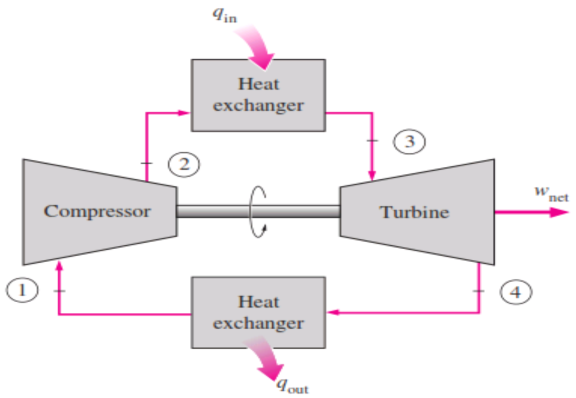

Fig 3: Gas turbine in closed cycle mode

The exhaust air has high temperature when compared to the inlet of the atmospheric air. This exhaust air has high temperature energy can be extracted from exhaust by connecting heat exchanger. One of the heat exchanger is connected between compressor and turbine. The other heat exchanger is replaced by combustion chamber. Heat is added in the process 2-3 which tends to shaft work and the heat is released in the process 4-1. The fig-3 shows the schematic diagram of the gas turbine in the closed mode.

IDEAL BRAYTON CYCLE

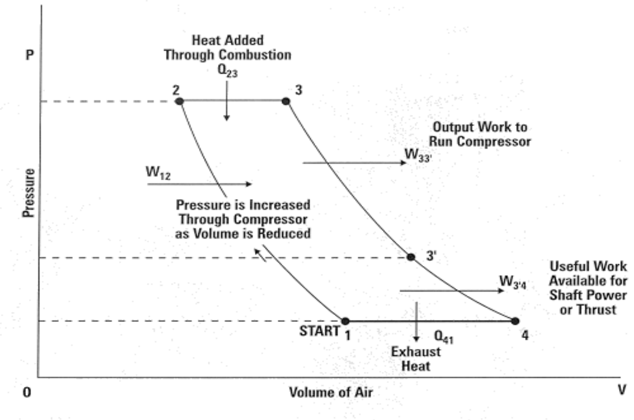

Fig 4: Ideal Pressure-volume Brayton Cycle

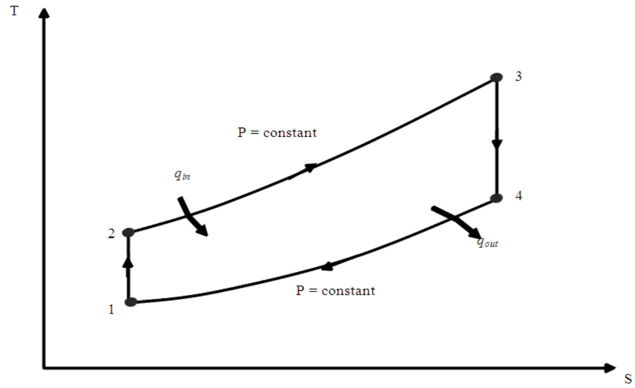

Fig 5: Ideal Temperature-Entropy Brayton cycle

The following shows the process involved in the ideal brayton cycle

Process 1-2: Isentropic compression

Process 2-3: Constant pressure energy addition

Process 3-4: Isentropic expansion

Process 4-1: Constant pressure energy rejection

Energy added, Q1 =mCp(T3-T1)

Energy rejected, $Q_2 = mC_p\,(T_4 - T_1)$

Thermal efficiency,

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$\eta = 1 - \frac{T_1\left[\left(\frac{T_4}{T_1}\right) - 1\right]}{T_2\left[\left(\frac{T_3}{T_2}\right) - 1\right]}$$

The pressure ratio of the Brayton cycle, r_p is defined as,

$$r_p = \frac{P_2}{P_1}$$

$$\frac{P_3}{P_4} = \frac{P_2}{P_1}$$

Then

The processes 1-2 and 3-4 are isentropic. Hence,

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

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

We get,

$$\frac{T_2}{T_1} = \frac{T_3}{T_4}$$

$$\frac{T_4}{T_1} = \frac{T_3}{T_2}$$

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

$$\eta = 1 - \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}}$$

Work delivered by the cycle is given by

W=hQ_1

Increasing Q_1 can increase work done by the cycle

Since the Turbine blade material cannot withstand very high temperature, T_3 and hence Q_1 is limited

The optimum pressure ratio for fixed values of T_1 and T_3, for which work is maximum, is obtained by,

$$W_{net} = Q_1 - Q_2 = mC_p(T_3 - T_2) - mC_p(T_4 - T_1)$$

$$W_{net} = mC_p[(T_3 - T_4) - (T_2 - T_1)]$$

$$W_{net} = mC_p\left[T_3\left(1 - \frac{T_4}{T_3}\right) - T_1\left(\frac{T_2}{T_1} - 1\right)\right]$$

$$W_{net} = mC_p\left[T_3\left(1 - \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}}\right) - T_1\left((r_p)^{\frac{\gamma-1}{\gamma}} - 1\right)\right]$$

For optimum pressure ratio,

$$\frac{dW_{net}}{dr_p} = mC_pT_3\left(\frac{\gamma-1}{\gamma}\right)(r_p)^{\left(\frac{1-2\gamma}{\gamma}\right)} -$$

$$mC_pT_1\left(\frac{\gamma-1}{\gamma}\right)(r_p)^{-\frac{1}{\gamma}} = 0$$

$$T_3(r_p)^{\left(\frac{1-2\gamma}{\gamma}\right)} =$$

Or $T_1(r_p)^{-\frac{1}{\gamma}}$

Or $\frac{T_3}{T_1} = (r_p)^{\frac{2(\gamma-1)}{\gamma}}$

Or $r_p = \left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$

Where r p is pressure ratio.

ACTUAL GAS TURBINE CYCLE

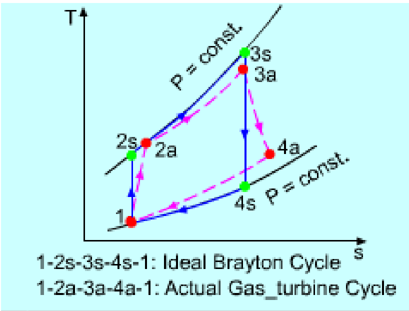

Fig 6: Actual gas turbine cycle

Actual gas turbine cycle is different from the ideal brayton cycle since there is irreversibility. Hence in an actual gas turbine cycle the compressor consumes more than that of ideal brayton cycle. The irreversibility in an actual compressor and an actual turbine can be considered by using the adiabatic efficiency of the compressor and the turbine they are

$$\eta_C = \frac{h_1 - h_{2s}}{h_1 - h_{2a}}$$

$$\eta_T = \frac{h_3 - h_{4a}}{h_3 - h_{4s}}$$

Another difference between actual brayton cycle and the ideal cycle is that there are pressure drops in the heat addition and heat rejection processes.

PARAMETERS EFFECTING THERMAL EFFICIENCY

The thermal efficiency of the gas turbine depends on pressure ratio of gas turbine and specific heat ratio of working fluid. Thermal efficiency increases with both parameters, which is also the case for actual gas turbine

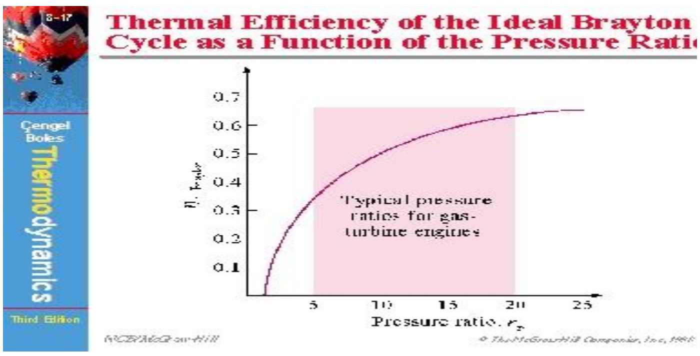

Fig 7

IMPROVEMENT OF GAS TURBINE PERFORMANCE

The early gas turbine found only limited use despite their versality and their ability to burn a variety of fuels, because its thermal efficiency was only about 17%. Effect to improve the cycle efficiency is concentrated in three areas:

1. Increase the turbine inlet temperature.
2. Increase efficiency of turbine machine component.
3. Adding modification to basic cycle.

APPLICATIONS OF GAS TURBINE

- For super charging of IC engine.
- Ship propulsion i.e. marine engine.
- Industrial application.
- Aircraft engines.
- Electric power generator.
- For turbojet and turbo propellers.

CONCLUSION

This paper shows the important components in the turbine. In spite of that it also tells the working principle involved and cycle involved in the gas turbine. It also shows the calculation part of gas turbine. This article gives the improvement of gas turbine. This discussion shows the application of gas turbine.

REFERENCE:

http://www.slideshare.net/luckyvarsha/gas-turbines-working-ppt

http://umpir.ump.edu.my/491/1/THE_STUDY_ON_THE_PERFORMANCE_OF_THE_GAS_TURBINE_FOR_POWER_GE.pdf

http://www.wartsila.com/energy/learning-center/technical-comparisons/gas-turbine-for-power-generation-introduction

http://www.mhtl.uwaterloo.ca/courses/me354/lectures/pdffiles/c8.pdf

https://en.wikipedia.org/wiki/Gas_turbine

http://home.iitk.ac.in/~suller/lectures/lec29a.htm