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Generation of Electric Power through Gas Turbine

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ABSTRACT

The major components of a gas turbine are compressor, combustors, turbine and generator. It operates by continuous drawing in fresh air into the compressor. The Air is then compressed to a high pressure in the compressor and discharge into the combustion. Here the air is missed with gas and burns continuous once ignited to increase its energy level at constant pressure. The high pressure and temperature combustion product enter an expansion turbine that converts the gas thermal energy into mechanical energy of a rotating shaft, which in turn drives the generator rotor. The resulting low pressure and low temperature gases are discharged to atmosphere at constant pressure after expanding through the turbine.

KEYWORDS: *Compressor, Temperature, Pressure*

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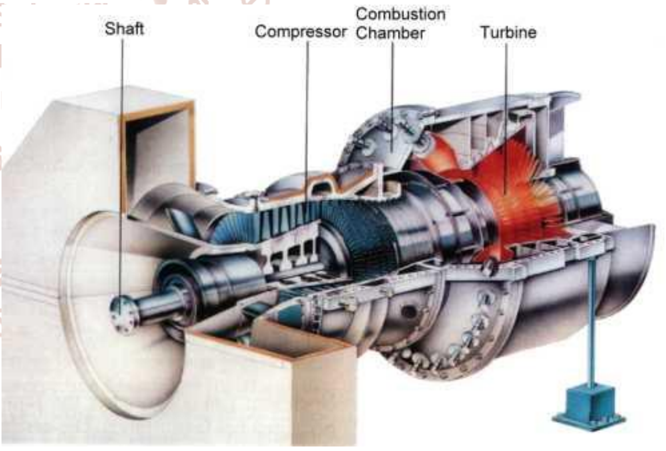
INTRODUCTION

The use of gas turbine for generating electricity dates back to 1939. Today, gas turbines are one of the most widely used power generating technologies. Gas turbine are a type of internal combustion engine in which burning of an air fuel mixture produce hot gases that spin a turbine to produce power. It is the production of hot gases during fuel combustion, not the fuel itself that the gives gas turbines the name. Gas turbines can utilize variety of fuels, including natural gas, fuel oils, and synthetic fuels. Combustion occurs continuously in gas turbines, as opposed to reciprocating IC engines, in which combustion occurs intermittently.

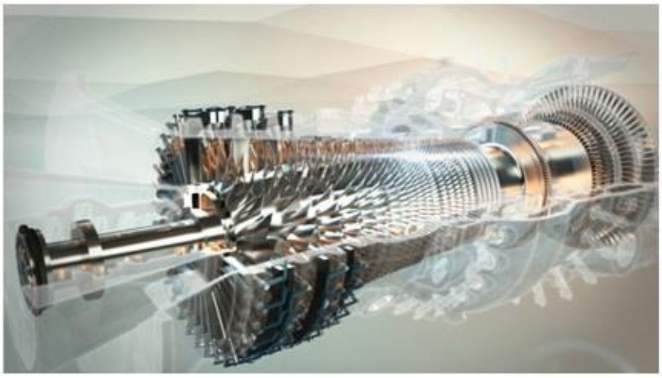
How Do Gas Turbine Works?

Gas turbine are comprised of three primary sections mounted on the same shaft: the combustion chamber and the turbine. The compressor can be either axial flow or centrifugal flow. Axial flow compressor are more common in power generation because they have higher flow rates and efficiencies. Axial flow compressor are comprised of multiple stage of rotating and stationary blades through which air is drawn in parallel to the axis of rotation and incrementally compressed as it passes through each stage. The acceleration of the air through the rotating blades and diffusion by the stators increase the pressure and reduces the volume of the air. Athrough no heat is added, the compression of the air also cause the temperature to increase.



The compressed air is mixed with fuel injected through nozzles. The fuel and compressed air can be pre-mixed or the compressed air can be introduced directly into the combustor. The fuel air mixture ignites under constant pressure conditions and the hot combustion process are directed through the turbine where it expends rapidly and imparts rotation to the shaft. The turbine is also comprised of stages, each with a row of stationary blades to direct the expended gases followed by a row of moving blades. The rotation of the shaft drives the compressor to draw in and compress more air to sustain continuous combustion. The remaining shaft power is used to drive a generator which produce electricity.

Approximately 55 to 65 percent of the power produced by the turbine is used to drive the compressor. To optimize the transfer of kinetic energy from the combustion gases to shaft rotation, gas turbine can have multiple compressor and turbine stages.



Because the compressor must reach a certain speed before the combustion process is continuous -or- self -sustaining initial momentum is imparted to the turbine rotor from an external motor, static frequency converter, or the generator itself. The compressor must be smoothly accelerated and reach firing speed before fuel can be introduced and ignition can occur. Turbine speeds vary widely by manufacturer and design raging from 2,000 revolution per minute(rpm) to 10,000 rpm. Initial ignition occurs from one or more spark plugs. Once the turbine reaches self-sustaining speed-above 50% of full speed – the power output is enough to drive the compressor, combustion is continuous, and the starter system can be disengaged

Gas Turbine Performance

The thermodynamic process used in gas turbine is the Brayton cycle. Two significant performance parameters are the pressure ratio and the firing temperature. The fuel-to-power efficiency of the engine is optimized by the increasing the difference between the compressor discharge pressure and inlet air pressure. The compression ratio is dependent on the design. Gas turbine for power generation can be either industrial or aeroderivative design. Industrial gas turbines are designed for stationary application and have lower pressure ratios- typically up to 18:1.

Aeroderivative gas turbines are lighter weight impact engines adapted from aircraft jet engine design which operate at higher compression ratios- up to 30:1. They offer higher fuel efficiency and lower emissions, but they are smaller and have higher initial costs. Aeroderivative gas turbines are more sensitive to the compressor inlet temperature.

The temperature at which the turbine operates also impacts efficiency. However, turbine inlet temperature is limited thermal conditions that can be tolerated by the turbine inlet can be 1200°C to 1400°C, but some manufacturers have boosted inlet temperature as high as 1600°C by engineering blade coatings and cooling system to protect metallurgical components from thermal damage.

Because of the power required to drive the compressor, energy conversion efficiency for a simple cycle gas turbine power plant is typically about 30 percent, with even the most efficient designs limited to 40 percent. A large amount of heat remains in the exhaust gas, which is around 600°C as it leaves the turbine. By recovering that waste heat to produce more useful work in a combined cycle configuration, gas turbine power plant efficiency can reach 55 to 60 percent. However, there are operational limitations associated with operational gas turbines in a comined cycle mode, including longer startup time, purge requirements to prevent fires or explosions, and ram rate to full load

Conclusion

Because increasing the air temperature reduces the density of air and there by reduces the air mass flow rate. An increase in the inlet temperature of the gas turbine, the overall efficiency of combined cycle power plant increases because gas turbine efficiency and steam turbine efficiency increases.

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