Application Note

Industrial Gas Turbines – An Overview

Industrial gas turbines

Today, the gas turbine is commonplace for providing prime movers in the Power Generation, Oil and Gas and Petrochemical industries. Over the past 30 years, the advantages of the gas turbine, in terms of capacity choice, flexibility of operation and environment, have outweighed its disadvantages of high component costs and maintenance. The condition monitoring of these machines offers challenges not encountered on other machines, but in order to understand these fully, an appreciation of the different types of gas turbine in service is helpful. This application note discusses the main engineering characteristics of gas turbines used in an industrial application.

Basic principles

A simplified schematic of the basic gas turbine components is given in **fig. 2**. The machine is divided into two main components: the gas generator and power turbine. The gas generator is made up of one or more "spools", each consisting of a compressor, shaft and turbine. The fundamental thermodynamic cycle is like that of any combustion engine, draw in air, compress it, mix it with fuel in a combustion chamber, ignite the compressed fuel/air mixture and exhaust the gas. Some of the energy of the exhaust gas stream is absorbed by the spool turbine, thereby completing the engine cycle by turning the compressor to draw in more air.

Fig. 1. Refinery.

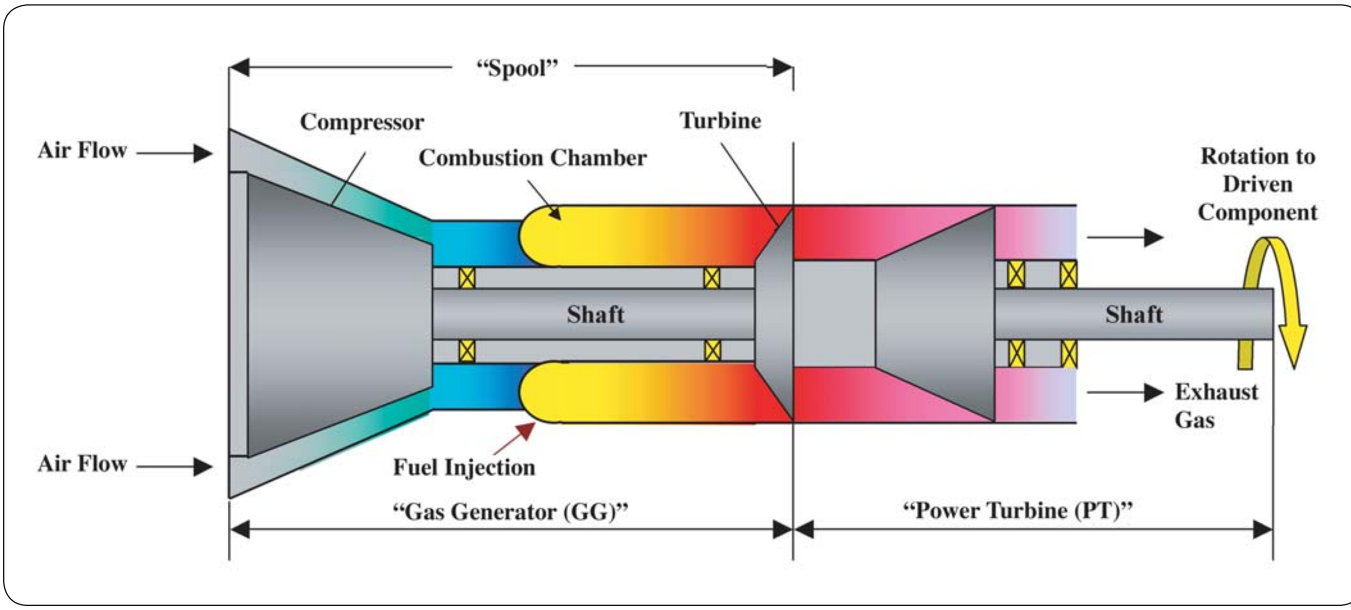

Fig. 2. Basic gas turbine components.

The majority of the energy is absorbed by the power turbine, the rotation of which converts the thrust energy of the gas into rotational energy to turn the driven machine. The remaining hot gas is exhausted to the atmosphere or to another process.

Although the applications of gas turbines are many, there is, nevertheless, a certain number of common aspects such that classifications are possible. The first possible classification is the mode of drive:

- Direct drive from the power turbine to driven
- Geared drive (speed reduction or increase)

The next possible classification can made as a function of rotational speed:

- Operational at constant speed, e.g., turbo alternators
- Operational at variable speed, e.g., turbo pumps or turbo compressors

Finally, there is the consideration of physical location:

- On-shore, e.g., refineries, pipelines, power-plant
- Off-shore, e.g., export gas compressors
- On-board, e.g., main propulsion for ships

The large variety of gas turbines available all have the above common class features. However, there is a broader grouping that is helpful when considering the vibration monitoring and condition monitoring of gas turbines, whether the gas turbine under consideration is an "aeroderivative" or a "heavy duty industrial".

Aeroderivative gas turbines

The aeroderivative (derived from aero engine) gas turbine is basically an aircraft engine adapted for use in marine and industrial applications. The major difference between the two applications is that the energy normally absorbed by the power turbine for conversion to rotational energy is instead exhausted directly out, providing thrust to propel the aircraft forward. The power generation capacity of these machines is typically in the 10 to 50 MW range.

The main features of these gas generators are light construction, high speed and generally rolling element bearings, which are usually not easily accessible.

Depending on the type, they can have one or two spools running inside each other at different rotational speeds: one spool for low pressure (LP) compression and a second for high pressure (HP) compression. The power turbine can be a light construction also, or a heavy type one, supplied with hot gas from several aeroderivatives.

The above mentioned facts indicate that the configurations of this kind of machine are numerous. Also, since their construction is light, and different rotational speeds can occur within the same machine, the vibration characteristics of these aeroderivatives are often complex and vary from type to type. Owing to the method of mounting and location, even machines of the same design can exhibit significantly different normal vibration behavior. Also, the light construction means the vibration of the driven machine will be transmitted back, so the entire train must be considered.

The lightweight nature of aeroderivatives, the presence of rolling element bearings, high temperatures and the need to measure wide bands of frequency to detect aerodynamic phenomena (blade-pass) dictates the type of vibration measurement and sensor appropriate on these machines – an "absolute" or "casing" measurement of acceleration or velocity using a piezo-electric accelerometer.

As one progresses down the train from the power turbine to driven machine, a "relative" measurement of shaft displacement, by use of eddy current probes, becomes more appropriate as the bearings move to journal type and the machines' construction becomes heavier.

Fig. 3. Aeroderivative gas turbine.

Heavy duty industrial gas turbines

The heavy construction of this type of gas turbine naturally predisposes them for stationary applications such as onshore power generation. As with aeroderivatives, there is a vast array of possible configurations indicated by their power range, from 10 MW to well above 100 MW. While machines at the bottom of the power range are largely similar to the aeroderivatives, the medium and high power machines have much bulkier structures, and the combustion chambers are not necessary annular (forming a continuous ring around the spool shaft, see **fig. 2**). Indeed, this class of machine could have one, two or more individual combustion chambers.

The smaller units use rolling element bearings, the medium ones have a mix of rolling element and journal bearings, and the mass of the heavier ones means that, almost exclusively, journal bearings are employed.

The low power units may have up to two spools, and hence two different rotational speeds. The higher power units are always single shaft with one rotational speed to consider. The vibration monitoring of the smaller units takes a form identical to that of the aeroderivatives.

The heavier nature of the larger units, the presence of journal bearings and medium temperatures, dictates the type of vibration measurement and sensor appropriate on these machines, a "relative" measurement of shaft displacement by use of eddy current probes. These are often mounted internally inside both gas generator and power turbine sections by the manufacturer.

However, the need to measure wide bands of frequency to detect aerodynamic phenomena (blade-pass) and gearbox frequencies also means that "absolute" or "casing" measurement of acceleration or velocity using a piezo-electric accelerometers are also appropriate at selected locations.

Fig. 4. Industrial gas turbine.

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