J. Chem. Eng. Energy Mater., **(2026),** Volume 2, Issue 3, 192-204

Journal of Chemical Engineering and Energy Materials (JCEEM)

Journal homepage: https://www.jceem.com/

DOI: https://doi.org/10.5281/zenodo.21473013

Description of Utility System in Petrochemical Company (Gas Power System)

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Article info

Received: 20.05.2025

Accepted: 23.07.2025

Available Online: 30.07.2025

Checked for Plagiarism: Yes

Keywords:

Description of Utility System, Petrochemical Company, Hot gases, filters, Combustion

ABSTRACT

KKS identification codes used to identify various components in the P&I diagram, equipment list, electrical load list, instrumentation list, function diagrams, terminal diagrams, system descriptions, and other documents. In this regard, the specification of power plant units not recounted in general. In addition, as a simple rule, the 4 digits of the equipment key (for example "-S01") are not listed in P&ID. Most valves, precision measuring instruments, etc. have a NAME PLATE installed on which the complete KKS code of the instrument inserted, which also includes the unit number of the power plant. The KKS technical issues in question fully recounted to determine which equipment discussed. For example, the phrase "solenoid valve" MBA41AA010A should be used instead of the phrase "solenoid valve" operating BLOW OFF 1.2, 1.1. KKS coding used to order spare parts. The uniaxial arrangement of the turbine allows the compressor to operate directly and independently of the generator. Combustion of gas or liquid fuel done in two symmetrical combustion chambers with several burners located on both sides of the turbine. Each combustion chamber has 8 burners. Air enters the compressor through the suction channel and through filters and mufflers. In the compressor, the air pressure increases by almost 11 times. Compressed air directed to the burners (above each combustion chamber) and burned in the combustion chambers. Hot gases burned and converted into mechanical power through a turbine. The generator connected to the turbine compressor through the shaft. The electrical power generated by the generator delivered to the transformer through the generator terminals. Exhaust gases reach atmospheric pressure at an approximate temperature of 545 C through an axial diffuser. Exhaust gas enters the open air through a vertical exhaust.

Introduction

In addition to the gas turbine/generator set, a cooling set provided for the lubricating oil and the generator. The above system is able to cool the turbine lubricating oil and generator bearings under any load and environmental conditions [1]. Also, the generator cooling air system reduces the generator temperature properly. The cooling system consists of two cooling cells (2 x 66%), each cell containing two fans. Normally one cell works with both of its fans and the other cell uses only one of its fans.

If any of the fan's trips for any reason, the fourth fan will start automatically. This redundancy considered as an implicit means of increasing the level of heat exchange. The location of the power plant designed to arrange all the equipment in such a way that it divided into four main areas:

- ✓ Gas turbine and generator field.
- ✓ Control and electric field.
- ✓ Auxiliary systems area.
- ✓ Gas/Diesel area [2].

The layout of the gas turbine and generator field is designed in such a way as to provide the best

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conditions for the operation and maintenance of the turbine. In addition to nclosure, the building designed to prevent noise. The generator and its auxiliary equipment are located in a separate chamber and the necessary projections considered open the rotor [3-10]. An inlet air filter installed above the generator. The turbine and generator control systems of the building installed separately from the false floor (to pass the cables). The third area related to the water treatment system and external auxiliary equipment of the turbine. Gas/diesel fuel area includes gas pressure reduction station, main fuel tank, fuel discharge station, pumping station and chemical tanks.

Design Principles

The Ansaldo gas turbine is a single-axle, single-shell turbine that is ideal for rotating a generator for production at base or peak loads and even for rotating mechanical components [11-20]. This turbine used in a combined cycle power plant. This device can consume liquid fuel or diesel with different calorific values. This turbine also works well with gas fuel. Compressor and turbine are the main components that are inside a shell and form a common rotor that is located on two bearings in a low-pressure chamber at both ends, thus providing coaxially and ease of use.

A central housing, which connected to the end housing of the compressor fixed blades on one side and to the end housing of the turbine on the other side, creates a high-pressure chamber that encloses the turbine rotor and the compressor. On the exhaust side, the end of this shell connected to the exhaust shell that encloses the bearing [21-38]. Due to the rigidity of the central shell; Compressor fixed blade holding shells the turbine fixed blade holding shells are designed in such a way that they allow free thermal expansion inside this shell [39-50]. The exhaust shell consists of a spindle-shaped chamber that allows air to pass easily through the turbine outlet. The inner cylinder in this shell connected to this skin by two ducts through which the bearing pipes pass.

The general location of the power plant, including buildings and equipment, is as follows:

- ✓ The main gas transformer Condensate polishing plant (future).
- ✓ The main transformer of the heating section (future) of the rest area for guards and drivers.
- ✓ Auxiliary equipment building (future).
- ✓ Lubricating oil heat exchanger.
- ✓ Water treatment station.
- ✓ Diesel generator emergency sewage station.
- ✓ HRSG Unit Motor Transformer (Future).
- ✓ 132KV exhaust outlet.
- ✓ Steam Hall Turbine Gas Pipeline Post Building (Future).
- ✓ Deinterlaced water line turbine gas units.
- ✓ Air Condenser Water Tank (Future).
- ✓ 230 KV substation cooling auxiliary system.
- ✓ Mechanic workshop fire building.
- ✓ Gas Pressure Reduction Station (Future).
- ✓ Fire station switch building (future).
- ✓ Central control building of office building.
- ✓ Mosque gas station and lunch.
- ✓ Fuel tank gate house.
- ✓ Path (hole) for collecting guard oil.
- ✓ Pump house parking cooling system water generator parking.
- ✓ Warehouse demineralization system.
- ✓ Electrical system configuration.

A 3-phase transformer provided for the generator output. This transformer selected in such a way that it will transfer the output power of the unit under any conditions [51-60]. A SURGE ARRESTER is installed at the end points of each high-pressure line. Star Point 1 HV wires permanently grounded. The generator connected to the main transformer directly through separate bus ducts after passing C.B 2.

The star point of the generator intended for the output of the generator through a single-phase distribution transformer to a 3-phase transformer. This transformer selected in such a way that it will transfer the output power of the unit under any conditions.

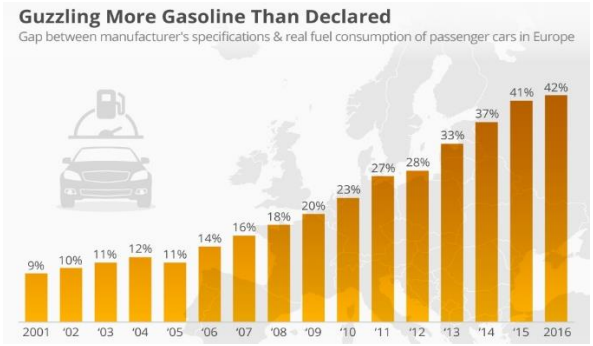

Figure 1. The Growing Gap Between Declared & Real Fuel Consumption

A SURGE ARRESTER is installed at the end points of each high-pressure line.
Star Point 1 HV wires permanently grounded. The generator is connected to the main transformer directly through separate bus ducts after passing C.B The star point of the generator is connected to ground via a single-phase distribution transformer. In the second, this resistor connected once a resistor so that it detects the ground fault current. This current is equal to the current capacity of the generator voltage circuit [61-70]. All of the above equipment housed in a metal box. The necessary power supply for the auxiliary equipment of the unit and other systems provided through the auxiliary transformer of the unit. Emergency loads supplied by an emergency diesel generator.

Energy distribution for ancillary equipment includes:

1) **AC power:**
2) **DC power:**
3) **Vital AC power supply:**
4) **AC uninterruptible power supply:**

1) AC power: AC power includes medium voltage level (6.6KV) and a low voltage power line (400V). Medium voltage is supplied through the switch board of each unit. In this board, feeders for excitation transformers, SFC transformers and single auxiliary MV/LV transformers are considered. The MV switch is located next to the control system and the single switch room. Connections are made from single transformers to the corresponding board switches via medium pressure cables.

Low voltage power includes

The main distribution board is powered by dry MV/LV transformers and supplies all GT island loads. An emergency connection to the diesel generator set will be required to supply emergency load, for example rectifiers, TURNING GEAR, also in case the MV/LV transformer is tripped or the AC mains voltage is cut off.

2) DC power: DC power includes only one voltage level (220V dc) Lead batteries, rechargeable batteries and distribution board are required for safe and secure SHUT DOWN unit [71-80]. The DC boards of both units connected to each other in such a way that each is an extension of the other.

3) AC power: The above power supply system (220vac) includes inverter, static switch of stand-by transformer and distribution panel of units, which is also shown in the old 1 single line diagram.

4) AC Uninterruptible Power Supply: Uninterruptible power supply supplied by diesel generator (400v) voltage and provides dc and ac emergency loads. Each diesel generator is selected in such a way that it provides emergency loads of two units.

Reference data used to design the site:

- ✓ 230KV voltage level.
- ✓ Site ambient temperature.
- ✓ 45°C Design temperature.
- ✓ -30°C Minimum temperature.
- ✓ 41°C Maximum temperature.
- ✓ 35% relative humidity.
- ✓ 1750 meters above sea level.
- ✓ Northwest to southeast wind direction (normally).
- ✓ 40 M/S Medium wind speed.
- ✓ Dusty environmental dust conditions.
- ✓ KG/CM Soil bearing capacity (soil resistance).
- ✓ $37^{\circ C}$ Cold water temperature.
- ✓ The horizontal acceleration of the earth.
- ✓ 0.36g Maximum allowable earthquake (MPE).
- ✓ 0.22 g Design Earthquake (DBE).

Figure 2. Corrosion protection for industrial equipment

Fuel specifications

- ✓ Specifications of natural gas 8690 +/- 10% kcal / Nm 3 LHV 1
- ✓ Gas temperature 45°C (Max): $12^{\circ C}$ (min)

Ingredients:

- ✓ N_2 5.34% (mol)
- ✓ CO_2 0.0% (mol)
- ✓ CH_4 88.59% (mol)

- ✓ C_2H_6 4.16% (mol)
- ✓ D_3H_8 1.18% (mol)
- ✓ i-C_4H_{10} 0.22% (mol)
- ✓ n-C_4H_{10} 0.29% (mol)
- ✓ i-C_5H_{12} 0.06% (mol)
- ✓ n-C_5H_{12} 0.06% (mol)
- ✓ Hexane and heptane 0.06% (mol)
- ✓ WATER 0.01% (mol)

Diesel specifications

- ✓ 38220 KJ / lit HHV
- ✓ 36280 KJ / lit LHV
- ✓ 843.8 kg / m3 density
- ✓ 3.8 cst kinetic viscosity (at 100F)
- ✓ 62°C Combustion temperature
- ✓ -10°C Liquidation temperature (summer)
- ✓ -30°C Liquidation temperature (winter)
- ✓ Total sulfur 1% by weight
- ✓ Sodium + Potassium less than 0.3 ppm (Wt)
- ✓ Calcium less than 10 ppm (Wt)
- ✓ Diesel temperature at least 100°C above melting temperature
- ✓ Maximum 50°C below the ignition point.

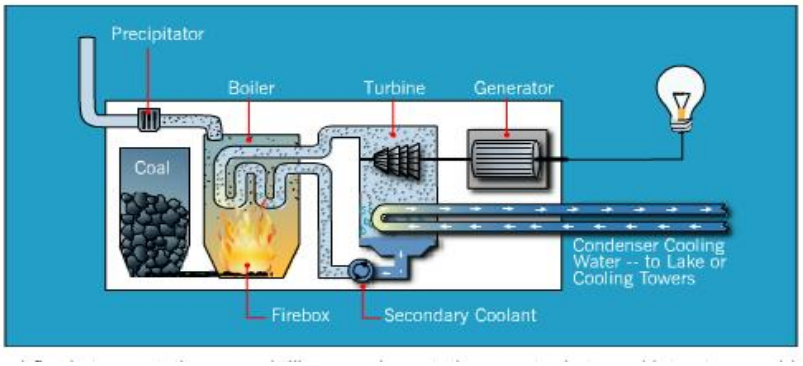

Figure 3. Utility systems

Principles of General Design

The gas turbine uses air as a fluid so that this air is first compressed and then moved by burning fuel in the combustion chamber and creating heat and raising the temperature of the air entering the turbine. This hot, high-pressure air expands into the turbine until it reaches atmospheric pressure [81-90]. This air passes through the divergent duct before entering the flue (or boiler connected to the combined cycle power plant).

The generating power transmitted to the generator through an intermediate shaft at the end of the compressor [91-100]. The gas turbine rotor assembly consists of a turbine and a compressor and rotates in a high-pressure chamber on two supports. The outer shell consists of the following components: compressor bearing housing and shells and exhaust shells which are connected to each other with bolts and nuts. The initial shell of the compressor is connected to the air inlet duct and the last shell is connected to the exhaust duct. At this distance, the middle shells hold the compressor and turbine blades fixed. Exhaust ducts also allow these shells to expand longitudinally. The shell of the compressor bearing contains the journal and thrust bearings, which prevent the longitudinal movement of the rotor relative to the shells.

At the end of the shaft is the turbine journal bearing, which is protected by the turbine bearing housing inside the exhaust chamber. Two legs at the beginning of the compressor and two legs on either side of the turbine and a holder under the turbine shell transfer the weight of the set to the foundation. Sub-compressor bases; They are fixed points of the machine and the bases on both sides of the turbine are designed in such a way that in addition to bearing the weight of the turbine, they can withstand longitudinal movements due to temperature changes and are very flexible. The holder under the turbine also directs the longitudinal motion of the turbine.

Gas Turbine V94.2

A gas turbine has an axis and interconnected shells that have two combustion chambers and considered a heavy industry. Design principles are: The rotor consists of discs that are connected to each other with a central rod and these discs They have radial expansion. They have two journal rooms. It moves the back generator through the compressor. The exhaust divergence duct is located along the unit. The exhaust shell connected to a divergent cylinder through which the turbine bearing protected. The middle cylinder also connected to the outer shell and allowed to expand inside [101-111]. Two large combustion chambers are located vertically on either side of the turbine, which connected to the shells by flanges. Each combustion chamber is equipped with eight burners for fuel entry.

Introduction to Gas Turbine

The gas turbine uses air as the working fluid and compresses it with a 16-row compressor. The fuel is added to the hot air in two combustion chambers and then ignited. Each chamber contains 8 burners to add heat to the turbine inlet air. The hot gas expands in 4 rows of the turbine and is discharged to the

environment at atmospheric pressure. The exhaust gas leaves the turbine through the exhaust diffuser and reaches STACK [112-123]. The useful output power is transferred to the compressor and finally to the generator.

General Design of Gas Turbine

The V94.2 gas turbine is a single-axle turbomachine with a single shell. Suitable for connection to generators or other mechanical applications. The application and installation of this gas turbine is in simple cycles (gas to atmosphere) or combined cycles (gas to steam recovery generator) in order to increase power generation by a steam turbine and the relevant generator. Possible fuels include light liquid fuel, heavy liquid fuel, gas oil with different heat capacity and also natural gas or furnace gas. The turbine and the compressor are mounted on an axis (the same as the rotor) and consist of a single shell, and the assembly is pressurized on two bearings outside the area. The outer joint shell is cylindrical and suitable for maintaining internal pressure. It is initially connected to the other part of the outer shell by the compressor. In this part, the compressor fixed blade is in the first row and is located at the beginning of the thrust bearing and the journal.

The outer common housing is located at the turbine outlet at the end bearing and fixed. Inside the common central housing are two transmitters, one for the compressor blades and one for the turbine blades. The outer part of the front bearing is made in a way that directs the incoming air. In this part, hydraulic swivel and pickup 1 speed are located. The exhaust shell is made by an internal cylinder and covers the inside of the magazine bearing. Gas flows through the two cylinders to the STACK.

Turbine

Fixed blade carriers and their bases (STATOR BLADE CARRIERS AND THEIR SUPPORT)

The compressor fixed blades are placed between the rings, from the blade root, in the grooves carrying the fixed blades, which are circular. The inner rings for sealing are placed in front of the fixed blades in front of the rotor.

The inlet guide vanes are mounted on gears driven by a SERVOMOTOR. This movement is limited and is to control the flow of mass. The carrier of the first row of the compressor fixed blade is fixed and is located between the input shell (INTAKE) and the main turbine shell and it is part of the outer shell. The other two carriers of the blades are not fixed to the main shell in order to be free from thermal expansion. Their concentricity is done horizontally and vertically by horizontal and vertical screws. The screws absorb the forces as well as the torque and adjust the retainers without creating a problem for the shell. The axial position is adjusted by a loop that surrounds the retainers and is fixed in the circular groove of the shell. The lower parts of the carriers can be replaced without removing the rotor.

The circular spaces between the fixed blades allow a proper suction (BLOW OFF) of the air flow to operate the compressor at low speeds, when starting and also shutting down the engine. Suction of air during the circular cross section prevents the vibration of adjacent blades. The fixed turbine blades are placed in the corresponding grooves with a special outer cover. In rows 2, 3 and 4, the annular parts are connected to the inner cover for sealing in front of the rotor. The turbine fixed blade carrier is engaged in the axial side and in its special groove, with a grooved ring to the shell. This creates a contact surface to hold large axial forces.

Fixed blade carriers and rows of rows 1, 2 and 3 are cooled by compressor air flowing through the spaces between the carriers and the outer cover, through the hollow blades of rows 1 and 2. In rows 2 and 3, cooling air is used as a protective fluid in order to seal the inner path more.

The use of fixed vane carriers ensures that the flow of compressed air through the hot part of the turbine shell remains close to the temperature ratio of the compressed air. With this arrangement, the adjustment between the moving parts and the fixed in all modes of operation will remain constant and small distances will not affect the reliability of the operation.

Rotor

The moving blades of the turbine and the compressor are mounted on the rotor and convert the released energy into output torque. Some of this mechanical energy is released during the compressor cycle and the rest is transmitted to a generator via the middle shaft.

The basis of the rotor building

The rotor consists of turbine and compressor parts that rest on two points at both ends. It consists of a number of discs and a middle cylinder in the middle. Each disc carries a row of blades. All the discs and the middle cylinder are connected to each other by a central rod. A hydraulic system is installed to open and close the center bar in the power plant so that the discs and the middle cylinder can be tightly fastened together.

There are grooves in the radius direction on each disk. The reason for the existence of these grooves on the disk; Allow thermal expansion in the direction of the radius to each disk. There are spaces between the bars and discs through which the required air passes to cool different parts. The seals in the mentioned space regulate the amount of this air for different points.

There is a total of six plates for adding balance weight to the rotor; Three of them are accessible without opening the rotor. The opening and closing of the rotor are performed during major repairs at the

power plant site. All turbine and compressor blades can be replaced even without the need to remove the rotor.

Turbine Stator Blades

Along with the rotating blades, the fixed turbine blades also convert the fluid heat energy into mechanical energy. The airfoil blade is formed to characterize the maximum current as well as the power of the current. Fixed blades will include an outer cover, airfoil and an outer part for placement of the blade holder and placement, as well as exposure to gases. The inner cover of the boundary layer forms the path of the gases and also causes the sealing of the inner axis. Airfoil rows 1, 2 and 3 are hollow and are cooled by cool air. The rows of rows 1 and 2 have holes for draining at the edge. In order to withstand high stresses and high temperatures during operation, the blades are plated with high temperature alloys. Due to the fuel, the first row of blades will have a suitable cover.

Turbine Rotor Blade

These blades convert thermal energy into mechanical energy. These fins include the airfoil (aerodynamic section), the surface of the fins and the roots of the fins. The airfoil cross-sections are shaped like the wings of an airplane and are chamfered for greater strength at the base. These blades had screws from the base to the end, the corresponding calculations being proportional to the fluid velocity generated along the blade.

The location of the blades is a set and includes the protection of the rotating disk against the gas path and high temperature. On the other hand, the roots of the blades contain a pine-like shape with two or three teeth. The blades are placed in special grooves on the rotating disk and locked in place in the axial direction by keys. All movable blades are produced with alloys resistant to high thermal and mechanical stresses.

The blades of the first two rows are air-cooled. The blades of the first row are hollow and are cooled by the air coming from the roots of the blades. This air enters radially and is discharged through the holes behind the edge. The second row of blades is formed by several radial channels that form inside the airfoil. Cooling air enters through the holes and the root of the blade and the end holes are drained in the radial direction. The blades are covered to reduce the effects of heat and corrosion.

Central Casing

The central shell is attached to the holder of the fixed vanes, and to the exhaust outlet shell, and also contains the internal pressure. It consists of a compressor and a turbine and is connected to the combustion chamber by flanges.

It has a welded structure and includes an outer cylindrical shell with horizontal connection and also lateral branches. Flanges 1, 9, and 13 are provided for connection to the fixed blade holder, the exhaust shell, and the combustion chambers, and components 4, 5, and 6 divide the cylinder into several parts. The turbine and compressor fixed blade carriers can be adjusted vertically and horizontally, and can be lifted from the outside by placing special parts through holes in the upper shell after placing and assembling the entire shell.

Internal shell (INNER Casing)

The inner shell directs the hot gases from the combustion chamber to the turbine inlet and surrounds the compressed air flow in all directions. The inner shell is a welded structure without shell knots made of heat-resistant alloys. It is around the rotor and has a protective cover and is located around the hollow axis. It closes with a rotor to provide uniform cooling by compressed air in front of the inner shell is a protective net 1 and at the end with a wall of air flow. The four support legs and the two central guides and the protective shell of the inner shell are placed in the center and control the thermal expansions. The indentation is designed to withstand thermal expansions and is attached to the inner shell and protective cover. The peripheral indentation is located around the inner shell of the compressor diffuser in the central protective cover. Two sealing rings are placed between the first row of fixed blades and the protective cover. A two-half sealing ring is attached to the seals (SEALS) holding the fixed blade.

Axis

Axial glands are used to minimize leakage of higher-pressure compression between fixed and rotating parts. The efficiency and reliability of the set depend on the optimal design of the glands. The turbine and compressor shaft glands are of the helical type. Spiral floods are located in both fixed and rotating components. They are machined on moving and rotating parts with machine teeth. On fixed parts, the coils are very close and consist of a single screw with a screw in the opposite direction of the leak gas flow. Most screws on fixed components placed as protective strips on the grooves and joints (A). Machined teeth (B) have seen in high temperature areas. If the teeth are lost, new sealing tapes replaced.

Conclusion

These glands minimize drops and prevent hot gases from escaping from the space between the fixed and rotating vanes. The axle gland at the turbine outlet prevents the exhaust gas from escaping into the ambient space as well as the flood air (SEAL) entering the bearing space. Axial glands in the second, third and fourth rows of fixed rows include

spirals or machined ribs on both sides. In the second and third rows of the ring, the fixed blades of the spirals installed with the sealing air provided by the fixed perforated blades also coming out of the holes. This prevents hot air from entering the coils and any other additional entry into the rotating parts. ANNULAR sealing air enters at through the hollow end. The coils seal the exhaust gas space. Leakage air mixed with the exhaust gas and the screw reduces the leakage of air into the atmosphere. The gland shaft is located at the location of the turbine bearing to allow thermal expansion and is protected by an outer shell and is positioned vertically by wires and the center guide horizontally. The gas turbine airflow can be controlled by adjusting the compressor inlet vanes (IGV). When the vanes open, the gas turbine airflow increases. When closed, the current decreases. This keeps the turbine outlet temperature constant over a load range. As a result, the combined cycle efficiency increases at partial loads. These vanes are driven by an electric motor with a gearbox which is connected to the foundation. This motor moves an open on the compressor in a circular direction. The eight bearings on the holder of the first row of fixed blades are responsible for adjusting the ring and are connected with levers and a push rod.

Disclosure Statement

No potential conflict of interest reported by the authors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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