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THE ROLE OF THE TURBINE GLAND SEAL STEAM SYSTEM IN A THERMAL POWER PLANT

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ABSTRACT

The Turbine Gland Seal Steam System (TGSSS) is a crucial and independent auxiliary system in thermal power plants. The system performs two functions at the gland seals along the turbine shaft. On the high-pressure side, it prevents high-pressure steam leakage from the turbine. On the low-pressure side, it supplies positive pressure steam to prevent outside air entering the vacuum section of the condenser. Maintaining system stability optimizes thermal efficiency, protects equipment, and maintains absolute vacuum throughout the operating cycle.

KEYWORDS: Gland Seal, Steam turbine, steam leakage, vacuum, positive pressure steam.

1. INTRODUCTION

In thermal power plants, steam turbines operate based on the enormous pressure difference between the inner stages of the turbine blades and the external atmosphere. The turbine shaft is a continuously rotating component that passes through the fixed turbine casing, creating natural mechanical gaps. Without control, two serious problems can occur: high-pressure superheated steam will escape, causing energy loss and operational safety hazards, or cold air from the environment will enter the low-pressure stages, destroying the vacuum of the condenser.

The Turbine Gland Seal Steam System is integrated into the cycle and it utilizes a series of labyrinth seals combined with the supply and recovery of steam at automatically controlled pressure.

The system includes the following core components:

- Steam supply source (main steam), reheat steam, or turbine extractive steam depending on the unit load.
- Gland Steam Regulator: Automatically adjusts the steam pressure to maintain a stable positive pressure.
- Gland Steam Condenser: Creates a slightly negative pressure to take the leaked steam and air mixture, condensing the steam into water for recirculation and releasing non-condensable gases.

2. STRUCTURE AND OPERATING PRINCIPLE

In the thermodynamic cycle of a power plant, the steam turbine is the device that converts the thermal energy of steam into mechanical energy to rotate the turbine and the generator. The turbine shaft is a large metal block that rotates continuously at high speed (usually 3000 rpm or 3600 rpm) and must pass through a fixed turbine casing. At these points of shaft penetration, mechanical clearances are unavoidable. The extremely large pressure difference between the inside of the turbine and the atmospheric environment creates two challenges:

- On the high-pressure (HP/IP) side: Steam, carrying high energy, tends to leak out.

- On the low-pressure (LP) side: The pressure inside the discharge chamber is lower than atmospheric pressure. Air ingress will cause loss of condenser vacuum, reducing pulsation efficiency and causing equipment oxidation. The Gland Seal Steam System is the mandatory technical solution to completely address these two risks.

The system operates based on a combination of mechanical jet structure and a pressure-controlled piping network.

The gland sealing diagram of a single-casing high-pressure turbine is shown in Figure 1. The end gland is designated as A, while the rear gland with vacuum is B. The front gland is divided into multiple sections by compartments a, b, c, and d. The inner part of the gland assembly has a larger diameter to balance the axial force acting on the turbine rotor. Compartments a and b are connected to non-regulated extraction steam pipes, where steam from compartment a is drawn back to the feedwater heating extraction line.

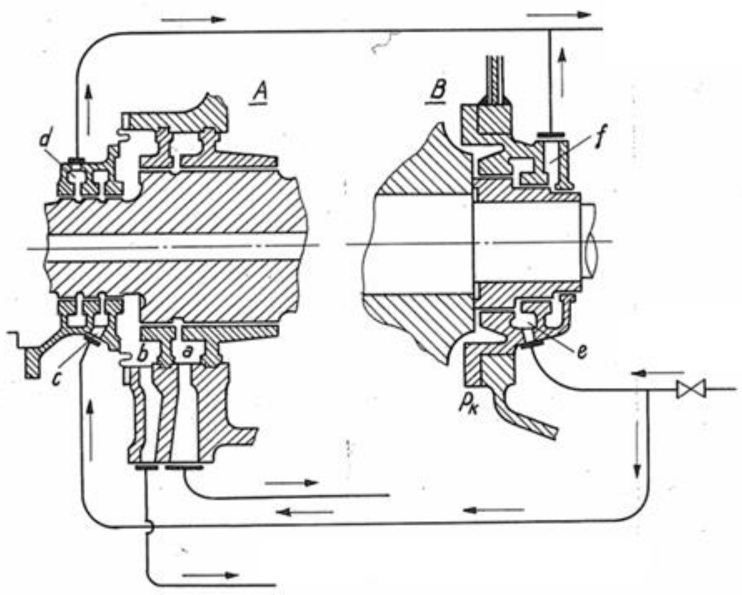

Figure 1. Diagram of steam supply to the high-pressure turbine Gland Seal Steam System.

In the front gland, saturated steam is supplied from compartment c to compartments b and d to prevent the possibility of air leaking through compartment b into the heater.

Relatively low-temperature steam is introduced into the front chamber of the gland assembly to prevent high-temperature steam from the turbine casing from flowing along the shaft toward the front section.

For the rear gland, saturated steam is delivered into compartment e to prevent air from leaking into the turbine exhaust pipe.

Supplying low-temperature steam to the low-pressure section is particularly important, because when the shaft carries shrink-fitted discs, the shaft journal must not be allowed to overheat.

To eliminate steam escaping through the pipes, an ejector is used to bring steam from compartment d of the high-pressure gland and compartment f of the low-pressure gland to the surface heater. Here, both the steam from the glands and the working fluid (steam) of the ejector will condense.

3. COMMON PROBLEMS AND SOLUTIONS DURING OPERATION

In power plant operation, the steam main system is one of the areas requiring strict monitoring due to the high risk of chain reactions and malfunctions: Optimizing thermal efficiency by thoroughly recovering the leaked steam and its heat at the GSC unit to preheat the feedwater, the system minimizes energy losses for the entire plant.

During power plant operation, the gland steam system is one of the areas requiring strict monitoring due to its high susceptibility to cascading failures as bellow:

No	Operational Incident	Cause	Consequences	Solutions
1	Loss of vacuum in the insertion system (Increased insertion pressure)	The GSC's exhaust fan is broken; its filter is clogged; the amount of steam leaking from the HP wall is too large, exceeding the capacity of the Dump Valve.	The steamescapes forcefully into the turbine chamber, destroying the oil film at the bearings and causing water contamination of the oil.	Switch to backup exhaust fan; Check and manually expand the excess air release valve (Dump Valve); Clean the GSC filter.
2	Pressure drop	The GSR pressure regulating valve is stuck closed; the external steam supply (auxiliary boiler) experienced a sudden pressure drop during startup.	Air is strongly drawn into the low-pressure (LP) turbine; the condenser vacuum drops rapidly; the low-pressure turbine casing temperature rises sharply.	Immediately open the bypass valve of the GSR pressure regulator to maintain pressure; urgently check and restore the auxiliary steamsupply.
3	Insertion steamtemperature is too low (Axial thermal shock)	The drain system on the steam pipe is malfunctioning; the attemperator is supplying too much water.	Causes sudden metal shrinkage; Increased eccentricity; Risk of mechanical contact between turbine blades and casing.	Check the steam traps; Open the manual drain valvesto drain the condensate; Adjustment the defrosting water flow to reduce the amount of defrosting water.
4	Flooded steam condenser insert (GSC)	The GSC's condensate drain steam trap is clogged; the condensate recovery line pressure has suddenly increased.	The exhaust fan draws water back out; the suction function of the packing system is completely lost.	Isolate and clean the steam trap of the GSC unit; Open the emergency bottom drain to release condensate.

4. CONCLUSION

The turbine gland seal steam system is a core auxiliary system in thermal power plants. Although the steam turbine gland steam system is an auxiliary system, it acts as the 'lifeline' controlling the pressure boundaries of the entire generator unit. The stability of this system directly dictates the condenser vacuum – a vital indicator of the power plant's thermal efficiency. Understanding the self-balancing operating principle, it strictly maintains the design pressure (0.1 - 0.3 bar) and temperature parameters along with the capability to promptly handle valve jamming or GSC (Gland Steam Condenser) flooding. It is the golden key for operation engineers to ensure safe, continuous, and highly economic power plant performance.

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