The Problem Solving of Exhaust Frame Air Cooling System Pressure Low in GE Frame 9 Gas Turbine

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ABSTRACT

EGAT's Bangpakong Power Plant has The Combined Cycle with Gas turbine GE Frame 9 with 4 Units, produce 100 MW each. The exhaust frame air cooling system consists of parallel blowers of two units (Exhaust frame blower). The ambient air used in cooling is supplied for the turbine shell, the exhaust diffuser radial struts and third stage aft wheel space. The exhaust frame system control flow and pressure cooling air by the flexible seal clearance. The important flexible seal clearance it’s between upper and lower half exhaust casing and between third aft wheel space. The effect for over clearance of flexible seal made exhaust casing distortion, high temperature on bearing No.3, high vibration, trouble alarm of “Unit Auto Reducing Load by Exhaust Casing Cooling Pressure Low” and shut down in a shutdown sequence. The maintenance & operation team monitored closely all systems and founded unusual exhaust frame air cooling pressure reduced. When unit reserved shutdown the exhaust frame system had inspected by visual. We founded that flexible seal damage such as material lost, melting and seal welding crack. Meanwhile we carefully considered to change flexible seal material to avoid thermal fatigue and welding residual stress for cyclic load operation, we was monitoring cooling air pressure rated and temporary repaired for availability of Power Plant. The preparation of spare part and scheduling provide for next interval inspection. For the cyclic load operation, all units must be monitored and corrected the data for the primary goal that can reduce power plant production costs. The improvement of inspection interval or inspection scope and spare part management should be considered for long life time operation, maintain function for availability and reliability electrical system in the country.
INTRODUCTION

The Bangpakong Combined Cycle Power Plant, BPK-CC3 and BPK-CC4, has been in commercial operation since 1994. Each block is a multi-shaft combined cycle system that has two gas turbine generators and two heat recovery steam generator (HRSG), in which supply steam through a common header to a single steam turbine-generator. Gas turbines are heavy duty industrial gas turbine served by Gas turbine GE Frame 9. The performance of plants have reduced and founded mechanical degradation in many compartments. Due to the fact that the plants generated over twenty years, and the merit order is the method used in the electricity market in Thailand, the both reason effect to Bangpakong Combined Cycle Power Plant generate in the cyclic duty operation instead of the continuous duty operation in which was demanded to start/stop every weekend.

Gas turbines wear in different ways for different service-duties. Thermal mechanical fatigue is the dominant limiter of life for peaking machines, while creep, oxidation, and corrosion are the dominant limiters of life for continuous duty machines. Interactions of these mechanisms are considered in the GE design criteria, but to a great extent are second-order effects. [1]

For the starts-based maintenance criteria, operating factors associated with the cyclic effects produced during startup, operation and shutdown of the turbine must be considered. Operating conditions other than the standard startup and shutdown sequence can potentially reduce the cyclic life of the hot gas path components and rotors, and, if present, will require more frequent maintenance and parts refurbishment and/or replacement. [1]

In term of effect by the cyclic duty operation in Bangpakong Power Plant, we found low pressure problem in exhaust frame cooling system which is significant by reason of it alarm trouble of “Unit Auto Reducing Load by Exhaust Casing Cooling Pressure Low” and cause shut down gas turbine in a shutdown sequence.
LOW PRESSURE PROBLEM IN EXHAUST FRAME COOLING SYSTEM

The exhaust frame cooling system consists of parallel blowers of two units (88TK - 1, 88TK - 2). The ambient air used in cooling is supplied for the turbine shell, the exhaust frame radial struts and third stage aft wheel space, as shown in Figure 1. Air separately supply to cool the turbine shell and the exhaust frame radial struts for maintaining tight turbine-section clearance control and to prevent the cracking, distortion and deform in exhaust frame. The air flow pass the struts for cooling and maintaining uniform temperature of the struts. Then air going to third stage turbine aft wheelspace and remainder running to the load tunnel.

![Diagram of exhaust frame air cooling system](image)

Figure 1. Exhaust frame air cooling system – Gas turbine

As the concept of exhaust frame cooling system, low pressure was unquestionably a sign of air leakage from some of cracking and/or over clearances in case of completely inspection of blowers, motor and functions. The maintenance & operation team monitored closely all systems and founded unusual exhaust frame air cooling pressure reduced. Therefore the exhaust casing was inspected immediately for the period of reserved shutdown condition and we found over clearance between upper half and lower half inner exhaust diffuser, as shown
in Figure 2. Air leakage test by running the exhaust cooling blower founded truly leakage stream through between clearances. The possible improvement response to the reliability and have no an impact on the plant availability is temporary repairing by using metal plate bar and welding both side along clearance. Figure 3 illustrate the way to temporary repair exhaust diffuser distortion. Nevertheless temporary repairing was done, the monitoring cooling air pressure rated still be running for certain reliability of power plant and prepare potentially scheduling of inspection and better enhancement in next interval.

Figure 2. Clearance of upper-lower half inner exhaust diffuser

Figure 3. Temporary exhaust frame repairing
SOLVING AND DISCUSSION

According to possible failure discussion by thermal mechanical fatigue and high cyclic fatigue, which may be exhaust diffuser distortion, flexible seal damage and deteriorate on third stage buckets. Scheduling provide for additional failure in the next hot gas path inspection.

Figure 4. Flexible seal cracked

Figure 5. Damaged key of upper half outer exhaust casing

For the duration of hot gas path inspection, there are several failures occur on exhaust diffuser part and construction. Figure 4 illustrate flexible seal crack which described reasonably damage by deforming of exhaust diffuser. The key of upper half outer exhaust casing damaged and dowel pin between upper – lower half exhaust diffuser failed and
distorted as shown in Figure 5 and Figure 6 respectively. Some of dowel lost by distorted casing.

![Image](image_url)

**Figure 6.** Damaged dowel and dowel hole

Discussion, firstly, as air separately supply to cool the turbine shell and the exhaust frame radial struts for maintaining tight turbine-section clearance control and to prevent the cracking, distortion and deform in exhaust frame. The cyclic operation cause thermal mechanical fatigue and effect to exhaust frame distortion. Moreover the flexible seal misaligned to end with crack. Figure 7 described low pressure exhaust cooling system due to air leakage through flexible seal to exhaust stream.

GE fundamental of gas turbine training manual describe “Exhaust frame radial struts cross the exhaust gas stream. These struts position the inner cylinder and third bearing in relation to the outer casing of gas turbine. The struts must be maintained at a constant temperature to control the center position of rotor in relation to stator. Temperature stabilization is accomplished by protecting the struts from exhaust gases with a metal fairing that forms an air space around each struts. Turbine shell cooling air flows through the space between the struts and the wrapper to maintain uniform temperature of the struts”.

The low pressure cannot stabilize temperature around struts and exhaust frame construction, meaning the center position of rotor in relation to stator uncontrolled. Temperature gradient occur on struts, exhaust frame deformed, the upper-lower half separated as showing as clearance. Likewise loss of cooling and sealing at third stage aft wheelspace and small flow to the load tunnel which effect to high temperature on third bearing. Exhaust gas stream may slightly run to root section of third stage bucket cause of short life third stage bucket and all seal around.
Secondly, problem solving, the effect of plant generate in the cyclic duty operation instead of the continuous duty operation in which was demanded to start/stop every weekend. The starts-based maintenance criteria were considered for preventing the thermal mechanical fatigue. The compartment was repaired, refurbished and considered new material for serving cyclic duty operation. The first question was “Which material is suitable for high cyclic fatigue?” the flexible seal material was changed from SUS 304 to SUS 310S which is more
composition of Ni and Cr. Inner cylinder liner was carefully replaced as shown in Figure 8 and additionally changed dowel pin and key of upper half outer exhaust casing.

Figure 9. Distortion solving by adding dowel pin

Figure 10. New flexible seal material SUS310S
CONCLUSION

The cyclic duty operation of gas turbine develop crack and failure in various seals for instance sheet metal and/or plate and welding for construction, sealing and clearance, especially deteriorate mechanical hot gas path. Exhaust diffusers should be inspected clearance of upper-lower half inner exhaust diffuser, for cracking at every combustion, hot gas path and major outage. It not only exhaust diffuser but also parts in hot gas path section should be apprehensively monitored and corrected the data for the primary goal that can reduce power plant production costs. The improvement of inspection interval or inspection scope and spare part management should be reconsidered. Optimized planning and correct implementation for maintenance is necessity for reduced forced outages unscheduled repairs and downtime, long life time operation, maintain function for availability and increased starting reliability electrical system in the country.

REFERENCES

[1] Heavy-Duty Gas Turbine Operating and Maintenance Considerations, GER-3620L.1 (10/10) GE Energy, Atlanta, GA