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Hot Gas Path Inspection (Hgpi) Of Gas Turbine Unit Type Ge Frame 9e An Documentary Study Involved the Steps of the (Hgpi) After 32k Running Hours of The Unit

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Abstract
This paper details the Hot Gas Path Inspection (HGPI) procedure, a crucial periodic maintenance task for Frame-9E gas turbine units manufactured by General Electric. Regular HGPIs are essential for ensuring efficient and reliable operation of the turbines and preventing internal component damage. The HGPI process is divided into three main stages: disassembly, inspection, and reassembly. During disassembly, various components are meticulously removed, including the turbine roof, burners, combustion chambers, and turbine blades. A detailed inspection follows, focusing on parts designated for replacement and those generally left untouched during HGPI. Based on the inspection findings, necessary replacements are made, and components are thoroughly cleaned before reassembly. The reassembly stage involves meticulously reinstalling all previously removed components while adhering to strict measurements and specifications. Following the successful completion of HGPI and any related auxiliary system maintenance, the gas turbine unit is signed off as operational and ready to be handed over to the operations team.
Keywords: Turbine, Iraq, GE Frame 9E, Replenishment Principle.

1. Introduction

the gas turbine units are equipped with a gas turbine produced by General Electric, known as the Frame-9E. Some of its key specifications include:
- Operating speed: 3000 RPM
- Configuration: Single-Shaft
- Cycle type: Simple-Cycle

The gas turbine unit consists of the following main components:
- Inlet air system
- Compressor
- Combustion chambers
- Turbine
- Exhaust system
- Generator
- Auxiliary systems

To ensure the efficient and reliable operation of the gas turbine units and to prevent equipment damage, regular maintenance activities recommended by the manufacturer are carried out periodically.
Pre-maintenance preparations include:
1. Recording unit readings and variables (temperature, pressure, vibration) and documenting them for comparison after completing the maintenance.
2. Providing a maintenance schedule specifying the required maintenance duration and tasks to be completed during the maintenance period, along with daily progress updates.
3. Procuring necessary tools, spare parts, and preparing the maintenance team.

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4. Obtaining official approvals and shutting down the unit for maintenance purposes.
5. Performing chemical washing and internal parts cleaning of the turbine after shutting down the unit to facilitate disassembly and ensure worker safety.
6. Organizing a mechanical work order including work tasks, worker names, and daily approval by the station engineer.
7. Shutting down all equipment and pumps, conducting electrical and mechanical isolation, and placing warning signs on circuit breakers, which are only to be reactivated after approval by the team leader and station engineer.
8. Securing a crane and positioning it as directed by the team leader to lift and extract heavy parts, with crane operation overseen solely by the team leader or an authorized individual trained for the task and knowledgeable about occupational safety precautions.
9. Safety department head approval of safety conditions and precautions at the work site, ensuring any noted safety concerns are addressed before work commences.

1.1 The goal of this research

In this paper, we will detail one of the most important periodic maintenance tasks for the Frame-9E gas turbine unit, which is the Hot Gas Path Inspection (HGPI).

The Hot Gas Path Inspection (HGPI)

(HGPI) is one of the most important maintenance tasks recommended by the manufacturer to ensure the units remain within the required efficiency and to prevent damage to the internal parts of the gas turbine. This is crucial as the internal parts have a designated operational lifespan set by the manufacturer, which should not be exceeded.
The Hot Gas Path Inspection is primarily divided into three main activities:

- Disassembly
- Inspection
- Reassembly

Disassembly and reassembly

involve several activities, including:

1. Erecting scaffolding at the turbine room entrance near the grid to facilitate the extraction of parts and ensure smooth movement for the team entering and exiting the work site.
2. Installing scaffolding beneath the ceiling to allow for opening the roof fasteners and preparing it for lifting, as well as opening pipes and parts that obstruct the path of lifting the roof and the parts intended to be lifted.
3. Opening the air ducts for the fans (BT), opening both fans and lifting them with their bases.

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Figure 1 ***BT fans with air ducts***

4. Elevating the roof and its support structure.

Figure 2Turbine roof

5. Numbering fuel nozzles, air and gas ducts for combustion chambers, and all related accessories for ease of reassembly during maintenance activities.
6. Opening and extracting air and gas ducts for combustion chambers, along with removing fuel pipes and drains.
7. Measuring the six-point check and recording it in special forms. This involves measuring the distance between the inner cover of the main compressor and the end of the rotor from specific inspection points and at several defined stages.
8. Installing two jacks under the turbine and compressor bodies.
9. Opening and extracting burners for all combustion chambers.
10. Opening all burner gates, totaling 14 chambers.
11. Opening and extracting spark plugs and flame detectors.
12. Opening and extracting retainers for all combustion chambers, used for securing flame carriers.
13. Opening and extracting liners.
14. Opening and extracting cross-fire tubes.
15. Opening and extracting flow sleeves for all combustion chambers.
16. Opening and extracting outer cross-fire and packing for combustion chambers.
17. Opening combustion chambers CAN NO. (4 & 11).
18. Measuring clearance values for transition pieces and recording them in special forms.
19. Opening and extracting flame carrier transition pieces.

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Figure 3 Dismantled old CI parts

20. Measuring the central readings of the first stage nozzle inside the CDC and recording them in special forms.
21. Installing scaffolding in the AUX room below the accessories shaft and lifting the mentioned shaft cover. Installing the rotation lever (ratchet) for manual rotation purposes using the lever or a special electric motor for the rotation lever during the process of opening and installing the blades, as well as inspection operations for the blades and, when needed, for pushing the turbine shaft for clearance readings.
22. Opening and extracting cooling fan pipes for the turbine casing, as well as bleed valve 1+2 pipes with their valves, along with opening the second support vent pipe.
23. Opening and extracting the ball horn.
24. Opening turbine cover bolts.
25. Lifting the upper turbine cover.

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Figure 4 upper turbine cover with old internal parts

26. Measuring the clearances for the three turbine stages and documenting them on special forms.
27. Opening and extracting the first stage nozzle for both the upper and lower sides.
28. Opening and extracting the support ring for the upper side only.
29. Opening and extracting the shroud first stage for both the upper and lower sides.
30. Opening and extracting the second stage nozzle for both the upper and lower sides.
31. Opening and extracting the second stage shroud for both the upper and lower sides.
32. Opening and extracting the third stage nozzle for both the upper and lower sides.
33. Opening and extracting the third stage shroud for both the upper and lower sides.
34. Opening and extracting the bucket first stage.
35. Opening and extracting the second stage bucket.
36. Opening and extracting the bucket third stage.

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Figure 5 Old turbine blades for the three stages

Figure 6 NOZZLE and FIRST STAGE NOZZLE

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Figure 7 RING SUPPORT upper part

By completing the first main activity, which is dismantling, we will proceed to the second stage, which is inspection.

INSPECTION:

The inspection process is divided into:

- Inspection of the materials intended for replacement during maintenance according to the recommendation of the American company GE, which includes:
    - Transition Pieces
    - Composition Liners
    - Dual Fuel Nozzle
    - First Stage Nozzle
    - Second Stage Nozzle
    - Third Stage Nozzle
    - Shroud First Stage
    - Second Stage Shroud
    - Third Stage Shroud
    - Bucket First Stage
    - Second Stage Bucket
    - Bucket Third Stage

The purpose of inspecting these mentioned parts is to determine whether there is any damage, study its causes, and prevent its occurrence.

- Inspection of parts that are usually not replaced during HGPI maintenance, including:
    - Airfoils for rows (BT) and also fans with passages and fans (VG)
    - Roof and supporting structure of the roof
    - All pipes, valves, and associated parts in the turbine room
    - Iron structure of combustion chambers and associated parts inside and outside
    - Materials that are not replaced during maintenance

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- Upper and lower turbine covers
- Gas diffuser and gas passage and associated parts
- Turbine shell cooling fans (TK) and associated parts

During the inspection of these parts, damages are identified for appropriate treatment.

PREPARATION BEFORE ASSEMBLY:

Before commencing the assembly process, it is necessary to remove combustion residues and wash the upper and lower turbine covers, and prepare and drill the shroud as outlined below:

1. Clean the upper and lower turbine covers and remove deposits and calcifications from them.
2. Clean the teeth of the vanes in the turbine cover and for all vanes that have been opened.
3. Perform visual inspection and inspection with the aid of a magnifying glass for the turbine body window and ensure there are no defects. In case defects are found, their causes and treatment methods are identified and removed.
4. Install shrouds for the three turbine stages sequentially and on both sides for proper alignment and fixation.

Special measurements and dimensions are adhered to, considering metal expansion under specified standards. After marking, shrouds are extracted, drilled, and the excess from drilling is removed for their fixation with the body.

Reassembly:

The reassembly process involves several activities, including:

1. Preparation and numbering of turbine blades (buckets) for all three stages.

Figure 8 Preparing the blades before installation

2. Installation and fixation of third stage bucket.
3. Installation and fixation of third stage shroud for both upper and lower sides.
4. Installation and fixation of second stage bucket.
5. Installation and fixation of second stage shroud for both upper and lower sides.
6. Installation and fixation of third stage nozzle for both upper and lower sides.
7. Installation and fixation of first stage bucket.
8. Installation and fixation of first stage shroud for both upper and lower sides.
9. Installation and fixation of second stage nozzle for both upper and lower sides.

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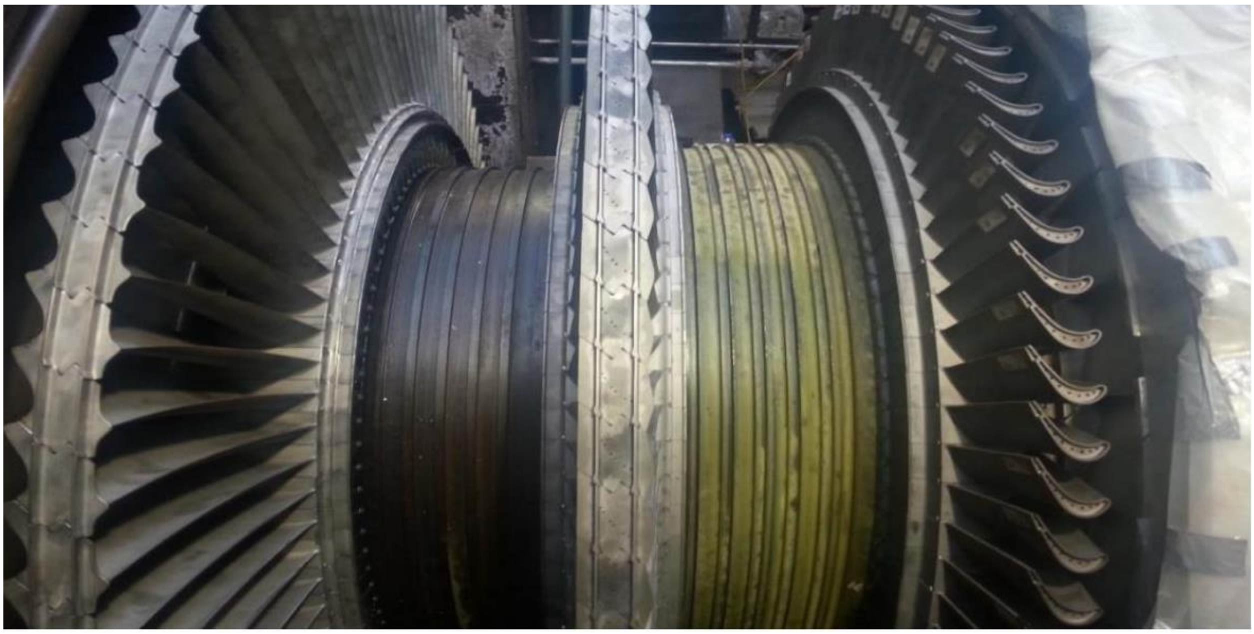

Figure 9 Completing the installation of the above-mentioned parts

10. Completion of installation of the aforementioned parts.
11. Installation and fixation of support ring (upper part).

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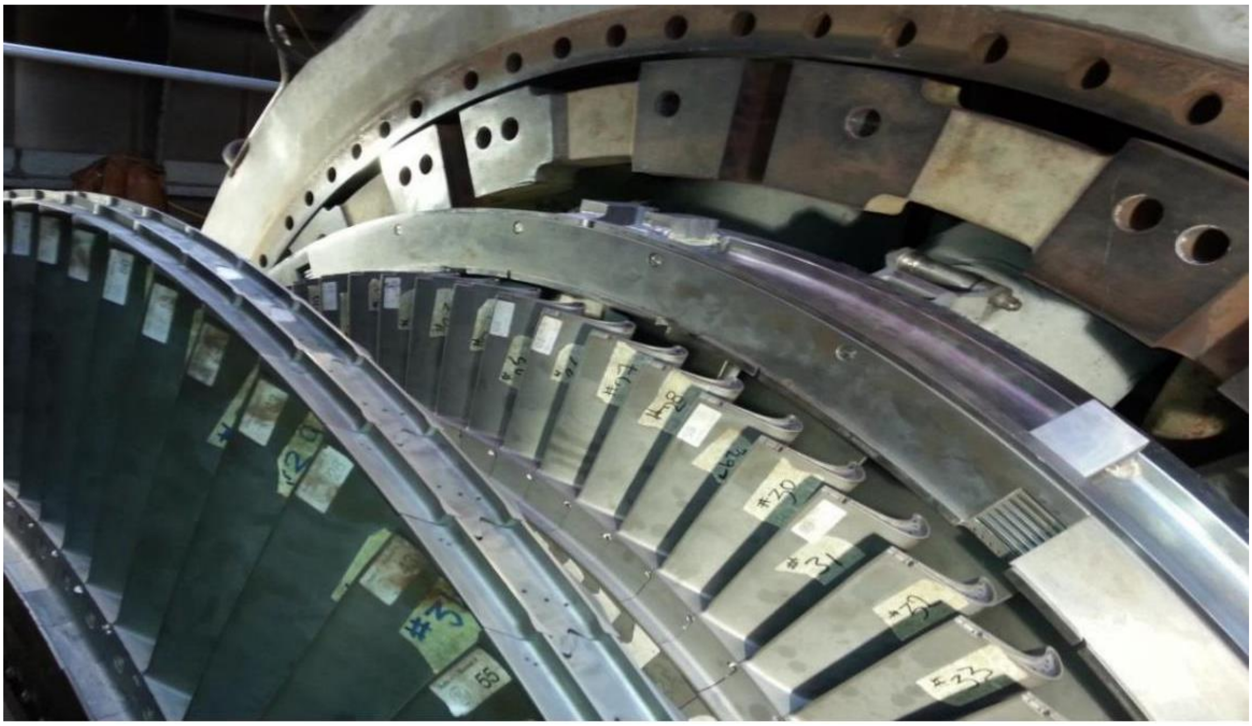

Figure 10 shows the installation of all internal parts of the turbine

12. Installation and fixation of first stage nozzle for both upper and lower sides.

13. Figure 11 illustrates the installation of all turbine internal parts.

14. After completing the assembly process, turbine clearances for all three stages are read and recorded for both sides.

15. Preparation of the upper turbine cover for lifting purposes for reinstallation.

16. Reinstallation of the turbine cover.

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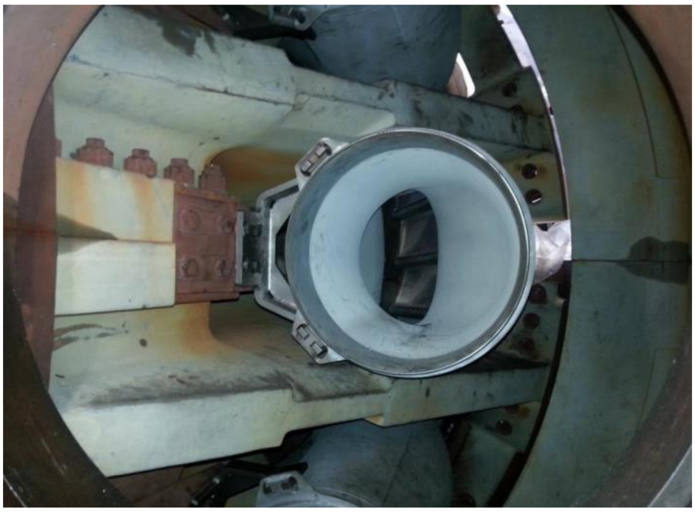

Figure 11 shows the installation of the new parts (N HOR BULL&TP)

17. Installation and tightening of turbine vanes.
18. Measurement of central readings for first stage nozzle inside the CDC and recording them on specific forms.
19. Installation and fixation of bull horn bases and bull horns.
20. Installation and fixation of transition pieces.
21. Figure 14 depicts the installation of new parts TP&BULL HORN.
22. Measurement of clearances (gaps) for transition pieces and recording them on specific forms.
23. Installation and fixation of combustion chambers (CAN NO. 4 & 11).
24. Installation and fixation of flow sleeves for all combustion chambers.
25. Installation and fixation of outer cross fire and packing for combustion chambers.
26. Installation and fixation of cross fire tubes.
27. Installation and fixation of liners in sequence with cross fire tubes.
28. Installation and fixation of retainer for combustion chambers.

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Figure 12 Closing the combustion chamber gates and installing fuel nozzles

29. Installation and fixation of spark plugs and flame detectors.
30. Closing of all combustion chamber gates (14 chambers) and installation of dual fuel nozzles.
31. Installation and fixation of fuel and purge valves with all fuel system accessories.
32. Installation and fixation of purge and water injection nozzles.
33. Installation and fixation of fuel lines, air hoses, and gas hoses.
34. Installation of bleed valves and second stage support bracket vents.
35. Installation of turbine shell cooling pipes with tightening of their respective vanes.
36. Installation and tightening of vanes for fan pipes (TK).
37. Installation and fixation of roof and roof support structure.
38. Figure 18 depicts roof installation.

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Figure 13 Assembly of pipes connected to the combustion chambers

39. Installation and fixation of BT fan bases with fans and their respective air ducts.

40. Figure 19 illustrates the reinstallation of BT fans with air ducts.

41. Lifting of the Rajit device with scaffolding in the auxiliary room and reinstallation of the shaft cover (ACCESSORIES SHEFT).

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Figure 14 Reinstalling BT fans with air ducts

After completing the assembly work, the following activities are carried out:
1. Removal of jacks (2 in total) from beneath the turbine body and compressor and extracting them from the site.
2. Measurement of Inlet Guide Vanes (IGV) openings and calibration if necessary, based on measurement results.
3. Removal and extraction of all scaffolding from the site.
4. Removal of all maintenance-related items from the site.
After completing the activities of hot path maintenance (dismantling, inspection, reassembly), in addition to the activities performed during the maintenance period on auxiliary systems related to the unit, the unit readiness for operation is signed off. This involves closing the work order and handing over the unit to the operation team for unit readiness preparation for operation.

Conclusion

The Hot Gas Path Inspection (HGPI) serves as a critical preventative maintenance procedure for Frame-9E gas turbine units. By meticulously disassembling, inspecting, cleaning, and reassembling key internal components, HGPIs ensure the efficient and reliable operation of these turbines while preventing potential damage. Regular execution of HGPIs in accordance with manufacturer recommendations is paramount for maintaining optimal power generation and avoiding costly downtime or equipment failures. This comprehensive inspection process safeguards the longevity and performance of the gas turbine units, ultimately contributing to a reliable and cost-effective power generation system.The Hot Gas Path Inspection (HGPI) is an indispensable preventative maintenance procedure for Frame-9E gas turbine units. This meticulous process, encompassing disassembly, inspection, cleaning, and reassembly of critical components, offers several key benefits:

- **Enhanced Efficiency and Reliability:** Regular HGPIs identify and address potential issues before they escalate, preventing costly breakdowns and ensuring the turbine operates at peak efficiency.

- **Extended Equipment Lifespan:** By proactively mitigating wear and tear on internal components, HGPIs contribute significantly to the longevity of the gas turbine unit.
- **Improved Safety:** Timely detection and rectification of equipment anomalies during HGPIs minimizes the risk of safety hazards associated with turbine operation.
- **Optimized Maintenance Costs:** HGPIs promote a proactive approach to maintenance, potentially reducing the need for unplanned repairs and associated downtime.

In conclusion, adhering to a well-defined HGPI schedule, as outlined by the manufacturer, is a strategic investment for power generation facilities. This comprehensive inspection process safeguards the health of the gas turbine units, fosters reliable power generation, and minimizes the risk of unexpected outages and associated costs. By prioritizing HGPIs, facilities can ensure their gas turbines operate efficiently, reliably, and safely for an extended period.

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