EFFICIENCY RERATE EXTENDS THE OPERATIONAL LIFE OF A 40+ YEAR OLD STEAM TURBINE

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ABSTRACT

Steam turbines are powerful workhorses that provide years of exceptional performance with routine maintenance and upgrades.

Steam turbine operating conditions often change over time. Different operating conditions or a change in application can affect a turbine's efficiency and increase operating costs. Off-design operating conditions can also cause premature wear of critical components, resulting in higher maintenance costs and increased downtime.

Elliott Engineered Solutions can rerate your Steam Turbine to increase its efficiency and capacity, while reducing operating and maintenance costs.

Elliott knows how to optimize your turbine's performance.

INTRODUCTION

A petroleum refinery in Louisiana was preparing for an upcoming 45-day plant outage and wanted to improve the operational efficiency of one of its steam turbines. The 15,000 hp, non-Elliott steam turbine was being used to drive a high-speed coker wet gas compressor. The efficiency improvement required a complex rerate to reduce the turbine's power, flow, and speed, and it needed to be completed in an accelerated time frame.

With the outage fast approaching, the refinery turned to Elliott to determine the best solution to maximize the steam turbine's efficiency. A team of Elliott engineers, technicians, and project managers from the Engineered Solutions group in Jeannette, PA and from the New Orleans service center worked together to plan and execute the rerate.

Steam turbine arrived at Elliott service center.

MATERIALS AND METHOD

Elliott was able to begin work on the rerate project while the turbine was still in operation prior to the plant shutdown. Since Elliott had not originally manufactured the turbine and did not have the equipment drawings, the engineering team relied on observations of the turbine while onsite and documentation provided by the refinery, including an instruction manual and operational data. The refinery also shipped a spare rotor, along with the turbine's spare journal bearings, a thrust bearing assembly, and oil seals to the service center for inspection and reference. The information collected from the observations, documentation, and spare parts enabled Elliott to approximate the steam path and estimate the scope of supply.

Steam Turbine before rerate

The original five-stage steam turbine had a double flow exhaust with short blades (rotating) and nozzles (stationary vanes) to accommodate the high-speed. This design limited the changes that could be made to improve the efficiency of the turbine. There were also operational issues with the turbine that needed to be investigated.

In an ideal situation, Elliott would have proposed a modern design steam turbine with a single flow exhaust and either increased blade height or an additional stage for maximum efficiency. However, the original turbine design made these options impossible. Elliott engineers opted for the next best solution, which was to focus on blade and nozzle design to minimize throttling losses and optimize efficiency.

The team also conducted a root-cause analysis prior to unit shutdown to identify design deficiencies that may have been causing the operational issues. This analysis was necessary to ensure that design weaknesses were not carried over into the rerated turbine design.

After evaluating all data and information provided, the engineering team determined that the turbine rerate required Elliott to manufacture several new components, including:

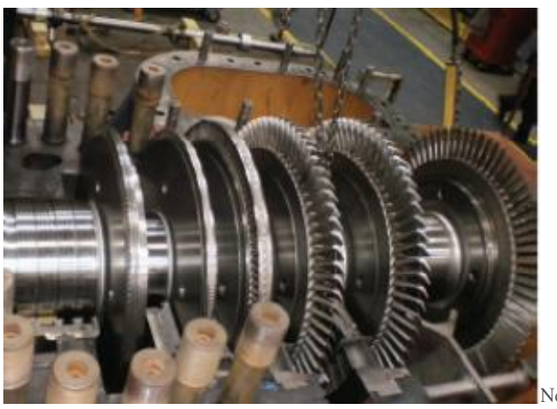
- Complete rotor assembly
- Set of diaphragms
- Nozzle ring
- Tip seals
- Labyrinth diaphragm seals
- Labyrinth steam-end and exhaust-end gland seals

With the tight rerate timeline, Elliott engineers began designing and manufacturing specific components immediately to ensure that they would be ready when the outage began. The new rotor was manufactured at Elliott's Jeannette, PA facility. The spare rotor provided by the refinery was used as a model, but Elliott used a single, solid forging for the new rotor and incorporated modern staging design to maximize efficiency. The rotor was also at-speed balanced in Jeannette to ensure mechanical integrity and smooth operation. The New Orleans service center manufactured the diaphragms and a special nozzle ring.

The refinery shipped the steam turbine to Elliott's New Orleans service center as soon as the unit shutdown for the outage. The service center worked around the clock to complete the rerate within the 45-day time frame.

The project team confirmed the scope of work with visual inspections and coordinate measuring machine (CMM) scans. The new components received final machining for precise fit in the existing casing, and the parts to be reused were refurbished. The turbine was reassembled, and an Elliott nameplate was affixed to the casing to classify it as an Elliott machine. The rerated turbine was then returned to the refinery for installation.

The projecteam documented all changes and provided the refinery with updated equipment manuals and drawings. The documents serve as an essential reference for future maintenance and to simplify the ordering of spare parts.


New integral rotor

Existing Turbine with new internal installed

RESULTS

Elliott Field Service managed the re-installation of the turbine at the refinery. The team configured the turbine controls and installed several components and systems critical to the new process requirements, including a new trip and throttle valve, a sealing steam and leak-off system, and oil piping. Performance testing was also performed on the steam turbine to validate that it was operating properly. The rerated turbine was successfully brought online on schedule with the plant turnaround.

Rerate Turbine ready for shipping

CONCLUSION

Elliott Engineered Solutions has the engineering knowledge and expertise to rerate any type of turbomachinery. Whether the equipment was originally manufactured by Elliott or by a different manufacturer, Elliott understands the critical function of specialized components and uses modern materials and manufacturing methods to fabricate the highest quality parts that are designed to fit the equipment perfectly and meet the specified operating conditions.