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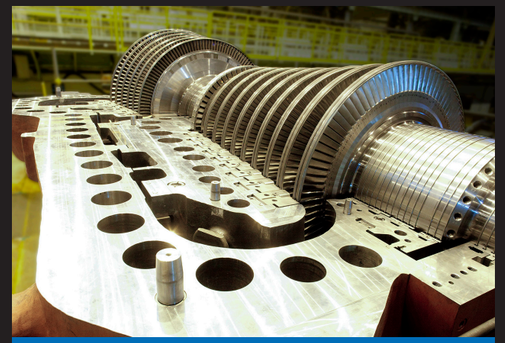
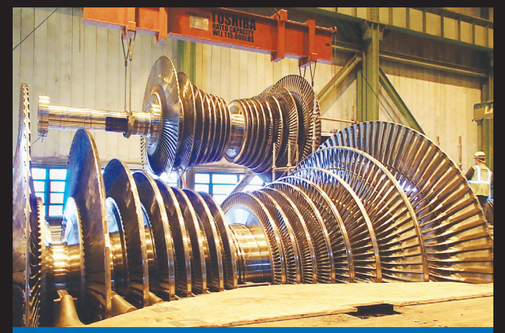
TOSHIBA

STEAM TURBINE RETROFITS

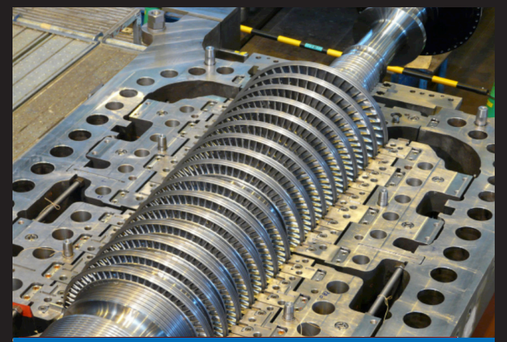
HP Inner Module for G3 Turbine



HIP Inner Module for G2 Turbine



LP Inner Block Retrofit



Toshiba Test Facility (actual power station)

Toshiba America Energy Systems (TAES) presence in the North American power generation market has grown significantly since our first units were installed in the US in the late 1960s. Toshiba's North American installed base now stands at over 110 units. Our US based infrastructure has grown proportionately to serve this fleet of large steam turbine-generators. All of the parts manufacturing and repair capability to support the US Toshiba fleet is done in the 165,000 square feet of our Milwaukee Service Center (MSC). MSC is a fully-integrated turbine and generator service facility with state-of-the-art equipment and a crane capacity of 300 tons.

Toshiba Experience
Toshiba was a licensee for G2/G3 type steam turbine-generators from the 1950s until the early 1970s. During that time, Toshiba supplied a significant number of units based on those designs to Japanese utilities and to overseas customers. Because of this history, Toshiba not only knows the details of G2/G3 type machines, but the design philosophy as well.

Toshiba continues to develop unique, cutting-edge steam turbine/generator technology to enhance efficiency, reliability and flexibility. Beginning in the mid-70s Toshiba supplied units of our own design including world-class ultra-supercritical turbines.

Since introducing Toshiba Retrofit Products to the US in 2005, we have engineered these Toshiba components into existing G2/G3 type steam turbines and generators. Retrofit Products include steam turbine section upgrades, valve casing replacements, multi-hole bypass valves, liquid-cooled stator rewinds and generator rotor replacements. We are staffed to support this aftermarket Retrofit upgrade business from the MSC in addition to servicing the US Toshiba steam turbine-generator fleet.

Purpose of Retrofitting
Since many fossil fueled steam turbines are currently operating at less than optimal efficiency and ever changing conditions, the following benefits can be realized by retrofitting the steam path inner module:

- Matching turbine operation to changed dispatch parameters
- Increasing turbine efficiency (reduced plant CO_2 emissions and heat rate)
- Matching of the turbine swallowing capacity to suit current or planned boiler capacity
- Extending outage intervals
- Improving reliability with new rotor(s), steam path components and upgraded designs
- Replacing components at or near end of design life
- Increasing MW output
- Mitigating operational challenges by replacing with the latest proven technology, including advanced L-1 and L-0 blades

Customized Retrofits Leveraging Toshiba's Advanced Flow Path Design
In general, a turbine retrofit is a complete steam path replacement customized to your specific application requirements. Turbine retrofits are designed to fit within the existing outer casing, saving money and reducing outage duration. Toshiba's state-of-the-art turbine retrofit utilizes the Advanced Flow Path design which will likely increase the stages in the turbine sections compared to the original design. The new retrofit steam path design significantly increases turbine efficiency and extracts the maximum available energy from the steam supply.
In addition, Toshiba's focus on advancing our steam turbine technology results in class-leading performance, reliability, sustained efficiency and operational flexibility. This all leads to extending outage intervals.

Highlights of our HP and IP turbine section retrofits include:

- AFP (Advanced Flow Path) steam path optimized using the latest 3D CFD flow analysis for exceptional efficiency and performance
- Snubber blades with integral covers are continuously coupled for efficient tip sealing and excellent vibration dampening characteristics, providing high performance and reliability
- Advanced steam sealing features for high, sustained efficiency and operational flexibility
- Steam path geometry with advanced materials and coatings to mitigate solid particle erosion (SPE)
- Throttle and nozzle governing mode operation for optimal operational flexibility and efficiency at essential load ranges
- Rotors made from high purity monoblock forgings without bores and with optimized geometries reduce stresses for high reliability
- Shop pre-assembly and Computer Aided Assembly of new retrofit components to ensure proper fitment and shorter installation duration

Highlights of our LP turbine section retrofits include most of the above and:

- Proven designs and materials mitigating the mechanism for SCC which allows for increased outage intervals and superior reliability
- A complete range of advanced steel last stage blades for maximum efficiency and output
- Reliable last stage blade designs permitting flexible low load and extended high back pressure operation
- Highly effective moisture erosion protection, featuring available EBW Stellited last stage blades

Fully 3D Steam Path Design
Using the latest in computational fluid dynamics (CFD) has enabled Toshiba to develop and optimize our fully three dimensional blade designs. These designs consider both distribution losses and leakage losses at the root and tip. The technology allows the interaction of stages within Toshiba's optimized reaction design steam path to be carefully adjusted, while satisfying the constraint of retaining the outer shells.

Full-Scale Test Facility
In order to precisely demonstrate reliability and efficiency, Toshiba operates a full scale test facility that also acts as a functioning generating unit. This unit is connected to the commercial grid and allows Toshiba to install and operate full scale "test steam paths" that can be tested and analyzed under a range of live plant conditions.