Modernization for Ammonia Syngas Trains with Steam Turbine Drives

Modernization options for ammonia syngas trains can meet a wide range of plant requirements for uptime, efficiency, costs, and footprint.

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Many ammonia plants in the United States and abroad are more than 50 years old. As operators seek to extend the life of these facilities, syngas trains have become a target of modernization projects due to their significant impact on overall plant efficiency, production capacity, and operating expenses.

In recent years, revamp requests for ammonia syngas trains have focused on upgrades to legacy steam turbine drives. Currently, more than 35 Delaval 103-JAT steam turbines are in operation in Kellogg process-based ammonia plants globally. There are many available upgrades for syngas trains that utilize the 103-JAT frame. Modernization options are diverse and can meet a wide range of plant requirements for uptime, efficiency, costs, and footprint.

STEAM PATH REVAMP

Steam path revamps are an effective way to improve a steam turbine's power, reliability, and efficiency.

With modern thermodynamic and mechanical design software, in certain cases, it is possible to pass more flow through a turbine and increase its rated output by simply changing the design of the first-stage blades and nozzle plate. Advanced 3D modeling software enables OEMs to implement new designs with greater predictability and fewer challenges, such as vibration. This capability is especially relevant today, with many customers opting for performance guarantees, particularly when it comes to uptime.

In one case study, upgrading multiple steam pathways increased the turbine's rated power from 13,095 HP to 17,000 HP, in addition to a 6 - 7% efficiency improvement.

New steam paths utilize optimized airfoil designs, improved seals, and a fine-tuned aerodynamic match of stationary to rotating airfoils. Additionally, improvements to the mechanical components such as bearings, seals, and valve operating gear parts can lead to improved reliability.

One revamp to the Delaval 103-JAT is a conversion from a two- to three-wheel configuration. Original two-stage 103-JAT frames can generate around 11,000 HP. Converting to a three-stage design offers several advantages, including an approximate 6% increase in steam rate, higher reliability, and improved rotor dynamics due to thicker shafts and larger journal bearings. Original internals can be kept and used as spares.

Several other minor upgrades can be made during the same scheduled maintenance period. Some examples include but are not limited to:

FIGURE 1: Performance Comparison Before and After Steam Path Revamp

Original Steam Flow @ 13,095 HP	Adjusted Steam Flow for Aging Loss (est'd) 13,095 HP	Revamp Steam Path @ Orig 13,095 HP	Revamp Steam Path @ 17,000 HP
116,000 Lb/hr	124,000 Lb/hr	109,000 Lb/hr	140,600 Lb/hr
8.86 Lb/HP-Hr	9.47 Lb/HP-Hr	8.32 Lb/HP-Hr	8.27 Lb/HP-Hr

Spherical nuts for control valves. Nearly all Delaval turbines use an internal lifting bar to sequentially raise the steam control valves. Older units use flat-bottomed nuts assembled to individual valve stems to set the lifting adjustment and lift the valves. In cases where the valve seat and control valve are misaligned, a bending moment can be introduced into the valve stem during the initial lift—this could eventually lead to valve-stem failure. Installing nuts with a spherical bottom addresses this problem. The nut allows the valve to place itself in the valve seat and eliminates the inherent bending moment. This design has been successfully used for over 20 years.

Anti-lube valve rack bushing conversion. On older machines, the main lever arm on the control valve rack is fixed in end support columns by ball or roller bearings. These bearings are in a high-temperature area atop the steam chest and require routine lubrication with high-temperature grease. The location and temperature are a challenge to any form of maintenance and, as a result, the bearings eventually seize or wear prematurely.

Self-lubricating sleeves can be installed in place of the original bearings to eliminate routine lubrication requirements. These have been proven for years on later-designed turbines. The conversion package consists of sleeves and custom-designed adapter bushings as direct drop-in replacements—no field machining is required. The conversion package includes the parts, plus an updated valve gear assembly drawing showing these parts for future records.

Retrofitting control systems to enable remote monitoring and diagnostic services (RDS). Many legacy steam turbines are still operated using mechanical-hydraulic or older electronic controls. Wear and tear on components and an uncertain supply of spare parts for older electronic systems can impair efficient operation. In many cases, RDS can be implemented to enable advanced capabilities, such as early warning of failures, root cause analyses, remote troubleshooting, etc.

TRIP AND THROTTLE VALVES

One of the most challenging tasks for ammonia plants utilizing steam turbine drives for syngas compressors is to prevent a turbine overspeed triggered by designated turbine monitoring inputs.

Trip and throttle valves (TTVs) are designed to protect personnel and plant assets by rapidly stopping steam flow into the turbine. Many syngas trains today still utilize mechanical latch TTV technology, which was developed in the 1950s. While proven, past experiences overhauling TTVs have shown that many pressure boundary components, like cast valve bodies and yokes, are used well beyond their normal service life due to years of exposure to unknown pressure and temperature transients. Issues such as erosion, corrosion, and stress cracks have been discovered while performing non-destructive testing. These components can usually be repaired or replaced; however, lengthy and costly weld repairs or complete casting replacements can exceed new technology valve replacement costs and extend loss of production.

Siemens Energy's Gimpel TTVs have been used on a wide range of OEM steam turbine frames since the 1950s. The top inlet Gimpel valves (TITTVs) on the Delaval 103-JAT steam turbine frame have always been challenging to replace. The mechanical latch design is outdated, and standard valve replacement options do not fit the available deck space.

Corrosion and contaminate build-up on TTVs are also problematic, as they can affect trip-time or full close of the valve. In most valve designs, spring compression is used to reset the TTV during partial stroke testing (PST) through direct mechanical movement

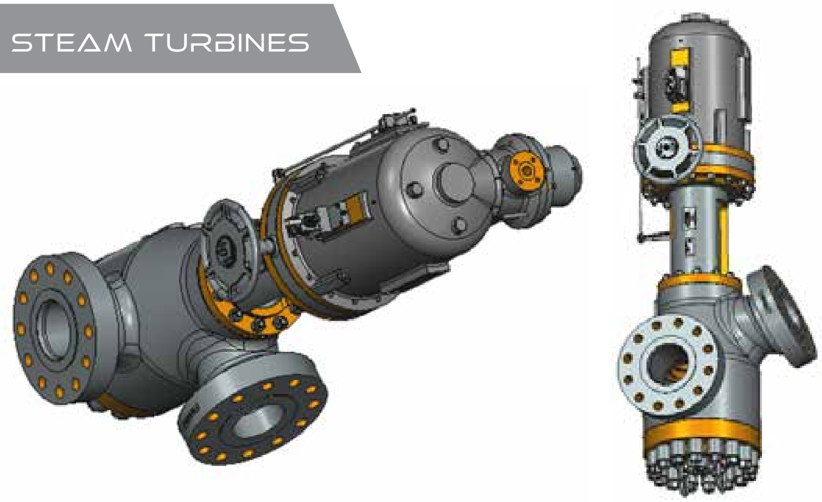

FIGURE 2: Gimpel oil-operated trip and throttle valve with unique steam section casting.

via handwheel operation. The potential for spurious trips caused by the TTV during PST can lead some operators to avoid and/or delay recommended stroke testing (every 2 - 4 weeks), which presents a significant safety risk.

Improvements to the Gimpel TTV technology are continually made to address operational pain points and support the increasing demand for plant safety. Currently, Gimpel offers two types of modern valve replacements for TITTVs on Delaval 103-JAT frames, designed with unique steam section geometry to facilitate space constraints on existing deck arrangements.

Fully Oil-Operated TTVs (OOTTV). Designed for pull-to-close operation, OOTTVs utilize hydraulic oil pressure supplied by the turbine control oil system for valve reset and PST. With hydraulic operation, OOTTVs utilize a stronger closing spring for faster trip time (0.03 second versus 0.05 second for TITTV) and more accurate throttling at start-up. Both oil-operated trip valves (OOTVs) and OOTTVs are available depending on the turbine's in-operation throttling requirements.

Electro-Hydraulic TTVs (EHTTV). Designed for pull-to-close or push-to-close operation, EHTTVs have a self-contained hydraulic system and a microprocessor-controlled electro-hydraulic actuator. EHTTVs close in 0.3 seconds or less and provide the most accurate turbine throttling on start-up. No turbine oil is required. The valves can be installed in any orientation based on the available space and are most adaptable for integration into a distributed control system.

Replacement of a mechanical latch TTV with one of these two options can yield a high return on investment. In recent years, Siemens Energy has executed numerous TTV replacements on ammonia syngas trains and received positive feedback from customers. Real-world experience has shown that, in many cases, the costs of installing new technology versus repair costs of a decades-old safety device provide a lower total cost of ownership and improved operational and performance benefits.

FOOTPRINT SOLUTION

In recent years, footprint solutions have emerged as an economical alternative to short-term repairs or partial modernizations.

A footprint turbine is a replacement machine that can be installed with few—and in some cases, zero—modifications to the existing foundation or piping interfaces. The current oil system, the driven machine, and/or the gear can be reused or adapted according to new operating parameters. The approach is especially appropriate when modifications must be made for new operating data or when the service life of highly stressed components has been exhausted.

One significant advantage of a footprint turbine is the increase in plant availability resulting from lower production downtime. The components in the new turbine are designed and manufactured according to unique customer requirements. As existing capital and spare parts can still be used, the investment expense is comparatively lower than purchasing a brand-new turbine system.

COMPRESSOR REVAMPS

Compressor revamps are applicable when process conditions have changed sufficiently such that the original compressor aero design is no longer appropriate, i.e., the unit is operating at or near its boundary conditions. While there are cases where the installation of a new compressor package and foundation, piping, ancillary systems, etc., is unavoidable, operators can save on CAPEX and associated downtime by modifying or upgrading the existing compressor. Potential upgrades can include:

- Complete re-aero of the compressor internals and conversion of the gearset, including stationary and rotating parts, without changes to the casing, external process connections, and/or existing footprint
- Upgrades to the lube oil or control system to enable remote monitoring
- Material upgrades to O-rings (upgrade to polymer or Teflon) or labyrinth seals (from aluminum to PEEK/PEK)

DETERMINING THE RIGHT MODERNIZATION APPROACH

For any ammonia plant modernization project, a comprehensive analysis of the steam turbine and compressor condition, along with customer objectives, is required to determine the optimal approach. A look at the current and future requirements will quickly reveal which systems, components, and parts can still be used and which have to be adapted and replaced.

After a preliminary evaluation, a feasibility analysis can be conducted, which allows the operator to evaluate the costs of retrofits or upgrades for the existing turbine(s) and system. Modernization activities can then be scheduled to coincide with planned outages so that customer downtime can be minimized and operators realize a maximum return on investment. ■

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