Axial Compressors

When an application demands high flow and high efficiency at relatively low pressure ratios, axial compressors are preferable to either centrifugal or reciprocating compressors. Axial compressors can achieve pressure ratios up to 5.5 while handling up to 350,000 CFM of working fluid with polytropic efficiencies up to 90% and beyond. They are commonly used as main air blowers for Fluid Catalytic Cracking processes in refineries and as blast furnace blowers in steel mills. Other uses include air separation, sewage aeration, aero test facility supply air, and compressed air energy storage.

How they work

Axial compressors consist of a series of stages, each with a rotating component (blade) and a stationary component (vane). The working fluid is accelerated by the blades, while the vanes convert this kinetic energy into static pressure. Axial compressors generally have between 3 and 17 stages, depending on the required pressure ratio and rotational speed. Volume capability is controlled by varying the size of the flowpath.

Off-design operation is achieved through the use of variable geometry (adjustable vanes in the first few stages) or variable speed to meet changing process requirements.

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imagination at work

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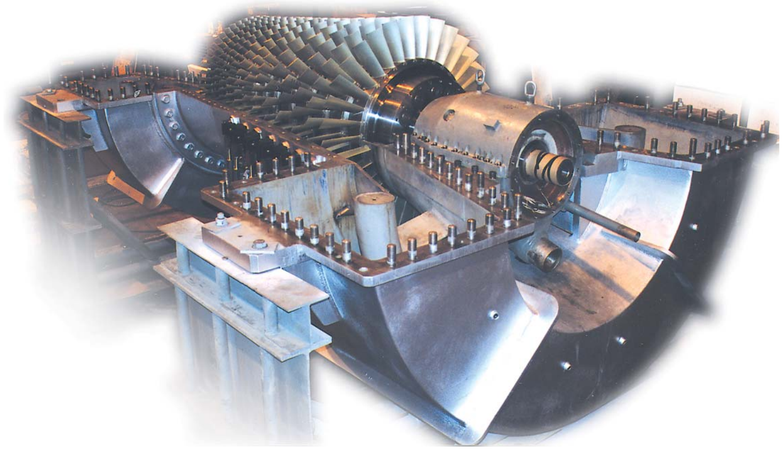


Axial Compressors

New units, rerates and full service for all OEMs

Comprehensive solutions

GE's Conmec compressor services provide specialized, highly engineered solutions to the most challenging problems in turbomachinery. Whether we're building a compressor of our own design, or uprating one of another manufacturer, our machines are unique and highly reliable. Every project incorporates innovative design solutions to overcome operational difficulties such as airfoil erosion and corrosion, performance deficiencies and mechanical problems.

Uprate existing units

Using our extensive expertise backed by the latest technologies and analytical tools, we have transformed many outdated axial compressors into modernized, efficient machines. We can rerate an axial compressor to deliver substantially different flow conditions and pressure requirements. Your plant's existing equipment can be modified and rebuilt to maximize frame capability – sometimes even beyond the OEM's standard model limitations.

Build complete new units

Our installed base continues to grow as more users become familiar with the significant advantages of our turbomachinery design capabilities. Our axial compressors range in size from the AX1700 series to the AX3700 series, with flow capabilities ranging from 20,000 CFM (40,000 m^3/hr) to 350,000 CFM (595,000 m^3/hr). They are custom designed to meet an almost limitless combination of flow and pressure requirements.

State-of-the-art analytical tools

GE has developed and invested in powerful analytical capabilities. These tools, and the skilled engineers who use them, are your resources to solve nearly any aerodynamic, mechanical or stress/structural related design challenge.

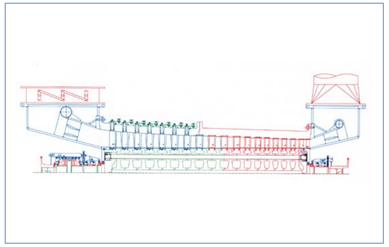
Finite Element Analysis (FEA)

Utilizing ANSYS® and Pro/MECHANICA analytical tools, we optimize components to safely expand the design parameters of existing equipment. Areas of consideration range from transient vibration and modal analysis of airfoils to steady state stress analysis of rotor blades and attachment areas.

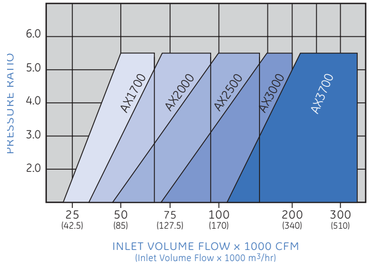
Computational Fluid Dynamics Analysis (CFD)

CFD analysis allows us to design more efficient flow path components while decreasing the effects of solid particle erosion and fouling deposits. CFD analysis, in conjunction with our laboratory test stand analysis, lets our engineers correlate field data with predicted model data. Optimizing the flow path allows for reduced deposition as well as enhanced performance and reliability.

Axial compressors you can rely on



Schematic of AX3017-7 axial compressor with original (blue), new (red), and reworked (green) components.



New life for old machines

Maximizing the service life of equipment from any manufacturer is the objective of every repair and overhaul we undertake. Each project is supported by GE's world-class machinery and manufacturing capabilities, quality control, project management and field service.

Component parts replacement and manufacturing support

All our axial compressor repair and overhaul work is driven by our high quality replacement parts, manufactured at competitive prices, with deliveries that meet or exceed customer requirements.

Replacement parts include:

- Rotor blades and rotor components
- Fixed and variable stators
- Variable stator positioning systems and components
- Casings and casing components
- Bearings, seals and fasteners
- Couplings and guards

With proven manufacturing methods and practical experience, we can refurbish or remanufacture an axial compressor unit to "zero time" condition. Our industry-proven methods include:

- Rotor blade slot rebroaching/remilling
- Rotor shaft weld repair
- Airfoil blending and frequency retuning
- Seal redesigns/upgrades
- Material upgrades
- Critical component replacement

Complete solutions from one source

We provide increased capacity, improved reliability and decreased maintenance costs through uprated compressor component designs, including rotor blades, stator vanes, and casing components. Engineered uprates are available in the following areas:

Mechanical uprates
Replacement of existing compressor components with state-of-the-art designs to improve performance.

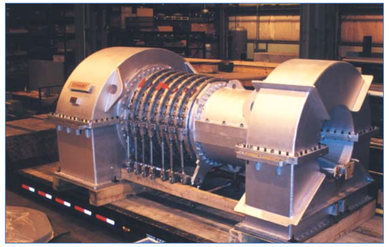
- Mechanical design improvements for reliability
- Aerodynamic design improvements for increased flow/pressure capability
- Metallurgical upgrades for corrosion resistance
- Structural design upgrades for mechanical stability
- Rotor redesign for reliability and maintenance

Performance rerates
We can uprate an existing unit's performance by applying advanced design and metallurgical techniques to redesign the aerodynamic flow path components for different inlet conditions, increased capacity or discharge pressure.

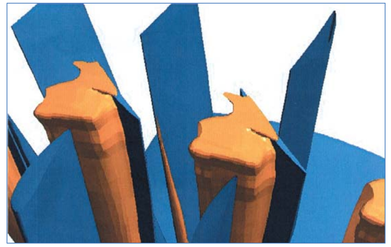
Reapplication of turbomachinery
For expedited installation, or as a cost-effective alternative to new equipment, we can locate a previously owned axial compressor and remanufacture it to meet the required conditions.

On-line wash systems
Provisions for on-line solution washing of an axial compressor can be incorporated for recovery of some of the performance lost through fouling during normal operation.

Surge control systems
We can evaluate your existing surge control system and make recommendations for improved operation. The system and load control can be optimized with an uprate and/or conversion to our Turbo353 PLC-based controller, or that of any other manufacturer.



I-R 4013 axial compressor completely refurbished to "zero time" condition after 30 years of service.



Computational Fluid Dynamics (CFD) model of Mach 1 Iso-surfaces.

Case study

Same footprint – more kick

A refinery on the Texas gulf coast was about to undergo a plant-wide turnaround including a major revamping of its Fluid Catalytic Cracking Unit (FCCU). The facility was under its fifth owner and consistent operating and maintenance procedures had been lacking through the years. The condition of the FCCU had declined so that productivity now suffered due to a bottleneck caused by limited air supply and unplanned outages.

The goal was to increase the FCCU production rate by 10,000 BPD that year and allow for an additional 15,000 BPD in three years. The rerate required a 16% increase in supply air from the axial compressor at an increased pressure ratio of 10%. To meet this objective, the axial compressor would need to supply an additional 100,000 lbs/hr of air at 66.5 psia.

Background

The original PRT configuration was an Ingersoll-Rand META-4015 axial compressor driven by an Ingersoll-Rand E-148 hot gas expander, a Westinghouse 4,000 HP motor/generator and a Murray R2JD7M2 6,000 HP steam turbine.

In addition to the air compressor, the hot gas expander and starter steam turbine were also uprated.

The increase in air flow from the rerated compressor and oxygen supplementation resulted in a comparable increase of process flue gas to the hot gas expander, which resulted in approximately 2 MW of additional power recovery.

The increased power requirement of the larger axial compressor required a significant steam turbine uprate to approximately twice the power.

Practical and economical modifications

To achieve the flow and pressure ratio increases with the same number of stages, the existing axial unit would have required a significant speed increase and replacement of nearly all the flow path components (including rotor blades, stator vanes and stator casings) due to changes in the flow path shape, airfoil frequency tuning, etc.

However, a speed change was not a viable option since the train speed was fixed by the motor/generator at 3,600 RPM. There was no room for a gear in the train. The alternative was to increase the number of stages and increase the flow path diameter to accommodate the new conditions.

We concluded that the existing speed and footprint could be maintained by changing the flow path airfoils and increasing the stator casing flow path diameter. The original compressor employed identical airfoils for all 15 stages. By changing the stage spacing in the rear of the compressor, two additional stages could be added while maintaining the rotor bearing-to-bearing centerline distance. And since a new high pressure stator casing was already required, adding stages was a viable option. This approach also meant that existing piping connections and base plate pedestal connections could remain with no special foundation or piping work required.

In the interest of saving time and money, we proposed the use of components from a surplus axial compressor. Doing so reduced the estimated cost to just 55-60% that of similar new components. Benefits included a significantly lower overall budget, plus reduced on-site work scope.

Following completion of the project upgrades, the FCCU was restarted on schedule with all of the turbomachinery meeting or exceeding performance expectations.