Expanders

Expanders are typically used to recover energy from process tail or waste gas, or in pressure let-down stations in place of a throttle valve. The energy recovered, which would otherwise be wasted, is used to drive other equipment needed for the process (air compressor) or to produce electricity (generator drive) thereby increasing the efficiency of the plant. Common applications include:

- Steel mills (blast furnace)
- Air separation plants (cryogenic)
- Oil refineries (FCC)
- Chemical plants (nitric acid, ethylene oxide)

How they work

The gas passes over the nose cone of the expander, into the stator blades and impacts the rotor blades. The rotor blades extract the energy from the gas and convert it into rotational energy through the disc and shaft. This expansion process results in a temperature drop in addition to recovery of the pressure energy. Hot gas expanders are very much like power turbines in aircraft derivative gas turbines and can be designed and fabricated with special metallurgy and features required by the process conditions to ensure long life.

GE Oil & Gas
1333 West Loop South, Suite 800
Houston, TX 77027 USA
T +1 713 803 0900
F +1 713 803 0499

1480 Center Valley
Bethlehem, PA 18027 USA
T +1 610 758 7500
F +1 610 758 7501

Nuovo Pignone S.p.A.
Via Felice Matteucci, 2
50127 Florence, Italy
T +39 055 423 211
F +39 055 423 2800

www.ge.com/oilandgas

24-hour customer support
Inside US: 866-GEOILGAS
Outside US: 484-821-0400

imagination at work

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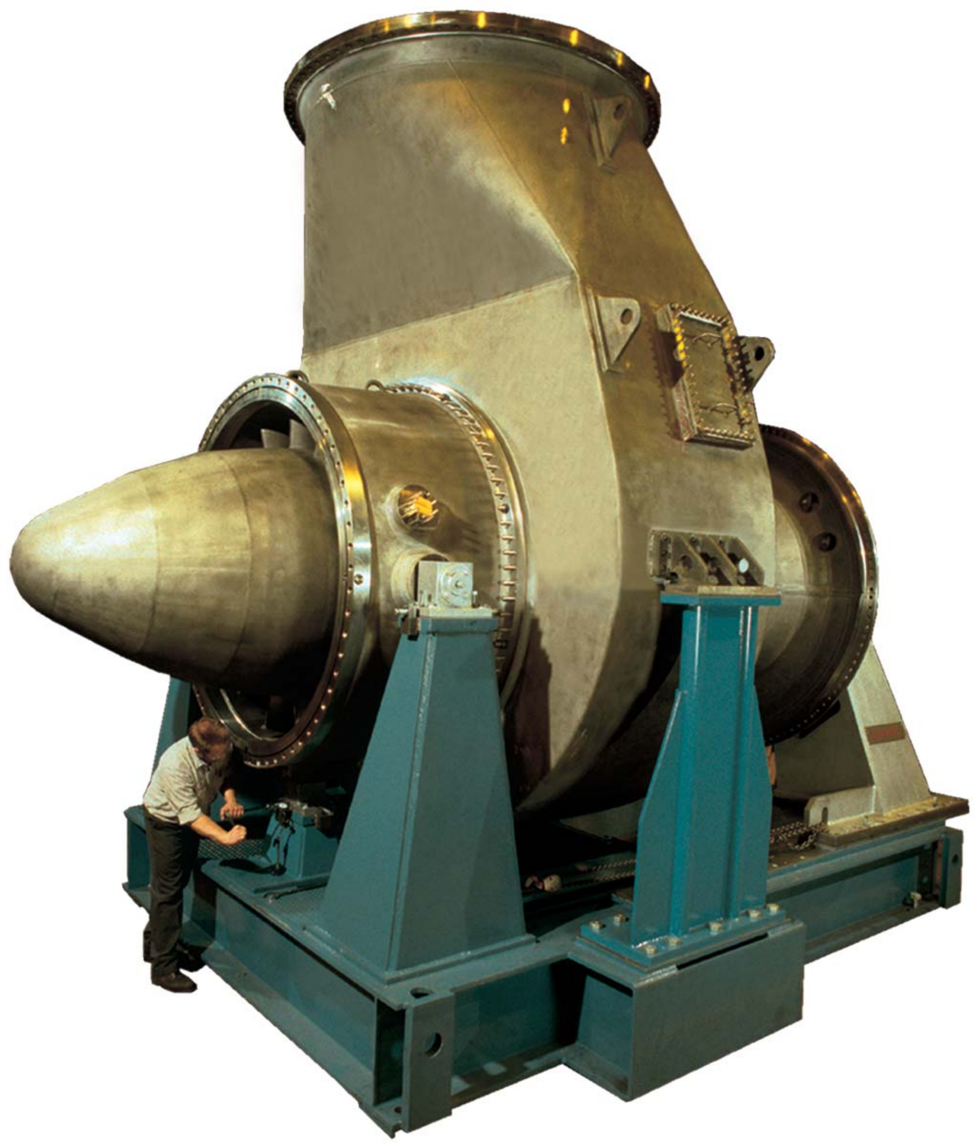


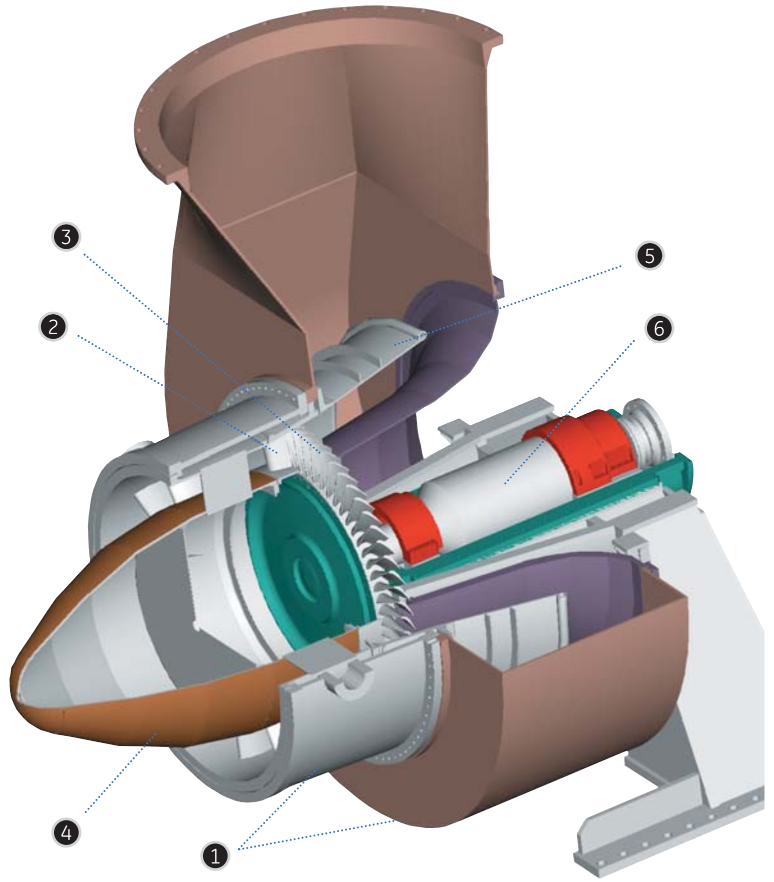
Expanders

Enhanced design and rerates for increased productivity

Expanders you can rely on

GE's Conmec expander service specializes in highly-engineered solutions to the most challenging problems in turbomachinery. Whether we're building an expander of our own design, or uprating one of another manufacturer, our machines are unique and highly reliable. Every project incorporates innovative design solutions for all operating conditions including severe erosion, deposition, corrosion, performance deficiencies and mechanical problems.

Using the latest design and manufacturing technologies, we have upgraded every aspect of the hot gas expander. Our installed base continues to increase as more users become familiar with the significant advantages of our machines. They are used successfully in the industry's most demanding applications. Years of experience in the turbomachinery market enable us to design and construct expanders with the highest power levels, operating temperatures and pressure ratios in the world.



FEX-125 power recovery train.

Performance-driven engineering

1. Outer Casings
   - Designed and manufactured in accordance with ASME pressure vessel codes
   - Full solution and stabilization heat treatments performed for optimum structural margins and corrosion resistance
   - Designed to withstand greater piping loads, and enable single lift capability for the entire outer casing assembly
   - Upgraded fastener design and materials
2. Integral/Stator Shroud
   - Increases expander efficiency by 2–6% over cantilevered stator designs
   - Significant reductions in nose cone stress levels (typically 40–60%)
   - Easy removal from the back of the expander, eliminating the need to disassemble inlet or exhaust piping
   - Improved metallurgy reduces the effects of in-service aging and welding problems
   - Most current chromium carbide coatings over the full pressure side and leading edge of stator vanes
   - Various materials available to accommodate different high temperature requirements
   - Designed for minimum flow-path erosion and deposition
3. Rotor Blades
   - Optimized airfoil aerodynamic designs for high efficiency and minimal erosion through the use of three-dimensional Computational Fluid Dynamics (CFD) software
   - Increased structural and vibration margins due to reduced steady state and gas bending stress levels
4. Nose Cone
   - Improved aerodynamic design provides smoother acceleration of flue gas and more uniform distribution of catalyst into stator blades
   - New inlet strut design minimizes aerodynamic losses, and improves catalyst distribution and structural integrity
   - Increased structural margins with weld neck support flanges in optimum locations
   - Full radiographic quality welds
5. Exhaust Diffuser
   - Highly efficient designs through Computational Fluid Dynamics (CFD) analysis
   - Elimination of diffuser cracking and failures through Finite Element Analysis (FEA) of transient and steady state stresses, including diffuser natural frequencies
6. Upgraded Shaft Design
   - Increased stress margins and torque capacity from larger journal diameters and coupling
   - Shaft extends beyond the bearing housing to allow coupling installation or removal without bearing disassembly

Rigorous testing capabilities

All our expanders are tested for mechanical integrity by running the units at maximum continuous operating speed in excess of 1,000°F (538°C) for four hours. Air at atmospheric pressure is heated in a recirculation loop by friction heating (windage) as it passes through the rotor blades. During this test, the expanders are also run at trip speed to verify operation of the over-speed trip system.

Some of our other testing capabilities include dynamic stress, structural vibration, performance, erosion, corrosion, and metallurgical evaluations. This broad selection ensures you of the best possible design, coatings, and materials solutions for your application.

Finite Element Analysis (FEA)

Utilizing ANSYS® and ProMechanica® tools, we optimize new designs and can safely push the design boundaries of your existing equipment. Areas of review range from transient heat transfer analysis of casings to steady state stress analysis of rotor blades and discs.

Computational Fluid Dynamics Analysis (CFD)

We use CFD to design more efficient flow paths while decreasing the effects of erosion and deposition. In conjunction with hot erosion testing, CFD enables us to predict flow path erosion and correlate it to field data. Optimizing the flow path delivers increased performance, reduced erosion, reduced flow path deposition, and increased reliability. In addition to our own equipment, we have analyzed and optimized flow paths of numerous manufacturers, including Dresser-Rand®, Elliott® and Ingersoll-Rand®.

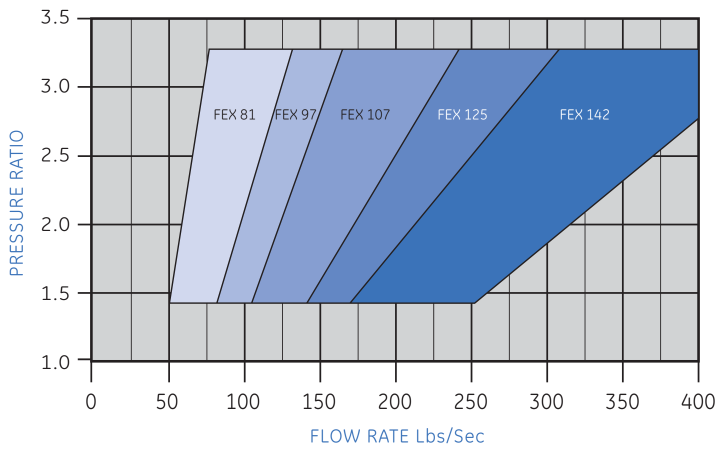
Review and interpretation of high speed expander blade photographs

Photography or videography enables us to draw conclusions about the operating condition of an expander. Scheduled maintenance can then be planned based on the actual condition of the rotor. Our on-line expander blade photography or videography is an economical method of assessing the condition of an expander.

Expander sizing

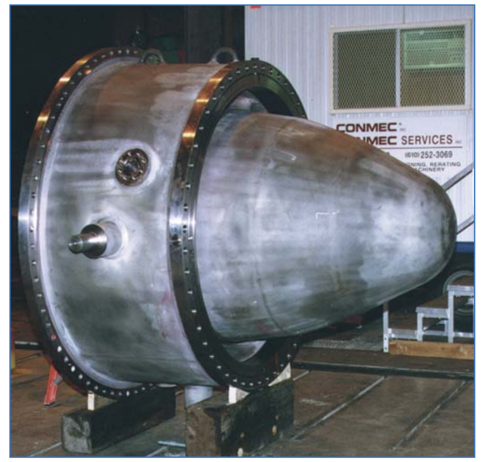
A properly-sized expander provides peak power recovery. We offer five frame sizes to match your process conditions and optimize your results.

Frame Selection Chart

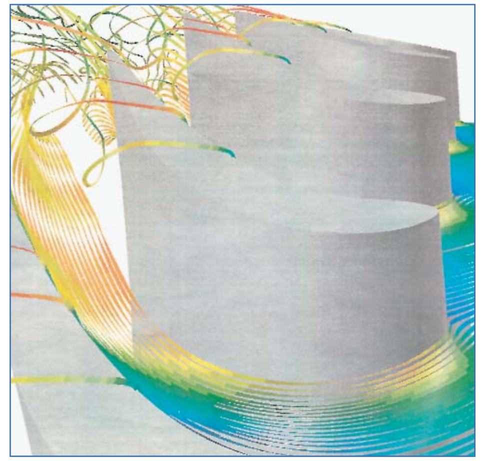


Our field performance questionnaire will help to properly size your expander. To request a copy, or for further information, please call 610-758-7500, fax 610-758-7501 or visit www.gepower.com/conmec.

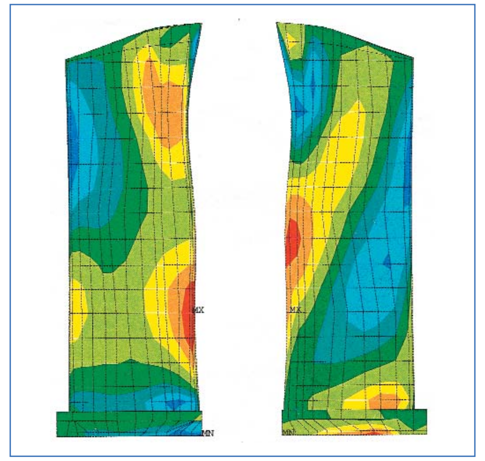
Innovative design solutions



Improved aerodynamic nose cone design.



Velocity magnitude of catalyst particles through the rotor blades.



Rotor blade contour map.

Case study

Expander as part of refinery overhaul

A refinery on the Texas gulf coast was about to undergo a plant-wide turnaround including a major revamp 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 FCCU condition had declined so that productivity now suffered due to bottlenecking caused by limited air supply and unplanned outages.

During the planning phase, we worked with the refinery owner to develop the most cost effective means of achieving critical equipment performance and reliability by re-applying a combination of existing and surplus components, rerated and custom designed to meet the process needs.

Background

The original power recovery train (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. Among the components we uprated were the air compressor, hot gas expander and starter steam turbine.

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. To accommodate the increased production capacity, the FCCU regenerator required an additional 100,000 lbs/hr of air from the axial compressor, equating to a 16% increase. The process changes also resulted in a comparable increase in process flue gas, which provided an additional opportunity for power recovery through the hot gas expander.

The existing steam turbine was originally designed for 6,000 HP and was intended for train start-up purposes only. It was not capable of accelerating the pre-rerate equipment train from slow roll to full speed. In the absence of an effective workaround, "bootstrapping" had become a standard practice for accelerating the train to motor energizing speed (i.e., a partial start-up of the FCC process to generate process flue gas and allow the expander to assist the turbine in accelerating the train to motor energizing speed).

Expander modifications

Some of the existing expander's components had reached the end of their design life. Now, with the increase in compressor airflow, there was an attendant increase in process flue gas generated, which equated to approximately 2 MW of additional power available for recovery. To accommodate this increase, the flow path section components (such as the nose cone, stator, shroud, and rotor blades) required replacement.

We proposed the re-application of a surplus Conmec FEX-125 expander flow path assembly and rotor blades. These components had been supplied as spares to another customer who rerated its unit beyond the assembly's capacity without ever using the parts. Our engineering review determined that the expander's performance with the surplus components closely matched the new process conditions for the future case conditions.

The reapplied components were capable of producing approximately 21,200 HP (15.8 MW) with the year-one conditions and an expander inlet pressure of 24.8 psig. This new flow path would also accommodate the anticipated year-three flue gas flow of 970,000 lb/hr at an expander inlet pressure of 33 psig and recover approximately 29,100 HP (22 MW). By reapplying these components, the project cost was 40-45% lower than it would have been using new components.

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