POWER

COMBINED CYCLE **POWER GENERATION**

Combined cycle power utilizes a combination of the combustion turbine (Brayton Cycle) and the steam turbine (Rankine Cycle). While the combustion turbine generator creates electricity, heat recovery steam generators (HRSG) repurpose waste heat to create steam and power a turbine. This makes combined cycle power plants far more efficient than traditional fossil-fired power plants. This combination of systems using air and water as the working fluids provides efficient, reliable and economic power.

Combined cycle power is a compliment to today's energy market, which frequently requires plants to come online and shut down quickly. This fluctuating demand requires increased operational flexibility - critical to success. With environmental requirements continuing to change, combined cycle plants are always working to improve efficiency for intermediate load operation. The focus has shifted to shorter ramp times, frequency support and reliable operation to maintain grid stabilization and achieve financial goals.

ELECTRAULIC™ ACTUATION

Combined Cycle Power Generation

At REXA, we have more than 20 years of experience in the combined cycle power market. We offer high-quality, low/no maintenance Electraulic™ Actuators that have been field-proven in some of the most critical and difficult applications:

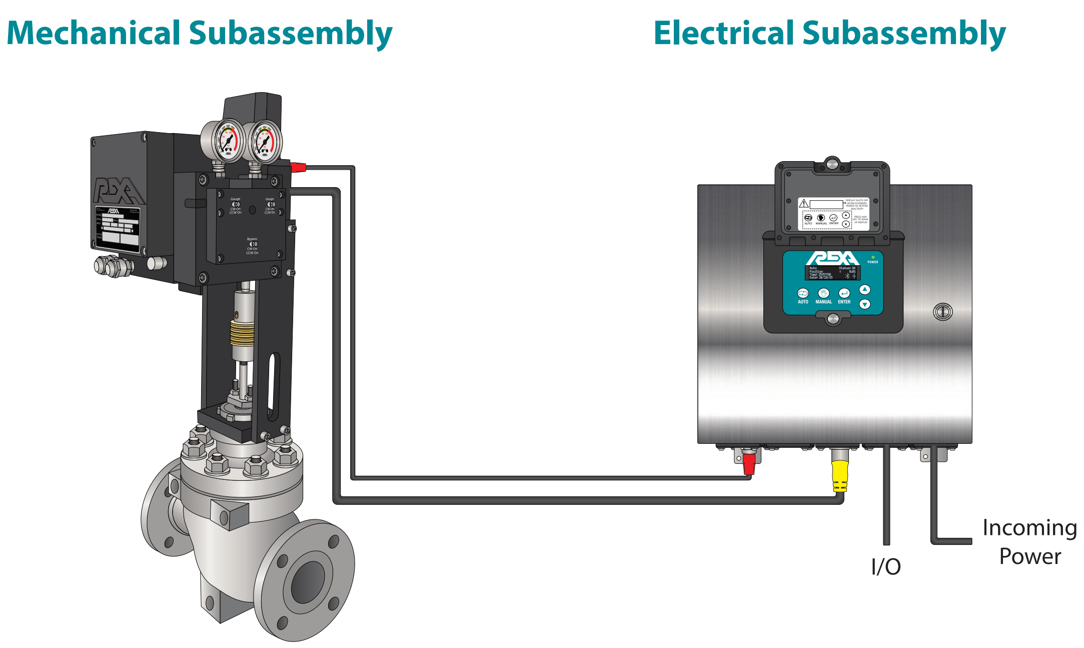
- Inlet Guide Vanes
- Fuel Gas/Oil
- Steam/Water Injection
- Inlet Bleed Heat
- Diverter Dampers
- Feedwater Control
- Superheat Attemperator Spray
- Reheat Attemperator Spray
- Turbine Bypass Systems
- Sky Vent

Why REXA?

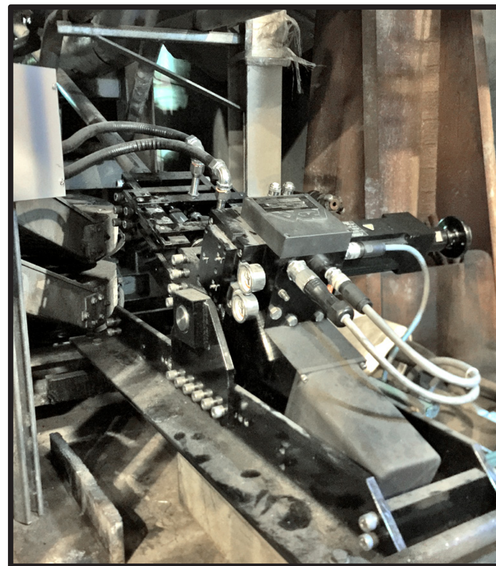
The REXA Xpac Electraulic™ Actuator is a superior positioning device well suited for critical control applications, such as those found in combined cycle plants. It controls severe process conditions in harsh environments and provides high reliability. REXA Electraulic™ Actuators and Drives provide the final control element capabilities to match the most sophisticated instrumentation and distributed control systems.

The Xpac is comprised of the mechanical subassembly and the electrical subassembly. The mechanical subassembly consists of a double acting hydraulic cylinder, position feedback sensor and an Electraulic™ Power Module. The power module is a unique, self-contained, sealed hydraulic pumping system which manages oil pressure and flow to and from the cylinder. The electrical subassembly consists of the power supplies, motor drivers and a dedicated microprocessor.

The combination of these mechanical, hydraulic and electronic technologies ensures accurate and repeatable control of combined cycle plant processes.



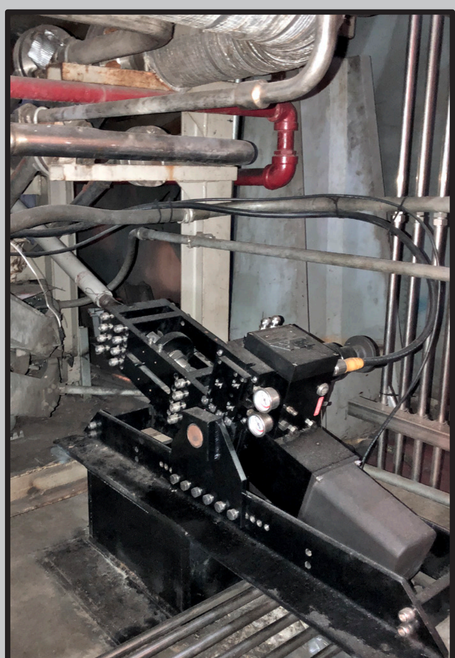
Inlet Guide Vanes

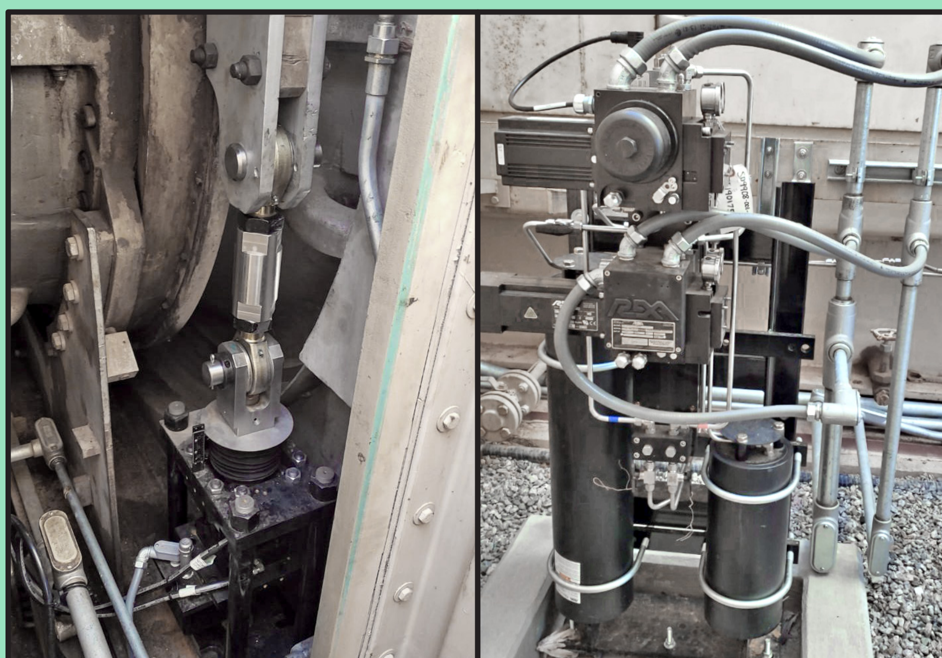


Inlet guide vanes (IGVs) deliver air to the inlet of the gas turbine's axial compressor, maintaining proper fuel air ratio through various load ranges and minimizing potential unwanted emissions. In combined cycle plants today, IGVs ultimately control the exhaust gas temperature – a critical input to the heat recovery steam generator (HRSG).

Accurately and reliably controlling air to the combustors keeps flame temperatures low, reduces emissions and maintains a stable combustion range. Positioning IGVs to maintain flame stability is a challenge during low fuel flow/low load scenarios, since there is a tendency for exhaust temperature to increase. To prevent exhaust temperature from surpassing set limits, the vanes are modulated. This increases duty cycle and response requirements for the IGV actuator.

Designed for continuous modulating service, REXA Electraulic™ Actuation provides responsive and repeatable IGV control. The technology can be adapted to any major manufacturer's combustion turbine. Plant operators will immediately notice improved control and consistent exhaust gas temperatures throughout the entire load range.





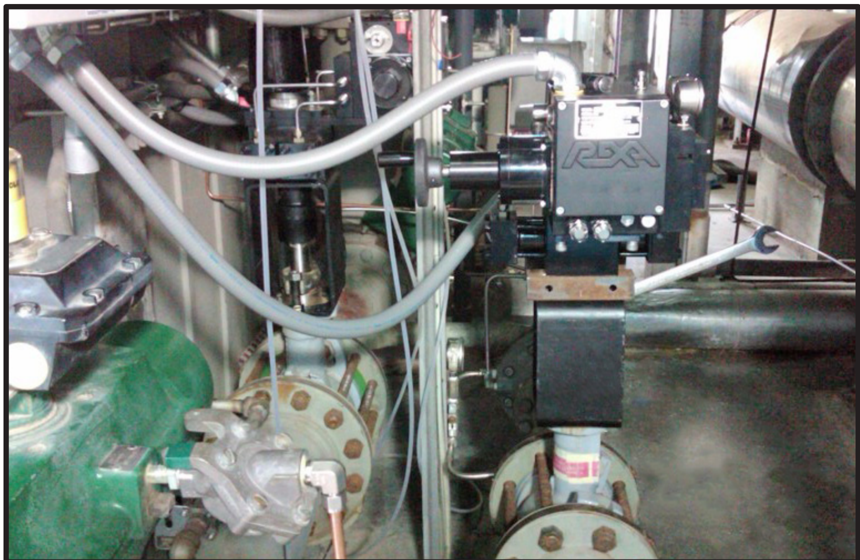
Remote-Mounted Power Module and Accumulator

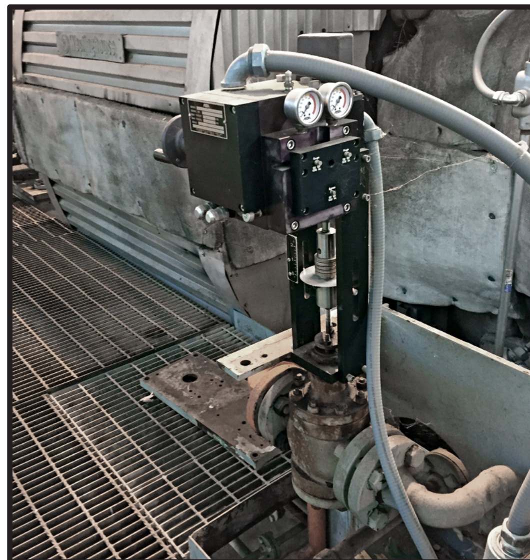
"With REXA drives installed on my combustion turbine inlet guide vanes, we eliminated an on-going problem with hydraulic leaks, now I have exhaust temperature control like never before!"

Fuel Gas/Oil

Gas turbine speed is controlled by the amount of fuel supplied to the combustion chamber. Fuel gas or fuel oil valves work together with inlet guide vanes to deliver the proper air/fuel ratio through various load ranges. This ensures maximum output and minimized emissions.

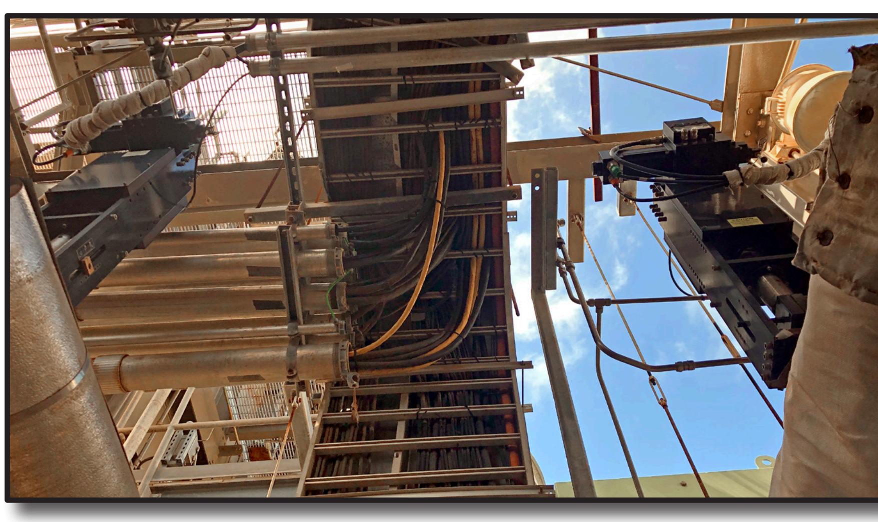
Poor fuel control during reduced power output can cause a lean die-out or a flame out. Inversely, adding too much fuel during an increased power requirement causes damage to the turbine due to excessive heat, or a compressor stall from high chamber pressure.





Steam/Water Injection

Industrial gas turbines use steam or water injection to increase power output and reduce NOx emissions. Generated by engine exhaust through the HRSG or a separate boiler, steam injected directly into the combustion chamber increases mass flow. Water or steam injection directly into the fuel nozzles lowers flame temperature, thereby lowering NOx emissions.



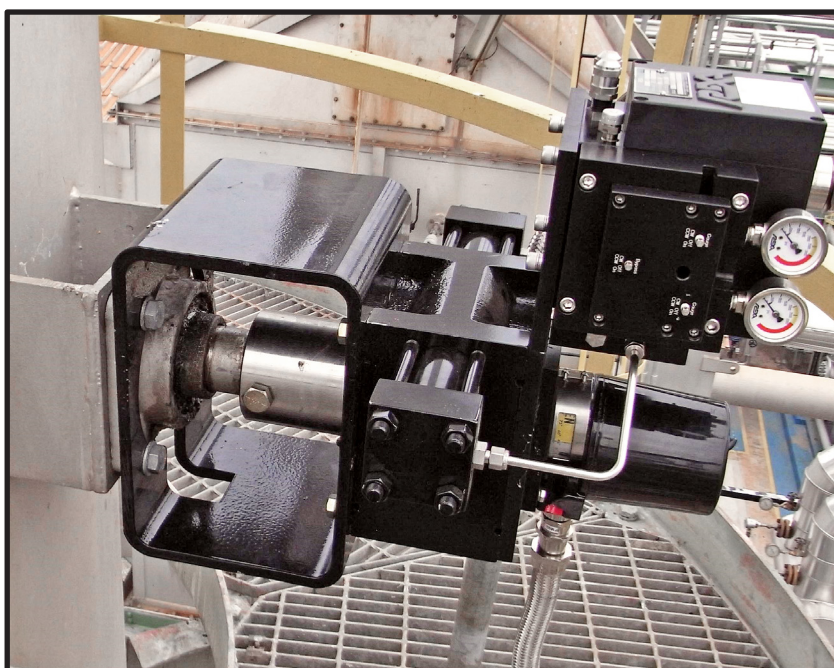
Inlet Bleed Heat

The Inlet bleed heat (IBH) system draws air from the gas turbine axial compressor and recirculates up to 5% of rated flow through a control valve and back into the turbine inlet to heat the air stream. This is important while starting and stopping the turbine when the inlet guide vanes are positioned below a specified minimum angle. During this condition, the heated air reduces the mass flow and back-pressure on the axial compressor, protecting it from a stall as discharge pressure is relieved. Some gas turbines can also use the IBH system to prevent icing of the inlet guide vanes in high humidity conditions.

REXA Electraulic™ Actuation immediately responds to the command signal, delivering accurate inlet bleed heat control. This proven and highly reliable actuation technology provides improved control performance, ensuring plant operators can confidently rely on REXA.

Diverter Dampers

Diverter dampers are critical pieces of equipment in a combined cycle power plant located between the gas turbine and the heat recovery steam generator (HRSG). The damper diverts hot flue gas to either the atmosphere during simple cycle mode, or the HRSG to maintain combined cycle mode operation.

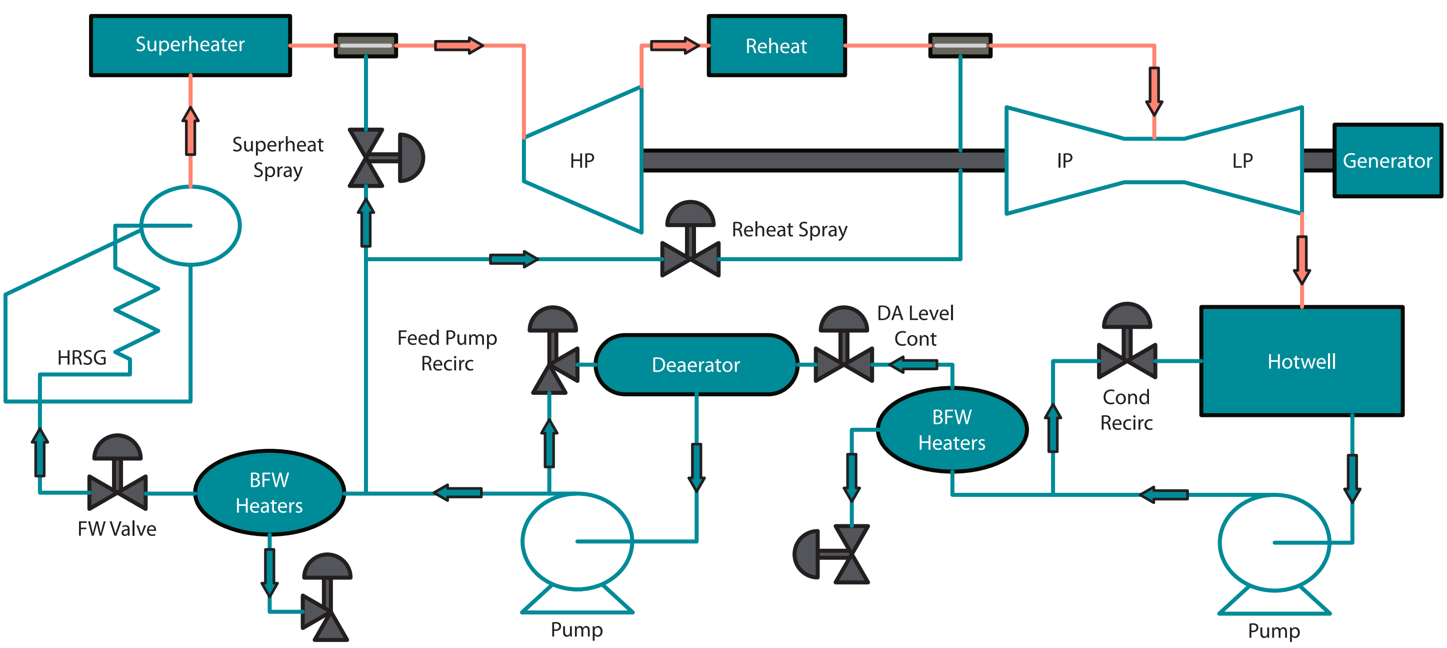


Adjusting to cyclical grid demands often means gas turbines are brought online quickly in simple cycle mode. Flue gas is sent up the stack and gradually diverted to the HRSG during startup to allow system warmup. Dampers must close off tightly to ensure no heat energy is lost, and trip quickly in the event there is a problem. REXA actuators ensure these dampers operate efficiently and react quickly in case of an issue with the HRSG.

Feedwater Condensate System

In a combined cycle power plant, flue gas from a combustion turbine is the energy source for the heat recovery steam generator (HRSG). A well-controlled feedwater system is a key part of the rankine cycle for stable plant operations. At the beginning of the process, condensate is pumped from the condenser through a heater to the deaerator. The condensate pump recirculation valve is important in the startup process, and must remain tightly closed during operation. With a high frequency response, the deaerator control valve can maintain proper level in the tank during ramp times and cycling periods. The main feedpump draws on the deaerator supplying water through the HRSG economizer to the steam drum(s). During plant cycling and upset conditions, the feedpump recirculation valve maintains a minimum flow through the pump dumping water back to the deaerator (DA Tank).

This is a critical valve in the process and the most severe service in the plant. It must respond instantly to control signal changes to avoid drum level trips, and a hydraulic lock in place helps reduce trim destruction and efficiency loss. The main feedwater valve plays an equally important role in maintaining plant stability with minimum deadtime and high frequency response control. Drum levels can remain predictable during load changes. Attemperators for superheat and reheat temperature control use high pressure feedwater from the pump to cool steam temperature to the desired level, and are the final control element for turbine admission. Even a 10°F change in steam temperature can equate to a 0.1% efficiency change. High resolution and tight deadband allow these valves to accurately control water flow and achieve plant goals. Power is not required to maintain actuator position. The motor and pump sit idle until a new command signal is received.



Feedwater Regulator

Maintaining accurate and stable drum level control is vital for efficient plant operation, but this process presents many inherent challenges. With an increase in steam demand, the drum pressure decreases, causing additional steam to be created through water evaporation and expansion of vapor bubbles below the water's surface. This phenomenon causes the drum level to rise initially instead of the expected drop due to more steam leaving the drum.

Responsive and repeatable control of the feedwater regulator valve is essential for a successful process. REXA actuators provide the continuous modulating service with a tight dead-band (0.05%), while eliminating dead time and overshoot caused by hysteresis found due to pneumatic actuation.

Feedwater Recirculation

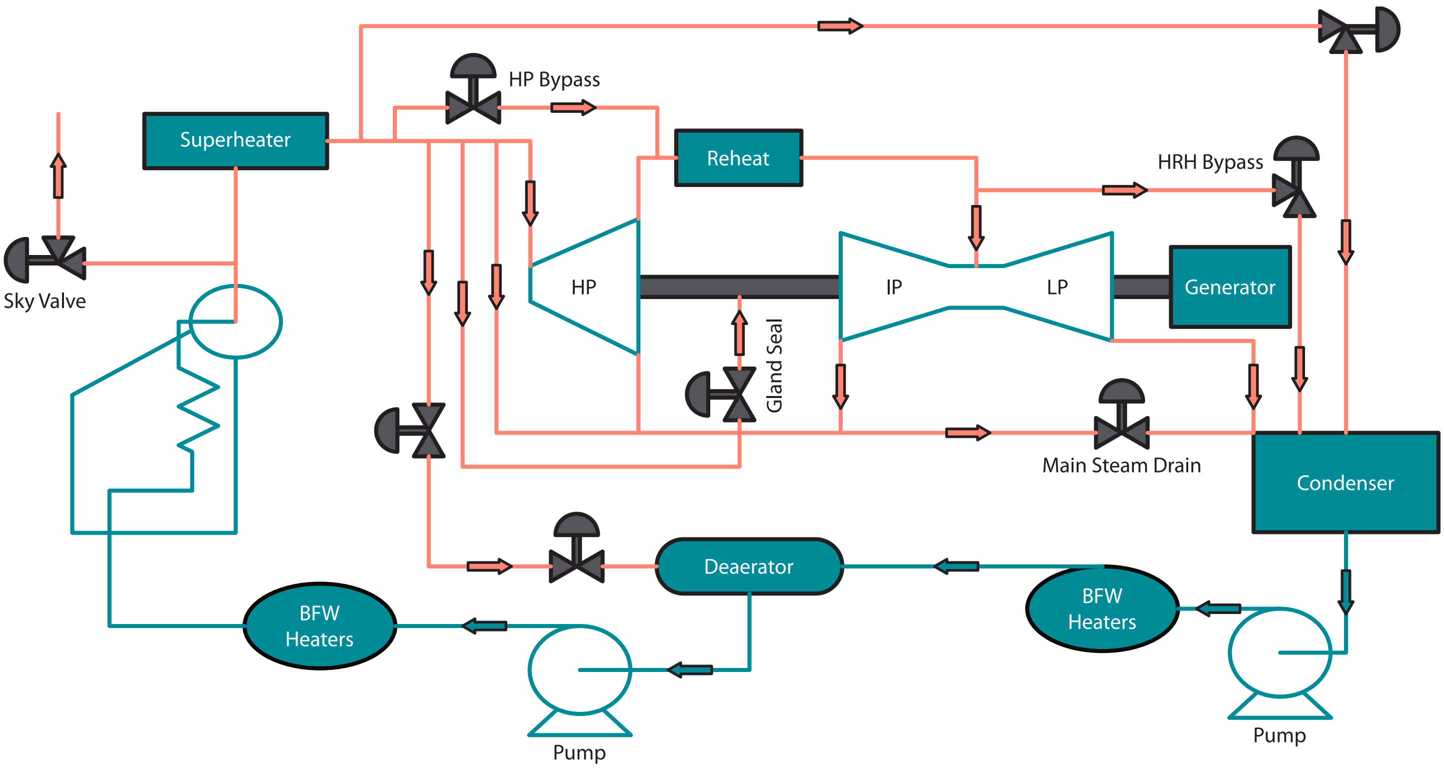
Responsive and repeatable control of the feedwater recirculation valve protects a plant's investment in the boiler feedpump while allowing it to deliver the required flow to the HRSG. The recirculation valve is designed to take the full feed pump outlet pressure drop as it dumps to the DA Tank. It is typically designed for Class V or MSS-SP-61 shutoff to prolong valve trim life. This valve is closed during normal operation and must open on a trip event.

Most plants still utilize long stroke pneumatic piston actuators for their BFR valves. Unfortunately, pneumatic actuators lack the necessary rigidity to accurately control small steps. REXA actuators, however, offer repeatable, stiff and accurate valve control performance – allowing for tight shut-off.

Steam System

The steam side of the rankine cycle is an important part. Stable pressure and temperature control in all load ranges enables optimal turbine efficiency and operating reliability. As feedwater is converted to HP steam in the HRSG, it passes through the superheater and attemperator prior to entering the HP turbine at the desired temperature. Once the heat energy is used, it's led out of the turbine as "cold reheat" steam and back to the reheater section of the HRSG. The HP bypass valve and IP superheat steam are also tied into this same cold reheat line. The bypass valve is critical to the plant during ramping scenarios and trip events, with high frequency response and fast stroke speeds as necessary features. From the reheater, "hot reheat" (HRH) steam passes through another attemperator prior to entering the IP turbine.

The HRH bypass valve operates similarly to its HP counterpart, protecting the IP turbine and bypassing to the condenser. It interacts with all turbine admission steam systems, as well as feedwater demand. Minimal deadtime and smooth operation help keep turbine transitions predictable. IP turbine exhaust steam is then combined with LP superheated steam to drive the LP turbine. An LP bypass valve protects the LP turbine and exhausts to the condenser. Tight shutoff is important here to maintain heat rate and reduce valve trim erosion. Additionally, the sky valve is a key component of the HP steam system, and is used in conjunction with the turbine bypass valves during startup, shutdown and trip conditions. Tight shutoff and rapid stoke capability are standard performance requirements for this valve.



Superheat Attemperator

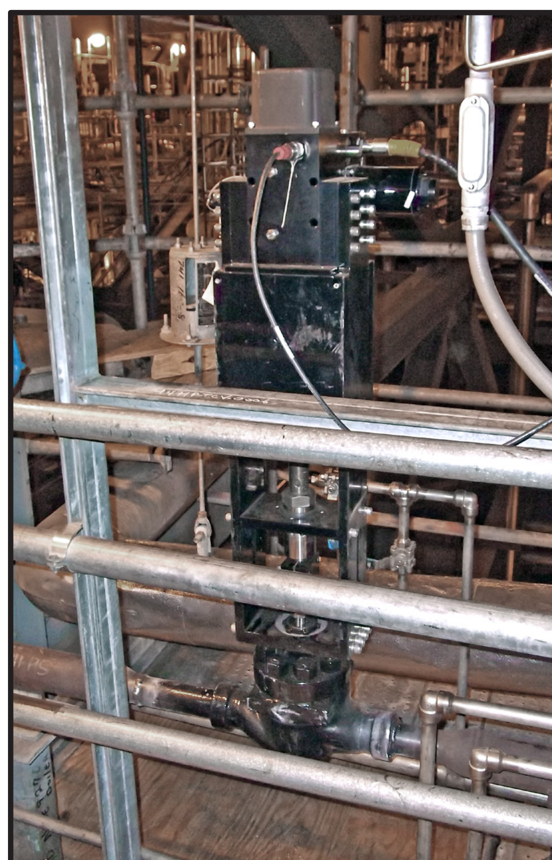
In today's world, plants are ramping up and down daily – consequently putting a strain on steam temperature control regulation. Controlling superheat temperature enables plants to maximize efficiencies and improve heat rate.

Depending on type and design, each plant uses multiple strategies across various systems to accurately control temperature. Almost all use superheat spray valves as the "final" control of steam temperature entering the turbine. In response to being required to cycle to lower loads more frequently, many of these plants use feed-forward, cascade and adaptive-predictive control strategies which result in tighter control of superheat steam temperatures.

REXA linear actuators are key components in helping plants achieve efficiency goals by maximizing performance through tighter resolution, repeatable positioning and high duty cycle operation.

Reheat Attemperator

Reheat attemperators are used as a final control element of steam temperature into the IP section (sometimes LP section depending on plant design) of the steam turbine. The steam extracted from the HP turbine is passed back through the boiler and reheater prior to entering the next stage of the turbine.



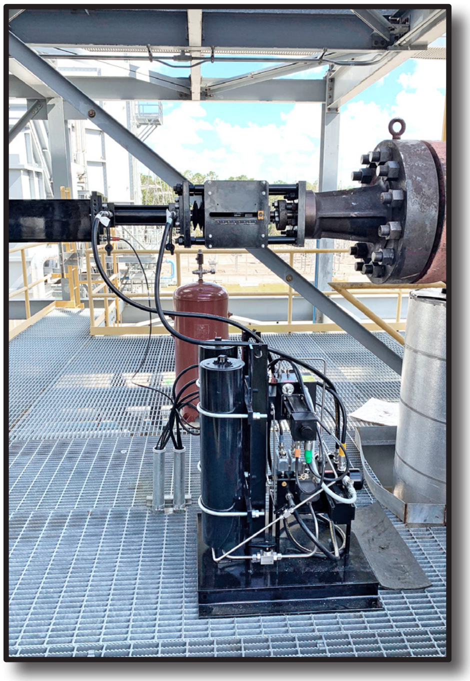
A reheat attemperator is used to spray water into the reheat line to control the steam temperature. Like superheat attemperators, reheat attemperators are subject to the changes made in controlling flue gas temperature in combustion. However, the reheat steam pressures exiting the HP are much less than superheat steam pressures entering them – meaning the pressure drop across reheat temperature control valves is much greater. This dynamic can lead to cavitating process conditions creating rapid and excessive trim wear in these valves.

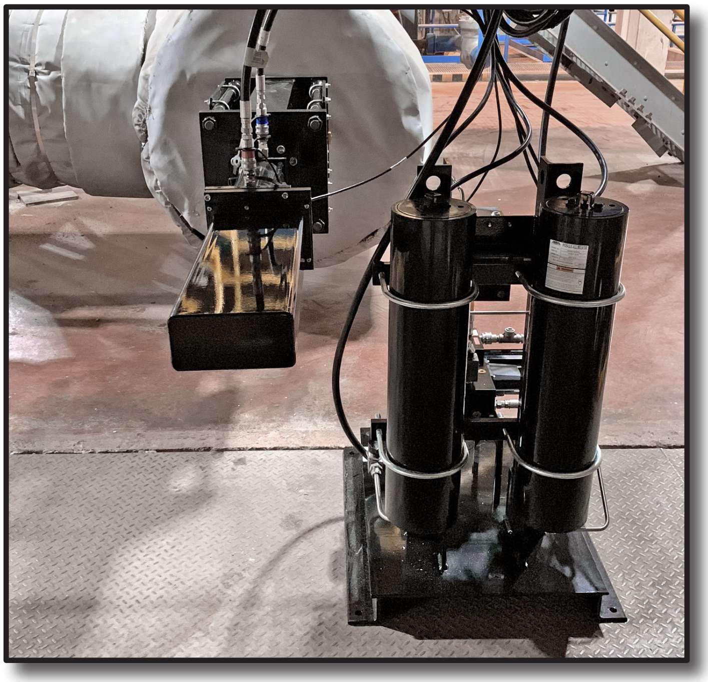
Using REXA linear actuators in reheat temperature control applications enables cycling power plants the ability to increase efficiency, allowing for precise valve throttling capabilities, tight shutoff and maximum trim life.

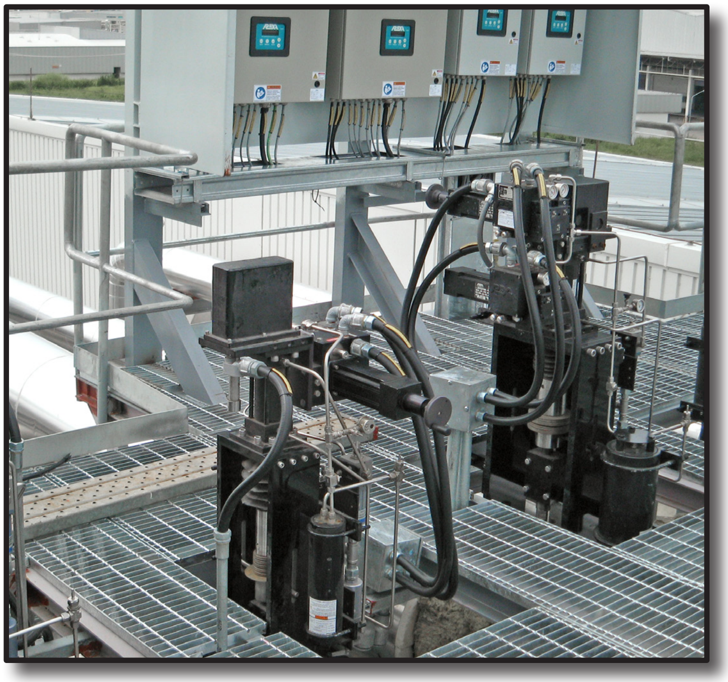
Turbine Bypass Systems

Turbine bypass systems in combined cycle power plants are utilized to divert steam away from the turbines in the event of a load shed condition and when shutting down. They are also used to ramp-up units, allowing gradual warming of the turbine and related equipment. Improperly functioning turbine bypass system valves routinely contribute to unscheduled downtime and trip events. These events can add to equivalent operating hours that greatly reduces planned maintenance intervals, causing plants to unnecessarily spend millions.

With REXA actuators, combined cycle plant operators can optimize transitions and eliminate nuisance trips during ramp-up, ramp-down and emergency response scenarios.





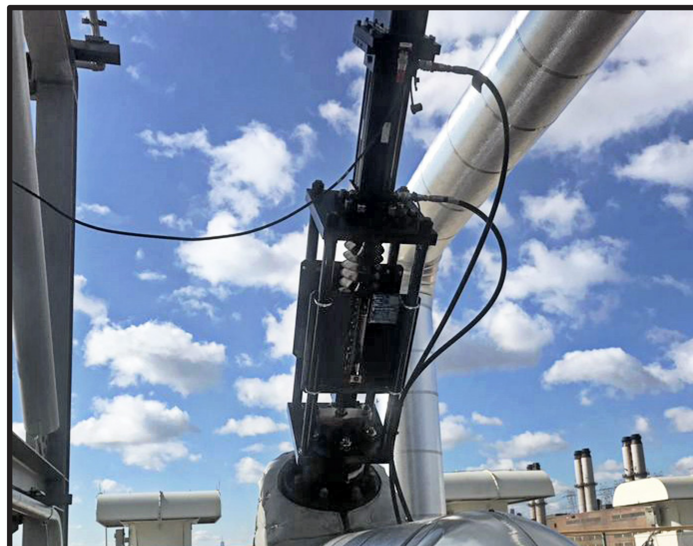


Sky Vent

Used during ramping scenarios in conjunction with the turbine bypass system, sky valves help maintain steam temperature control as units are brought on-line by dumping steam to atmosphere.

One of the biggest requirements for sky valves is tight shut-off. This ensures the plant doesn't lose efficiency and/or increase heat rate. Due to their traditional pneumatic operation, sky valves have a slow response time. Other problems associated with pneumatic actuators include excessive vibration, loose positioner linkage and the high ambient temperature eventually destroys the actuator's diaphragm and seals.

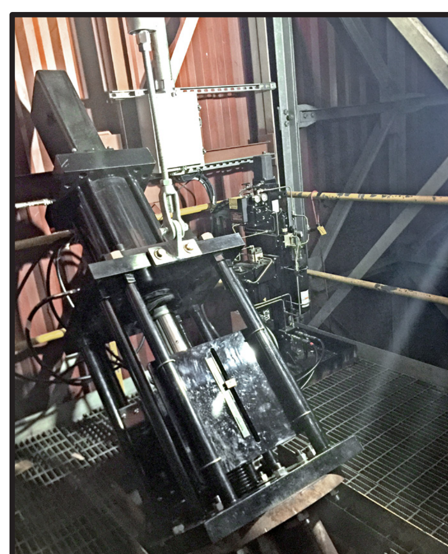
With REXA, high ambient temperatures and vibration aren't a problem. Our actuators provide high frequency response for accurate and reliable control during ramping, as well as tight shutoff for reduced heat rate.



Additional Applications

Condensate Level Control

Steam to Fuel Gas Heater



HP Steam Stop

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