TURBOEXPANDERS

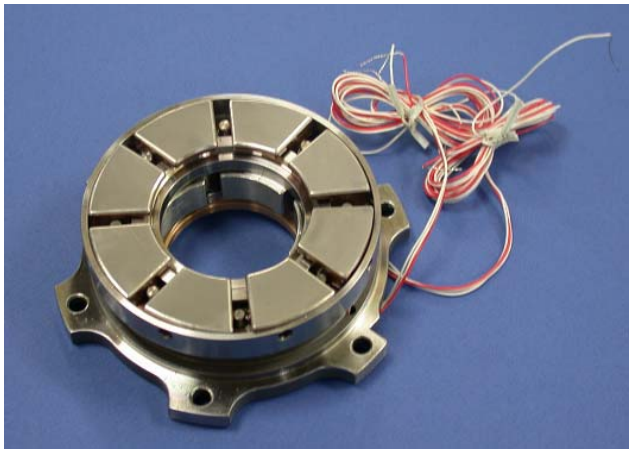
Turboexpander is a machine, which continuously converts kinetic energy into mechanical energy. This is done by expanding the high pressure gas from upstream to a lower pressure downstream through the expander. The high pressure gas causes the radial expander to rotate. Rotation is transmitted to the shaft, which is supported by a set of bearings. The power transmitted to the shaft can be used to drive a compressor, drive an electrical generator or can be dissipated through an oil brake or air brake.

ACD has built hundreds of machines with different loading devices, from compressors to oil brake, and from generator loads to air brake loads. We have built equipment for every major Industrial gas company and have machines in use in over 40 countries throughout the world.

Each machine is customized for the specific requirements, that is the expander and compressor wheel is optimized for optimum efficiency. The system and controls are built per the customer's requirements. ACD prides itself for being the first company to test their expanders cryogenically, this has allowed us to provide peak efficiency and has given us a background far beyond our competitors in tested efficiencies.

MACHINE FEATURES:

Bearings:



ACD uses hydrodynamic bearings with tilt pad journal design and tilt pad thrust faces for most compressor loaded designs. All pads are babbitted with a tin/lead material to increase durability and increase life. These bearings provide rotor dampening throughout the operating range, which provides optimum reliability of the rotor dynamics. Each bearing has an imbedded RTD in the thrust face of two pads to monitor bearing temperature; one RTD is for primary use while the second is used as a backup.

Shaft:

Each shaft is made from a solid wrought bar and heat treated to assure mechanical properties at operating conditions. Each bearing journal and thrust face is dense hard chrome plated to reduce wire wooling, and therefore increased life. The wheel attachment at each shaft end is tapered to guarantee accurate alignment of the wheel for balance repeatability. The torque is transmitted through the shaft via tangs machined at the ends of the shaft. Every shaft has two notches machined at 180^0 for the speed pickup. Each shaft has two ground surfaces that are used to monitor the vibration. These areas are checked at final assembly to assure that the maximum mechanical and electrical run out is within .00025 inches. This allows use of four vibration probes during test and operation. A Key phasor slot can be added to the shaft for angular displacement monitoring. Labyrinth teeth are machined into the shaft at each end for the shaft seals. These hardened teeth run in close proximity to the soft babbitted seal runners.

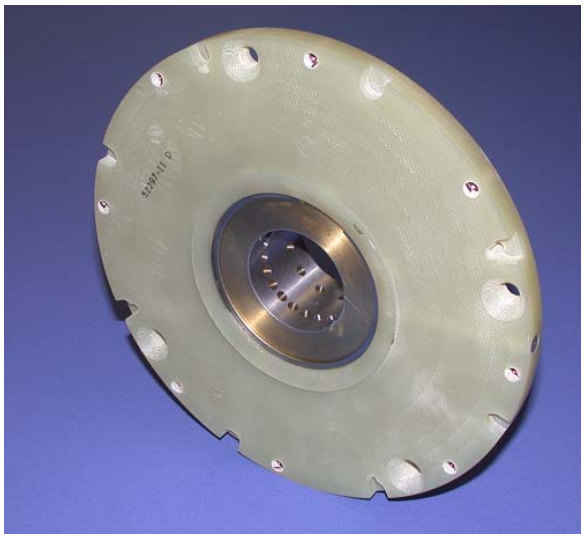
Expander and Compressor Wheels:

Both the expander and compressor wheel are manufactured from a solid forging. Each forging is ultrasonically inspected and a test specimen is taken from each forging and checked for mechanical properties prior to manufacturing of the wheel. Each wheel is designed for a specified set of operating conditions. These conditions may require either an open or closed wheel depending on several parameters, specific speed, power,

shaft speed and efficiency. Additionally each compressor wheel may require either a vaned or vaneless diffuser, depending on the specific speed, flow parameter and efficiency. The wheel design is based on providing the highest efficiency at the design conditions for both the expander and compressor wheel. Often Computational Fluid Dynamics is employed to assure the optimum design.

Shaft Seals:

ACD primarily employ's labyrinth shaft seals for use on our machines. These labyrinth seals use a toothed labyrinth on the shaft, which run in close proximity to a babbitted stationary sleeve. Seal gas is injected into a port on the stationary seal close to the expander wheel. Some of the gas flows towards the expander wheel to prevent cold process gas losses. The remainder of the gas flows to the bearing cavity to prevent oil from entering the process gas. This gas is then vented to atmosphere through the mist eliminator on the lube oil system. On high pressure machines an intermediate port is used to between the supply port and the oil cavity to recover or vent the seal gas prior to entering the bearing cavity. The compressor end uses a similar babbitted shaft seal to prevent oil from entering the process gas, but the flow from behind the compressor is used as the seal gas and throttled across the labyrinth before entering the bearing cavity. High pressure units receive a recovery/vent port to minimize the flow of compressor gas into the bearing cavity. Each of these recovery ports are plumbed together and can be vented to the recycle compressor by the customer.



Expander Guide Vanes:

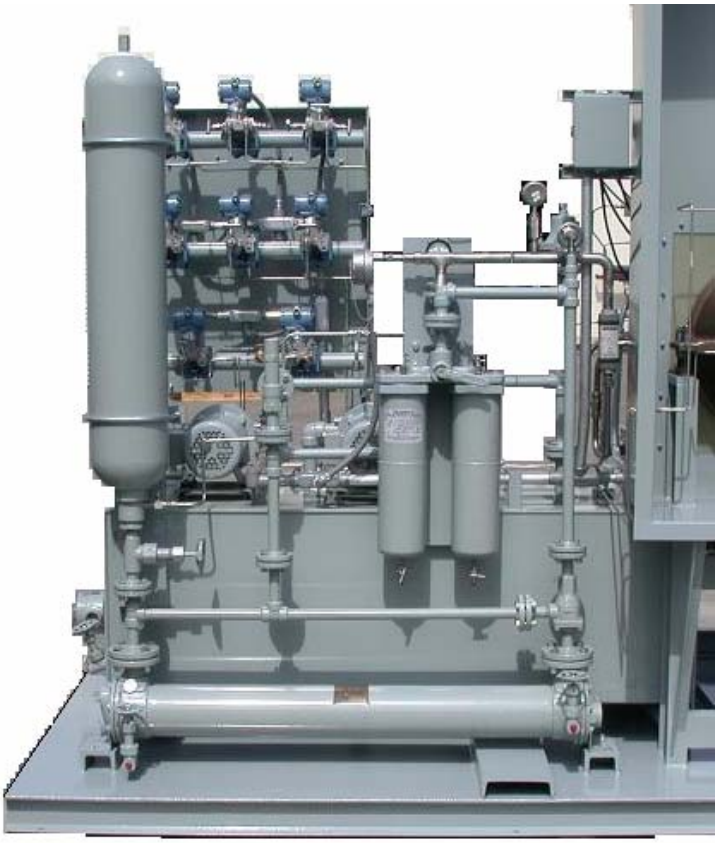
The expander guide vanes are used for adjusting the flow of gas into the expander wheel. An externally mounted pneumatic actuator operates the guide vanes. The internal mechanism relies on a pin and slot principal for accurate movement. All stainless steel materials are chosen for a low friction coefficient to minimize galling and binding during operation. Surfaces adjacent to the nozzles are sprayed with an impinged dry lubricant, again to minimize friction. To maximize expander efficiency, a nozzle pressure plate is employed to minimize leakage across the nozzle faces. The lever arm is attached to the pinion via a clamp arm. This attachment reduces the excess movement within the linkage assembly.

As an option ACD offers Low Hystersis nozzles. These are designed with less than 3% hystersis and use special bearings at each pivot point. This type system is designed for processes using nozzle control that must be adjusted multiple times each hour.

SYSTEM FEATURES

Lube Oil System:

The lubrication system is critical to support the machine bearings. ACD provides a large carbon steel reservoir with baffle plate. A non vented oil fill port with cap is used for oil filling. Large inspection port with drain valve in the end of the reservoir allows ease of internal inspection and cleaning. An oil sight glass with integral thermometer permits oil filling to the correct level.



A coalescing demister is used to allow separation of seal gas entrained in the oil. A drain line runs from the bottom of the demister back to the reservoir to recover excess oil

An immersion heater with integral thermostat is used to heat oil to proper operating temperature.

A suction strainer keeps large particles from entering the positive displacement vane pump which is coupled to an electric motor. A relief valve downstream of the pump discharge provides protection of any over pressurization.

An accumulator is provided to allow oil to be fed to the bearings during coast down in the event of an electrical failure. A check valve upstream of the accumulator prevents backflow through the pump.

An AMOT temperature control valve is used to maintain proper oil temperature to the bearings.

A shell &tube water cooled heat exchanger is furnished to dissipate heat generated by the system. The exchanger is equipped with vent and drain ports. Various certifications can be supplied with this exchanger as well as special materials as dictated by project requirements. An air to oil fan type cooler can also be supplied as an option.

The oil filter is a twin cartridge type equipped with a full flow transfer valve. The filters can be changed over during operation. The cartridges are pleated paper type rated at 5 micron filtration. Vent and drain ports are supplied for each element.

ACD provides an oil flow meter for visual monitoring and troubleshooting during operation.

CONTROLS

Most systems of today are designed to interface with the customers DCS or PLC. At ACD we have designed our controls to provide an easy transition between the ACD controls and monitoring and the customers controls.

The nozzle (inlet guide vane) actuator is pneumatic. An I/P transmitter is supplied to accept a customer 4-20 ma signal for full range stroke.

A locally mounted emergency STOP pushbutton is supplied mounted on the control box.

Monitoring
Expander reference pressure
Oil Reservoir temperature
Oil pump discharge pressure
Oil supply temperature (after oil cooler)
Oil supply pressure
Lube Oil Flow meter
Seal Gas Flow meter

Alarms
Expander bearing temperature (with spare rtd)
Compressor bearing temperature (with spare rtd)
Low expander bearing temperature (permissive)
Over speed
Low Oil Pressure
Low seal gas pressure
High vibration

Shutdowns
Expander bearing temperature (with spare rtd)
Compressor bearing temperature (with spare rtd)
Over speed
Low Oil Pressure
Low seal gas pressure
High vibration

Additional monitoring, alarms & shutdowns can be provided, or a complete local control panel as required by customers specifications.

QUALITY ASSURANCE

ACD has been certified to ISO 9001 since 1994 by Det Norske Veritas. A quality plan is submitted with each project and completed and signed prior to shipment.

Additionally ACD has a complete set of Inspection Procedures and Test Documentation on file for each project.

Vendor qualification and supply auditing is enforced on a regular basis.

Oxygen cleaning of parts and assemblies can be incorporated as an option should the customer specify.

TESTING

All Turboexpanders assemblies are mechanically tested at ACD for a minimum of 1 hour. This test consists of running the machine at design speed along with the contract lube system for one hour. All mechanical functions are checked at this time.

As an option, ACD offers a Cryogenic Performance Test of the machine. ACD is the first expander manufacturer to offer a cryogenic test. This test is conducted on cold gaseous nitrogen. Design pressure ratios, U/Co, mach numbers and volume ratios are maintained. The compressor is tested in a closed loop cycle with an aftercooler. This provides the greatest assurance of guaranteed efficiencies in field operation.

SOUND LEVELS

ACD estimated the sound levels associated with the compressor; we do also offer insulating material to reduce these sound levels. ACD cannot guarantee sound levels due to the transmittal of sound throughout the plant piping.

EXCLUSIONS

ACD scope of supply is limited to the items noted on the quotation. Major options are also noted. The following items are not included:

Process piping after the machinery housing interface. Cooling water manifolds and piping. Instrument Air and Seal Gas piping to ACD connections..

Expansion joints for Expander and Compressor piping. Provided by customer.

Expander and compressor block valves provided by customer

Compressor aftercooler provided by customer

Expander derime (heat up purge) piping provided by customer.

Skid mounting and grouting provided by customer.

All wiring shall terminate at the ACD supplied electrical enclosure. Customer shall wire to DCS and main control room

Wiring for oil pump motor and Oil Heater shall terminate at enclosure on device. Customer is responsible for Oil pump and electric heater motor starter.

Oil fill to be supplied by customer.

Insulating material for expander ducting supplied by customer.