Thermocompressors use high-pressure steam or gas as a motive fluid. The motive enters the steam chest and expands through the converging diverging nozzle. The high velocity fluid entrains a suction fluid entering at the suction inlet, forcing both into the mixing chamber where the two fluids are combined.

The mixed fluids are then recompressed to an intermediate pressure through the diffuser, which functions as a nozzle in reverse, reconverting velocity energy to pressure energy.

This three-step process can be followed graphically on the diagram shown below.

**Thermocompressor Efficiency**

Since Thermocompressor design addresses a theoretically isentropic process, its overall efficiency can be expressed as a function of the entrainment efficiency. Because of impact and turbulence, the entrainment of the low velocity suction fluid by a high velocity motive fluid results in an unavoidable loss of kinetic energy. The kinetic energy of the mixture that remains is only a fraction of that originally possessed by the motive fluid.

The fraction that is successfully transferred to the mixture through the exchange of momentum is referred to as "entrainment efficiency". The portion of the motive energy which is lost is transferred into heat that is absorbed by the mixture, producing an increase in enthalpy.

A thermocompressor has optimal efficiency at a single set of suction, discharge and motive pressure conditions. At this point, it also has its maximum capacity. Different capacities can be obtained by altering the suction and/or discharge pressures.

Each thermocompressor has a characteristic performance curve. The capacity at a given suction and discharge condition is directly related to steam pressure. By throttling the steam input to a thermocompressor, the steam consumption is reduced, but the compression range is reduced as well. This is not, however, a straight-line relationship. At low pressures, capacity is reduced more significantly as a function of absolute pressure than at higher pressures.
The steam nozzle is a fixed orifice-metering device. Any change in motive pressure causes a proportionate change in the quantity of motive fluid. This relationship is a function of the ratio of the absolute pressures-for example: a thermocompressor designed to use motive steam at 100 psig will use 43.5% more steam at 150 psig. It will use 21.7% less steam at 75 psig. As the relationship indicates, operating at design discharge pressure, while using higher than design steam pressure, will result in wasted steam and higher energy costs.

**Critical vs. Non-Critical Design**

Thermocompressor designs are defined as either critical or non-critical, depending on the required compression ratio.

When fluid velocity in the diffuser throat is sonic, the design is defined as critical. For a steam motivated unit, handling steam, sonic velocity exists when the compression ratio (discharge pressure/suction pressure) is equal to or greater than 1.8 to 1.

The value of this ratio changes as a function of the ratio of the specific heat of the motive and suction fluids.

The motive steam pressure used to operate critical design units cannot be decreased without a resulting change in the suction pressure unless the discharge pressure is decreased proportionately. If the discharge pressure is not decreased, a sudden increase in suction pressure will result. The relationship between motive pressure and discharge pressure depends on the specific characteristics of the individual design.

For Operating conditions where the fluid velocity is subsonic, (i.e., where the "non critical" compression ratio, discharge/suction pressure is less than 1.8 to 1). Changes in the motivating pressure and discharge pressure will cause gradual changes in both suction pressure and capacity. While it is possible, in some cases, to increase capacity by increasing motive pressures, the increase is not proportional.

Lower capacities can be obtained by throttling the motive steam pressure.

**Thermocompressor Types**

Croll-Reynold's fixed-orifice Thermocompressors are available in either single nozzle or multiple nozzle designs. Each has its own advantages. Single nozzle units can be equipped with an automatically controlled spindle. This regulates motive steam flow through the nozzle to compensate for varying suction/discharge conditions. The spindle actually adjusts the cross-sectional area of the orifice, thereby changing the motive flow while still maintaining the upstream pressure.
**Single Nozzle**

The design and construction of a Croll-Reynolds single nozzle fixed orifice Thermocompressor is similar to that of a standard steam ejector.

Single Nozzle units are used for either critical or non-critical flow, but usually for one set of design conditions. While a modest degree of variation can be achieved by throttling the motive steam valve upstream of the unit, this reduces the energy available to the thermocompressor, thereby decreasing its efficiency.

One of the advantages of a single nozzle Croll-Reynolds Thermocompressor is its compact size. Single nozzle units are offered in sizes ranging from 2” to 6” suction and discharge, although larger units can be made. Where first cost is the prime consideration, single nozzle units are recommended. Single nozzle units are also the preferred approach where large compression ratios are involved.

**Single Nozzle Spindle Operated**

The diffuser configuration of a Croll-Reynolds single nozzle Thermocompressor, equipped for spindle operation, is similar to that of a standard fixed orifice unit. The nozzle itself, however, is quite different.

The nozzle and spindle assembly combines a rounded entrance orifice with a straight section into which a tapered spindle is guided. Its operation is very much like that of a needle valve. The length of the spindle travel is based upon actual design specifications.

Spindle operated units are used where suction and discharge pressure vary greatly, requiring large compensating changes in motive fluid flow. Higher efficiencies are obtained by maintaining high motive pressure rather than throttling.

The pneumatic actuator is an air-to-open device that operates on an air pressure range from 3 to 15 psi. A sensing device is employed for triggering the actuator. It may be activated by temperature, pressure, flow or pressure ratio.
Multiple Nozzle

Croll-Reynolds multiple nozzle Thermocompressors are unique in both design and performance. In most cases they achieve steam savings of 10% to 15% when compared with single nozzle units designed for the same conditions. In many specialized installations, even greater savings result.

The construction of the multiple nozzle fixed orifice thermocompressor is the same as the single nozzle unit, except that it employs several steam nozzles. The usual configuration has one nozzle on center with remainder of the nozzles equally spaced peripherally around it. This type of unit may be used for applications requiring critical or non-critical flow design. Its characteristic curve is similar to that of a single nozzle unit.

The advantage of the multiple nozzle design is its higher efficiency versus a single nozzle thermocompressor. It is also considerably shorter in length than an equally rated single nozzle unit.

Although multiple nozzle units are significantly more efficient at a given set of conditions than standard single nozzle designs, they have less flexibility than a spindle operated unit, since they cannot automatically compensate for variations in conditions.

Materials of Construction

The no-moving parts simplicity of a Croll-Reynolds Thermocompressor minimizes maintenance and downtime. They can be fabricated from any workable or weldable material that the user’s special needs may demand.

Standard materials of construction for small, single nozzle unit are cast-iron with a stainless-steel nozzle.

Spindle operated and multiple nozzle thermocompressors typically have carbon steel bodies and stainless steel nozzles as standard materials of construction. In spindle operated units, spindle and spindle guide are also stainless steel.

For most conventional applications, these materials will withstand abrasion and corrosion resulting from the passage of steam at supersonic speeds through the basic body and the stainless steel nozzle. However, where highly corrosive conditions exist, or where special industry requirements demand (as in the food industry), units can be fabricated entirely of stainless steel or from Hastelloy, Titanium and other exotic alloys.

Since the user is best qualified to determine the corrosive properties of the process gas in his application, materials of construction are normally specified by the customer, Croll-Reynolds Company will, of course offer its technical input based upon our experience in the design and manufacture of steam ejectors and similar equipment for the process industries.