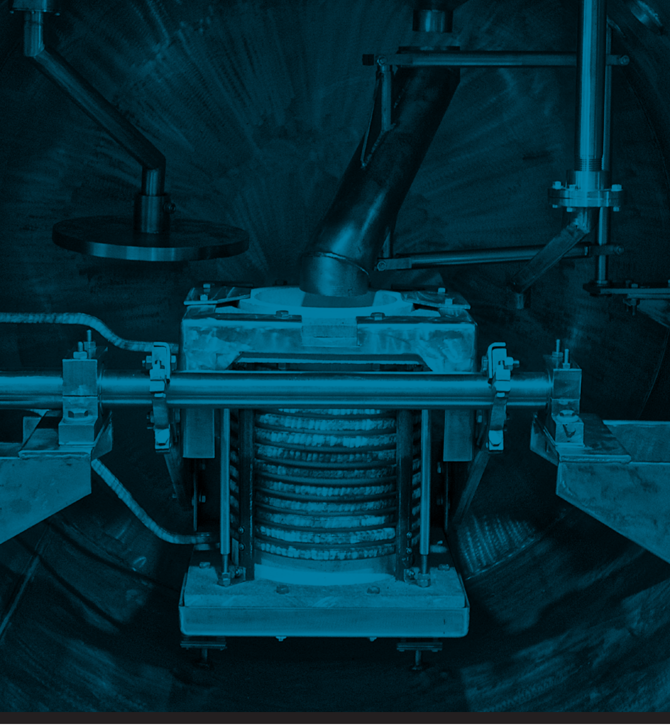

KINNEY®

CASE STUDY

VACUUM PUMPS FOR VACUUM FURNACES

METALLURGICAL PROCESSES

Vacuum furnaces are used for the following metallurgical processes:

- Hardening-heating steel above the critical temperature for austenitizing to occur and rapid quenching (cooling) to transform austenite into martensite microstructure for a harder steel or alloy.
- Tempering-controlled heating of iron based alloy below its critical temperature to reduce hardness while increasing toughness or ductility (less brittle).
- Annealing-controlled heating softening, and cooling of a metal to reduce dislocations in its microstructure to increase ductility and workability while reducing hardness and internal stresses (stress relieving).
- Nitriding-adsorption of Nitrogen into the surface of the heated metal at controlled temperature and pressure to increase its surface hardness without much dimensional change.
- Carburizing-adsorption or diffusion of Carbon from a source such as CO_2 or CH_4 into the surface of the heated iron based alloy at controlled temperature and pressure to increase its surface hardness.
- Quenching-rapid cooling, normally using an inert gas (Nitrogen, Helium, Argon), of a heated iron based alloy to achieve increased hardness by controlling the microstructure formation.
- Brazing-metal joining process using a filler metal that is heated to its melting point such that it will flow through capillary action into the joint of the two metals with higher melting points.
- Sintering-metallurgical bonding of compacted metal powders at controlled temperature (below the melting point of any constituent) and pressure.

VACUUM FURNACE APPLICATIONS

Why are vacuum furnaces used? Because of the advantages they offer over atmospheric furnaces:

- Reactive gases such as Oxygen and Water Vapor are removed that might cause an adverse reaction at elevated temperatures.
- Vacuum furnaces provide a better contained environmental chamber with control of pressure, humidity, and gas species besides temperature and flow.
- Lower contamination of product.
- Lower contamination of the environment.
- Better product homogeneity and repeatability.
- More uniform temperatures and choice of gas quenching for rapid cooling.

Vacuum furnace type and designs vary widely depending upon the process. The operating pressures can vary widely as well, depending upon the process, with typical pressures varying from 760 to 10^{-6} torr, with most heat treating applications occurring between 0.1-10^{-6} torr. The vacuum pumps are the pumping heart of the vacuum furnace with the brunt of the work handled by the roughing mechanical pumps, which typically pump the system down from atmosphere to 10^{-2} torr, before turning it over to the high vacuum pumping system normally consisting of an oil diffusion pump. The roughing mechanical system is normally a two-stage pump or booster/mechanical pump system depending upon the furnace size. Because of the pumping demands and processes occurring in a vacuum furnace, the roughing pumps must be rugged and reliable.

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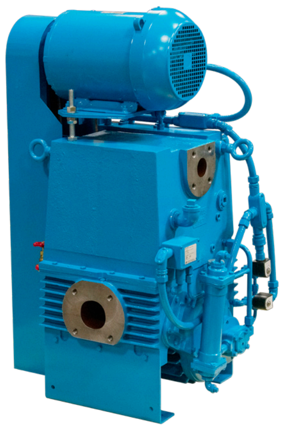
Two-Stage Pumps:



Compound Rotary Piston Pump

Booster/Rotary Piston Pump System

Single-Stage Pump:

Single-Stage Rotary Piston Pump

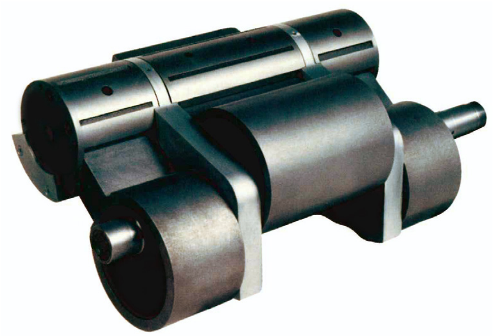
Comparison of Vacuum Pumps for Vacuum Furnace Applications

Feature	Oil Sealed Rotary Piston Pumps	Oil Sealed Vane Pumps	Dry Pumps
Ruggedness & Robustness	Most rugged/robust pump due to all cast iron rotary internals, larger clearances, lower RPMs, oil flush medium, and lower internal temperatures	Least rugged/robust pump due to flimsy vanes that can stick or break, lower oil flow rates, and higher RPMs	More rugged/robust pump due to lack of contact of rotary internals
Clearances	Largest internal clearances since liquid sealed with robust oil flow rates	Smaller internal clearances than rotary piston pumps	Smallest internal clearances because of lack of sealing fluid to reduce gas slippage
Sensitivity to Particulate	Least sensitive to particulate because of larger clearances, large oil flows for flushing, and lower RPMs	Most sensitive to particulate because of rotary vanes and smaller oil flow orifices that can plug	More sensitive to particulate because of small clearances, lack of flush medium, and higher RPMs
Internal Temperatures	Lowest internal temperatures because of lower RPM, reduced surface contact of rotary components, and heat transfer fluid	Higher internal temperatures because of direct drive RPM of motor, frictional vane contact, and lower cooling oil flows	Highest internal temperatures because of lack of internal fluid for heat transfer and higher RPM
Repair-ability	Most easily repaired on site due to doweled heads and simplicity of design	More easily repaired on site if replacement pump module is used	Most difficult to repair on site
Capital Cost	Lower capital cost	Lowest capital cost	Highest capital cost

Vacuum boosters and oil sealed rotary piston vacuum pumps are all manufactured by MD-Kinney in Springfield, MO and the vacuum systems are totally assembled and tested by Kinney at the same location. Kinney has provided thousands of these pumps and systems which have an exceptional track record in providing reliable performance for the vacuum furnace market.

WHAT ROUGHING PUMP IS RECOMMENDED FOR VACUUM FURNACES?

The chart on the following page illustrates how the oil sealed rotary piston pump best satisfies the vacuum furnace requirements for reliability, and has been used for decades to provide either the pump down or processing pressures in the range of 760-10^{-2} torr.



Triplex Rotary Piston Pump Internals

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