Multi-stage **steam jet vacuum systems**

Körting

THE EJECTOR COMPANY

Technical vacuum up to 0.05 mbar

The vacuum application experts

Multi-stage steam jet vacuum systems

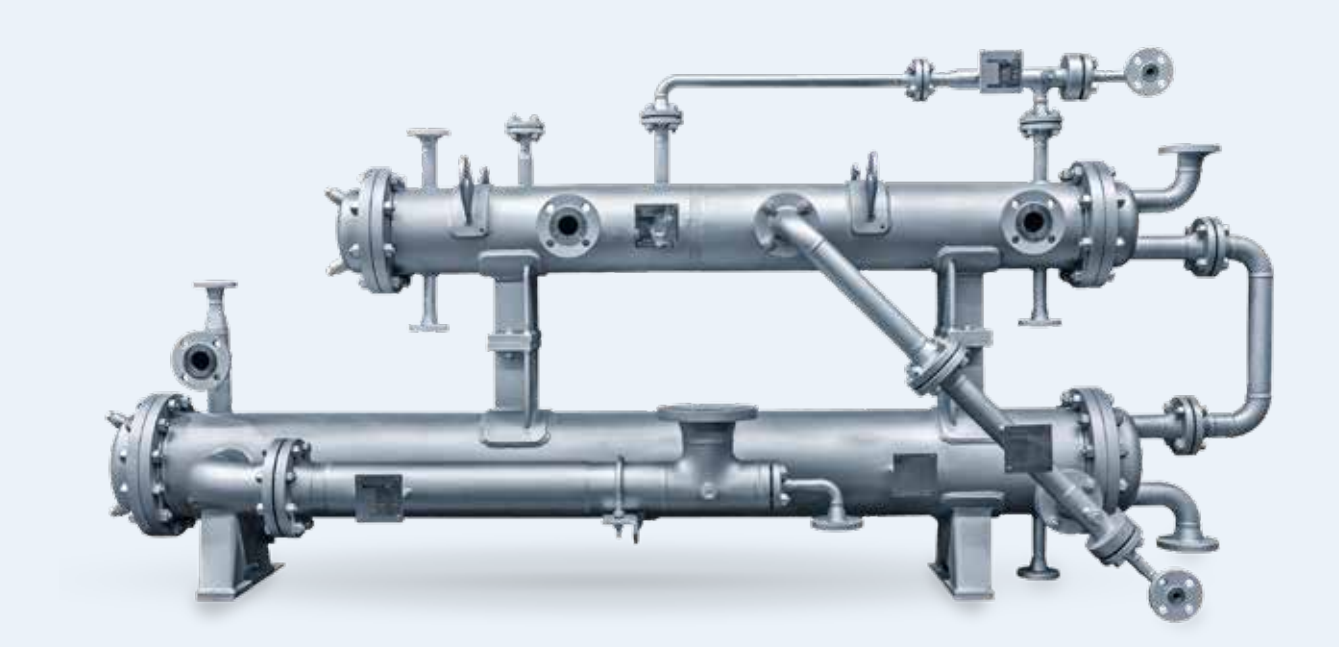
IDEAL SOLUTIONS FOR ANY APPLICATION

The potential for multi-stage steam jet vacuum systems in the processing industry is virtually unlimited. A diverse range of these systems is used to match the application concerned. A steam jet vacuum system typically consists of one or several **steam jet vacuum ejectors**, one or several upstream, intermediate or downstream **condensers**, and another steam jet vacuum ejector or **liquid ring vacuum pump** as the final stage. The process vacuum required, the amount of process vapors and gases, cooling water temperature and motive steam pressure applied play a major role in determining the number of stages, condensers and steam jet vacuum ejector design. The materials used, ambient conditions and the customer's and operator's specs and standards must be reflected if a multi-stage steam jet vacuum system is to be operated reliably. Körting Hannover GmbH incorporates all these factors to develop the perfect **vacuum system** for every customer.

When it comes to constructing an end-to-end multi-stage steam jet vacuum system, Körting Hannover GmbH occupies a unique position and leads the industry. In terms of development, design, manufacturing, inspection and sales, it's been offering end-to-end solutions for over 150 years. Consequently, its multi-stage steam jet vacuum systems are top quality.

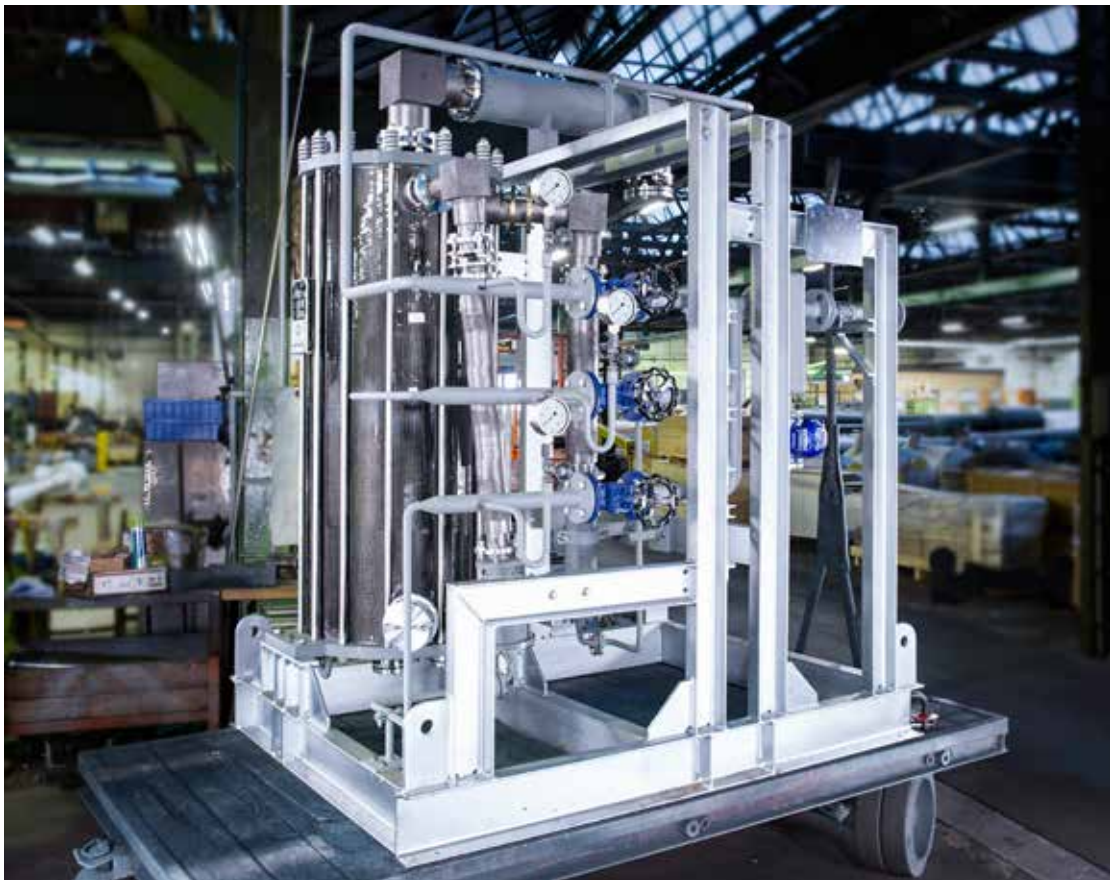
Today, the reduction of all resources used, motive steam in particular, takes centre stage. Körting Hannover GmbH reflects this requirement by basing its steam jet vacuum ejectors' designs on results from thousands of tests that are constantly enhanced and updated. Because, to date, there are still no satisfactory theoretical and numerical methods for designing steam jet vacuum ejectors. At Körting, we perform rigorous tests on steam jet vacuum ejectors to ensure they can be used whatever the application. A vacuum up to 0.05 mbar is achieved, motive steam below 100°C can be used and steam jet vacuum ejectors with a compression ratio of 16:1 are in use.

Three-stage steam jet vacuum system



The practical questionnaire to request a quote quickly is available at **koerting.de/en/multi-stage-steam-jet-vacuum-systems.html** and elsewhere.

Frame-mounted, three-stage steam jet vacuum system made of graphite



BENEFITS OF KÖRTING STEAM JET VACUUM SYSTEMS

- **No moving mechanical parts**
- **Customised materials possible**
- **Minimal maintenance**
- **Top levels of availability (even after lengthy downtime)**
- **Exceptional safety in all respects (e.g. no cavitation risk)**
- **Little safety technology and process monitoring required**
- **Hermetically sealed, without any additional devices needed**
- **No potential sources of ignition, the EU ATEX explosion directive doesn't apply**
- **Superior (low) steam consumption thanks to continuous performance checks under real process conditions**

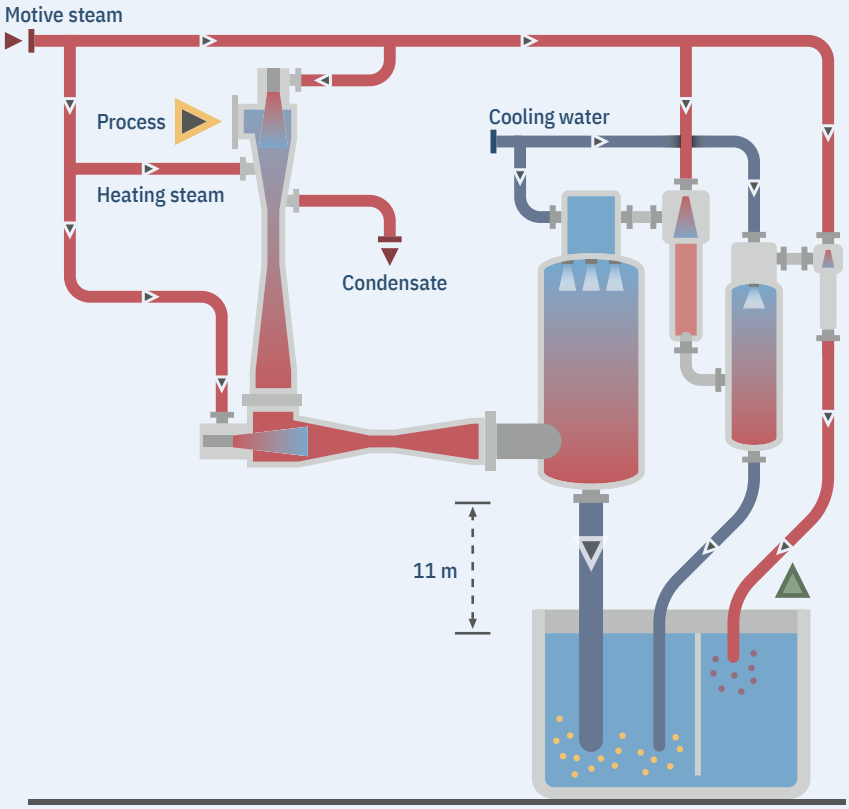
Process management in multi-stage steam jet vacuum systems

The tendency of media to make equipment dirty is one of the factors that governs process design, particularly which condensers are chosen. The type of process design and selection of materials is adapted to suit requirements.

These variants are used when designing steam jet vacuum systems:

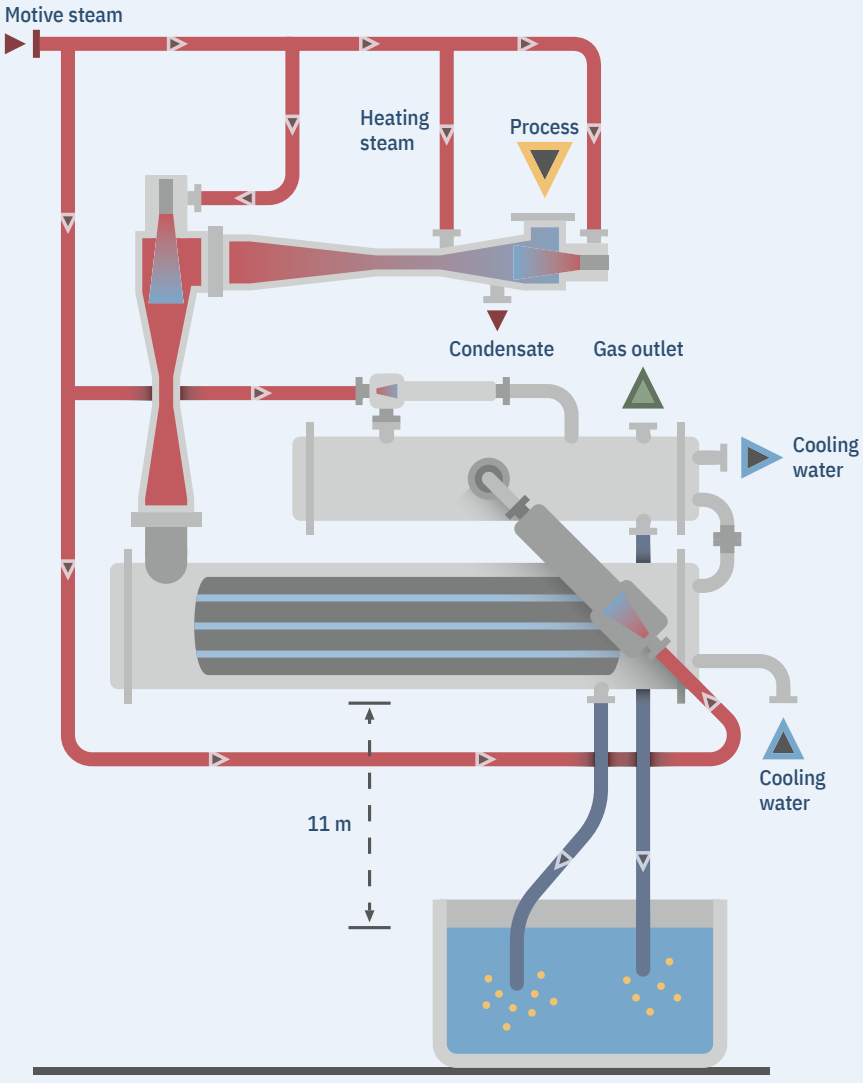
- Mixing condensers with cooling water or process medium, open or closed cooling loops
- Surface condensers with cooling tower water or chilled water
- Surface condensers with the process on the shell or tube side, vertical or horizontal
- Surface condensers with fixed tube sheets or removable tube bundles, floating head or u-tube design
- Unheated, partially heated or fully heated steam jet vacuum ejectors to prevent ice and deposits from forming
- Steam jet vacuum ejector with steam or organic vapour as the motive fluid (e.g. ethylene glycol, butanediol, phenol)
- Liquid ring vacuum pump with water or organic fluids
- A liquid ring vacuum pump with an open or closed loop
- Material selected depending on processes and customer requirements
- Steel and cast iron, as well as all types of stainless steel and any combination of these are used
- Graphite and high-alloy materials, as well as coatings and linings, are also possible

Two-stage, steam jet vacuum system with a surface condenser after final assembly



STEAM JET VACUUM SYSTEM WITH MIXING CONDENSERS

Two jet ejector stages are connected in series in this four-stage steam jet vacuum system with mixing condensers. The jet ejectors take the suction flow and compress it into the main condenser. Two more jet ejectors then vent the main condenser. An intermediate mixing condenser condenses the third jet ejector stage's motive steam. Depending on the cooling water temperature in the first mixing condenser, this type of vacuum system can achieve suction pressure under 1 mbar.



STEAM JET VACUUM SYSTEM WITH SURFACE CONDENSERS

The diagram shows a four-stage steam jet vacuum system with surface condensers. In this example, two jet ejector stages are connected directly in series to achieve suction pressure below 1 mbar. Two more jet ejector stages compress components of the suction flow that can't be condensed from the first surface condenser to atmospheric pressure. The motive steam from the upstream jet ejector is condensed in the intermediate and downstream surface tandem condenser.

Selecting venting units

A HYBRID SYSTEM OR A MULTI-STAGE STEAM JET VACUUM SYSTEM AS A VENTING UNIT

Each vacuum system must be designed for a certain quantity of inert gas, but for the process unit's air leakage at the very least. Ultimately, in a multi-stage steam jet vacuum system, the role of the venting unit (one or more stages) is to convey the steam-saturated inert gas from the main condenser to the atmosphere. The amount of entrained steam is determined by the pressure and temperature at the condenser's outlet.

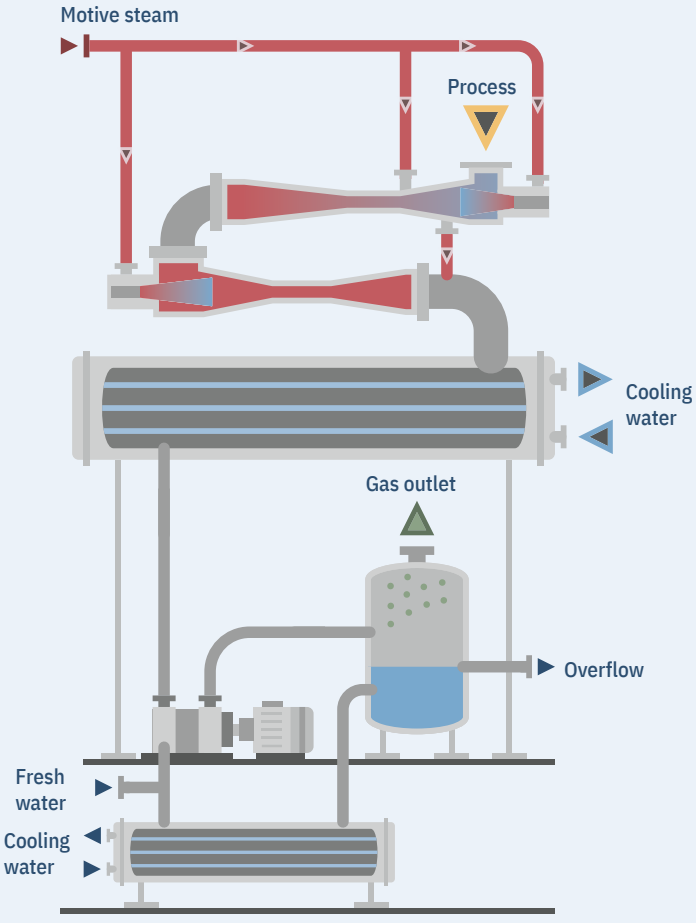
Commercial and engineering considerations govern whether a liquid ring vacuum pump or a multi-stage steam jet vacuum ejector is chosen as the venting unit. Low energy requirements and superior evacuation performance are the strong points of liquid ring vacuum pumps. On the other hand, the benefits of a steam jet vacuum ejector are its reliability and ability to withstand internal soiling and ambient factors.

In addition to traditional steam jet vacuum ejectors, Körting Hannover GmbH has also been providing its own liquid ring vacuum pumps since 2016.It selects components, manufactures, assembles and tests them itself. Over 150 liquid ring vacuum pumps have already been produced and successfully commissioned worldwide. The company excels in providing fully assembled units with instruments, controls and performance checks.

Decades of experience in using steam jet ejectors, condensers and ring pumps makes Körting Hannover GmbH today's most professional supplier of these vacuum systems worldwide. What's more, it offers its customers end-to-end system solutions.

CRITERIA FOR SELECTING THE VENTING SYSTEM

A hybrid system consisting of two steam jet vacuum ejectors with surface condensers and a liquid ring vacuum pump



HYBRID VACUUM SYSTEM WITH SURFACE CONDENSERS AND LIQUID RING VACUUM PUMP

This is a three-stage hybrid vacuum system with surface condensers. A liquid ring vacuum pump vents the surface condenser. This mechanical pump is the vacuum system's last stage. The combination of steam jet vacuum ejectors and mechanical vacuum pumps is also called a hybrid system.

Controlling steam jet vacuum systems

Three methods are possible:

- Controlling suction capacity in single-stage steam jet vacuum ejectors
- Changing the quantity of motive steam
- Controlling the vacuum in multi-stage vacuum systems

A steam jet vacuum ejector's motive steam flow is governed by the cross-section in the motive nozzle orifice and the condition of the motive steam pressure applied. The flow can only be changed via these parameters. In terms of efficiency, using a nozzle needle is superior to simply throttling the motive steam. The lower the motive steam pressure is, the greater the benefit of the nozzle needle.

When operating steam jet vacuum ejectors with low compressions, using a nozzle needle simultaneously changes the motive steam flow, discharge pressure and suction capacity. As a result, complex control of all parameters is possible. Körting Hannover GmbH has its own calculation programs to enable customised designs and control of these steam jet vacuum ejectors for the relevant application.

In multi-stage steam jet vacuum systems, each of the stages functions at different pressure levels. The compressions achieved per stage are usually greater than 3:1 (discharge pressure to suction pressure).

These compression ratios can only be achieved if the motive steam expands to supersonic velocity and sonic velocity is achieved with the suction flowin a steam jet vacuum ejector's mixing section. Therefore, this mixed flow is the maximum for one of the steam jet vacuum ejector's operating points and can't be increased any further.

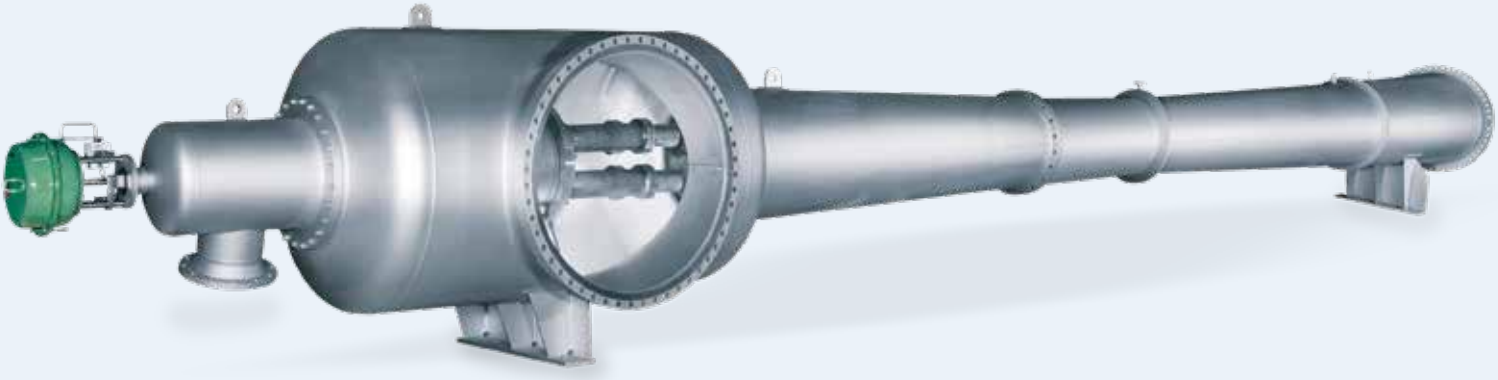
Decreasing the motive flow (via throttling, nozzle needle) causes a small change in a steam jet vacuum ejector's suction capacity. However, a much more important effect occurs on the steam jet vacuum ejector's outlet. The lower motive energy also decreases the achievable discharge pressure.

Therefore, in a multi-stage steam jet vacuum system, motive steam pressure can only be reduced if permitted by the discharge pressure required (usually the condenser pressure). In other words, in multi-stage steam jet vacuum systems, using nozzle needle control or throttling the motive pressure only serves to reduce the quantity of motive steam to save energy. Controlling suction pressure isn't possible in this way.

SUITABLE WAYS OF CONTROLLING THE VACUUM OF A MULTI-STAGE STEAM JET VACUUM SYSTEM ARE AS FOLLOWS:

- **In small and medium-sized systems, throttling on the suction side**
- **Adding motive steam as ballast to the suction side for small control ranges**
- **Recirculating mixed steam from the steam jet vacuum ejector's discharge side to the suction side via a control valve**
- **Running steam jet vacuum ejectors in parallel**
- **Cascade controlling**

Steam jet vacuum ejector with nozzle needle to cut motive steam



Motive steam requirement for multi-stage steam jet vacuum systems

When designing a system for a quote or an order, a steam jet vacuum system's motive steam requirement is calculated individually in each case. The goal should always be to design a system that uses a minimum quantity of motive steam.

Lots of factors influence the quantity of motive steam in each steam jet vacuum ejector and the requirements of all stages.

The quantity of motive steam is governed by the amount of compression per steam jet vacuum ejector, number of stages, cooling water used, motive steam pressure, amount of air leakage, and design of the last stage.

When suction pressure is under 10 mbar (absolute), a steam jet vacuum ejector's compression ratio is often a factor of 8 and even higher in the range below 2 mbar (absolute). These compressions are also achieved at low motive pressures, since the expansion of the motive steam to the process vacuum is very high.

The compressions in the venting unit are significantly lower and a factor of 3 to 4. In this case, the motive pressure selected has a huge impact on motive steam requirements. The higher the motive pressure, the lower the requirement for steam. The expansion factor of the motive steam has an impact.

This disadvantage can be compensated for by increasing the number of stages with smaller compressions. Therefore, at low motive steam pressure of 2 to 4 bar, good consumption figures at 8 to 16 bar are possible.

The temperature of the cooling water determines the pressure in the condenser, where motive and suction steam condense to the greatest extent possible. This reduces the suction flow (volume and mass) for the next stage and makes operating a multi-stage steam jet vacuum system possible in the first place. The impact of the cooling water temperature on the quantity of motive steam is considerable, because the maximum cooling water temperature always has to be taken into account in the design. The steam jet vacuum system can be adjusted at a later date to reflect the annual or daily cooling of the water (see Controlling). The biggest saving is only achieved when consistently cold water is used. A traditional steam jet vacuum system requires approx. 50% more motive steam at cooling water of 30°C than at 15°C, and even 65% more than at cold water of 5°C.

In surface condensers, the condenser pressure is always higher than in mixing condenser, which increases motive steam requirements by 10 to 30%.

In order to reduce both the motive steam and exhaust gas required, it's vital to reduce the quantity of leakage air from a vacuum system. It's calculated by measuring the rise in pressure, but a higher value is always applied when designing a steam jet vacuum system.

In new and legacy steam jet vacuum systems, motive steam is saved in the following ways:

- By using cold water in the condensers
- By using a liquid ring vacuum pump as the last stage
- By increasing the steam jet vacuum ejector's number of stages
- By checking and setting the right motive pressure
- By frequently inspecting a steam jet vacuum ejector's inner cross sections for wear
- By replacing faulty gaskets
- By looking for and reducing leaks
- By replacing overdesigned steam jet vacuum ejectors

We'd be delighted to send you a quote to inspect your steam jet vacuum system on site. Our experts log measurements, troubleshoot, train your employees and liaise closely with you to find tailor-made solutions.

In-house manufacturing

As we produce jet ejectors and condensers in our own plant in Hanover, Germany, we can quickly implement process-enhanced designs at top quality in efficient production systems. We can process all standard types of steel, as well as high-alloy stainless steel, duplex steel and various special materials and plastics.

This is some of the certification Körting Hannover GmbH can present:

- TÜV-Cert DIN EN ISO 9001
- AD 2000 HP0/DIN EN ISO 3834-2
- DGRL 2014/68/EU
- ASME Certification Mark
- Manufacture License of Special Equipment People's Republic of China

You can find these and lots more certificates at:
koerting.de/en/certificates-and-licenses.html

Our own R&D department

As a leading manufacturer of jet ejector, vacuum and environmental technology solutions, application-driven research and development are required. These foundations underpin continual improvement and are indispensable when launching new and innovative engineering solutions.

We have our own test rigs and testing equipment for nearly all products and components. Steam jet vacuum ejectors can be tested for up to DN 1,000 and 4,000 kg/h of motive steam at 1 to 20 bar.

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