Designs
Applications
Mechanics

THE EJECTOR COMPANY

The basics of jet ejectors

Körting Academy

Körting jet ejectors

THE BEGINNINGS

On 1 November 1871, Ernst and Berthold Körting founded a general partnership called Gebr. Körting to construct jet pumps.

In the same year, Ernst Körting applied fluid mechanics to design and develop the injector as a steam jet boiler feed pump.

Back then, the company primarily focused on designing and making its own jet ejectors and injectors with jets of steam or water, which act as propellants to convey and mix liquids and gases. These are some of the core products still made in-house at the Hanover site in Germany today.

Each jet ejector is custom made and based on over 150 years of experience and consistent enhancements.

Depending on the design, it can be made in diverse materials:

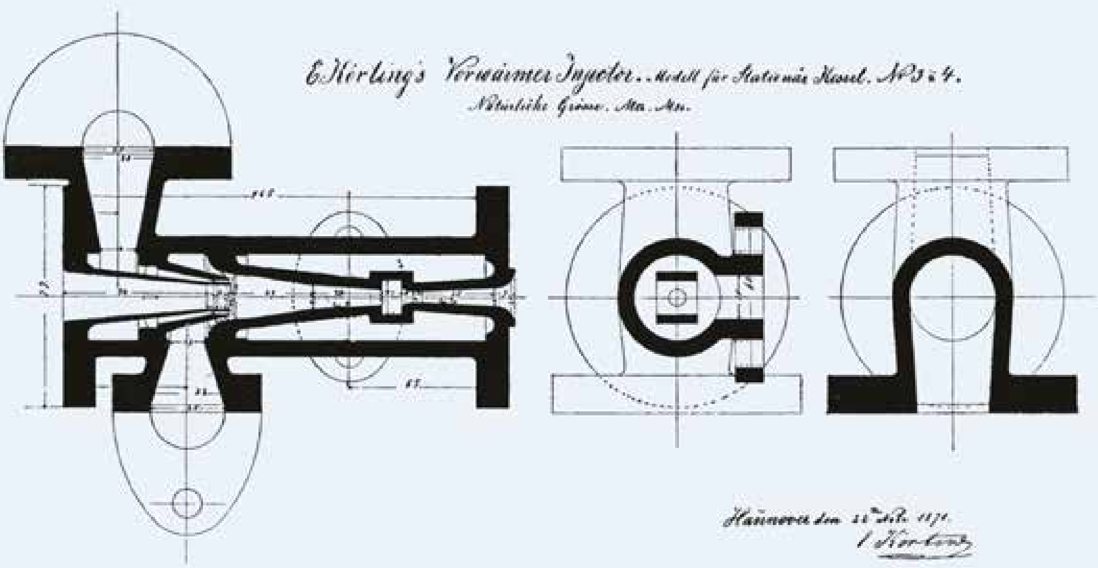
- Nodular cast iron/grey cast iron
- Carbon steel
- Stainless steel
- Special materials such as titanium, Hastelloy and graphite

To make and use jet ejectors in the areas concerned, in-depth knowledge of flow processes and experience with applying the laws of thermodynamics and hydrodynamics are required. This brochure's goal is to explain the mysteries of the jet ejector.

For more information on Körting Hannover GmbH's products, go to **koerting.de/en**

INJECTOR DRAWING FROM 1871

Ernst Körting developed his jet pumps himself – just like this steam jet ejector, which was also used in locomotive furnaces.



APPLICATIONS

Because of the exceptional benefits they offer, Körting jet ejectors are used in virtually all industries and applications worldwide today.

This video explains more about the benefits of Körting jet ejectors: **koerting.de/en/jet-ejectors.html**

Jet ejectors are used for the following purposes:

- To generate a vacuum
- To compress gases and vapours
- To convey liquids
- To convey solid matter
- To mix gases
- To mix liquids and gases
- To mix and dilute liquids
- To dissolve and dilute solid matter and chemicals
- To heat liquids
- To condensate and absorb vapours or gases
- To cool superheated steam to the temperature of saturated steam

BENEFITS OF KÖRTING JET EJECTORS

- No electricity required
- Cost- and energy-efficient
- Reliable and maintenance free
- Simple, robust designs
- Durable and low wear
- Low weight and space saving
- Exceptional reliability
- No moving parts or unwelcome constrictions

An over 30-metre-long, Körting steam jet compressor at the Hanover site

DESIGN AND HOW THEY WORK

A jet ejector achieves a pumping action via a propellant fluid as the energy source. As a result, a jet ejector requires no mechanical drive, in other words, no moving parts. This principle applies to all jet ejectors, regardless of design and application. The application governs the shape of the flow areas.

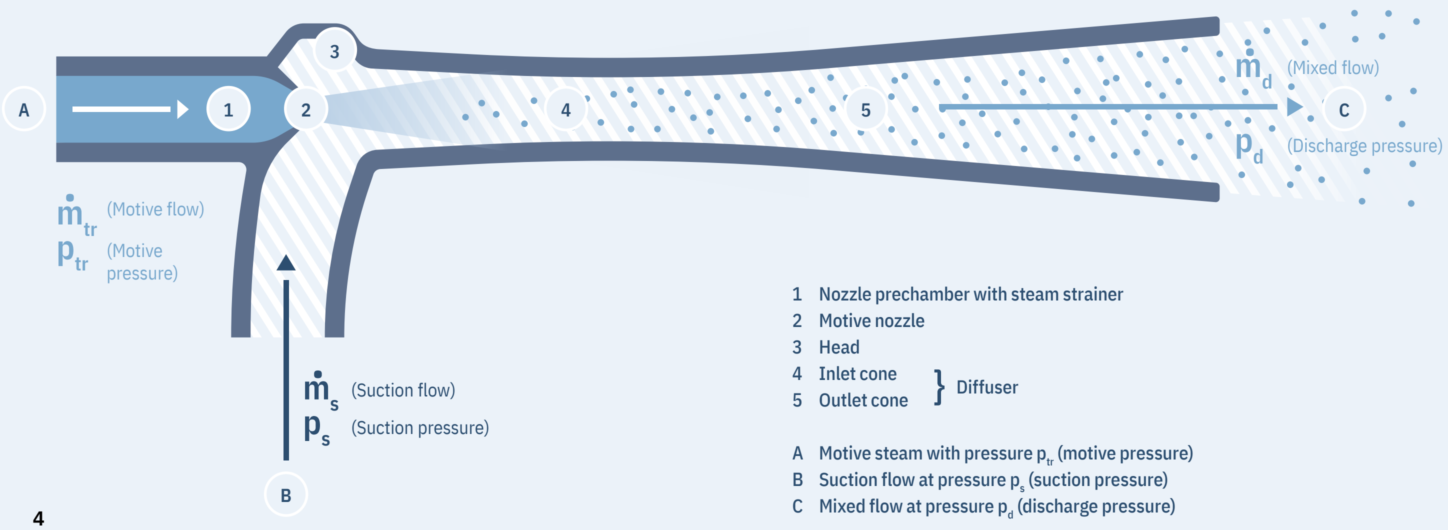
The following diagram shows the design of a jet ejector. The motive nozzle (2) and inlet and outlet cone (4 + 5) are vital for the jet ejector to function properly. The motive fluid flows through these components one after the other.

The flow area changes along this path. Pressure falls in the motive nozzle (2) and velocity increases. In the opposite way, the flow in the cones (4 + 5) is slowed down again. In the process, the pressure increases to the discharge pressure at the jet ejector's outlet.

The area with the lowest static pressure is between the motive nozzle (2) and the diffuser (4 + 5); this is approximately the suction pressure p_s (actually slightly lower than the suction pressure because the pressure loss at the inlet has to be compensated for). This is where the suction flow is fed into the head (3) through suction port B and mixed with the propellant, which flows very quickly here. This is carried out by momentum exchange where some of the propelling jet's high kinetic energy is transferred to the suction flow. The motive and suction flows pass through the diffuser and gain pressure through deceleration.
As regards the suction flow, the rise in pressure of the suction pressure p_s to the discharge pressure p_d equals the jet ejector's delivery head (or pressure difference).

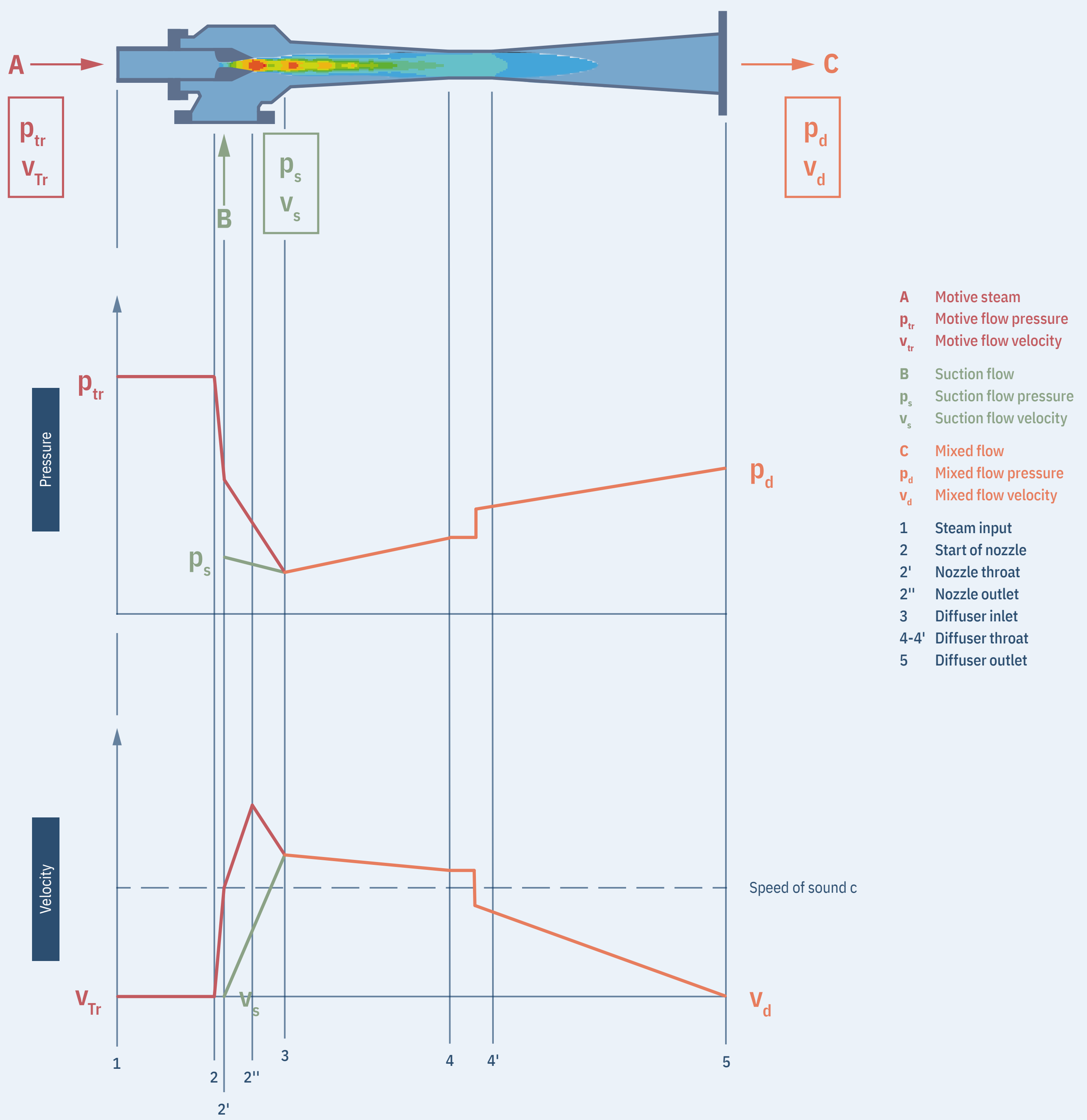
In other words, in a jet ejector, the energy from the propellant's static pressure energy that can't be directly transferred is converted to kinetic energy, which can be delivered to the suction flow by impulse during mixing. The diffusor then converts the kinetic energy from the mix of motive and suction flows back into static pressure energy.

DESIGN OF THE KÖRTING JET PUMP



SUPERCRITICAL FLOW STEAM JET EJECTOR

Top: CFD simulation (Mach number)
Bottom: velocity and pressure profiles (simplified diagram)



In this steam jet vacuum ejector, the critical pressure ratio in the motive nozzle (2 - 2”) is exceeded, as the widening of the nozzle’s cross-section behind the narrowest point (nozzle throat 2’) indicates. This accelerates the motive steam (1) to way above the speed of sound c and lowers the pressure to slightly below the suction pressure p_s (3). Motive and suction flows are mixed in the inlet cone at supersonic velocity and slowed down to about the speed of sound when they reach the diffuser throat (4 - 4‘). A sonic shock, also familiar from supersonic aircraft, occurs here where the flow is reduced to subsonic speed. The remaining rise in pressure to the discharge pressure p_d occurs in the diverging diffuser section (outlet cone) when the speed is reduced because the cross section expands (4‘ - 5).

DEFINING KEY FIGURES

To assess jet ejectors regardless of their size or area they're used, the following ratios are normally applied:

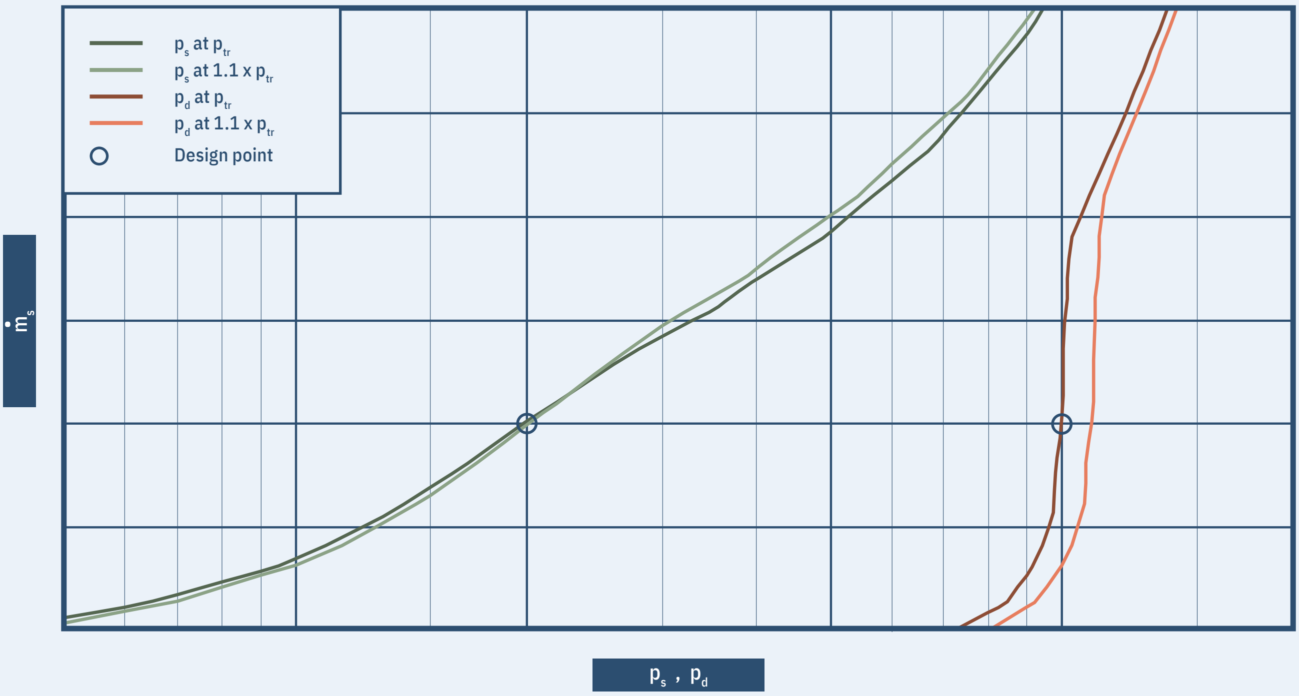
- In a jet ejector, the p_d /p_s ratio is the compression ratio. The compression ratio of steam jet ejectors spans from 1 (just slight compression in steam jet ventilators) and about 18 (specially enhanced steam jet compressors for vacuums). However, the usual range is between 1.5 and 10.
- The p_s /p_{tr} ratio is called the expansion ratio. It has to be much lower than 1 for the jet ejector to operate in a range that's reasonable in terms of energy.
- The relative suction flow (entrainment ratio) $1/\mu = \dot{m}_s/\dot{m}_{tr}$ depends, among other things, on the first two ratios mentioned.

The three ratios are dependent on one another. If the motive pressure's changed, it's not the expansion ratio that alters but the suction pressure. Since the compression ratio is identical, the discharge pressure will change as well. Due to the different motive pressure, the motive flow passing through the nozzle also varies. However, as the relative suction flow also stays the same, the suction flow will adapt to the new conditions.

But in reality, due to the jet ejector's characteristic curve, this means that when the suction flow stays the same and the motive pressure changes, suction pressure only alters slightly, whereas the discharge pressure changes to the same extent as the motive pressure.

DIAGRAM HIGHLIGHTING HOW A JET EJECTOR'S PERFORMANCE DEPENDS ON THE MOTIVE PRESSURE

The diagram shows the impact of a 10% motive pressure increase (light-coloured lines). Based on the gradient in the characteristic curve, changing the motive pressure at constant suction volume, particularly in the design point area, often only results in very slight alterations in the suction pressure (green lines), but the change in the discharge pressure (orange lines) matches the motive pressure.



TYPES AND NAMES

Jet ejectors can be powered by diverse media.

Motive fluids can be as follows:

- Steam and other vapours at overpressure
- Steam and other vapours at normal pressure*
- Vacuum vapour (steam and other vapours)*
- Compressed gas or compressed air
- Normal air
- Water or other liquids

* If the jet ejector's discharge pressure or jet ejector level concerned is low enough.

The following diagram provides an overview of the names of jet ejectors based on the DIN 24290 standard. Regarding the names of special jet ejectors, the general terms for propellants and pumped material (gas, vapour, liquid, solid matter) can be replaced by terms to suit preferences.**

**** Example:**
A liquid jet solids ejector with water as the propellant to convey gravel, could also be called a water-jet gravel ejector.

A steam jet ejector being made in Hanover

To obtain detailed information on each of the jet ejectors, click on the overview in the appropriate link

Based on suction medium	Based on propellant	Gas jet ejector	Steam jet ejector	Liquid jet ejector
Gas jet pump	Jet ventilator	Gas jet ventilator	Steam jet ventilator	Liquid jet ventilator
	Jet compressor	Gas jet compressor	Steam jet compressor (thermocompressor)	Liquid jet compressor
	Jet vacuum pump	Gas jet vacuum pump	Steam jet vacuum ejector	Liquid jet vacuum pump
Jet liquid pump		Gas jet liquid pump	Steam jet liquid ejector	Liquid jet liquid pump
Jet solids ejector		Gas jet solids ejector	Steam jet solids ejector	Liquid jet solids ejector

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