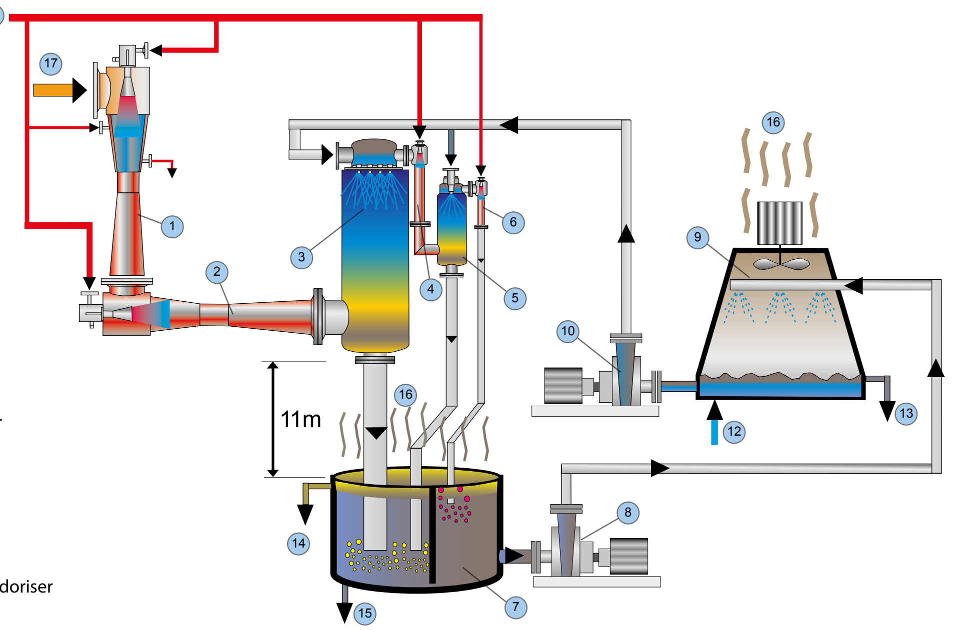
Conventional multi-stage ejector system

greasy cooling tower

Conventional multi-stage steam jet ejector systems are still being used in the edible oil industry worldwide.

1 booster (stage 1)
2 booster (stage 2)
3 mixing (direct contact) condenser
4 ejector (stage 3)
5 intercondenser
6 ejector (stage 4)
7 seal tank
8 cooling water pump I
9 cooling tower
10 cooling water pump II
11 motive steam
12 fresh water cooling tower
13 bleed
14 overflow of fatty water
15 draining
16 gas outlet
17 sparging steam from deodoriser



The conventional multi-stage ejector system consists of:

Two serial-connected boosters (1 and 2), a main mixing (direct contact) condenser (3) and a downstream 2-stage air evacuation group consisting of a steam jet ejector (4), an interconnected mixing condenser (5) and a steam jet ejector (6) as final stage. Together with the required motive steam from the boosters/ steam jet ejectors, the exhaust water vapour and fatty acid components are condensed inside of the mixing condensers. The polluted cooling water for condensation purposes in the mixing condensers circulates via the cooling tower (9) using centrifugal pumps (8 and 10). Furthermore, a seal tank (7) has also been included in the water circuit which, in addition, serves to separate fatty components from the circulating water.

Advantages

- low investment costs
- low maintenance costs
- simple and reliable operation
- no risk of condensers fouling by fat carry-over

Disadvantages

- high water temperature, equivalent to the high pressure in the main condenser requires relatively high motive steam consumption (two booster stages upstream of the main condenser).
- polluted cooling water
- odour can't be avoided
- the cooling tower must be cleaned from time to time (because of the high pollution with fat)

Körting ICE Condensation Vacuum System

Comparison with conventional vacuum systems

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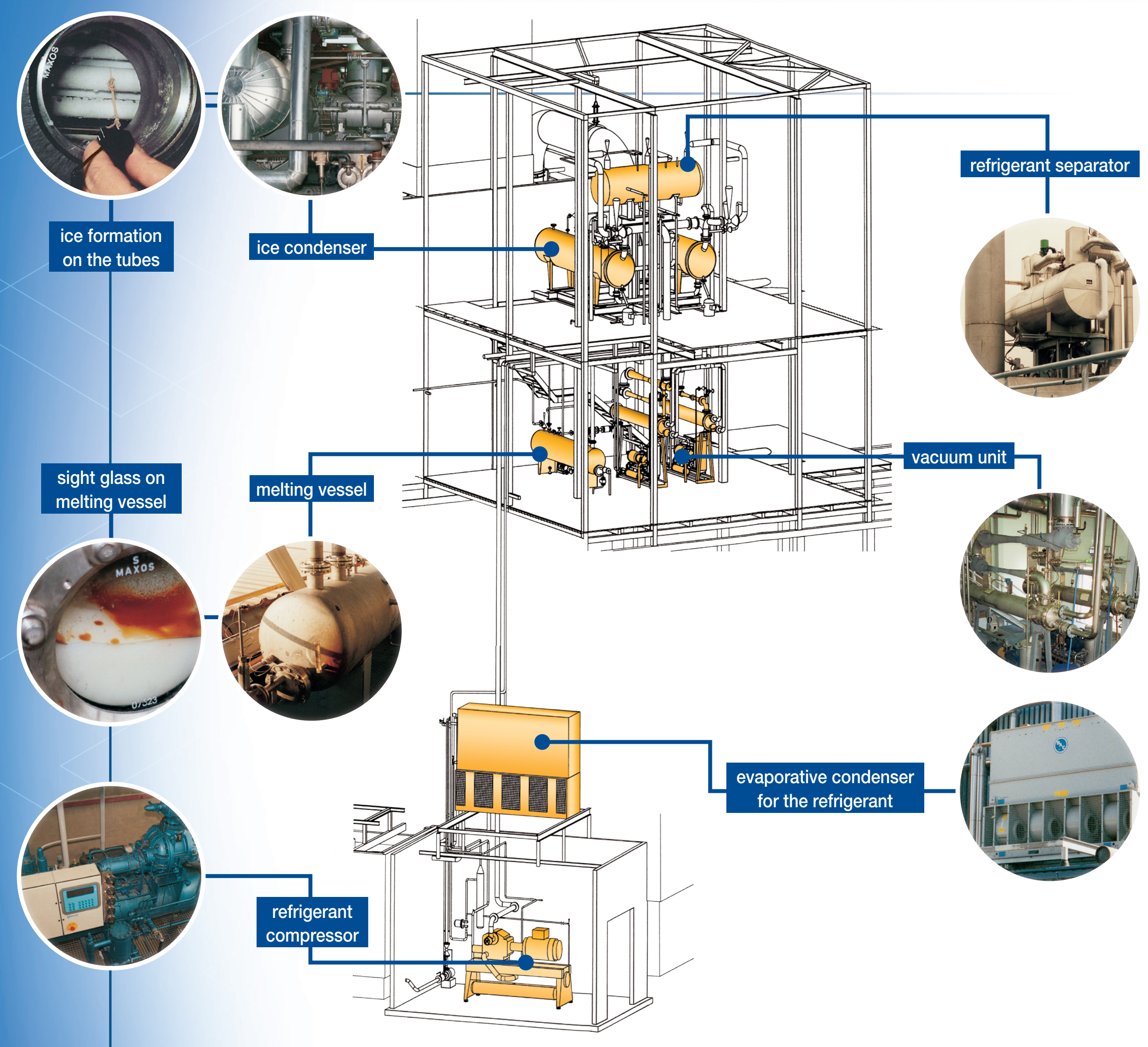
Körting ICE Condensation Vacuum Systems

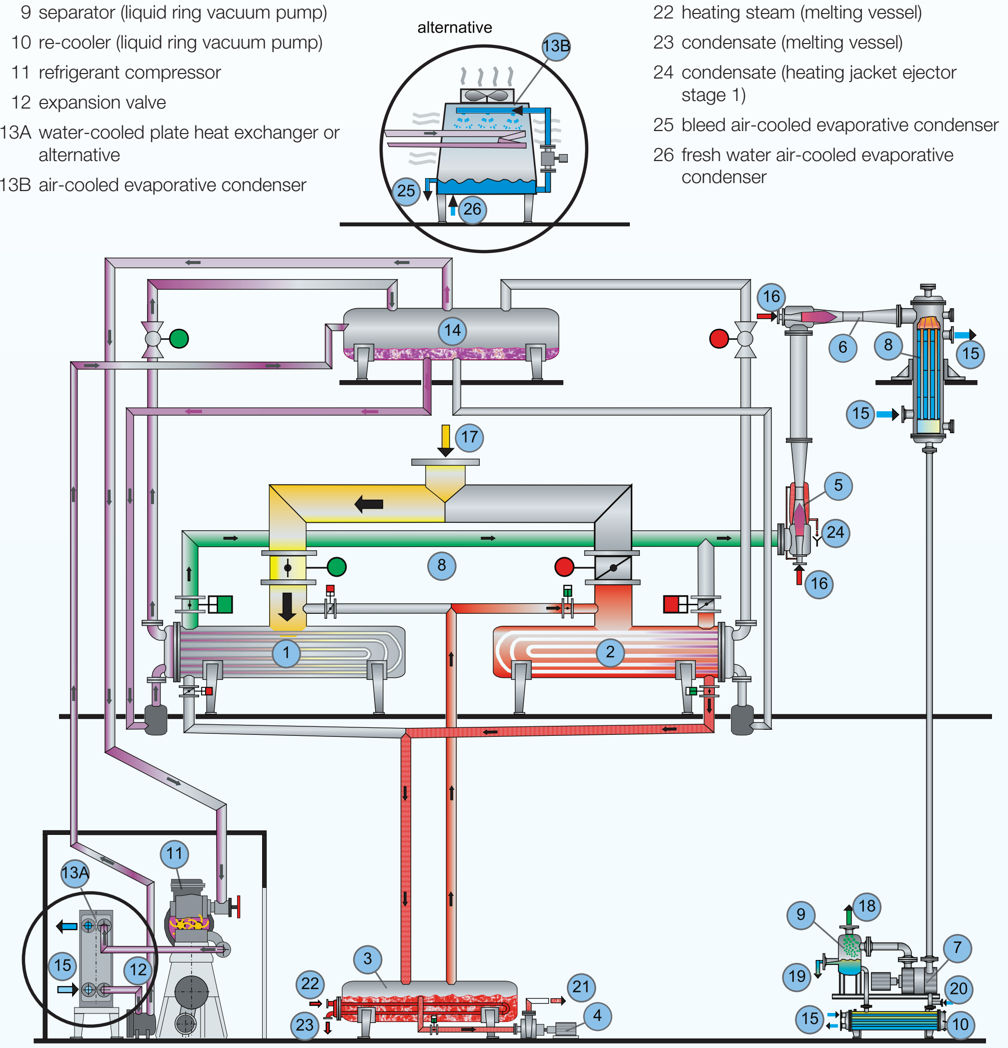
The decision for the suitable vacuum system is a question of economic viability. Apart from the plant's size and its effectiveness, the operating and investment costs also play an important role. Rising costs for utilities such as steam, water and electricity all form the basis for assessing a system.

On the following pages you will find a comparison between a conventional multi-stage ejector vacuum system and a Körting ICE Condensation Vacuum System.



Körting ICE Condensation Vacuum System (clean cooling tower)

1 ice condenser I
2 ice condenser II
3 melting vessel
4 condensate pump
5 ejector stage 1
6 ejector stage 2
7 liquid ring vacuum pump
8 air evacuation condenser
9 separator (liquid ring vacuum pump)
10 re-cooler (liquid ring vacuum pump)
11 refrigerant compressor
12 expansion valve
13A water-cooled plate heat exchanger or alternative
13B air-cooled evaporative condenser
14 refrigerant separator
15 cooling water
16 motive steam
17 process flow
18 gas outlet (liquid ring vacuum pump)
19 overflow (liquid ring vacuum pump)
20 fresh water (liquid ring vacuum pump)
21 overflow (melting vessel)
22 heating steam (melting vessel)
23 condensate (melting vessel)
24 condensate (heating jacket ejector stage 1)
25 bleed air-cooled evaporative condenser
26 fresh water air-cooled evaporative condenser



Utilities

cooling water temperature	33 °C
wet-bulb temperature	26 °C
motive steam pressure	9 bar (abs)

Utility price

cost for motive steam	30.0 Euro/ton
cost for electrical power	0.10 Euro/kWh
cost for re-cooling the cooling water	0.05 Euro/m³
cost for waste water	4.0 Euro/m³

The advantages of Körting ICE Condensation Vacuum Systems are:

- significant energy saving
- steam generator can be smaller sized (investment costs for the steam boiler are much lower)
- virtually zero environmental emission by separating of refrigerant and polluted sparging steam
- simple and reliable operation

How the Körting ICE Condensation works

The installation in the figure on the left illustrates that ice condenser (1) is in use (being charged), where as ice condenser (2) is in the melting cycle. The sparging steam (17) from the deodoriser, polluted by fatty acids, is alternately supplied to these ice condensers. Isolation of process and condensers is done by high-performance butterfly valves. The condenser being charged is kept at low temperature by circulating a refrigerant at a temperature of around -28 °C using a refrigeration unit comprising compressor (11). A refrigerant condenser (13A) or (13B) is used to condense the compressed refrigerant.
-28 °C is below the condensation temperature of the sparging steam used in the deodoriser at approx. 1-2 mbar operating pressure. So the steam is condensed together with most of its impurities on the cooling elements as a coating of ice mixed with fatty crystals.
The ice condenser under melting is entirely separated from the deodoriser and heated to approx. 60 °C to 80 °C with vapour originating from the polluted condensate in the indirectly heated melting vessel (3). The surplus liquid is discharged by a condensate pump (4).
To evacuate only the non-condensable gases a small steam jet ejector vacuum unit combined with a liquid ring vacuum pump unit is used. Required cooling water for the interconnected shell and tube condenser (8) as well as for the re-cooler (11) at the liquid ring vacuum pump (7) is kept clean. Only the small amount of condensate leaving the condenser (8) can be slightly polluted and is drained at the liquid separator (9).

Comparison figures of the conventional multi-stage steam jet ejector vacuum system and Körting ICE Condensation Vacuum Systems

	Conventional multi-stage steam jet ejector vacuum system	Körting ICE Condensation Vacuum System operating with water-cooled refrigerant condenser	Körting ICE Condensation Vacuum System operating with evaporative air-cooled refrigerant condenser
Design Parameters			
suction flow (kg/h) H_2O + 8 air + 5 kg/h FFA	300	300	300
suction pressure (mbar)	2.0	2.0	2.0
suction temperature (°C)	80	80	80
Consumption			
total motive steam (kg/h)	**2 280**	**180**	**180**
heating steam (kg/h)		110	110
cooling tower water (m³/h)			
vacuum condensers and liquid ring vacuum pump	333	24	24
refrigeration unit	----	130	2
total water (m³/h)	**333**	**154**	**26**
electrical power (kW)			
refrigeration compressor		190	205
liquid ring vacuum pump		5	5
condensate pump		1	1
total electrical power (kW)		**196**	**211**
Waste water (m³/h)	2.585	0.485	0.485
operating hours per year	8 250	8 250	8 250
steam costs (Euro per year)	564 300	71 775	71 775
waste water costs (Euro per year)	85 305	16 005	16 005
recooling costs for the cooling water (Euro per year)	137 363	63 525	10 725
electrical power costs (Euro per year)		161 700	174 075
Operation costs (Euro per year)	786 968	313 005	272 580
saving after 1 year (in Euro)		473 963	514 388
saving after 2 years (in Euro)		947 926	1 028 776
saving after 3 years (in Euro)		1 421 889	1 543 164
saving after 4 years (in Euro)		1 895 852	2 057 552