Alkaline Closed Loop Vacuum System

Comparison with conventional vacuum systems

Körting HANNOVER AG

THE EJECTOR COMPANY

Alkaline Closed Loop Vacuum Systems (ACL)

The attractiveness of a vacuum system is a question of economic viability. Apart from the plant’s size and its effectiveness, also the relationship between operating and investment costs has great influence. Rising costs for commodities utilities like steam, water and electricity form the basis for assessing a system.

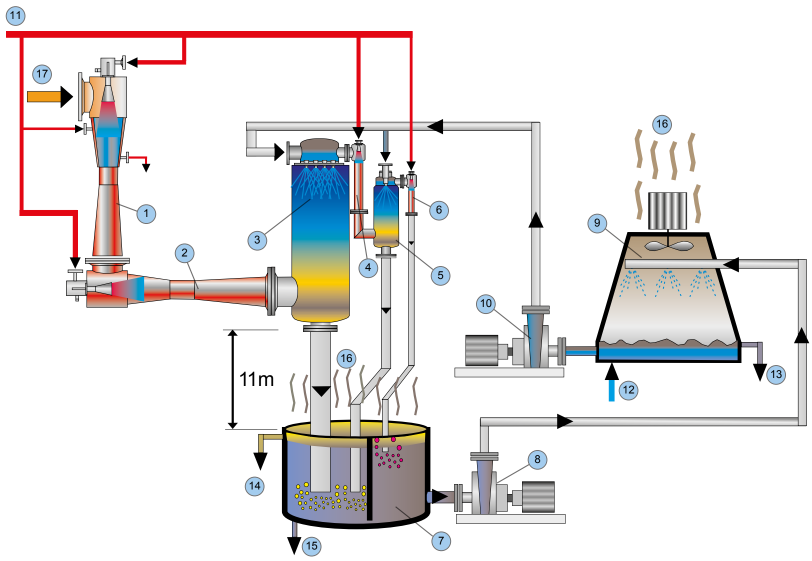
On the following pages you will find a comparison between a conventional multi stage ejector vacuum system and an Alkaline Closed Loop Vacuum System (ACL), also called an **ACL System.**

Conventional multi-stage ejector vacuum system

with 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 interconnected mixing condenser
6 steam jet 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 deodorizer



The conventional multi-stage ejector vacuum 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)

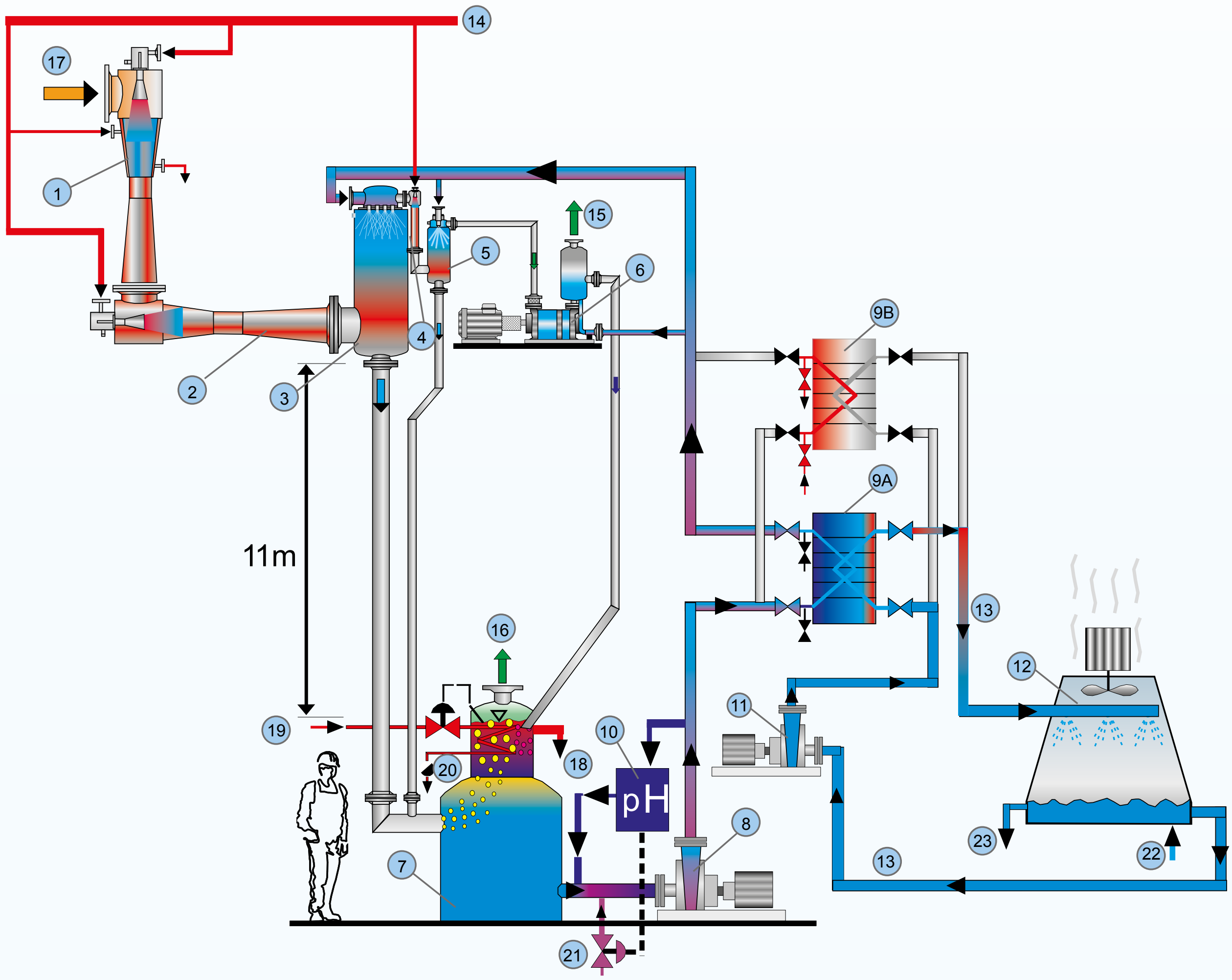
Alkaline Closed Loop Vacuum System (ACL)

with clean cooling tower

As illustrated in the figure below the ACL System consists of: Two serial-connected boosters (1 and 2), a main condenser (3) and a downstream 2-stage evacuation group. Consisting of a small ejector (4), a small mixing condenser (5) and a liquid ring vacuum pump (6) as final stage. Cooling water required for condensation purposes in the mixing condensers circulates within a closed loop by way of a centrifugal pump (8). The closed loop water is re-cooled in plate heat exchanger(s) (9A/B) by clean cooling tower water.

A CIP unit can be used for regular cleaning of the polluted plate heat exchanger without shutting down the whole plant.

Furthermore, a buffer/separator tank (7) is also included in the water circuit to separate and discharge fatty components at the overflow. The pH-value of the closed loop water should be kept at a constant pH-value by using a pH-control unit (10). This is necessary in order to saponify the fatty acids introduced into the water circuit and so to avoid fouling of the plate heat exchangers.



1 booster (stage 1)
2 booster (stage 2)
3 main mixing (direct contact) condenser
4 ejector (stage 3)
5 interconnected mixing condenser
6 liquid ring vacuum pump (lrvp)
7 buffer/separator tank
8 circulation pump
9A plate heat exchanger (in operation)
9B plate heat echanger (in standby)
10 pH-control unit
11 cooling tower pump
12 cooling tower
13 cooling water
14 motive steam
15 gas outlet (lrvp)
16 gas outlet (buffer/separator tank)
17 sparging steam from deodorizer
18 overflow of contaminated liquid
19 heating steam
20 condensate
21 caustic soda (NaOH)
22 fresh water
23 bleed

Advantages

Alkaline Closed Loop Vacuum System (ACL) with clean cooling tower

To operate an ACL system virtually costs the same as the conventional system, but offers the following advantages:

- reliable operation due to two-plate heat exchangers (one in operation, one in standby)
- high efficiency promoted by the mixing (direct contact) condensers
- clean cooling tower, no air pollution
- maintenance-free
- government restrictions are be fullfilled

How the ACL system keeps environmental restrictions

In many countries and regions worldwide vacuum systems must comply with environmental regulations. The Alkaline Closed Loop vacuum system is particularly suited to meet these regulations. Thanks to the closed loop whether smell nor polluted cooling water occur. In addition, the cooling tower don‘t has to be cleaned regularly.
The following components considerably contribute to the environmental-friendly ACL system.

The buffer/separator tank discharges fatty components at the overflow.

By using a pH-control unit the pH-value of the closed loop water is kept constant.

The closed loop water is re-cooled by clean cooling tower water in plate heat exchangers.

Which system is best suited?

The choice of the suitable system depends on many terms. Körting Hannover AG has been developing and manufacturing vacuum systems for more than 140 years. Get in contact with Körting specialists to find the best solution for your application.

Alkaline Closed Loop Vacuum System

with clean cooling tower using chilled water

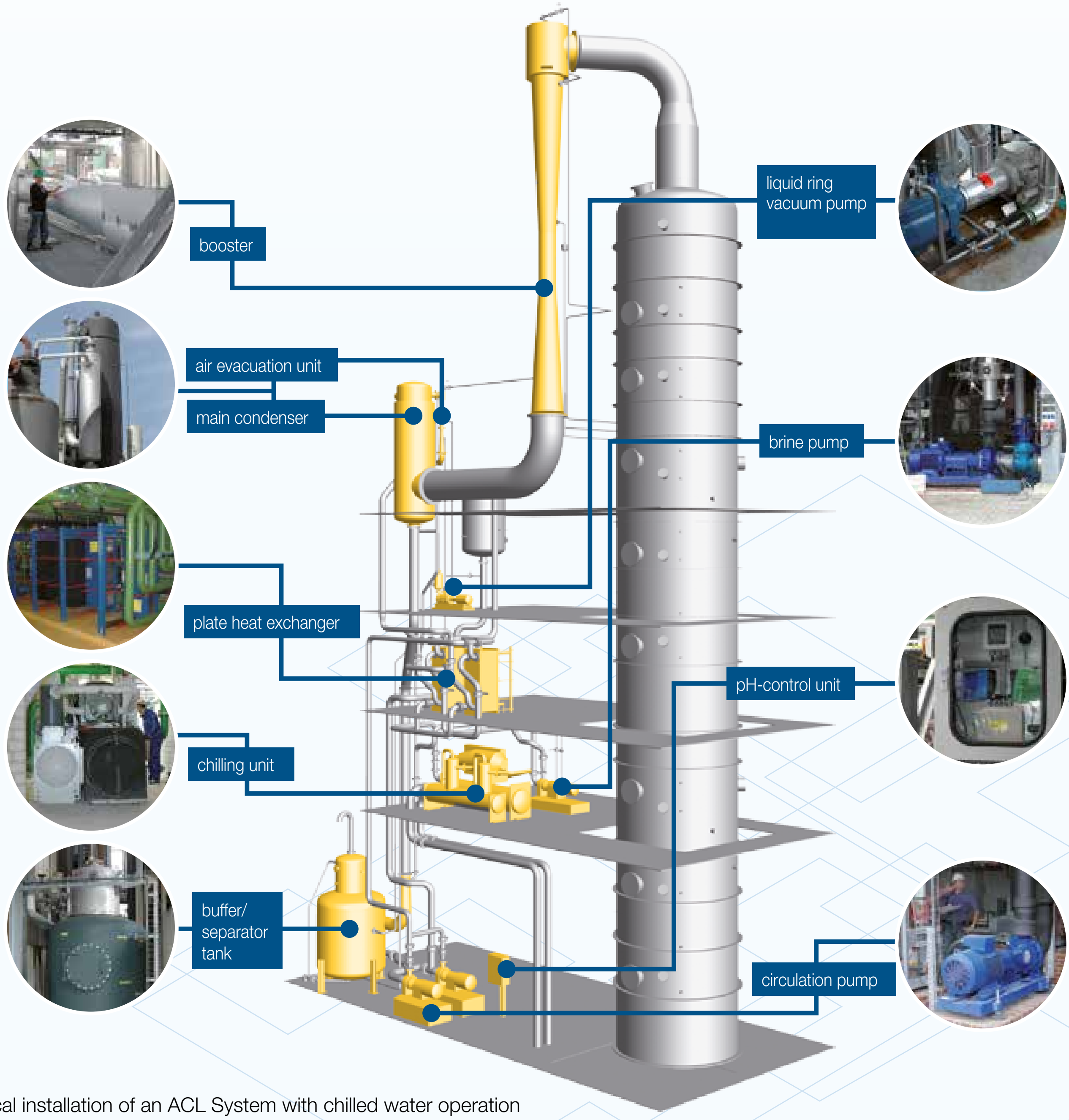
The pressure level for condensing the water vapour (sparging and motive steam) depends on the temperature of the cooling water in the first barometric condenser. The lower the pressure in the condenser, the lower the steam consumption for the whole vacuum system. The closed loop water temperature can be reduced by using a chilling unit which can be operated with water cooled or air cooled.

Because of using chilled water, resulting in a low pressure in the first condenser this system operates only with one booster. The motive steam, the sparging steam from the deodoriser and fatty acid components are condensed in the main mixing (direct contact) condenser. The inert gas flow, saturated with water vapour, is then compressed to atmospheric pressure by means of a steam jet ejector with a second small mixing condenser and a liquid ring vacuum pump as final stage.

Cooling water required for condensation purposes in the mixing condensers circulates within a closed loop by means of a centrifugal pump. This polluted closed loop water is re-cooled in plate heat exchanger(s) by the clean chilled brine.

Furthermore, a buffer/separator tank is also included in the water circuit to separate and discharge fatty components at the overflow.

The pH-value of the water closed loop should be kept at a constant pH-value by using a pH-control unit. This is necessary in order to saponify the fatty acids introduced into the water circuit and so avoid fouling of the plate heat exchangers.

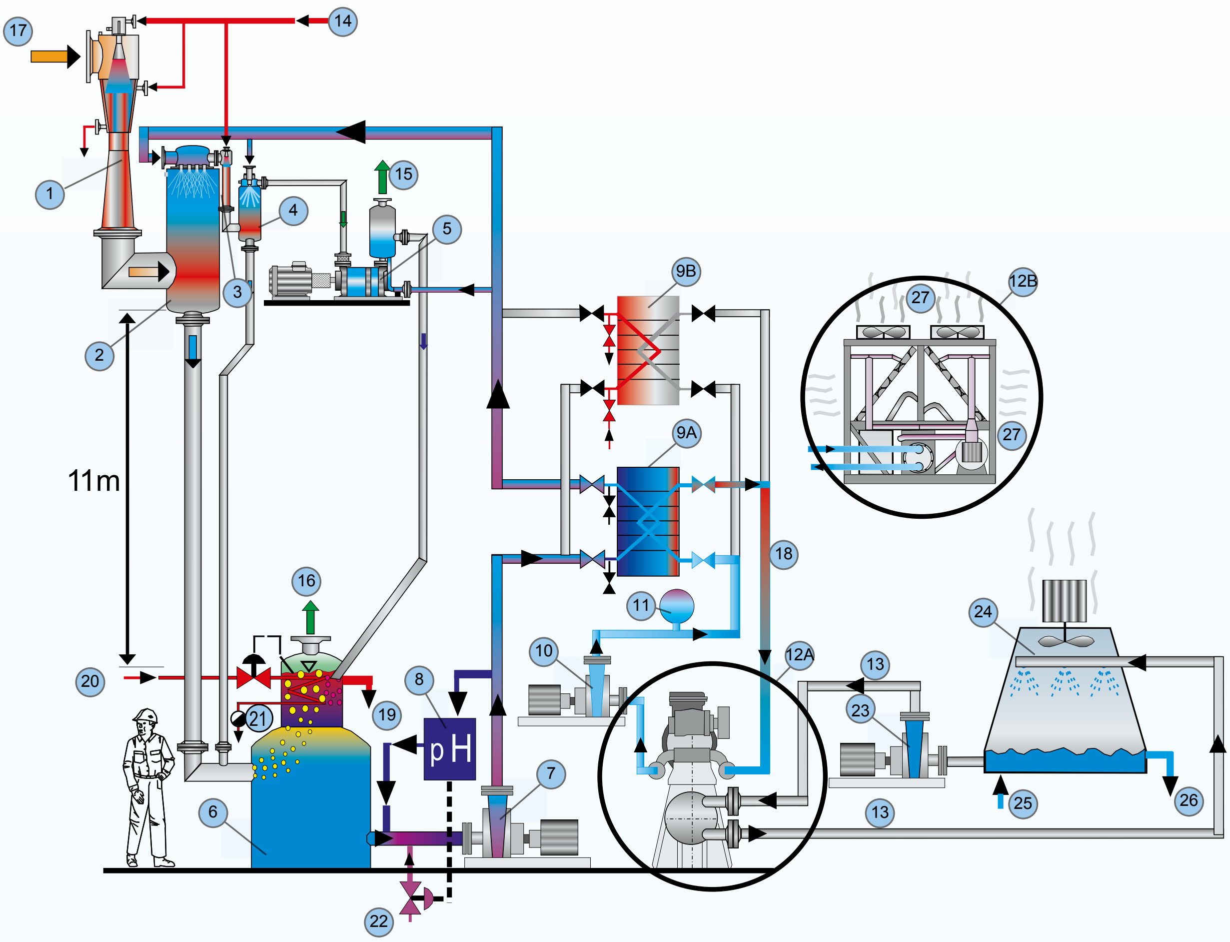


Typical installation of an ACL System with chilled water operation

Alkaline Closed Loop Vacuum Systems (ACL)

with clean cooling tower using chilled water

1 booster (stage 1)
2 main mixing (direct contact) condenser
3 steam jet ejector (stage 2)
4 interconnected condenser
5 liquid ring vacuum pump (lrvp)
6 buffer/separator tank
7 circulation pump
8 pH-control unit
9A plate heat exchanger (in operation)
9B plate heat exchanger (in standby)
10 brine pump
11 compensation vessel
12A coolant compressor (chiller water cooled)
12B coolant compressor (chiller air cooled)
13 cooling water
14 motive steam
15 gas outlet (lrvp)
16 gas outlet (fat separator)
17 sparging steam from deodorser
18 brine cycle
19 overflow of contaminated liquid
20 heating steam
21 condensate
22 caustic soda (NaOH)
23 cooling tower pump
24 cooling tower
25 fresh water
26 bleed
27 air in/out



The main benefits of this system compared to the conventional multi-stage ejector vacuum system are:

- lower operating costs
- steam generator can be smaller sized
- lower amount of waste water (motive steam for only one booster upstream of the main condenser)
- economically operating system (payback time approx. 1-2 years)
- clean cooling tower
- no air pollution
- environment-friendly

Comparison figures of the Alkaline Closed Loop Vacuum System (ACL) and the conventional multi-stage ejector vacuum system

		Conventional multi-stage ejector vacuum system	Alkaline Closed Loop Vacuum System (chiller water cooled)	Alkaline Closed Loop Vacuum System (chiller air cooled) Ambient temp. max. 40 °C
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**	**650**	**650**
cooling tower water (m³/h)		333 (polluted)	190 (clean)	
Electrical power				
chiller compressor unit (kW)			210	390
liquid ring vacuum pump (kW)			4	4
brine and circulation pump (kW)			46	46
total electrical power (kW)			**260**	**440**
NaOH 25 %(kg/h)			3	3
Waste water (m³/h)		2.585	0.958	0.958
operation hours per year		8 250	8 250	8 250
steam costs (Euro per year)	30.0 Euro/ton	564 300	160 875	160 875
waste water costs (Euro per year)	4.0 Euro/m³	85 305	31 614	31 614
re-cooling costs for the cooling water (Euro per year)	0.05 Euro/m³	137 363	78 375	-------
electrical power costs (Euro per year)	0.1 Euro/kWh		214 500	363 000
caustic soda costs (Euro per year)	0.25 Euro/kg		6 188	6 188
Operation costs (in Euro per year)		786 968	485 364	555 489
saving after 1 year (in Euro)			301 604	231 479
saving after 2 years (in Euro)			603 208	462 958
saving after 3 years (in Euro)			904 812	694 437
saving after 4 years (in Euro)			1 206 416	925 916

Utilities (example)

cooling water	33 °C
motive steam pressure	9 bar (abs)

Payback within one year

The payback time depends on the system and the utilities. In most cases, the payback period for an ACL system is less than one year.

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