Salt recovery from waste brine and waste salt

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After evaluation of several options for salt recovery vapor compression has been chosen for the local treatment of waste brines. In addition washing combined with clarification of the spent wash brine has been chosen for the treatment of solid waste salt. Treatment of both waste brine and solid waste salt is effected by combination of both treatments.

The developments in this field are elucidated by two examples;

1. To enable treatment of waste brines an already existing, stand-alone, energy efficient and small vapor compression unit as produced by a German firm was converted from an evaporator to an evaporator/ crystallizer. Also this basic unit was extended with a vibrating sieve and a decanter centrifuge. In this way an installation was created which produced only distilled water and a solid product consisting of salt plus the other components present in the waste brine. Using original waste brine from a cheese plant this installation was severely tested whereby major technical problems had to be solved.
2. To treat the solid waste salt and the waste brine from a hide salting plant a wash/ clarification/vapor compression installation was engineered. Hereby the wash/clarification part had to operate for about 8 hours per day whereas the vapor compression part had to operate continuously during the week.
   The normal particle size distribution of salt for hides can be obtained by a proper selection of the particle size distribution of indispensable fresh salt.

1. Introduction

Salt is indispensable in many processes as e.g. in the brining of cheese and the salting of hides or fish. Apart from the evident and beneficial effect of salt at these processes also the large quantity of waste brine or salt inevitably produced is noteworthy (see table 1).

Mass balances show that at the brining of cheese approximately 1/3 of the original salt leaves the cheese plant as concentrated waste brine.

At the salting of hides about 40 % of the applied salt becomes solid waste salt (which is sometimes reused). Roughly 15 – 25 % of this solid waste salt forms with the extracted water from the hides and the water for cleaning purposes a concentrated or even saturated waste brine. At the salting of fish sometimes 85 – 90 % solid waste salt is produced. In spite of this it is stressed that as long as these processes are executed at places where discharge of these waste salts and brines causes no problem salt recovery is not economically feasible due to the low salt price.

However even in cases where for some, mostly environmental reason salt recovery becomes necessary the suitable technology for salt recovery on a small scale is not yet fully developed.

Partly this is caused by the small scale but more importantly is the presence of a variety of components originating from the process in which the salt is applied.

Table 1

Overview of waste brine producing processes in the Netherlands.

Processes	Waste brine volume	Brine concentration	Waste salt	Remarks
	[m^3 per year]	[°Bè]	[tons per year]	
Cheese	30.000	17-18	4000	Contains calcium phosphate
Sauerkraut	17.000	0.75	130	pH = 3.8-5.5
Bacon	10.000	22.5	2250	Contains meat particles
Ham	11.000	18	2000	Contains meat particles
Salting of pork	150	20	40	
Conservation of hides	10.000	20	2000	
Fish processing	75.000	6	5000	High protein concentration
Intestine processing	6.000	22	1300	
Water demineralization	300.000	10	30.000	Contains Ca and Mg

For instance in the waste brine of a cheese plant Ca, PO_4, lactose, lactate, citrate, fat, protein, etc. is present apart from about 17 w% salt [1]. These impurities in the brine have a decisive influence on the suitability of various salt recovery processes available. Especially membrane processes are vulnerable in this respect because of severe fouling by these impurities.

After evaluation of several options for salt recovery Akzo Nobel Salt BV has chosen vapor compression for the local treatment of waste brines.

In addition a wash process combined with clarification of the spent wash brine has been developed for the treatment of solid waste salt. Treatment of both waste brine and solid waste salt is effected by combination.

2. Salt recovery from waste brine

In the past a German firm has developed a stand-alone, energy efficient and small vapor compression unit for the treatment of polluted liquids. Hereby only distillate and often 10 fold concentrated polluted liquids without solids were obtained.

However treatment of concentrated waste brine of a cheese plant in this basic vapor compression unit would unavoidably result in crystallization of salt after about 50 % increase of the salt concentration.

Consequently to enable treatment of waste brines this basic unit had to be converted from an evaporator to an evaporator/ crystallizer.

Also solid/liquid separation equipment had to be added.

In this way a vapor compression installation was created which produces only distilled water and a solid salt product consisting of salt plus the other components present in waste brine.

Using original waste brine from a cheese plant this installation was thoroughly tested whereby major technical problems had to be solved.

3. Description of the vapor compression installation

An overview of the vapor compression installation is given in figure 1.

Its main components are:

- evaporator/crystallizer
- vapor compressor
- circulation heat exchanger
- circulation pump
- throttling device
- vibrating sieve
- feed/distillate heat exchanger
- decanter centrifuge

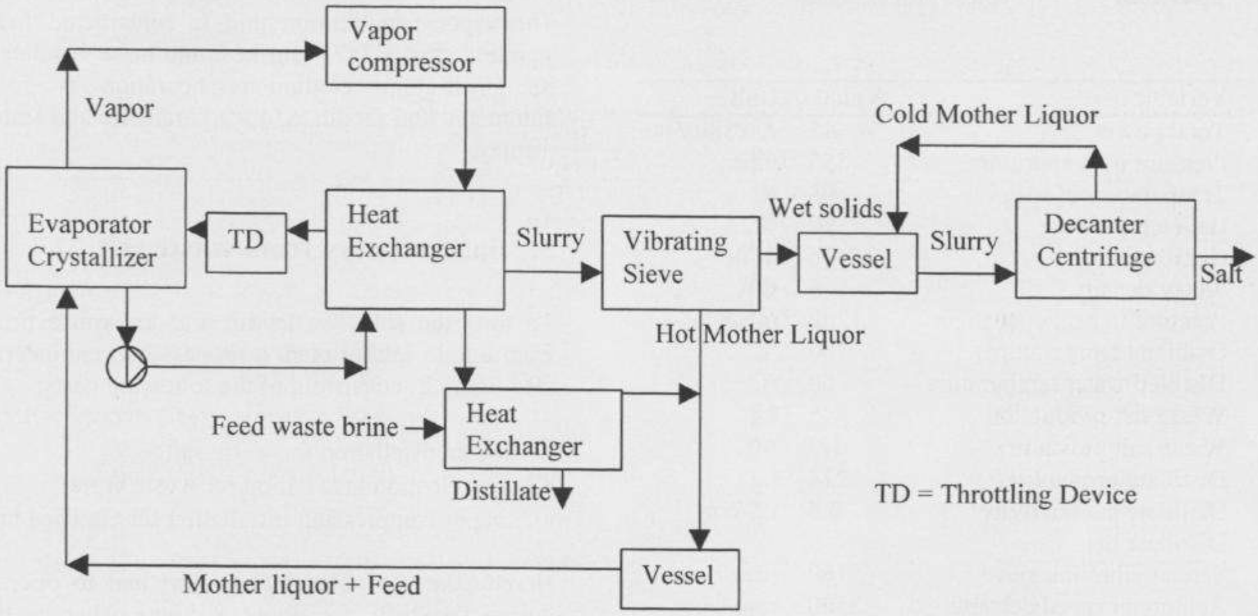

Figure 1 The vapor compression installation

In the evaporator/crystallizer water is evaporated and simultaneously salt slurry is formed. After compression the vapor condenses at the outside of the tubes of the heat exchanger thus heating the circulating salt slurry and producing distilled water. The distilled water is cooled further by countercurrent heat exchange with fresh feed (waste) brine. The throttling device situated between heat exchanger and evaporator/crystallizer secures that boiling at the heat exchanger tubes is prevented.

Apart from salt the circulating slurry contains other solid particles existing presumably mostly of coagulated proteins. The hot slurry is partly fed to the vibrating sieve, which separates the solids from the hot mother liquor. The hot mother liquor is mixed with preheated fresh feed brine and returned to the evaporator/crystallizer.

The wet solids are reslurried in cold mother liquor and fed to a decanter centrifuge which separates (most of) the solids from the cold mother liquor. Further drying of the salt product using waste heat and addition of anti-caking agents is optional.

The control of particle size is of crucial importance and effected as follows:

- The throttling device controls the nucleation rate by the velocity of pressure relief.
- Fine solid salt particles present in the hot mother liquor are (partly) dissolved by the preheated fresh feed brine (about 17 w% salt).
- The vibrating sieve determines the cut-off screen size of the salt.

4. Operation of the vapor compression installation

The most important typical data are given in table 2.

Table 2. Typical process data

Variable	Value	Unit
Total power	43	A (380V)
Pressure in evaporator	550	mbar
Temperature of vapor	98	°C
Bath temperature	90	°C
Circulation rate	16	m^3/h
Slurry density	6	w%
Pressure in heat exchanger	1200	mbar
Distillate temperature	100	°C
Distilled water temperature	60	°C
Waste salt production	46	kg
Waste salt moisture	1-2	w%
Distillate production	224	kg
Distillate conductivity	0.5	μS/cm
Distillate pH	3	
Screen vibrating sieve	160	μm
Rotational speed decanter	3500	rpm

If started-up with fresh feed brine, initial foam formation can be controlled by the temporary addition of antifoam. Preferably however the installation is started-up with kept back mother liquor to minimize foam formation and also to arrive more quickly at stable process conditions.
A rinsing program to prevent salting of critical parts of the installation is automatically executed using fresh (subsaturated) feed brine. Later on the obtained rinsing brine is fed back to the installation.

Several operational aspects are of key importance:

- Sooner or later all impurities have to leave the installation with the salt. If not, (a part of) these impurities will inevitably build-up and disturb eventually the evaporation process. So the salt product which is produced by the decanter centrifuge must have a brown color. If not, impurities are building up in the installation. It is stressed however that a brown salt product does not guarantee that all impurities are removed to a sustainable level, but only that some impurities are removed.
- It takes several hours before a stable situation is reached. The time to reach this stable situation depends basically on the ratio volume of the evaporator to feed rate and is for the salt in the order of 5 – 15 hours. However impurity build-up to a constant level may last much longer.

The vapor compression unit is constructed from stainless steel 1.4571 and heat and noise insulated. Its stand-alone continuous operation is fully automated and facilitated by a parameter and status display.

5. Salt recovery from waste salt

To treat the solid waste salt and the waste brine from a hide salting plant a process was engineered (see figure 2) consisting of the following parts:

- wash installation for waste salt
- clarification installation for waste brine
- vapor compression installation for clarified brine.

Hereby the wash/clarification part had to operate during dayshifts for about 8 hours whereas the vapor compression installation had to operate the entire week.

Wash installation

The wash installation for waste salt operates at ambient temperature and its main components are:

- coarse waste sieve
- wash column
- hydrocyclone
- centrifuge
- mixer

The almost dry contaminated waste salt is continuously fed to the coarse waste sieve to separate occasional coarse (non-salt) objects from the salt. The sieved salt is washed countercurrently in a wash column.
The wash brine consisting of overflow of the hydrocyclone, mother liquor ex centrifuge and clarified brine flows from the top of the wash column into a clarification vessel.
The slurry is pumped from the bottom of the column to the hydrocyclone.
The underflow of the hydrocyclone is mixed with slurry originating from the drowned salt storage (see later on) and subsequently fed to a centrifuge.

Finally the mixture ex centrifuge of fine evaporated salt as produced by the vapor compression unit and coarse washed salt is blended with fresh salt.
The normal particle size distribution of salt for hides can be obtained by a proper selection of the particle size distribution of this fresh salt.
The addition of a disinfectant is optional.

Clarification installation

The clarification installation for spent wash brine operates at ambient temperature. It consists of:

- clarification vessel
- filter
- clarified brine storage vessel

During dayshifts the clarification vessel is filled with spent wash brine and saturated waste brine.
If the waste brine is subsaturated saturation can be accomplished by dissolution of some salt from the drowned salt storage (see later on).
At the end of the day specific chemicals are added and thoroughly mixed with the contents of the clarification vessel during a quarter of an hour. During the night the mixer is switched off.
The next morning some sludge is situated on the bottom and a clear intermediate layer of clarified brine and a floating layer of fat and hairs is formed.
Prior to the start of the operation of the wash column the clear intermediate layer is pumped into the storage vessel via a filter. After discarding the sludge plus the floating layer of fat and hairs to the sewer the clarification vessel serves again to collect spent wash brine and (sub)saturated waste brine.
The clarified brine is partially fed to the wash columns and partially fed to the vapor compression unit.

The vapor compression installation

The vapor compression installation operates continuously from Monday morning till Friday afternoon and comprises the following parts:

1. basic vapor compression unit
2. heat exchanger
3. hydrocyclone
4. wash column
5. drowned salt storage

The clarified brine in the storage vessel is split into three flows. Two of these flows are continuous while the third one only rushes during dayshifts.
The first of the two continuous flows provides feed brine via the heat exchanger directly to the basic vapor compression unit.
The second continuous flow is feed brine for the hot wash column. In this column comparatively fine evaporated salt as produced in the vapor compressor unit is washed countercurrently.
Since the fine salt is cooled down at the same time by the feed brine the wash column also serves as heat exchanger. So the hot wash column separates the hot and the ambient part of the installation.
After mixing with both mother liquor from the underflow of the hydrocyclone and feed brine leaving the heat exchanger the heated wash brine is fed to the vapor compression unit. The operation of this vapor compression unit has been described earlier. In this case however the vibrating sieve and decanter centrifuge are absent. Instead the formed salt slurry is fed to a hydrocyclone.
The overflow of the hydrocyclone is returned immediately to the vapor compression unit. The potential building-up of impurities is controlled via a small bleed of mother liquor directly to the sewer.
The concentrated slurry from the underflow of the hydrocyclone is fed to the top of the wash column. The fine evaporated salt falls down and flows from the bottom of the wash column directly into the so-called 'drowned salt storage'.
Hereby brine is replaced and pushed upward into the bottom of the wash column.
The drowned salt storage is used to collect the fine evaporated salt during the evening and night when the coarse salt wash column is out of operation.
During dayshifts when this cold wash column is in operation the salt collected in the drowned salt storage is fed to the centrifuge by the third flow of clarified brine from the storage vessel. In this way the drowned salt storage is slowly emptied again.

References

1. P. Zoon, J. Straatsma and D. Allersma, Concentration of cheese brine by evaporation and its effect on cheese quality, (in Dutch), Voedingsmiddelentechnologie 24 (1991)(11) 13-16

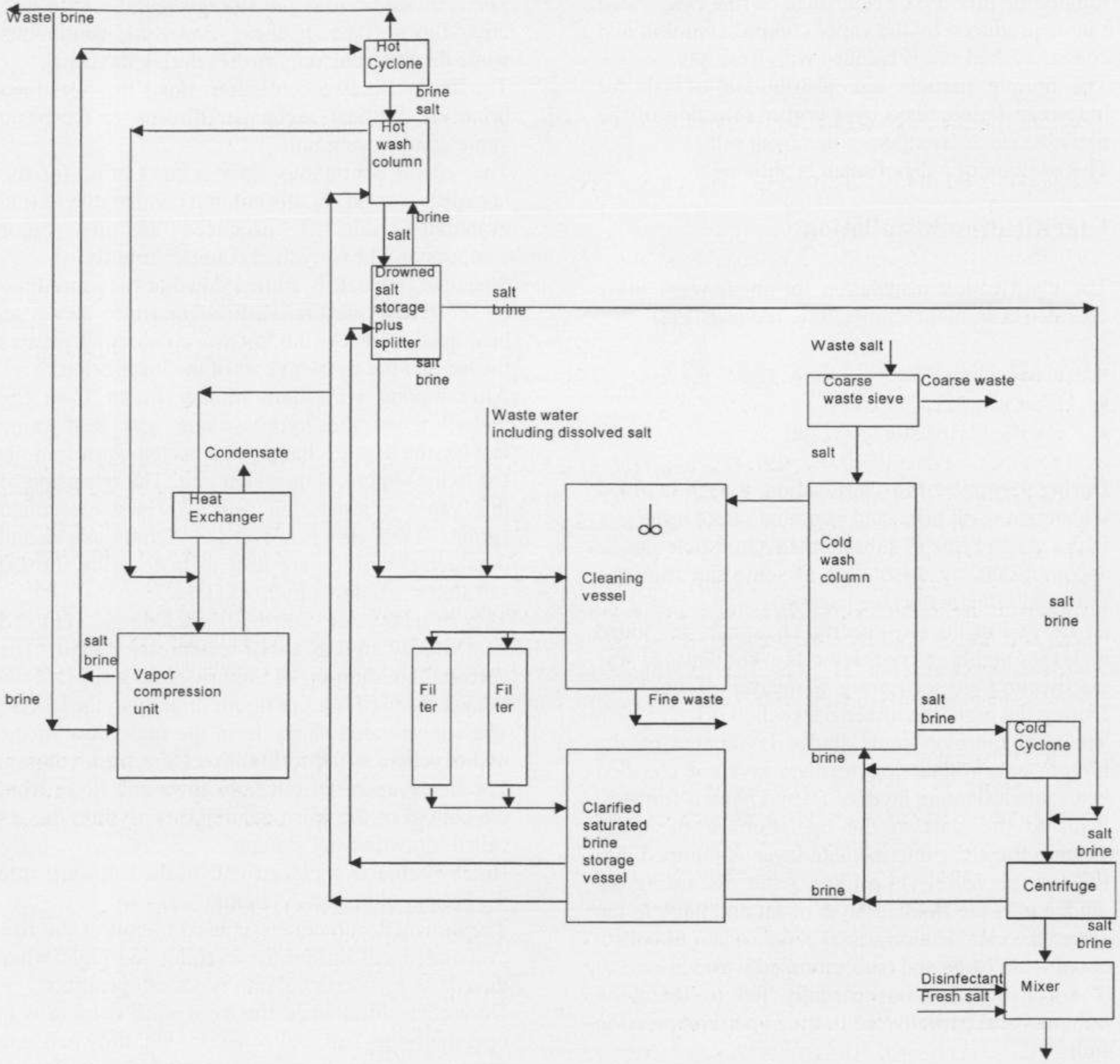

Figure 2 Block diagram of salt recovery process for waste brine and waste salt