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The industrial production of Salt

Vacuum salt

The production process

The recrystallized salt is produced through the concentration / evaporation technique of so-called "saturated" brines (that is, they are not able to bring other salt into solution).

These are prepared by injecting in the subsoil, in a controlled manner, fresh water that dissolves the rock salt, leaving on the bottom of the wells, the insoluble substances in water (clays and insoluble salts). After a certain time of contact, once the brine has reached the saturation condition, it is pumped to the surface plants.

It should be noted that this technique is used essentially in the presence of very deep deposits with a low-grade mineral, conditions that would not make traditional cultivation / extraction economical.

Due to the fact that we are in the presence of low-grade mineral, the brines are rich in the secondary salts accompanying the rock salt (essentially magnesium, calcium and potassium chlorides and sulfates).

Those impurities must be removed before the brines are fed to the evaporation plants, otherwise, by crystallizing together with the NaCl, they would penalize the title of the finished product.

Purification of the raw brine from solution mining

The raw brine from mine contains not only sodium chloride, but also variable quantities (depending on the quality of the mineral) of the other salts that normally accompany the rock salt, originating from ancient seawater. In particular, sulphates and chlorides of calcium and magnesium.

Normally the potassium content of the brine is so low that it does not give problems in crystallization.

As stated above, these components must be previously removed from the brine, in order not to compromise the purity of the finished product during the crystallization phase.

To carry out the removal of the secondary salts, the brines are subjected to a purification treatment, which consists in adding chemical reagents that transform the soluble salts into salts that are little or not at all soluble in saturated brines.

The purification of the raw brine occurs in two phases:

In the first one the raw brine is mixed with the recycle drains of the crystallization plants, rich in sodium sulphate in solution. This operation induces the precipitation of calcium in the form of Calcium Sulphate (gypsum) which is removed by physical separation from the liquid phase (sedimentation).

In the second phase the semi-purified brine from the first phase is treated with chemical reagents (sodium carbonate and sodium hydroxide), which induce the precipitation of the residual amount of calcium in the form of calcium carbonate and magnesium in the form of magnesium hydroxide.

Both of these reaction products are removed from the liquid phase by physical separation (sedimentation).

So-called polyelectrolytes (flocculants) are used to "help" these separations, both in the first and in the second phase, which are organic compounds, that have the characteristic of incorporating the precipitates, aggregating them, facilitating their sedimentation and therefore their separation from the liquid phase.

At this point the purified brine is fed to the crystallization plants in which, by evaporation of the water, the precipitation of the practically pure Sodium Chloride takes place, which crystallizes in white crystals, having dimensions between 0.15 and 0.60 mm.

The salt coming out from the last crystallizer as a slurry, is centrifuged in order to separate it from the brine and, finally, fed to a drier in order to remove the residual umidity.

Fig. 1. Brines Purification tanks- Vacuum Salt

Fig. 2. Crystallization Plants – Vacuum Salt

Fig. 3. Centrifuge and dryers

Sea salt

The sea salt facilities are normally constituted by a series of very large basins (salt marshes), separated from the open sea. The sea water is pumped into the first series of basins, named evaporation ponds, where the water start to evaporate (due to both sun and wind action), increasing the density of the seawater.

As the density increase, the brine is transferred to smaller and smaller ponds, until the right density is reached for salt precipitation (crystallization ponds). At this stage, almost 90% of water has been evaporated.

In the meantime, the brine gets rid of the less soluble salts contained in seawater, essentially carbonates and sulphates, and of the heavy sands which remain in the bottom of the ponds.

During this time the concentration of NaCl in the sea water rises up from 3% to 25% w/w.

Sea salt, produced in the precipitation ponds, is harvested by mechanical means as a raw product and transported, by truck, on large storage spaces.

In its raw state, the sea salt does not have those general hygiene characteristics that allow it to be used as food grades ingredient. It must therefore be subjected to a washing (refining) process in order to get rid from the impurities mixed with it, due to the deposition on it of various materials coming from the external context (sand, dust, feathers and bird droppings, various residues carried from the wind, etc.). The impurities that above all give the crude sea salt a tendency to brown-hazel color. Furthermore, since the raw sea salt is rich in secondary salts present in sea water, it is necessary to remove at least a part of it, to improve its NaCl content.

The refining of raw sea salt.

The sea salt facilities are normally equipped with two washing systems, called large and small volumes of water. The first operation is carried out with saturated brines and has the purpose of reducing insoluble substances to a minimum and eliminating about 50% of the gypsum by flotation (CaSO4 * 2H2O). It is carried out on the salt immediately after the harvest and before it is accumulated when the insoluble particles, the gypsum crystals and the other impurities are not yet intimately linked to the salt crystals and therefore more easily removable.

The plant essentially consists of a large cochlea, in which the salt moves in counter-current with respect to the washing brine. In these conditions, part of the insolubles and gypsum, as well as other light impurities, are removed by the washing brine.

The washed salt comes out from the opposite side of the cochlea and is placed on a mesh conveyor belt (drainer), in which most of the brine contained in the salt is removed.

On the conveyor belt, using special nozzles, more clean brine can be sprayed, to improve the washing itself.

The washed salt is stored, to allow it to lose the excess of moisture by natural percolation.

In this phase, the humidity drops from about 8 to 4% and the washed salt is ready to be fed to the second washing stage, or put on the market for not particularly critical applications.

This operation is able to remove light and superficial impurities, also enhancing physical appearance of the salt. In this phase there is a recovery of title of about 0.5%.

A portion of the salt from the first wash is fed to a second stage, in order to remove the magnesium and potassium salts, which are incorporated in the sodium chloride crystals. This is achieved by putting the salt in contact with a clean brine, which, being unsaturated with respect to magnesium and potassium salts, removes them by dissolution. The operation is carried out, in washing tanks (cones), from which overflow the brine comes out, enriched in potassium and magnesium, from underflow comes out the salt washed, in form of slurry, which, after thickening in hydrocyclones, is fed to a centrifuge, for removing the brine. Part of the final brine is recycled into the previous step of the process, the other part, discharged.

Based on the quality of the raw sea salt, in order to improve the washing effect, at this stage, it is possible to introduce a small amount of fresh water to substitute/dilute the washing brine, or in washing phase or directly into the centrifuge. In this phase there in an improvement of the chemical composition, with a recovery of about 1% of the NaCl content.

The washed salt comes out of the centrifuge, with about 2.5% humidity. Subsequently, the wet salt is fed to a dryer, in order to eliminate the residual humidity, which is reduced to less than 0.5%. Then, the dried salt is fed to a screening section to obtain commercial sizes, intended for packaging and sale.

Overall, to bring the raw sea salt to food grade, there will be a modest consumption of fresh water for: integration brine; washing in the centrifuges as above reported, if necessary; enlargement of the washing cycle as above reported, if necessary.

Fig. 4. Harvesting, Transport & Storage of Sea Salt

Fig.5. Sea Salt washing systems

Fig. 6. Centrifuges and dryers

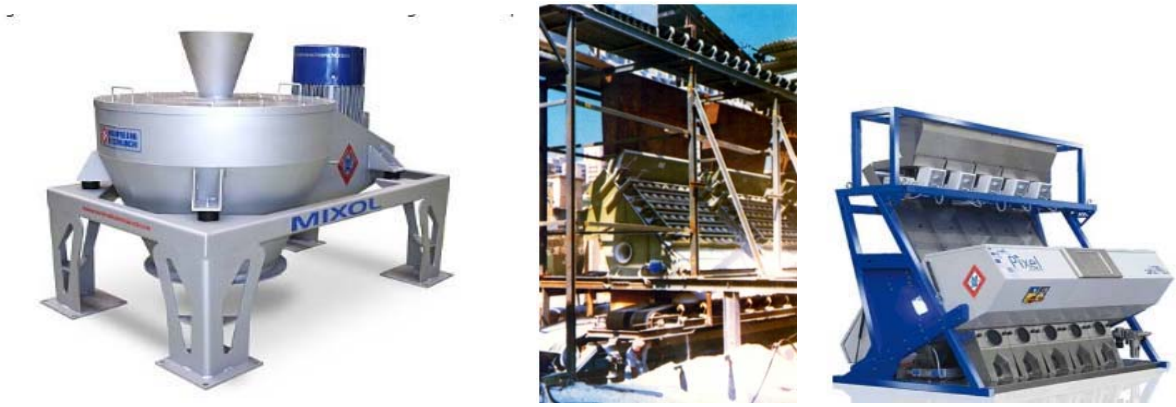

Fig. 7 Salt grinding and screening and Optical sorting

Rock Salt –Production by continuous mining

For the exploitation of rock salt deposits, a cultivation scheme called chambers and pillars is normally used. It is repeated on all levels of exploitation, maintaining the strict correspondence of full on full and empty on empty.

The high purity rock salt is "cultivated" by means of large electric machines called continuous miner, equipped with a toothed head that attacks the mineral on the forehead, breaking the mineral into lumps of various sizes. The machine is equipped with devices designed to convey the crushed salt, through a rubber conveyor belt, to a special truck and/or another convey belt positioned at the end of the machine, which will transport the salt to the primary crushing section. Here, the ore is reduced to a size less than 100 mm. Then, through a conveyor belt, the crushed mineral reaches the treatment plants, consisting of:

- secondary crushing plant (grinding to a size less than 10 mm)
- cylinder mills (grinding to a size less than 5 mm)
- optical selection section (for removing dark crystals due to natural clays inclusions) – if needed.
- screening section (separation of coarse, medium and fine fractions)

It should be noted that, no additives are used in the production process, since all operations are exclusively mechanical, because the rock salt does not need any enrichment or purification process, meaning that it keeps intact all its natural characteristics.

Fig. 8. Rock Salt Continuous mining & Transportation in Chambers & Pillars Mine structure

Fig.9 Rock Salt crushing, milling, screening & Optical Sorting

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