History and improvements on salt processing using fluidbed technology

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In the mid age the classical steps of thermal salt processing were exposition of wet salt to the sun or hot flue gases, assisted by mechanical movement of the crystals to be dried. Thermal salt processing has been developed by using rotary dryers with parallel flow operation. To date state of the art is fluidbed equipment developed to high efficient fluidbed dryers with integrated heat exchangers for direct heat supply and maximum thermal efficiency. Further fluidbed equipment can be applied for classification and conditioning of salt with advantages.

1. COMPANY PROFILE VA TECH WABAG FLIEßBETT-SYSTEME GMBH

Our activity on fluidbed equipment started in 1961 within the company ESCHER-WYSS GmbH in Ravensburg, Germany. During some reorganisations within the group the company name has been changed several times and became finally VA TECH WABAG Fließbett-Systeme GmbH under the roof of the Austrian technology company VA TECH With a staff of 60, we generate an annual turnover of approx. 22 mill.

2. THERMAL SALT PROCESSING IN THE MID AGE

It can be assumed, that men became acquainted with the mineral NaCl, vital to survivial, through discovery of salt containing rocks in mines and in southern regions through evaporation residues originating from sea water. The generation of salt from aqueous solutions and with that generating a dry product that can be stored and transported has been done in ancient times by the largest convective exchange mechanism known to men, the contact with the surrounding atmosphere and its heating system, the sun.

One example for this early, natural production method for dry salt is a setup called thorn house, in which brine is applied to the highest point of a suitable hedge. On its way down on the surface of the plant water is evaporated to the atmosphere, a salt crust is formed and then the salt is collected by shaking it off.

Later on men used simple forms of thermal process technology using kettles over open fires, later open pans with increased heating surface and enhanced production. First, the resulting hard layer was taken from the bottom of these pans as the dry salt. Later it was extracted from the pans as slurry and dewatered in basket like containers. The resulting salt pins were dried in hot flue gases, producing stone hard salt forms.

Already in the early middle ages the classical processes of modern salt work technology were applied:

- evaporating and crystallising in special vessels
- mechanical dewatering using gravity in permeable baskets

convective thermal drying through direct contract with flue gases.

Energy was supplied by wood, naturally with a very low efficiency, resulting that complete forests have been cleared, replanted and cleared again.

Development of better forms of energy application, for example, utilising steam, finally brought the technologies of thermal salt production to today´s state of the art.

Practically all forms of this drying principle can be found in salt works. Beginning with the old kiln, in which the salt is still moved by hand, through belt dryers, plate dryers, flash dryers up to the main kind of dryer used nowadays, the rotary kiln operated in parallel flow.

Supposition for the fast introduction of fluidbed drying is the fact, that fluidbed dryers, utilising the cross flow principle, consistently use 20 – 30 % less heat than dryers operating in parallel flow (e.g. flash dryers) operating with the same hot air temperature. This difference in heat consumption results from the difference in exhaust gas temperatures. While the mean exhaust gas temperature of the cross flow

fluidbed dryer is always lower than the maximum necessary product temperature, it is always lower than the maximum necessary product temperature. It is always the opposite in a parallel flow system due to the exchange mechanism.
This kind of dryers, looked at from today´s technology have been more or less compromises. They were solutions of their period, determining the sate of the art until the 60ties.
At this time the fast and successful introduction of fluidbed dryers, operated in cross flow, begun.

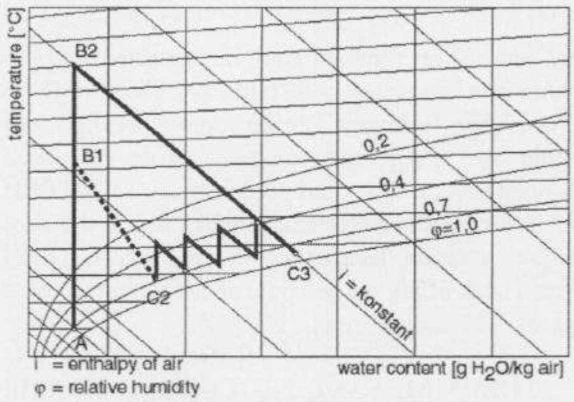
3. EARLY DEVELOPMENTS IN FLUIDBED TECHNOLOGY

At the beginning the mostly used variety of fluidbed unit was the *vibrated fluidbed*, allowing reliable operation for fluctuating feed conditions in moisture and particle size as well as design of parameters (e.g. air flow) within a wide range. Due to the required mechanical strength of the vibrated construction the lower part or windbox had to be fabricated in carbon steel or cladded stainless steel.
Some of this old installations are still in commercial operation today for more than 30 years, e.g. at the Saltworks Schweizerhalle, Basel, due to excellent maintenance and operation conditions.
With gained knowledge about fluidisation also *stationary fluidbed* have been used for salt. For proper fluidisation of the salt a higher fluidised layer is needed than for the vibrated fluidbed which leads to a higher electrical consumption for the fans. The advantage of this type was that there were no moving parts with the consequence of less need for maintenance and that it could be built completely in stainless steel to pay attention to the corrosive environment in a salt plant.
Also supporting the improved operation of such salt dryers was the development of new *air distribution plates*. Beside the plate with punched holes (e.g. CONIDUR®plate) nozzle plates and slotted plates have been introduced, decisively reducing scaling on the air distribution plate itself.

4. LATEST DEVELOPMENTS IN FLUIDBED TECHNOLOGY

Further progress was the introduction of *fluidbed equipment with integrated heat exchangers*. The originally main purpose of the fluidising gas which usually defines the size of the fluidbed unit, namely introducing the energy, is now handled separately. An essential reduction in gas flow became possible. This results in:

- distinct reduction in convective heat losses
- less energy consumption for fluidisation
- equivalent reduction in effort to clean the exhaust gas due to less air volume
- high relative evaporation rates at low temperature levels
- smaller overall dimension of equipment with less required building space.

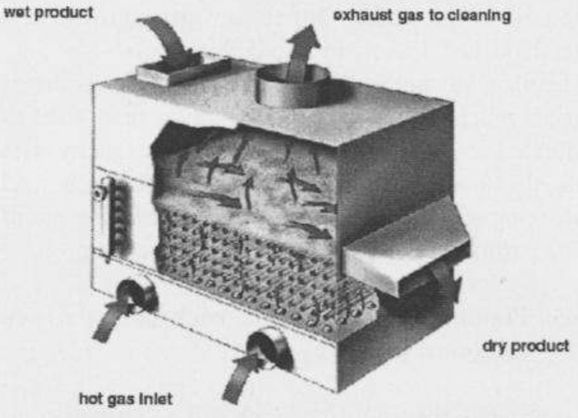


picture 1: Mollier diagram

The Mollier-diagram, showing the moisture and enthalpy of humid air, illustrates the exchange mechanism in a dryer with in-bed heat exchangers. The combined heat transfer phenomenon leads to a remarkable increase of the water content in the dryer exhaust air.
Line A to B1 indicates the heating of ambient drying air to hot air temperature. Line B1 to C 2 indicates the air condition during the drying process with air as only energy supplying media.
Line B1 to C2 to C3 indicates the change in condition of drying air when additional heat is supplied by immersed heat exchangers.
With a given maximum hot air temperature according B1 the water acceptance is increased to an extend equal to the hot air temperature of point B2.
Also due to the higher susceptibility to corrosion in a fluidbed with integrated heat exchangers for salt –

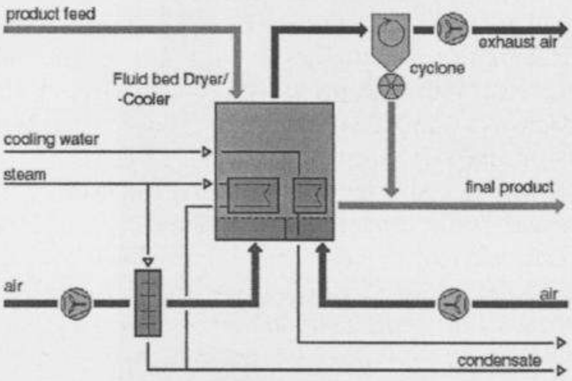
simply because of higher operation temperatures and water load in the exhaust air – materials like AISI 316 Ti or L have been abandoned for construction within the drying zone and replaced by higher alloys like 1.4439 (AISI 317 LN) or 1.4539 (AISI 904 L).
Because of the corrosive environment in a salt plant and the optional production of pharmaceutical salt of high purity most new fluidbed installations are fabricated completely in stainless steel, even including the total intake air installation.
Fluidbed dryer/ coolers with integrated heat exchangers for evaporation salt have been built up to capacities of 100 t/h in one line, and even larger installations have been projected.
VA TECH WABAG Fließbett-Systeme GmbH was the first company to introduce fluidbed equipment for crystalline products. Today the application of this type of fluidbed is not only limited to salt, but also used e.g. for: dense soda ash, ammonium sulphate, potash, PVC, soy beans and fertiliser to name a few.

5. PRINCIPLE OF A FLUIDBED



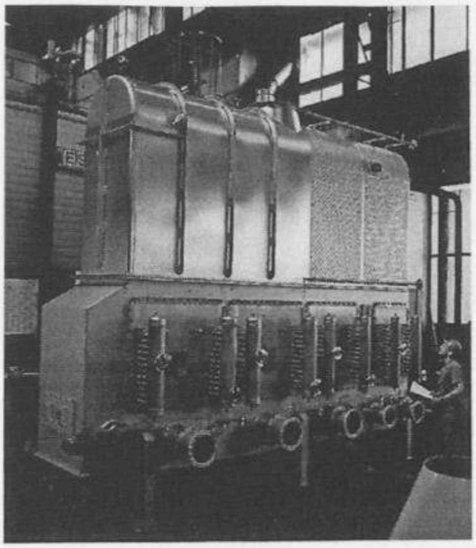
picture 2: principle of a fluidbed dryer with integrated heat exchangers

A fluidbed is characterised by the movement of the particulate solids, achieved by a gas stream passing through the product layer. The velocity of the gas is chosen to keep the product in suspension rather than pneumatically conveying it. The moving layer behaves like a fluid. Feeding product continuously to one end of the bed results in a consistent overflow at the lowest point of the bed, the designated product discharge. In all types of fluidbed units, the gas enters the layer through the gas distribution plate, such product and gas are operated in a cross-current mode. Besides keeping the product fluidised the gas is the media for heat and mass exchange of high specific efficiency. In addition to the energy coming from the gas, a significant amount of heat can be applied by immersed heat exchangers, thus greatly reducing the required gas flow.
All particles are consistently moved, exposing their entire surfaces to the exchange process. Despite the intensive movement of the particles the product is handled gently without significant abrasion.
The product leaving the fluidbed can be regarded as "dust-free" as most of the dust has left with the exhaust air from where it can be separated by cyclones, bag filters or wet scrubbers.
An additional advantage of fluidbed equipment is, that drying and cooling can be done in one single, combined fluid bed unit efficiently and resulting in cost saving.

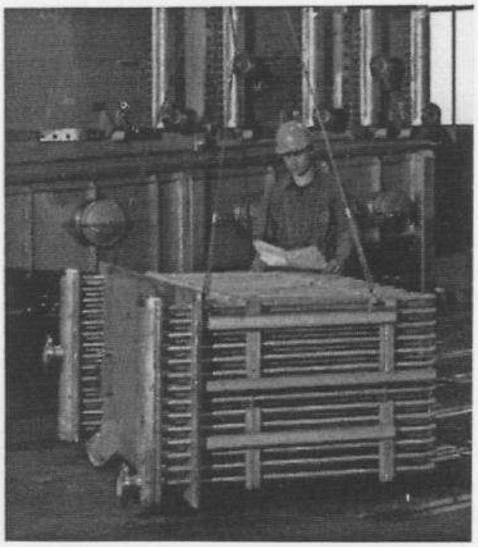


picture 3: drying/ cooling of table salt

Due to the increased water content in the exhaust air of the drying zone the suction hood has to be heated to compensate thermal losses and avoid condensation and salt incrustations inside the suction hood.
The heat exchangers are built for easy removal and easy maintenance, as modular, drawer-like units.
Table 1 shows significant operation data of selected fluidbed installations for drying of evaporation salt utilising fluidbed technology and their improvements during the last thirty-seven years.



picture 4: fluidbed unit with integrated heat exchangers for evaporation salt.



picture 5: patented tube bundle heat exchanger

6. Examples of fluidbed applications in salt industry

6.1 Fluidbed dryer/ cooler for evaporation salt at Kali & Salz AG, Bernburg, Germany.

This fluidbed installation type FTFKW 960 is a combination of a convective fluidbed dryer and a fluidbed cooler with integrated heat exchangers supplied by cooling water for effective cooling. It is designed to dry 30 t/h of evaporation salt to a final moisture of max. 0,02 % superficial moisture.

The drying air is heated up to 280 °C by natural gas in an indirect air heater to keep the off-gases containing $C0_2$ separately and reuse the generated and compressed $C0_2$ for brine purification of the salt brine from the drilling field before crystallisation.

6.2 Fluidbed classifier for rock salt at Domtar Inc., Goderich, Canada.

This fluidbed classifier type FTF 1200 is installed about 800 m below the surface of Lake Michigan in a rock salt mine. Due to it´s underground location it is operated in a closed gas loop to became independent from fresh air from the surface.

The installation is designed for classification of approx. 230 t /h crude rock salt at 60 mesh or 0,25 mm. Most of the fines leave with the recirculated exhaust air from the fluidbed and get separated by multi-cyclones. In this way approx. 45 t/h of fines containing a higher portion of impurities will not be hoisted to the surface but remain underground and get deposited directly in abandoned shafts.

The main advantage of a fluidbed-classifier is that is needs much less space for installation than a set of vibrated screens designed for the same capacity with all the operational problems like abrasion and blocking of the screens especially at screening out of fine particles which requires frequent cleaning.

6.3 Fluidbed conditioner for rock salt at a rock salt mine, Germany.

To improve their purity of rock salt a German company decided to introduce an electrostatic separation technology for separation of NaCl crystals from anhydrite.

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For increased separation efficiency of the separators the salt has to be heated up – a process similar to the separation process used by the German potash industry.

This fluidbed installation type FTF 600, also installed underground in a mine, is designed for heating up of up to 400 t/h crude rock salt of 1 – 4 mm particle size by hot air heated up in an electric air heater with a max. heat supply of 3 MW.
Up to date more than 160 ESCHER WYSS™ fluidbed systems have been sold world wide and commissioned successful for drying, heating, cooling and classification of evaporation -, sea – and rock salt.
Together with VA WABAG AG in Winterthur, supplying evaporation and salt washing technology and FERRUM in Schafisheim, Switzerland supplying pusher centrifuges, a whole salt works using the reliable ESCHER WYSS™ technology can be supplied.

			capacity		energy consumption	
year built	type of fluidbed	working area in m^2	capacity in t/h	capacity in t/m^2	kg steam/t salt	kW/t salt
1963	vibrated	6	8	1,33	92,2	3,1
1969	vibrated	8	33	4,13	69	3,1
1976	stationary	8	50	6,25	62,6	2,1
1987	with integrated heat exchangers	2,5	33	13,20	52	1,9

table 1: operation data of selected fluidbed dryers for evaporation salt