Opto-electronic Sorting and Screening of Rock Salt

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Rock salt is mined underground throughout the world and requires several stages of preparation to convert it into a clean, usable product. A high proportion of this rock salt contains anhydrite as an impurity and could not be made use of until recently, therefore, without its being firstly subjected to a flotation process.

The newly-developped **MikroSort®*** opto-electronic sorting system, however, is able to detect this impurity using a CCD colour line scan camera and separate it out by means of a bank of 256 compresses air valves and air jets arranged across a working width of 1.2 m. The advantage of this is that the process can be carried out underground. The need to transport the impurity to the surface is, therefore, eliminated. The first test installation, at Wacker Chemicals in southern Germany, has been working successful since mid-1998 and separates rock salt in the size range 8 – 22 mm at a rate of up to 20 tonne/hr. A second plant was installed at the Kali + Salz GmbH Grasleben Works in Germany at the end of July 1999. In this case the equipment was designed to carry out separations in the lump size range, 3 - 250, at rates of up to more than 100 tonne/hr.

Additionally the use worldwide of the **Mogensen Sizer®**** screening system for both rock salt and sea salt offers enormous advantages. This type of machine fitted with 3 to 6 screen decks placed one above the other at different slopes in a totally dust-enclosed frame can achieve 2 to 5 separations in one pass. The **Mogensen Sizer®** offers up to 10 times the capacity of a conventional screen occupying the same space.

1. Occurrence (1)

Rock salt occurs in beds and also in structures variously known as bosses, plugs, ridges or domes. These are found in areas of sedimentary rock throughout the word but are structurally and genetically different from ordinary bedded deposits.

Rock salt ore lenses are interstratified with other sedimentary deposits of various geological ages such as sandstone, shale, and, less commonly, limestone.

Gypsum, anhydrite, potash and other salts may also be present. Some deposits consists of almost pure salt, whereas other saline minerals are abundant in many deposits. Clay and sand are always likely to be admixed more or less intimately at least in some portions of a deposit.

2. Treatment (1)

Treatmend methods vary widely according to the character of crude salt and the use, to which the processing is directed. Rock salt as mined is shipped and sold for many purposes after a minimum of hand picking, sizing and screening. For certain purposes, however, even small amounts of impurity are unacceptable.

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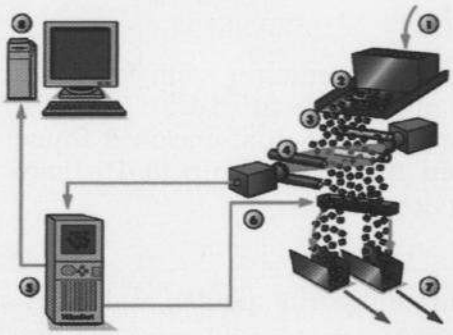
* MikroSort is a registered trade mark of CommoDas Systemtechnik GmbH, Wedel, Germany

**Mogensen Sizer is a registered trade mark of Fredrik Mogensen AB, Hjo, Sweden

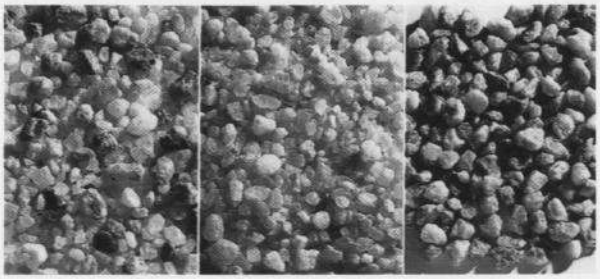
Material previously used for stowing only has been processed at the south-German salt works belonging to the Wacker Chemicals Company since the middle af 1998 using an opto-electronic sorting system.
This material, principally contaminated with anhydrite, contains 30 to 50% of pure rock salt, which, because of the lack of a suitable processing method, was previously lost. It is possible, however, to detect optical differences in the stowing material and separate out the pure, white salt crystals by means of the MikroSort® opto-electronic sorting system developed jointly by Mogensen and the Technology System House, CommoDas.
The 30 – 50% rock salt component with a NaCl content of 99% is thereby now recovered.

3. Working Principle



The contamined rock salt in the size range, 8 – 22 mm, is fed at a rate of 20 t/h through a feed hopper (1) and then over a vibratory feeder (2), from which is passes in free fall through an acceleration zone (3). The material stream is illuminated and, depending on the specific duty, scanned making use of the light either reflected by or transmitted through the material. The scanning device is a high-resolution CCD colour line-scan camera (4), which detects colour variations. Image evaluation is carried out using rapid parallel processor technology (5). This produces the signals, which trigger product selection by means of highly accurate compressed air impulses (6). In the present case 256 compressed air nozzles installed across a working width of 1.2 m are individually controlled. Finally the two products streams are conveyed away separately (7).

4 Sorting Results



Feed **Pure Salt** **Through-flow**

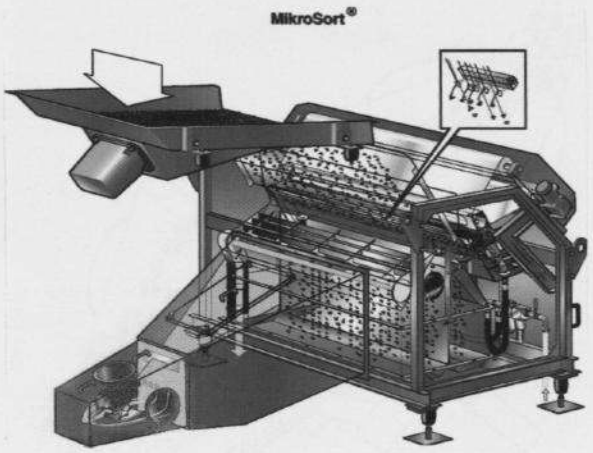
The aim was to separate clean rock salt with a better than 99% NaCl content from the waste in order to be able to market it without further processing. This aim was realised.
Salt in the range, 3 – 8 mm, is now successfully separated at a feed rate of 5 t/h in a further processing stage.

5. Preparation of Regeneration Salt

Regeneration salt for use in water-softening plants, food-quality salt and road salt are produced at the Grasleben Works of Kali + Salz GmbH. The raw, run-of-mine salt, 0 – 250 mm, is milled and sieved underground. It then arrives at the preparation plant above ground as road salt or commercial grade salt. Up until the end of 1999 a part-stream of material, 12t/h and in a size range 7 - 18 mm, was conveyed to a pilot installation and fed through a MikroSort® opto-electronic sorting plant, which separated 1 - 5% of anhydrite-contamined salt from the pure NaCl to produce a clean, white regeneration salt with a NaCl content of 98%. The reject material was added to the

road salt so that no product loss occured. The results of these trials were outstanding.

Consideration is now being given at the Grasleben Works to two possible courses of action. The fist is to treat the entire 10 - 30 mm fraction (70t/h) underground to remove the anhydrite; the alternative is to process the 0 - 250 mm material before the first crushing stage in a large-scale opto-electronic installation. Mogensen already has experience of such large-scale equipment in the field of ore preparation.



6. Sorting Criteria (2)

The MikroSort® opto-electronic sorting system offers various sorting criteria. The capacity of the system depends on the combination of these criteria. The equipment is able to sort all free-flowing, particulate materials, which are unambiguously classifiable on the basis of their optical properties.

Intrinsic Colour
Image capture is effected by CCD colour line-scan sensors with three colour channels corresponding the primary colours red, green and blue. Each colour channel has a resolution of 8 Bit, so that up to 16 million colours may be reproduced. Even when in practice, because of external interference, this resolution is not fully usable, very exact colour capture is still possible. The result is completely new areas of application dealing with problems, for which hitherto no solutions were available.
In the case of non-homogeneously coloured materials, of which rock salt is an example, it is possible to preset the minimum reject size of falsely coloured inclusions, i.e. if the size of a falsely coloured sectiuon of an overwhelmingly „good" particle lies below this limit, the particle will not be rejected.

Particle Size
The area as well as the horizontal and vertical extent of all particles scanned is determined. These amount to classical selection characteristics and the MikroSort® assumes the function of an electronic sieve.

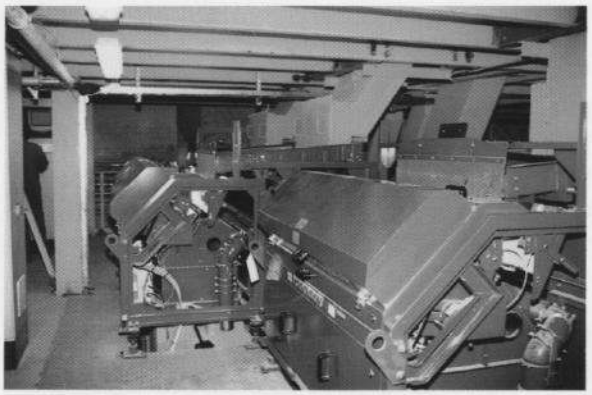
Brightness
The degree of brightness is evaluated from the light reflected back from the surface of the particle. Brightness is measured in 256 steps and then classified according to various criteris.

Shape
Simple shape recognition is possible in the case of loose, particulate materials in so far as the different characteristics may be derived from the sensor data within an acceptable expenditure of computing capacity. The decisive factor here is the number of objects, which must be evaluted within the period of free fall available. An example is the separation of batteries from other fine scarp material.

7. Capacity Data (2)

- Sorting capacities of up to 200 t/h depending on material and size fraction
- Size range of material, 3 – 250 mm, making use of separation by compressed air jets during free fall

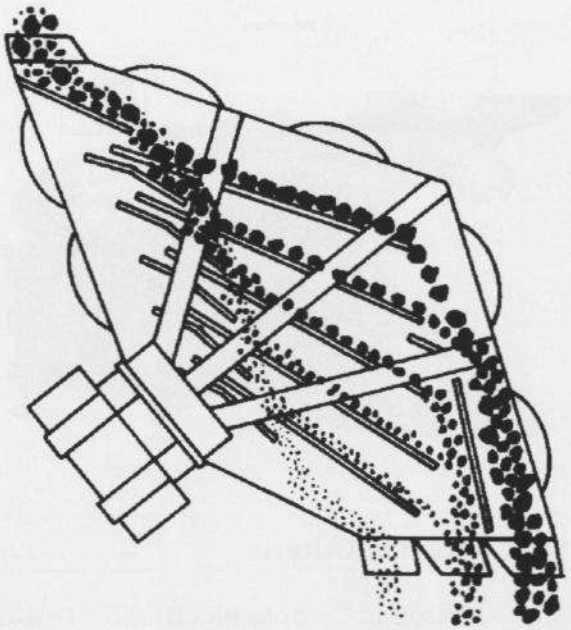
- Reject stream („bad" component) up to 40%
- Recognition and evaluation of more than 7000 objects per second
- Hight resolution of up to 0,5 mm in working width of 1000 mm
- Working width of up to 1200 mm
- activation of up to 256 separation channels
- Statistics functions
- Colour display of product stream in real time
- Multi-sided scanning as an option
- Production monitoring
- Fields-bus network connection to the control centre
- Remote assistance with diagnostic service
- Easily adaptable to product changes.



MikroSort® in production (ALBA Recycling Centre, Berlin)

8. The classic Mogensen Sizer®

Mogensen Sizers are in service today in rock salt preparation plants world-wide carrying out the most varied of duties. The machine can be used to achieve separations from 0.15 mm to 80 mm. The Mogensen idea, patented in the sixties, may be rightfully described today as a „classic" amongst screening system. There is scarely a single university chair in process technology, which does not deal with the Mogensen Sizer Principle. Only the functional principle, however, remains from the early days. A continual process of development has led to the optimal, mature screening system, which is now represented by more than 8000 installations world-wide. Of theses approximately 1000 are in use in the field of salt processing.
It would certainly exceed the purpose of this paper, if the whole range of applications in the potash industry were also be illustrated. It is fair to ask, however, how this extraordinary success came about.



Sectional drawing of a Mogensen Sizer

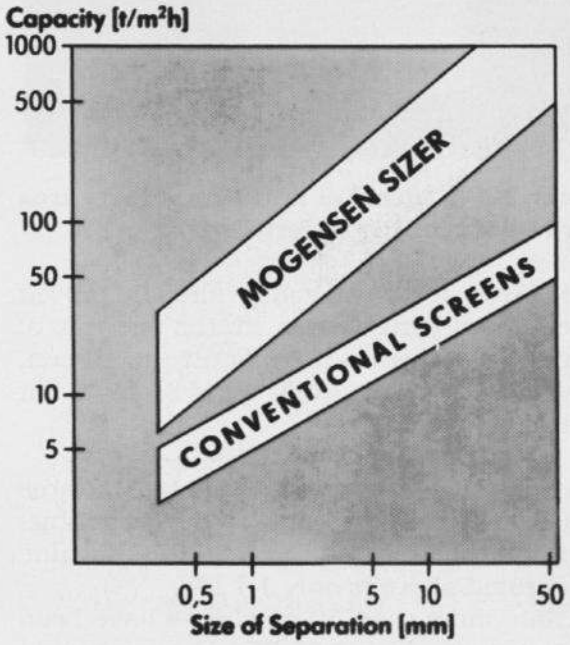
The Mogensen Sizer consists of 3 to 6 sieve decks arranged one above the other in a vibrating dust-tight housing. The mesh aperture sizes decline from top to bottom according to a system, which takes into account the principle criteria involved, i.e. product properties, the size distribution of the feed material, cut point(s) etc.

The sieve decks are inclined at progressively steep angles from the top to the bottom on the machine. The slope of each mesh produces in an effective screen

aperture, which is less than the absolute aperture. For this reason meshes with apertures considerably larger than the cut point(s) can be fitted and both coarse and fine particles are separated out of the feed material very rapidly. In contrast with the action of an conventional screening system no bed of material builds up on the meshes and the residence time of material in the machine is reduced. The advantages are clear :

- shorter sieve decks
- less abrasion
- higher throughputs

9. Higher flow-rates



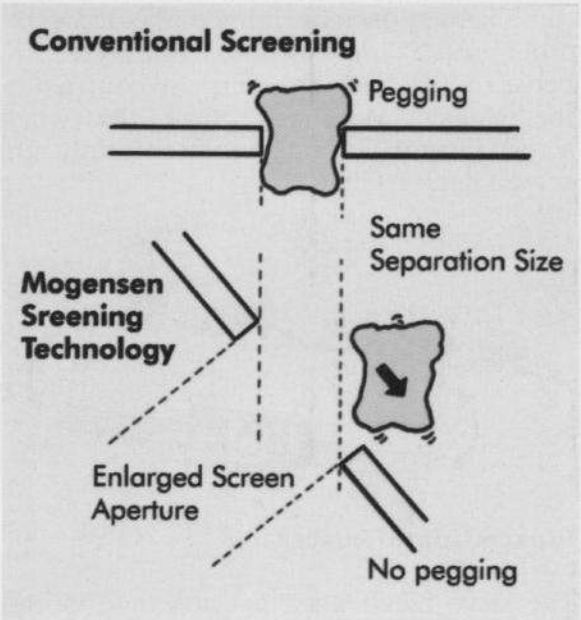
Comparison - Conventional Screens / Mogensen Sizer

The perfect matching of screen slopes, over-dimensiones mesh apertures and ideal vibrator amplitudes facilitates specific throughput capacities higher by far than are possible with conventional screening systems. The fine material flows unhindered and extremely quickly through the wide-aperture meshes, whilst the coarser particles are rapidly removed by the upper decks. The build-up of a bed of material on the screen decks is thereby excluded.

10. Operational security and accessories

Side by side with its high throughput capacity the Mogensen Sizer offers a high measure of operational security.

The larger projected aperture of a Mogensen screen deck for a given size of separation makes blockage-free screening possible.



In addition, optimised screening aids are available for use with „difficult" materials. These are:

- electric deck heating
- pneumatic screen cleaning
- screen deck breakage monitoring
- machine monitoring, local and remote

11. Applications in the potash industry

The screening of food-quality salt, chemical salt grades, salt granules and road salt from both rock salt and damp sea salt has already been realized with Sizer technology. Feed rates of up to 500 t/h on a single machine and cut-points between

0.25 and 14 mm have been achieved. In some instances 5 separations are carried out simultaneously in a single machine.

Related industries such as fertilizers have also valued the Mogensen Sizer for many years.

12. New development - the Sizer 2000

A new development, on the market since 1994, is the Sizer 2000. This machine is static, high-capacity sieve fitted with up to three screen decks arranged one above the other and is designed for fine screening between 0.1 and 5.0 mm. In contrast to the classic Mogensen Sizer the whole screen frame is not vibrated; only the screen deck itself.

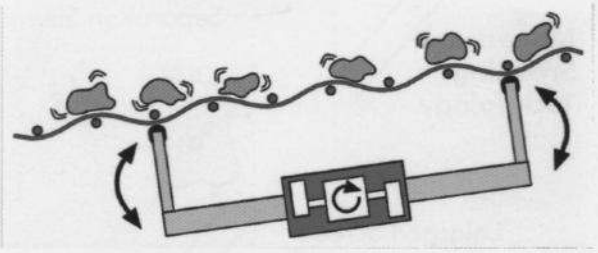
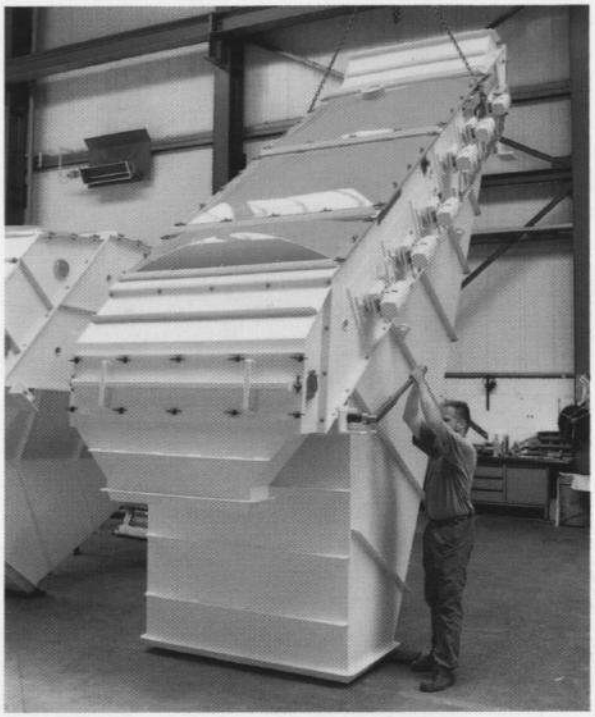


Illustration of beater bar

The sieve mesh itself is caused to vibrate by means of beater or rapping bars, which are actuated by vibrator motors. The accelerations force applied to the sieve mesh reach up to 30 g and can be varied, as required, using a frequency inverter. The machine itself remains static and no disturbing dynamic forces are transmitted into the building.
The rapping impulses imparted to the meshes keep them clear of „pegging" and material build-up.



Sizer 2000 with 1.5 x 4.8 m screen area for the screening of fertilizer

This Sizer technology has already proved itself many times over in the sieving of materials, which are difficult to screen, such as urea, NPK and also hot granulates.

A it is not necessary to accelerate a large mass in the case of this type of machine, the total power applied to the machine illustrated above is only 1.7 kW.
To date more than 50 machines have been installed, of which over 25 are operating in the potash and related industries.

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1. Taggart, Handbook of Mineral Dressing No. 50 (1954)
2. Harbeck, CommoDas GmbH, Wedel (1998)