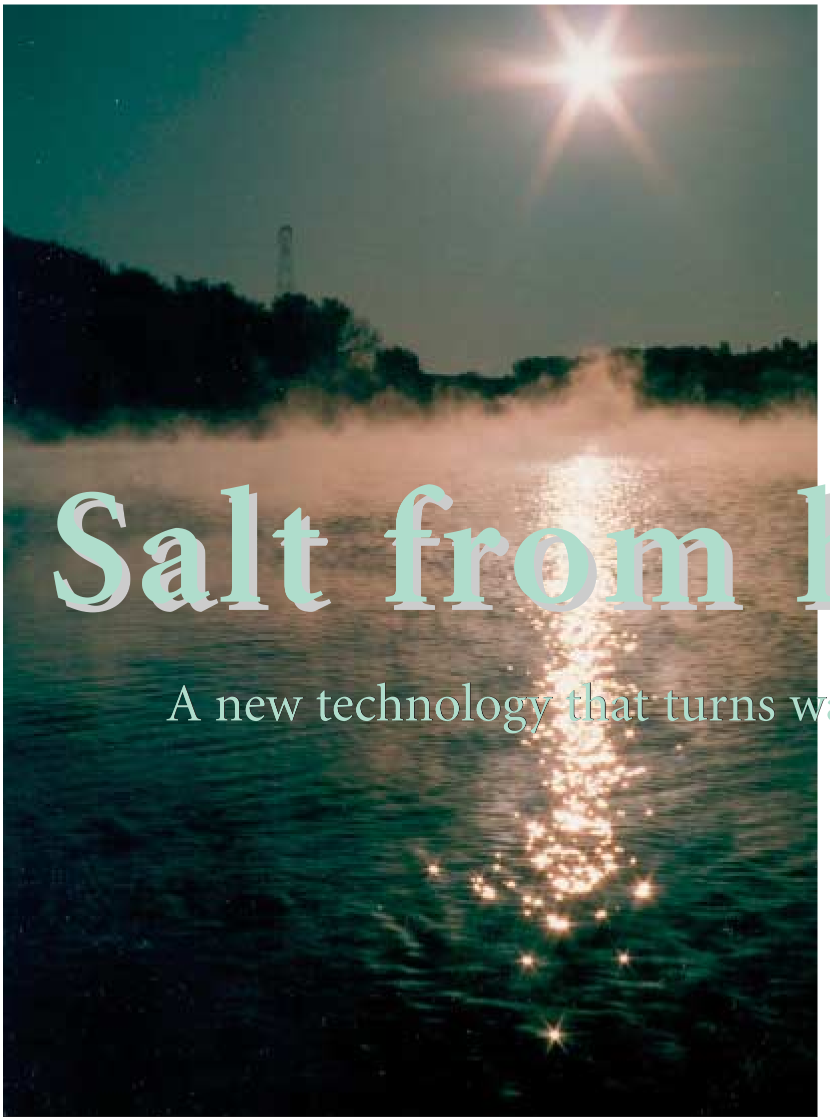

Salt from hot air

A new technology that turns waste heat into salt

Hot brine evaporating from a THERMOSAL pond (Peter Chromec)

by V.M. Sedivy*

Thermal salt production processes need heat at temperatures well above 100°C. As an economic measure this valuable heat has to be recycled several times in multiple effect evaporators. Evaporating plants are expensive and so is the salt that they produce. The new THERMOSAL® process utilises the residual waste heat available at much below 100°C. This low cost heat magnifies the evaporation rate of brines in open ponds and accelerates salt crystallisation. The heat can be obtained from the cooling systems of power generators, from chemical or electrolytic plants or from incinerators. Salt produced by the THERMOSAL® process can reach vacuum salt quality at significantly lower cost.

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A pipeline supplying the north of Spain with natural gas crosses a large diapiric salt formation underlying the area of Castejon del Puente in the province of Huesca. In 1992, *Sales Monzon SA* was established for the purpose of dissolving large cavities in the salt deposits to be used for the storage of natural gas. In the middle of an agricultural area, far from the sea, the resulting brine could not be just discharged to the river – the brine had to be evaporated and the crystalline salt recovered.

At first, the brine was evaporated by solar evaporation in a series of plastic lined ponds. Soon it became apparent that the evaporation rate was insufficient for the purpose. The idea of using the heat from the natural gas to enhance the evaporation rate was obvious. It resulted in examination of co-generation of electricity combined with salt production.

In 1993, the first 2 MW power plant and an experimental concrete salt crystallising pond were built. Subsequently, some 120,000 tpa of pure sodium chloride is now being produced at Sales Monzon, utilising the residual heat from production of 17 MW of electricity, adding some 60,000m^3 of natural gas storage space per annum.

Sales Monzon

The salt plant at Sales Monzon: in the foreground is the co-generation building and brine purification; in the background are the THERMOSAL crystallisation ponds (Vladimir Sedivy).

The operation of Sales Monzon consists of two brine cavities, one approx. 1,000 metres, the other approx. 1,400 metres deep. Water is injected into the salt deposit at a rate of approx. 50m³/h. ASR (Anhydrite Solubility Reduction) reagent is added into the injection water to reduce the sulphate content in the brine. The saturated brine is purified by addition of caustic soda and exhaust gas containing carbon dioxide from the engines of the co-generation plant. The purified brine is then transferred to the crystallisation pond through a heat exchanger where it is heated up by the cooling water from the co-generation plant.

The hot brine is discharged to a series of concrete crystallisation ponds having a total area of 34,000m². There the water evaporates assisted by sun and wind and the brine cools to the temperature of the environment. Depending on the climatic conditions, the hot brine is sprayed in the air through a series of nozzles to enhance the evaporation.

The salt crystallises at the bottom of the ponds forming a layer up to two metres deep in just one year of operation. The cold brine is recirculated to the heat exchangers. A small stream of brine is re-injected to the cavities in order to control accumulation of sulphates in the circulating brine.

Salt is harvested as required by a mechanical shovel from the bypassed and drained sections of the crystallising ponds. The purity of the salt at this stage is approx. 99-99.5% NaCl. In order to satisfy the most strict quality requirements, a salt purification plant based on the SALEX-C process is required.

The SALEX-C process can upgrade the salt to approx. 99.95% purity. A SALEX-RT salt refining process can produce table salt of a quality equal to PDV (pure dry vacuum) salt. For the drying of the salt, exhaust gas from the co-generation engines can be used, making the process particularly competitive.

The design of the power co-generation plant at Sales Monzon is modular for high efficiency at partial load. It consists of a series of Jenbacher turbo-charged, 16 and 20 cylinder, 4 stroke, spark ignition, natural gas driven engines.

The Jenbacher equipment features a highly ecological lean-burn combustion system with catalytic oxidation converter, microprocessor controlled engine management system, synchronisation with automatic power line isolation in case of failure and automatic reverse synchronisation when the line is recovered. The system includes a cooling water make-up unit and a cold cooling water reserve

At Sales Monzon all the installations are located outdoors, only the power generators and electrical equipment are inside closed buildings. The cost of civil construction was low because the engines work with very low vibration.

The total utilisation of primary fuel energy is approximately 90%. The high degree of utilisation of primary energy makes Spanish co-generation regulations applicable to this operation.

Economy of Sales Monzon operation

Revenues	US$11m.
Profit	US$4m.
Investment	US$12m.
Payback	3 years

Emissions from Jenbacher engines based on 5% O_2 in exhaust gas

NOx	500 mg/Nm³
CO	650 mg/Nm³
HC (non CH4)	150 mg/Nm³

Jenbacher engines at Sales Monzon

Number	Type	Power
3	JMS 316 GS-N.L	1,977 kVA
3	JMS 320 GS-N.L	2,766 kVA
8	JMS 616 GS-N.LC	12,440 kVA

Utilisation of primary energy in Jenbacher engines at Sales Monzon

Electrical power	40%
Utilised waste heat	50%
Exhaust and radiation	10%

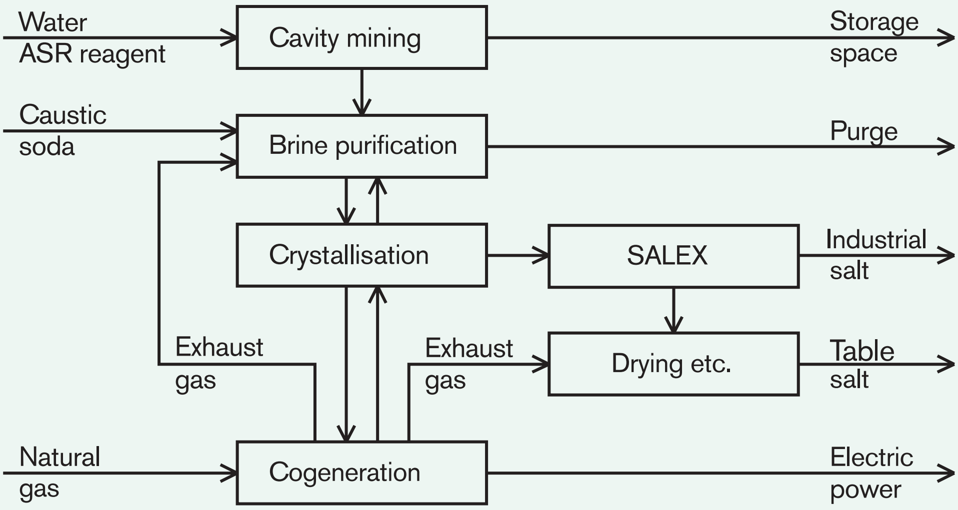

Figure 1. THERMOSAL process at Sales Monzon

Consumption figures of Sales Monzon THERMOSAL plant

Natural gas	0.25 Nm³/kW electricity
Residual heat	1.3 - 1.6 MWh/t salt
Water	2.8 - 3 m³/t salt
El. power	15 - 20 kWh/t salt
ASR reagent	20 - 50 g/t salt
NaOH (100%)	10 - 20 kg/t salt
Polyelectrolyte	30 - 50 g/t salt

Sources of raw salt and brine for the THERMOSAL process

- Mined rock salt. Dissolution with or without ASR
- Brine from cavity mining. Mining with or without ASR
- Well brine, brine springs
- Sea water (diluted or preconcentrated)
- Waste brines, by-product brines

Comparison of vacuum salt and THERMOSAL salt

	Vacuum salt	THERMOSAL salt
Ca	5 ppm	10 ppm
Mg	1 ppm	2 ppm
SO_4	400 ppm	200 ppm
Insolubles	<50 ppm	100 ppm

Salt purities achievable with the THERMOSAL and SALEX processes

Salt use	Process	Purity
General use	SALEX-B	99.8%
Electrolysis	SALEX-C	99.9%
Refined salt	SALEX-M	99.95%+

The unconventional, innovative and, above all, most economical concept of salt production at Sales Monzon appealed to *Krebs Swiss Salt Technologies* of *VA TECH WABAG* so much that they agreed to collaborate with Sales Monzon and develop the concept into a commercially marketable technology. This is how the THERMOSAL technology was born.

VA TECH WABAG Ltd is a 100% owned subsidiary of *VA Technologie*, Linz. VA TECH WABAG acquired Krebs Swiss activities in the field of salt processing in 1999. The innovative Krebs Swiss Salt Technologies ideally supplement the VA TECH WABAG's renowned salt evaporation Systems Escher Wyss. Through the acquisition, VA TECH WABAG strengthened its leading position in the field of salt processing.

THERMOSAL technology

Evaporation of water from brine in open ponds is the original, natural method of salt crystallisation. Weather conditions and area requirements dictate that this method is mainly employed in warm and dry climatic zones. However, the use of residual waste heat to enhance the natural evaporation considerably reduces the area requirements and compensates the climatic disadvantages of some locations.

Combined with the highly efficient SALEX salt purification process, THERMOSAL is the economic alternative to conventional vacuum crystallisation for the production of top quality industrial and food grade salt. The main physical principle of the THERMOSAL process is the utilisation of exponentially rising water vapour pressure with rising temperature.

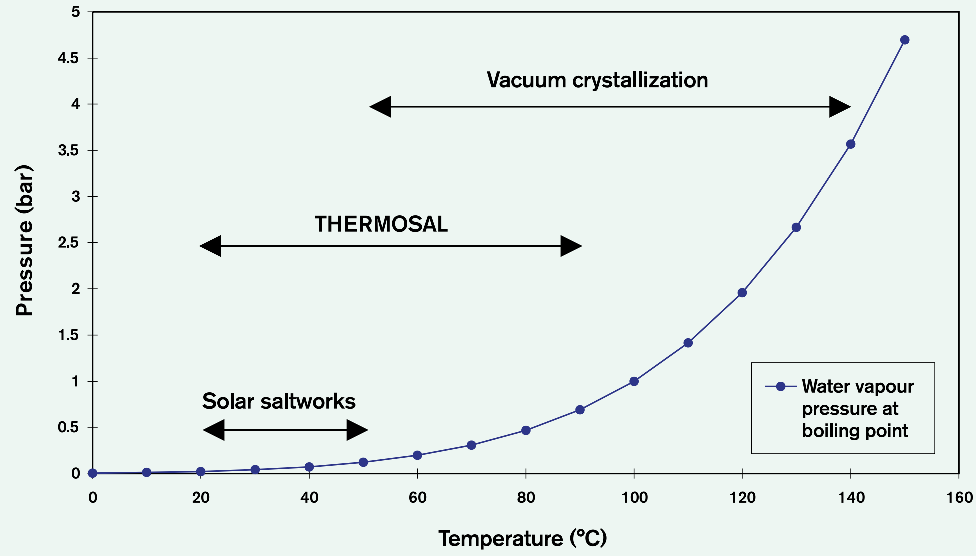

Figure 2. Operating ranges of salt production processes

For example, at the average temperature in solar saltworks, ie. at 30°C, the water vapour pressure is 0.042 bar. At 77°C, the water vapour pressure is 0.42 bar, ie. ten times higher. Consequently, the evaporation rate at 77°C is ten times higher than at 30°C. As a result, evaporation ponds required by the THERMOSAL process are much smaller than the solar evaporation ponds and the salt layer is much thicker.

Because of the faster growth rate of the salt crystals, the deposition of airborne impurities in the salt is much less per weight unit of salt than in the solar saltworks.

Compared to vacuum crystallisation, the THERMOSAL plant is substantially cheaper to build and operate. If the raw brine is purified, the quality of the THERMOSAL salt is comparable to the vacuum salt: the calcium and magnesium levels are almost the same, the insolubles are somewhat higher but the sulphate levels are lower.

THERMOSAL processing options

Worldwide, salt is produced from a great variety of raw materials, using all kinds of energy sources. The final salt product must fulfil a range of quality requirements. Under the variety of conditions, a marketable, commercially viable process must offer adequate processing options for any such combination.

Generally, the THERMOSAL process is applicable whenever the raw salt is available as brine. However, it can also be applied if crystalline raw salt is not sufficiently upgradable in a mechanical process. For example, the raw salt may be available as dark, coloured rock salt that should be made white. In such case, the salt can be recrystallised using the THERMOSAL process.

Brines originating from dissolution of rock salts are nearly saturated with respect to calcium sulphate. If the brine is not purified, the calcium sulphate precipitates on the surfaces of heat exchangers. It also precipitates together with the salt so that only approx. 97-98% NaCl purity of the salt crystallised in the ponds can be achieved. The upgradability of such recrystallised salt is somewhat lower than the upgradability of solar salt. After processing in the SALEX process, purity of 99.5-99.7% NaCl can be obtained.

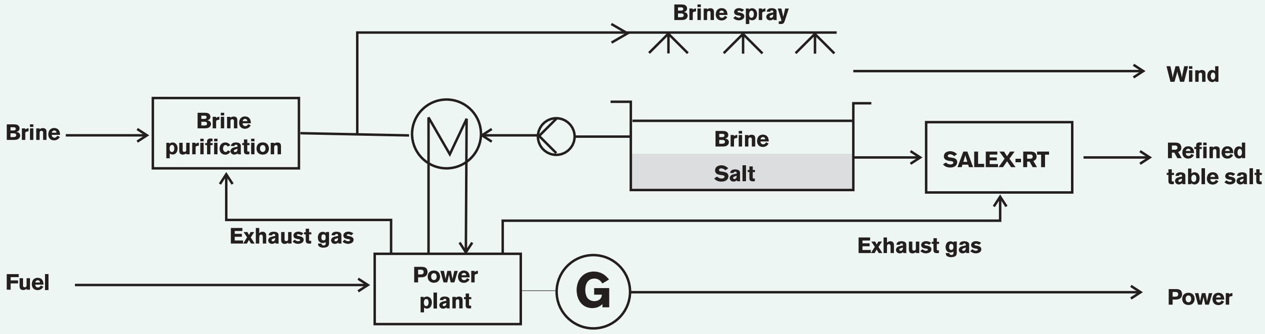

Figure 3: The THERMOSAL process

Anhydrite Solubility Reduction (ASR)

The ASR technology is based on the ability of certain chemicals in ppm concentrations to reduce the solubility of anhydrite in brine. The optimised blend of the chemicals and additives is supplied as the ASR reagent.

The ASR technology is applicable for dissolution of rock salt in brine caverns for salt crystallisation or to be used as feedstock in chloralkali plants with diaphragm cells. It is also applicable for dissolution of rock salt in saturators and for heating of liquids containing calcium sulphate in solution. The ASR technology is not applicable to salts containing gypsum or polyhalite.

Brine purification

The scaling problem can be completely eliminated if the raw brine is chemically purified. The partial purification process removes only calcium and magnesium from the brine. The purified brine is circulated in the THERMOSAL evaporating ponds until saturation with respect to sodium sulphate. The sulphate concentration is maintained below the crystallisation point of sodium sulphate by purging the brine. With this system, the salt in the ponds will be approximately 99% pure. The SALEX process will refine this salt to approximately 99.8-99.95% NaCl purity.

Brine purification processes applicable with the THERMOSAL process:

- Precipitation with caustic soda and carbon dioxide from the exhaust gas of the co-generation plant (partial purification)
- Precipitation with milk of lime, soda ash and carbon dioxide from the exhaust gas of the co-generation plant
- Precipitation with calcium chloride, soda ash and caustic soda
- Continuous or batch brine purification process

The final selection of the combination of the brine purification process and the SALEX upgrading process depends on economic considerations such as the cost of brine purification chemicals, the cost of SALEX salt processing and the end use of the produced salt.

For example, when SALEX-M refined salt is used as feedstock in membrane cell chloralkali electrolysis, the primary electrolytic brine purification can be omitted and the treatment reduced to secondary brine purification only.

The THERMOSAL technology is capable of producing high quality salt from any brine and from any co-generation plant or other residual heat source.

Sources of prime energy

It can be that as a source of prime energy, only diesel oil, heavy bunker oil or coal may be available. Sometimes, an incinerator or a process plant may supply the heat. For larger pants, turbines may be the more economical alternative than piston engines. Today, VA TECH WABAG, Krebs Swiss Salt Technologies offer co-generation plants 4 stoke engines; gas turbines; combined cycle turbines; steam generators and turbines combined with the SALEX process as a very attractive alternative to conventional vacuum crystallisation for the production of top quality industrial and food grade salt. IM