Salt Crystallization Systems: Design Features & Operating Advantages

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The following, abridged version of the paper, offers a brief discussion of USFilter's design experience at two premier salt production facilities. The complete technical discussion will be presented by USFilter Corporation during the symposium along with the unabridged paper, which discusses in detail various proprietary design characteristics and more thorough operational data.

ABSTRACT

For decades, USFilter's HPD Products Group of Naperville, Illinois, has successfully designed and supplied some of the largest evaporation and crystallization systems in the world. This paper will highlight some of the unique design features and operating advantages of two recent evaporated salt crystallization installations – each the world's largest of their kind – and discuss their performance.

HPD Products has designed, engineered and constructed the largest steam-driven and mechanical vapor recompression (MVR) evaporative salt plants in the world. A steam-driven, multiple effect crystallization system in the Netherlands produces 1,200,000 tons of salt per annum. The system has successfully demonstrated sustained operation since 1996. A large single effect MVR crystallization system located in the United States produces 700,000 tons of salt per annum. The system has been in operation since late 1998.

On both projects, USFilter's scope of supply ranged from raw brine pretreatment through evaporation, centrifugation and drying. Both systems have consistently achieved production and warranty targets.

1. Introduction

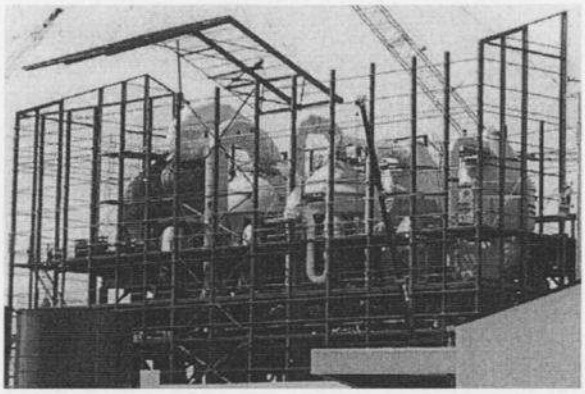
In the last ten years, evaporated salt crystallizer systems have become more sophisticated facilities. This was necessary to address various production issues - higher salt purity requirements, reduced outages, increased capacity, and to minimize production costs. The use of new materials and processing techniques had to be implemented to combat common crystallizer problems.

Many of these improvements were initially implemented in the 1988 Südsalz installation at Bad Reichenhall, Germany. The Bad Reichenhall plant has three MVR crystallizer systems operating in parallel and producing a total of 240,000 tons of salt per year. This very successful plant set the standard for evaporated salt crystallization in Europe. This positive experience combined with further improvements developed for the Frima and Texas Brine installations contributed to the overall success of each of these facilities.

2. Frima B.V.

2.1. Location and Purpose

The Frima Salt Production Facility, located in the port city of Harlingen, Netherlands, is designed to produce 1.2 million tons of solution mined salt per year. Most of the salt is sent by barges and sea vessels as centrifuged wetcake to several European chlor-alkali plants. The remaining portion is dried and amongst other ways, used in the food industry and for water softening.



2.2. System Design Requirements

Frima specified the following:

- Produce 1.2 million tons per year of salt based upon 8,000 hours operation per year.
- Use boiler steam in a multiple effect system to maximize economy. Utility consumption targets were less than 0.725 tons of steam and 25 kwh per ton of salt produced.
- Produce a salt product with a minimum purity of less than 400 ppm SO_4.

2.3. Design Configuration

The crystallizers are configured as a quintuple effect system operating at reduced pressure. Boiler steam is used to produce evaporation in the 1st Effect. The process vapors generated are used to drive the evaporation in the successive effect in series down the multiple effect train. This system configuration was selected to provide an economical capital cost, while achieving the steam economy requirement.

2.4. Large Vessel Construction

Due to the system's large throughput, and specifically, the large volumetric flow of vapor at low pressures, the 4th and 5th effects of the Frima train are very large (10 and 11 meters in diameter, respectively). The operational units incorporate a unique construction to provide an economically performing design.

2.5. Vapor Body Design

Proper crystallizer vessel design requires sufficient retention time for release of developed supersaturation and crystal growth. In addition, vapor release velocities should be low to minimize liquid entrainment in the vapor flow. These goals can be achieved by selecting a vapor body with sufficient cross-sectional area and volume to support the crystal production, recirculation rate and vapor volumetric flows. If the recirculating liquor stream can "short circuit" directly from the recirculation inlet to the outlet nozzle or if the boiling vapor release is violent and localized, a portion of the vapor body is effectively eliminated, thus wasting its size, and usually resulting in poor operation. The HPD design includes features to minimize short circulation. Use of the entire liquid surface ensures the vapors are released from the vapor-liquid interface at the lowest velocity, thus minimizing the amount of entrained liquid particles in the vapor stream.

The elutriation leg is designed for high efficiency washing, cooling classification and thickening utilizing internals that provide proper velocity and uniform fluidization.

3. Texas Brine Corporation

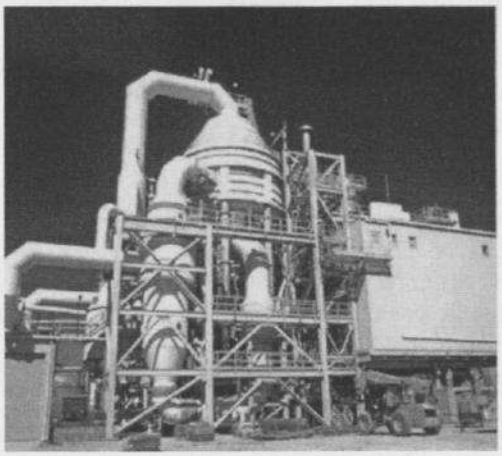
3.1. Location and Purpose

The salt production facility for Texas Brine is located in Baytown, Texas, near Houston. This facility produces 700,000 tons per year of high-quality salt for two users. Approximately one quarter of the production is marketed as dry salt for the United Salt Company of Houston, Texas, and utilized for the production of water softening pellets. The remaining production is sent as a slurry to the neighboring Bayer AG, Baytown production facility. The salt is used as feedstock to Bayer's chlor-alkali facility, and has strict requirements with respect to purity and reliability.

3.2. System Design Requirements

Texas Brine specified the following:

- Produce 700,000 tons per year of salt.
- Utilize a mechanical vapor recompression design. Process condensate was required to contain less than 10 ppm salt to protect the compressor and to be suitable for reuse in Bayer's process.
- Produce a salt product with a minimum purity of 99.95%.
- Provide a minimum of 95% on stream availability.



3.3. Design Configuration

The salt crystallizer design installed by HPD Products is a single effect system utilizing a single vapor body, dual heater/recirculation loop configuration with the motive energy for evaporation supplied by mechanical vapor recompression. Incoming brine feed is deaerated prior to the crystallizer. Slurry is initially washed in the elutriation leg, and subsequently washed in centrifuges. Wetcake is reslurried for transfer to Bayer. The balance of the salt is dried and cooled prior to dry salt processing.

3.4. Single Large Body Design

In order to avoid the large capital costs of multiple vessels and/or compressors, all of the salt crystallization occurs in a single crystallizer vessel utilizing a single compressor.

There are many advantages from a large production in a single crystallizer vessel. The single effect configuration has considerable savings in capital cost and footprint over a multiple effect design. Also, a single effect is easier to operate and maintain due to less

equipment being present. The dual heat exchanger recirculation loop configuration was selected due to the practicality of transportation and the capacity limitations of single recirculation pumps.

3.5. Compressor and Vapor Washer

The production of this system was chosen based upon the capacity of the largest commercially available steam compressor. The crystallizer vapor flow of 240 tons per hour corresponded to the largest overhung centrifugal compressor. This compressor with its 11.5 MW motor and 1 meter titanium impeller is unique in salt production. Any increase in plant capacity would have required a second compressor with significant increase in capital costs.

3.6. Slurry Handling Features

In all salt plants there are several critical areas related to slurry handling that can lead to frustrating outages. Water used to clear lines represents an increased evaporation load. For these reasons, important areas which require attention are centrifuge feed systems, slurry conveying, and centrifuge wetcake diverters.

3.7. Centrifuge Feed System

Direct feeding from the crystallizer to the centrifuges is not desirable due to the elevations that would be required, and the non-stable often dilute slurry present. The slurry must be pumped to a thickening device located above the centrifuge. In order to facilitate the use of multiple centrifuges and a continuous mother liquor recycle scheme, a thickener was used. The thickener is designed to dampen out upsets and allows for a centrifuge to be taken off line, washed and returned to service without interruption of the crystallizer operation.

3.8. Slurry Conveying

Slurry lines can be a troublesome source of down time. The slurry conveying employed mother liquor recycle to produce sufficient slurry velocities during normal and reduced rate conditions. If the plant production stops, the slurry conveying is kept operational until all solids are cleared.

3.9. Centrifuge Wetcake Diverters

The design of the centrifuge wetcake diverters was challenging due to multiple destinations for wetcake. The wetcake diverter was designed to feed either the reslurry tank (transfer to Bayer), the dryer or to a wash position. The design provides operators flexibility in selecting which of the four centrifuges will be utilized.

USFilter's technical presentation will discuss the unique design features, operating data and design requirements for both the Frima and the Texas Brine facilities.