NIRMA, an integrated Solar Salt, Vacuum Salt and Soda Ash project in India

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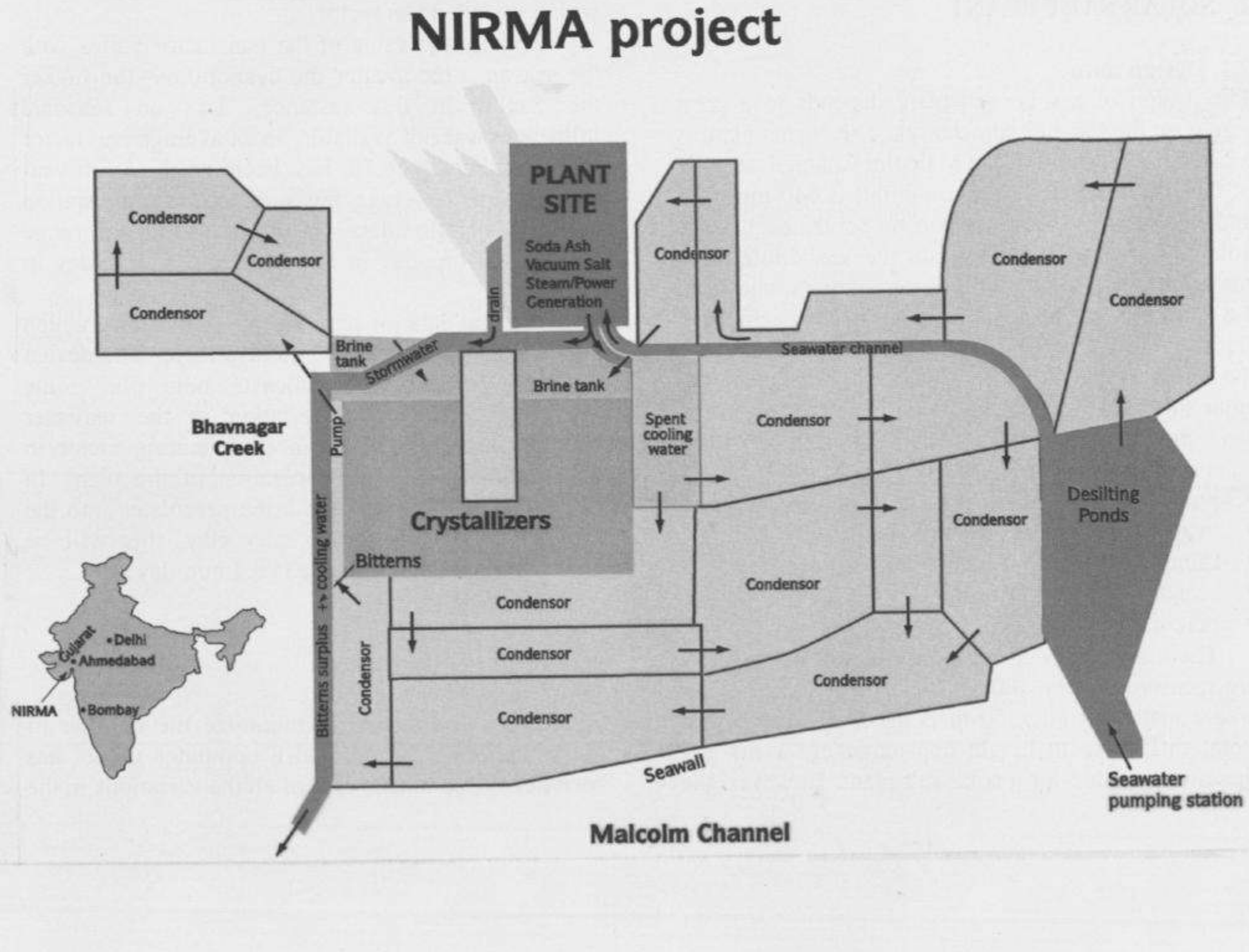
INTRODUCTION

In March 1995, Mr. Patel, the chairman and managing director of Nirma, India visited Akzo Nobel in Delfzijl and signed a contract with Akzo Nobel Engineering for the supply of know-how, basic engineering and technical assistance for setting up a Soda Ash Plant and all utilities, including steam and power. In 1997 a second contract was signed for the know-how and basic engineering required to build a three-stage vacuum salt plant using concentrated seawater as feedstock. A very important by-product of this plant is the condensate (pure water) which will be used as boiler feed water.

Nirma – a typical family company – is the undisputed market leader for soda ash-based detergents in India. Production facilities are located in Gujarat, a rapidly industrializing area. Today, Nirma is backward integrated with plants for manufacturing Sulfuric Acid, Fatty Acids, and Linear Alkyl Benzene. Facilities for producing the main raw material Light Soda Ash are under construction.



1. PROJECT DESCRIPTION

In 1997 Nirma started reclaiming an area of over 7,000 hectares near Bhavnagar. This site, which used to be flooded several times a year by the sea and which receives heavy rainfall during the monsoon, has been chosen for the greenfield Nirma project (initial investment US $
300 million). The site is composed of:

- a "dry-liming" ammonia soda ash plant, with a capacity of 1,200 tons of soda ash per day.
- a dedicated 17 MW power plant, with a capacity of 200 tons of steam (100 bar, 500°C).
- a three-stage vacuum salt plant with a daily capacity of 800 tons of salt and 2,300 m^3 of pure water.
- a solar salt plant to feed the soda ash plant with brine (harvested salt dissolved in water) and the vacuum salt plant.

The main feedstocks for this integrated complex – seawater, limestone and lignite – are all in plentiful supply in Gujarat.

2. SOLAR SALT PLANT

2.1. Design data

The design of a solar salt plant depends to a great extent on the local circumstances. The Nirma plant is located on the shore of the Malcolm Channel, an inlet of the Arabian Sea. Average rainfall is 640 mm/year and in the rainy season (June to September), large volumes of rainwater flow into the sea, diluting the seawater. As a result, salt concentrations range from 1.8 Bé in September to 3.5 Bé in May and tidal fluctuations are up to 10 m. Due to strong currents, the seawater contains a lot of silt, and the soil in the solar salt field – which has been reclaimed from the sea – is a silty clay. Key design data required for a solar salt plant are:

- areas of land available (plus qualitative data)
- evaporation patterns throughout the year
- rainfall patterns throughout the year
- seawater concentration data
- percolation data, etc.

The elevation contours – in a matrix of 300 m – are measured every 100 m, while in the crystallizer area a matrix of 50 x 50 m is used. The site is flat (total difference in height approximately 1 m) and therefore suitable for a solar salt plant. However, the plot contains a number of deep, wide creeks, which were a complicating factor in designing the layout of the salt field. In some places, the creeks were so large that they had to be re-routed. The total available area is approximately 7,000 hectares.

For the design of a solar salt field reliable evaporation data is essential, ideally ten or more years of historical data, measured locally in the evaporation pan. In this case, historically measured sweet water, evaporation pan data was available (with 30-year averages). The data were measured approximately 50 km from the plant site to eliminate local differences. Where measured data are not available, these can be 'guestimated' from climate data such as wind velocity, solar radiation, and cloudiness.

Akzo Nobel Engineering has designed a model for guestimating evaporation. The pan evaporation data (3.4–10.7 mm/day) have to be corrected for salinity and large body evaporation. Evaporation decreases as brine concentration increases. The salinity factor varies from 1 for sweet water to 0.6 for crystallizer brine at 25-26 Bé. Evaporation in a test pan is greater than in the solar salt field (large body). The pan evaporation data must therefore be corrected with a so-called pan factor.

Normally the value of the pan factor varies with the season – the greater the evaporation, the higher the factor. In this instance, data on seasonal influences was not available, so an average pan factor of approximately 0.70 has been used. A 30-year annual rainfall average, measured at the same station as the evaporation data, was used. The annual range is from 0.8 mm/day in February to 167 mm/day in July.

Historical data for seawater concentrations, which also vary seasonally, were not available. The design is based on a one-year measurement plus some guestimates. The large variation in the seawater concentration is of course a complicating factor in both the design and the operation of the plant. In most solar salt works some brine percolates into the ground, but thanks to the silty clay, this will be minimal (the design estimate is 0.2 mm/day).

2.2. Layout of the Plant

The layout is designed to minimize the number of pump stations required, and a computer model has been developed to take care of all the variations in the design data. The solar salt field consists of a condenser area – where the seawater is concentrated to form saturated brine and gypsum and calcium carbonate are precipitated – and a crystallizer area, where some of the salt precipitates and is harvested and magnesium salts are purged. The Nirma plant also contains:

- silt settling ponds to remove the suspended silt from the seawater;
- brine storage during the rainy season, to ensure a quick start after the monsoon and to feed the vacuum salt plant; and
- a wash plant (to wash the harvested salt).

The seawater is pumped to a silt setting pond for desilting. the desilted water then flows to the soda ash plant, where it is used as cooling water, while some goes direct to a small part of the condensors. The spent cooling water from the soda ash plant is fed into the first condensor pond, which is operated at maximum capacity. From here, the seawater flows by gravity via a series of ponds to a pumping station, which discharges the half-saturated brine into the second condensor area. This is above the spent cooling water/storm water drain channel, which is a former creek. The condenser area ends in a brine tank, from which the crystallizer area is fed by gravity flow. The directly concentrated seawater is used as feedstock for the vacuum salt plant and to feed the crystallizers.

2.3. Crystallizer operation

Harvesting of salt will take place in the months April, May and June (before the monsoon). The surplus brine stored in the brine tank serves two purposes, firstly to supply the vacuum salt plant and secondly to make it possible to restart solar salt production immediately after the crystallizers have been drained following the monsoon. The brine will not be saturated, as even a full, 2-meter deep brine tank will get diluted during the monsoon. The crystallizer area has been designed with most of the crystallizers in series of two or three, thus minimizing the number of canals required and optimizing evaporation.

The crystallizers – designed for mechanical harvesting with the help of mobile belt conveyors – are equally spaced at slightly over 300 m. Wide haul roads have been planned to allow
truck to maneuver while being filled and the link roads are somewhat narrower.

Culvert locations have been placed to minimize dike/road crossings, and the surplus brine from the wash plant – located in the middle of the crystallizer area – flows into the main crystallizer feed canal, which supplies all the crystallizers with brine. Around the crystallizer area there is a bittern channel.

3. HARVESTING THE SALT

Contrary to normal practice in India, harvesting will be mechanical. Due to the heavy monsoon, there will not be a salt floor, which requires at least one year's production to establish and is difficult to maintain. As a consequence, harvesting will have to be done at the end of the season, requiring high-capacity equipment and 24-hour shifts to minimize the number of weeks the crystallizers are out of operation.

Two parallel systems – a track-mounted harvester and a series of mobile conveyors belts with a truck loading device – will be used. The salt will be loaded into trucks or tractor carts, which will discharge directly into the feed hopper of the wash plant. The wash plant feed system, which has been designed to handle 2 X 500 tons per hour of salt, is of the screw/drain belt type. The washed salt will be stored on a stockpile with a capacity of one year. The stored salt is dissolved in water and pumped as brine to the brine purification area of the soda ash plant (lime/soda method).

4. THE VACUUM SALT PLANT

A source of pure boiler feed water is essential for a plant using open steam. For the Nirma soda ash plant Akzo Nobel Engineering has
combined its know-how and experience of solar salt production, vacuum salt production, and anhydrite scaling to design a pure water plant with consumer quality vacuum salt as a useful by-product. The daily capacity of the plant is 2,300 m^3 of water and 800 tons of salt.

As raw material for producing water, we have chosen nearly saturated brine from the solar salt plant. Low pressure steam at 2.5 bar absolute, available from the steam turbines and cooling water (seawater) at a temperature of 32° C, permit a three-stage evaporation. However, as
the incoming brine is saturated with calcium sulfate, special measures are required to reduce anhydrite scaling.

Using experience gained in Akzo Nobel's plants of the scaling behavior of anhydrite and a kinetic model for which we have determined parameters in the lab, we are able to predict the rate of scaling and how this is affected by seeding the evaporator.

In order to keep the anhydrite seeds in the evaporators and thus improve quality, the salt is withdrawn from the evaporators by means of elutriation legs. This not only reduces impurity levels, but also cools it down to a temperature suitable for centrifugation. The salt is dried and