INDUSTRIAL MINERALS

Sunny times for solar salt

Demand for solar salt in recent years has resulted in tighter supplies and higher prices. *Vladimir M. Sedivy* outlines new methods for solar salt harvesting to increase efficiency and profitability of solar saltworks

In 2005, the annual world production of salt exceeded 250 million tonnes for the first time. Since then, it has been fluctuating at around 260 million tpa. Recent upturn in demand, driven by chemical markets in Asia and de-icing markets in Europe, resulted in shortage of high quality solar salt, tightening supply and sharply increasing prices.

Forecast demand for salt in 2015 is 290-300 million tpa. Approximately 40% of all salt produced worldwide is manufactured by solar evaporation of sea water and inland brines.

The solar salt manufacturing method consists of evaporation of brines in a series of shallow ponds up to saturation, followed by further evaporation of saturated brine in crystallisers. Depending on the climatic conditions, the salt crystal layer that grows at the crystalliser bottom can become several centimetres thick in one year but under favourable climatic conditions the thickness can reach a few decimetres before it is harvested.

There are many methods of crystallising and harvesting solar salt:

- Salt crystals can grow on salt floor or on mud floor;
- The crystallisers can receive pre-concentrated brine in series or in parallel;
- The salt can grow as a compact layer or the crystals can be kept apart by regular raking;
- The brine level can be maintained deep or shallow;
- Thick or thin salt layer can finally be harvested.

Solar salt harvesting

There are many combinations of salt production and harvesting methods. In many parts of the world, for example in Africa, the most primitive salt harvesting method – by bare hand – is still being practised today.

Elsewhere, the salt harvesting methods invented long ago for example in ancient Rome or by the Arabs, are being practised. In India or in China, regular raking of salt crystals in shallow ponds allows manual harvesting of thicker salt layers.

Salt grown on the salt floor as a compact thick salt layer is usually of better quality. However, such salt must be harvested with mechanical machinery. The productivity of mechanised saltworks is higher, the production cost lower and the salt product is more competitive. The trend towards mechanisation of solar saltworks is prevailing worldwide.

Table 1: Worldwide production of salt, by type (million tpa)

Salt type	World production (tpa)
Solar salt	100
Rock salt	80
Brines and vacuum salt	80
Total	260

Durrant 566-70 salt harvester collecting salt for the first time by the client's driver under the supervision of the ROV Durrant commissioning engineer.

Mechanical salt harvesting

Mechanical salt harvesting has been employed by solar saltworks in a variety of forms, including simple power-enhanced devices, standard construction machinery – such as mechanical shovels and front end loaders – and purpose-built salt harvesters.

Perhaps one of the simplest mechanical devices used in solar saltworks is a wooden or steel plate with handles connected to a wrench of a tractor, which provides the pulling power. The workers drag the device away from the tractor to the far end of the crystalliser, lower it to the salt and then, when the tractor starts pulling, balance the plate so that the salt gets dozed to the side of the crystallising pond where the tractor is standing. Productivity of such devices is low and the people using them must work day and night to earn the cost of living and the diesel fuel they consume.

In many smaller mechanised saltworks, standard construction machinery is being employed for harvesting. This may include, for example, front end loaders, graders, mechanical shovels, and tractor-scrapers.

Usually, the salt layer is first ripped (scarified) to separate the salt crystals from each other. Various devices are used for this task, including simple hooks or rotating cutters. The loosened salt layer can then be collected with excavators fitted with wide shovels onto heaps. The same excavators, but fitted with high volume buckets, then transfer the salt from the heaps to trucks, trailers or dumpers, which transport the salt from the crystallisers to the washplant.

Much depends on the hardness of the salt layer and the bearing capacity of the crystalliser floor. A soft salt layer on a hard floor can be collected with tractor-scrapers and transported to the washplant in a single working cycle. Salt grown on a hard crystalliser floor can be cut with front-end loader buckets that have been equipped with a special cutting edge. The same front end loaders then lift the salt and fill the trucks.

For higher capacity, the salt is windrowed with graders and the salt is collected with harvesters that lift the salt to trucks. After the harvest, the crystalliser floor must be prepared for the next crystallisation cycle.

Solar salt harvesters

There are many types of salt harvesters. They vary in capacity, in ground pressure, whether

Spotlight on Salt Partners

Salt Partners are independent consultants and engineers active in the field of salt and chloralkali production, salt processing and hypersaline biotechnology. Salt Partners' worldwide reputation is based on 40 years of experience gained in projects implemented worldwide.

they cut the salt layer or just collect it, etc. The main types are:

- Tractor drawn or self-propelled;
- On wheels or on Caterpillar tracks;
- Driving on salt bed or on crystalliser floor;
- Lifting or cutting the salt layer;
- Cutting the salt layer upwards or downwards;
- Discharging onto belt conveyors or into trailers.

Tractor-drawn harvesters are usually made for smaller capacities. Their salt lifting gear can be propelled from the tractor drive shaft or they can have their own engines.

Wheeled salt harvesters are usually suitable only for crystallisers with a permanent hard salt floor. For higher capacities and for harvesting of salt grown on mud floors, only harvesters on Caterpillar tracks can be employed successfully. This is particularly the case when the harvester should separate the salt layer from the floor, because this task requires pushing. The pushing power can be best transmitted to the crystalliser floor by the Caterpillar tracks.

Unless the salt harvesters are excessively heavy, the ground pressure exercised by the Caterpillar tracks to the ground can be as low as the pressure of the human foot. This makes it possible for the harvester to drive even on the mud floor and lift the salt layer in the front, provided that the salt layer is not too hard and disintegrates on the lifting blade.

The configuration of such harvesters works successfully within a given set of parameters, such as the mud floor bearing capacity, thickness and hardness of the salt, harvester width, weight, power, etc. If some parameters change with time, or if such harvesters should be employed in some other saltworks, the harvester may fail.


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A team of men pick the salt from the mud floor of a crystalliser by shovels to suspended belt conveyors, which transport the salt to a slurring vessel located on a tractor. Salt is mixed with brine and pumped to a mobile washplant located at the side of the crystallising pond.

It is safer to design the harvesters so that they drive on the salt layer. Then they can be employed even in saltworks built on very soft ground. Some such machines harvest the salt on the side.

Usually, the elevation of the lifting blade is controlled by a worker, either sitting in a cabin with good view of the lifting blade or walking along the harvester. Such configuration limits the width of the harvesting path to approximately one metre. Placing the harvesting element behind the harvester facilitates a much wider harvesting path.

Typically, the harvesting element is 2.5 metres wide so that the harvester does not exceed the width of vehicles normally permitted for road traffic. Wider harvesters would require special transport should they be moved from one place to another on public roads.

Salt grown on salt has the advantage of minimised contamination with insoluble material originating from the crystalliser bottom. However, the new salt layer is firmly attached to the permanent salt floor. Unless the new salt layer is very soft, it cannot be lifted – it must be cut. This can be done either separately (ripping, scarifying), prior to windrowing, collecting and lifting the salt to the trucks, or in one working operation. Time, fuel and manpower can be saved if these operations are performed together by a single machine.

Simple ripping of the salt frequently results in large salt lumps, or blocks, being formed. Hard salt lumps cause problems in the washplant. Cutting of the salt layer is possible with rotary devices, which prevent the formation of lumps.

The rotation can be done either from top to the bottom or vice versa. If the cutting is done from the top to the bottom, then the salt is thrown behind the rotary device. Therefore, behind the cutting drum a blade must be provided, followed by a cover that facilitates collection of the cut salt to a lifting device. Salt slipping below the blade, remaining on the floor, can represent significant harvesting


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In Tuticorin, India, perhaps the simplest method of salt harvesting with wooden tools from shallow earthen ponds is being practised. A similar salt harvesting method is still being used in small saltworks all around the world.

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In Mexico, salt is grown on a salt floor. The salt layer is first ripped, then windrowed. The windrow is collected by a tractor-pulled harvester, which lifts the salt to a truck-pulled hopper-trailer equipped with bottom discharge gates.

loss. Besides, cutting elements that enter the salt layer from the top to the bottom cause a breakage of the salt crystals and create undesired fines.

Cutting of the salt layer from the bottom to the top, in the direction of harvester movement, lifts the salt layer and separates the crystals, minimising their breakage. The crystalliser floor is swept clean of salt. When the cutting elevation is effectively controlled, the crystalliser floor behind the harvester is ready to receive brine for the next crystallisation cycle.

Laser control of earth-moving machinery is an established practice, for example in road construction. In salt harvesting, the laser control is less common. In principle, a rotating laser beam marks a perfectly horizontal plane, for example four metres above the salt crystalliser. The harvester is equipped with a receiver reaching out above the harvester roof. The harvester is equipped with devices that measure and control the distance between the receiving point of the laser signal and the lowest point of the cutting drum. Should this device indicate that the distance is increasing, the controls of the cutting drum lift it to the desired level, and vice versa.

Thus, the crystalliser floor needs to be levelled only once, whether by some other equipment or by the harvester itself. The next harvest will separate the new salt layer from the crystalliser floor precisely at the correct elevation. When salt is grown on mud floor, the contamination of salt with insolubles will be minimised. When salt is grown on salt, the floor is maintained clean and ready for the next crystallisation cycle.

ROV Durrant salt harvesters

Salt Partners avail of more than 40 years of experience in solar salt production and processing. In search for equipment most suitable for solar salt production, the solar salt harvesters made by ROV Durrant have been determined to fulfil the requirements for versatile deployment under varying conditions.

ROV Durrant Engineering, based in Port Elizabeth, South Africa, made its first salt harvesters in 1964. The first machine was capable of harvesting 80 tph of solar salt. Its designation was SH80 (Salt Harvester 80 tph). Later, it was recognised that the same machine could perform differently, depending on the properties of the salt. Therefore, the type designation was changed. Today, this machine bears the type designation Durrant 130-60.

Over the years, larger machines were designed, the output increased and reached 1,000 tph with the type Durrant 916-120. Presently, the most popular size of the Durrant salt harvesters is in the middle of this range. Recently, ROV Durrant supplied type Durrant 560-75, Durrant 590-95 and Durrant 790-100 salt harvesters to solar salt producers in Turkey, the Middle East and India.

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Collecting and lifting salt harvester on double wheels. The wheels on the left hand side drive on the salt floor of the crystalliser. The wheels on the right hand side drive on the salt layer. Observe that the wheels on the right hand side are somewhat higher up. Therefore the harvester collects the salt on the left hand side deeper than on the right hand side.

Table 2: ROV Durrant chassis types

Chassis type	Harvesting capacity (tph)
Type 1	50-100
Type 3	100-200
Type 5	200-400
Type 7	400-600
Type 9	600-1,000

The type designation, for example Durrant 590-95, signifies the following:

- 5 is the type of the harvester chassis;
- 90 is the size of the engine, 9.0 litres;
- 95 is the diameter of the cutting drum (pick roll) in centimetres. 95 cm pick roll is designed to cut a salt layer 30 cm deep and fling it to the elevator.

In the Durrant 590-95 configuration, the harvesters have an instantaneous harvesting capacity of 200 m^3/h of the salt layer, corresponding to approximately 350 tph of bulk salt. Depending on turn-around times, waiting for trailers and operator breaks, the effective harvesting rate is somewhat lower. With mobile belt conveyors and mobile lorry loading hoppers, about 80% of the instantaneous harvesting capacity is achievable.

ROV Durrant's range of salt harvesters is based on the chassis types in Table 2.

Mounted on the chassis are the engines, hydraulic pumps, Caterpillar tracks, the pick roll, the elevator and the cabin for the driver.

Unlike other systems, the Durrant salt harvesters perform all the required harvesting operations combined:

- The pick roll cuts the salt and flings it to the elevator;
- The elevator lifts the salt to trucks, trailers or to mobile belt conveyors;
- The harvester maintains the crystalliser floor perfectly levelled for the next crystallisation cycle.

No separate ripping, windrowing, lifting and crystalliser floor maintenance after the salt harvest is required.

The harvesters travel on the salt layer and cut the salt behind them. The ground pressure is similar to the pressure exerted by a human foot; therefore, the harvesters can be used in crystallisers growing salt on soft mud as well as on a hard salt floor.

The pick roll arrangement prevents collection of unbroken salt lumps and formation of fines. The level of the cutting drum is laser controlled, which facilitates maximum salt recovery and minimises salt contamination with impurities. After the salt harvest, the crystalliser floor is perfectly levelled and ready to receive brine for the next crystallisation cycle.


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Salt harvester on Caterpillar trucks drives on the mud floor of the crystallising pond. It pushes a blade between the salt layer and the mud, lifting the salt layer, which disintegrates on the blade. The salt falls from the blade to a rotating device, which lifts the salt to a belt conveyor.


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On request of the client, this type Durrant 916-120F harvester has the driver's cabin located at the front, with the pick roll and the conveyor just behind it. The harvester drives on Caterpillar trucks only on the crystalliser floor. Also this harvester is laser controlled.

The Durrant salt harvesters are designed to significantly improve the productivity of solar saltworks and profitability of the salt production and exports.

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