THEORY AND PRACTICE OF SOLAR SALT HARVESTING

The methods and machinery involved in harvesting and transporting solar salt from the crystallizers to a wash plant are as varied as the weather and soil conditions where the salt is produced. The amount of evaporation and rainfall including the way the rainfall occurs has a great effect on the selection of a method to get the salt out of the pond without disturbing the mud below . It is very important to not mix the mud into the salt at the mud salt contact point and to not track bottom mud or road mud or gravel onto the pond salt surface to be picked up by the harvest device

It is the nature of solar salt that the solid crystals of salt are laid down in large flat ponds and the salt has to be transported to the pond edge to get it into haul equipment to transport the salt to a central location for washing and further processing. The usual and the most common is to transport the salt over the surface of the undisturbed salt crop. There have been some successful slurry transport systems--harvesting under water but not in any major size salt plants. There are slurry transport systems from a crystallizing area dump pit to a central wash plant in the US and China--there may be others.

Salt Floor Harvesting

The simplest solution is the use of a salt floor of enough thickness to allow the use of standard highway type haul equipment and place salt on the surface of the roads to keep dirt from being tracked onto the pond surface. This is the system used in most of the worlds major salt plants supplying the chemical industries that are using solar salt.

There are variations of the salt floor option where the climate is marginal and part of the salt crop is left in the pond occasionally to regrow the floor depth.

There are many types of systems used with salt floors, probably the simplest is to just rip the crop and grade it into a large windrow and load it into highway type trucks with Front End Loaders. Some of them double handling the salt to keep heavy equipment off the pond surface and to keep road impurities from being tracked into the pond

One of the harvest systems most widely used in large solar plants is the Palmer type machine that has evolved from the unit first developed near the Great Salt Lake in the US in the early 1960"s. There is one unit of that basic design rated at 3000 tons per hour at Essa in Mexico and several others rated at 500 tph,750 tph and 1200 tph. These are currently designed and built by J Frank Bonell of

Salt Lake City. A series of smaller harvesters, primarily for salt floor use are built by Serra Machinery of Spain to load various types of trucks, trailers and conveyors. Both of these type machines use a scoop blade at the front bottom with a drag conveyor right behind the blade to elevate the salt up a slope and discharge to a cross rubber belt conveyor sloping up over the haul truck or trailer transport equipment. These two principles are used for just about all harvesting machines--the use of drag conveyors at steep slopes right from the pickup point to keep the machine length short and to elevate the salt quickly.

The original depth of cut control for the Palmer design machines was to insert the scoop like pickup blade into a "split' in the salt crop

This "split" was a fracture plane in the salt at the base of the current years salt crop. The split was created by entering the pond with brine in it after making a small amount of salt and dragging the salt surface with a long piece of angle iron behind a farm tractor to create a layer of loose salt crystals-the "Split". The harvester pick up blade was simply shoved down until it reached the split-the new crop would lift slightly ahead of the blade and the forward travel speed could be increased. The lift rams were set at that point until a pass down the pond was completed. There is a sketch in the appendix showing this feature .titled "Harvester Depth Cut Control'

As this harvesting machine was used in areas where salt depths of greater than 6 " salt crops were common, the salt was ripped with a grader and pulled up into a single windrow for the harvester. After the harvester had passed; the grader smoothes the area-there is enough loose salt to create the split which fractures when the grader rips the next crop.

This machine also uses laser machine blade control technology to establish the cut depth in some plants today and there is no concern about a split. Various types of skids at the front of harvesters sliding on top of the salt crop are used to provide an adjustable gauge to regulate the depth of the cut.

Several types of road building machinery are used to pick up and load out salt. The most common of these is the Athey loader a rubber tired machine that picks up a windrow of highway material in front and loads a truck along either side. It is necessary to rip the salt crop for the Athey or similar machine. Scrapers are also used to pick up and transport salt.

Mud Floor Harvesting

Probably the most common of the harvest methods for mud floor ponds is hand harvesting. Most of the small salt operations scattered all over the world are in climates with too much rain and too small areas of suitable land.

The salt in these operations are usually made in thin crops and taken out by hand quickly to avoid rain and to sell it.

A lot of these operators take special steps with the pond bottoms, mixing something like sand, cinders or even clinker from cement manufacture into the surface to create a sort of pavement. For the intermittent crops during the year, a small salt

floor is left to keep the harvested salt clean and then taken out with the last harvest of the year. These repeated out of service periods for the pond to execute the thin crop harvest results in a very large part of the salt making season being lost.

These operations are for the most part too small to undertake special equipment steps to mechanize and there has been no mechanical system developed for small operators until recently.

There have been mechanized systems developed for large operations in France, USA, New Zealand Brazil and Australia. I believe there are some in Egypt and Turkey but I am not familiar with all of them. These are mostly pond conveyor systems except for the USA. The one in Brazil is from the harvester to the wash plant. These conveyor systems were designed and built by Salins du Midi. The harvesters were built by Salins du Midi except for the ones in the US, Australia and New Zealand which were plant owner designs. Several of the Salins du Midi harvester types use a fairly steep drag conveyor with space for a man under it with enough room to see the pond bottom just behind the cutting edge and control the depth of cut--also shown on the sketch in the appendix. The large capacity harvester uses the new crop lifting aspect shown with the Palmer-Bonell machine on the sketch to separate the salt crop from the mud cleanly. A tapered front edge of a floating shoe ,with very special blade angles is inserted into that joint and traveled at high speed to push the salt crop up the top slope of the shoe into the harvester.

The Rail system in the US (no longer in use after 70yrs) was at Leslie- Cargill Salt, developed at Leslie Salt in 1935 and used a portable mine railroad to transport the salt and a very large harvesting machine with extremely wide flat tracks.

This machine would operate on 2 ½" of salt without disturbing the mud-salt contact point;. It had a rotary tube just ahead of the pickup blade with picks to loosen the salt ahead of the pickup point and produced clean salt with only a very thin layer left. The cut control for this system was visible-the operator was directly above the "pickroll" and the picks threw a streak of brine from the digging operation up onto the salt just ahead of the spinning picks. The operator used the darkness of these streaks to make adjustments on the pickroll height. Two sets of automatic cut depth controls were developed for this machine and are shown on the sketch in the appendix.

The rail system ran all the way to the wash plant. This system was discontinued in 2005 when a salt floor operation was initiated due to a surplus of crystallizing ponds that allows salt floors to be regrown as necessary..

A series of small mud floor harvesters based on this salt pick up and transfer system are being developed using small rubber tracked front end loader power units that have a ground pressure of 5 psi very similar to the original Leslie machine and will operate anywhere a man can walk. The small machine of this type is intended to begin replacing hand labor in plants with small ponds and thin crops and increase production by extending the making season through the elimination of so much downtime hand harvesting thin crops frequently.

Industrial size units of this design are now being made and are in operation. These machines us an adjustable sliding skid at the front up on the new salt crop to set the depth of cut also shown on the sketch in the appendix.

These machines are built by Solar Salt Harvesters LLC of Ogden Utah

All sorts of schemes have been tried to mitigate the problems in the crystallizing area caused by heavy rains.. The large surface area makes the possible use of a removable cover just about impossible to try to protect a salt floor. Deep brine cover with surface skimmers are used to protect salt floors but the dilution of so much of the stored brines reduces production to re-concentrate the brine in the next season--delays the salt making start.

The use of deep storage high strength brine ponds with a dual purpose membrane has been proposed to protect brines over the rainy season. The membrane would cover the brine and collect the rain in the rainy season. The rain water would be drained off at the end of the rainy season-- the brine from below pumped up onto the surface of the membrane so it could evaporate and be sent on to the crystallizers during the salt making season. The strong brines from the crystallizing area would be saved and pumped back under the membrane before the start of the next rainy season

There are probably many other types of salt harvesting systems that are not covered by this paper and there will be many more developed in the future. Because of the critical need for salt this business will go on forever and the oceans are a virtually in-exhaustable supply.

Appendix

Harvester Photographs

1 Palmer Original Harvester-- 1963-Essa Harvester 1990

2. Bonell Harvester 2000

3. Palmer Type Harvester Australia 1985.

4. Leslie- Rail Transport Harvest System1950

5 Cargill-Leslie Harvester -Rail Haul 1985

6. Sallins du Midi Harvester Southern France 1980

7. Salins du MIdi Harvester Brazil 1980

8. Australia Harvester 1985

9. Road Machinery Harvest 2000

10. Road Machinery Harvester Athey.

11. New Development-Small Mud Floor Harvester 2005

12. New Development Large Mud Floor Harvester 2007

13. Hand Harvester India 1886

14. Hand Harvest Ghana 2002

15. Harvester Cut Depth Control