

AN IMPROVED HORIZONTAL SCREW CLASSIFIER/ WASHERY

Paper Track: Salt Production.

Abstract: A U-troughed horizontal screw conveyor is converted into a classifier that washes effectively solar salt, gypsum etc. by using pond brines in single pass. It is a condensed and composite design compared to the prior art of classifiers. The main inbuilt functions it covers are; selective rupturing of fragile crystals, using multi-wash liquors and dewatering the product. It is provided with perforated baffles, compartments and upward product discharge system.

Key words: Screw Conveyor, U-trough, Rupturing, Baffles, Compartments, Blocking plates.

Body of the Paper: The present paper deals with washing of common solar salt to upgrade raw materials. Washing is a cheap and first step to upgrade raw materials. Washing of salt is an art rather than complex technology. Raw salt/gypsum is a crystalline material. Use of raw salt is not practiced in chlor-alkali industries. The pollution control board prevents the processing of substandard materials. Hence; chemical industries are compelled to use up-graded washed material to reduce pollution. The directive invites us to wash raw salt effectively and efficiently. The function of the salt washery is to increase NaCl content of raw by reducing impurities like Ca^{++} , Mg^{++} , SO_4^{--} , insolubles, and so forth.

The patented horizontal screw classifier is more or less multi-functional, economical, combine and composite compared to prior arts for washing of marine salt or gypsum by gravity difference in wash liquor of pure brine, pond brine and brackish water. It does not create any choking problem if power supply fails as it happens in case of hydro-cyclone, elutriator & vessel type washery. The prior arts of washery contains; inclined screw conveyor, inclined wired drip-off conveyor belt, elutriator, bend sieve screen, hydro-cyclone, vessel type washery, centrifuge and crusher. Pumps and belt conveyors are common in any washery.

The conveying efficiency of Horizontal screws is high compared to any inclined screw conveyor. With this; the washing parameters were added to remove major Imbedded impurities of raw salt. We have provided few perforated baffles intermittently among screw flights and to create crushing/rubbing cum churning action in presence of wash liquors. Superfluous impurities are in fact easy to release first; compared to imbedded impurities. The spiral with low speed rotation

stirs the slurry, so that the fine particles rise, and the coarse particles sink to the bottom of the trough. In a trial run, we found major impurities were exposed and released by selective rupturing which in turn will break the particles gently in the presence of wash liquor along the planes where they are weakest. This weakness is often where the impurities lie in the crystalline structure. The performance is useful for producing salt for chlor-alkali industries.

In a horizontal screw classifier, material travels in the forward direction. And hence it is favorable for washing of different size crystals including the finer size of ground salt or gypsum. The performance is useful in producing salt for the food market.

The liquor quantity is also very important in washing. The flow current of wash liquor is adjusted to regulate the loss of fines in effluent to a minimum. The turbulence generated in the liquor by screw motion doesn't allow well-defined layer differences to be established between finer salt and finer impurities. The arrangement of placing plastic net above screw and within trough may be provided to reduce turbulence. The loss of finer salt to some minor extent should be permitted to achieve higher removal of impurities to get the best result of washing. This negligible finer salt quantity is removed by floating is always less than sieving or size separation technique. A fresh crop of salt will wash better than less recently harvested crop.

The lumps of mud in raw salt come from mechanical harvester operated salt works with low bed salt layer. De-mudding is a result of churning action of baffles and blades. Churning is more similar to crushing and replaces crusher to some extent. Mud is lighter sediment and floats first from salt/gypsum classifier and goes out in slurry form.

A horizontal classifier is most suitable for the application of multi-wash liquors. Such multi-wash liquors improve the product quality further by step washing. The classifier is provided with compartments for each washing zone. The sequence of wash liquors is selected to remove the most impurities. A blocking plate is placed in each compartment to retain salt. The cut flight screw provides intense interaction between salt and liquors.

Dewatering is very much needed after the washing process to make the washed salt free from adhering. An upward discharge outlet at the end of the classifier serves to drain down the liquor by both gravity and capillary action, while the salt is being pushed up continuously. The porosity of salt allows draining of used wash liquor and dewatering of washed salt. The upward discharge mouth is arranged to give more retaining time to dewater the washed salt at low reactive

resistance in the path. The upward discharge provides gravity advantage and partial centrifuge function.

Finally minor soluble impurities adhered to the crystals of dewatered salt will hinder the higher refinement of salt. Hence an air blower pushing air opposite to the direction of discharging salt is provided to force down the adhered soluble Mg^{++} impurities before it discharges. Air blow provides extreme dewatering and drying to some extent. Impurity reduction with this makes washed product useful for food market and Chlor-alkali industries.

Washing is carried out by using brine of about 25°Be', 6°Be' and brackish water also. Physical and chemical material balance can be checked by taking quality and quantity of inlets and outlets.

A common experience of a salt farm owner is that the heap of washed salt attains low level of soluble Mg^{++} impurities after getting some standing time with no loss of salt. This is nothing but draining by gravity and capillary action which is attained here by rising discharge mouth.

Whereas; usual practice of wet sieving method of wired belt conveyor loses finer salt to the size of screen openings and become woeful by dripping wash liquor and salt openly all around conveyor. Moreover; usual inclined screw conveyor type washery doesn't execute complete classification in absence of selective rupturing action.

All the required corrective measures are inclusive in horizontal classifier by using perforated baffles, compartments and blocking plates to remove maximum Ca^{++} impurities by rupturing and maximum removal of Mg^{++} impurity by step washing and gravity draining with air flow system, at negligible loss of crystalline solar salt. The dissolution loss is unavoidable in washing. Thus the washed salt of improved quality and quantity is produced economically suitable for food and downstream industries.

The design of horizontal classifier with compartmental zones facilitate one more advantage of separating and diverting Magnesium rich effluent away from the pond of Calcium rich effluent. The Calcium rich effluent gets settled and provides a long lasting recyclable washing source of brine available for continuous use and making washing of salt economical.

The liquid-solid or brine-salt ratio is responsible for quality washing. It is controlled by flow of different wash liquors in those washing zones.

The contact time of salt and brine is also responsible for quality washing. It is decided by length of washing zones of classifier, for a given capacity output. Extended contact time favors more removal of impurities and it is easy to manage with horizontal classifier.

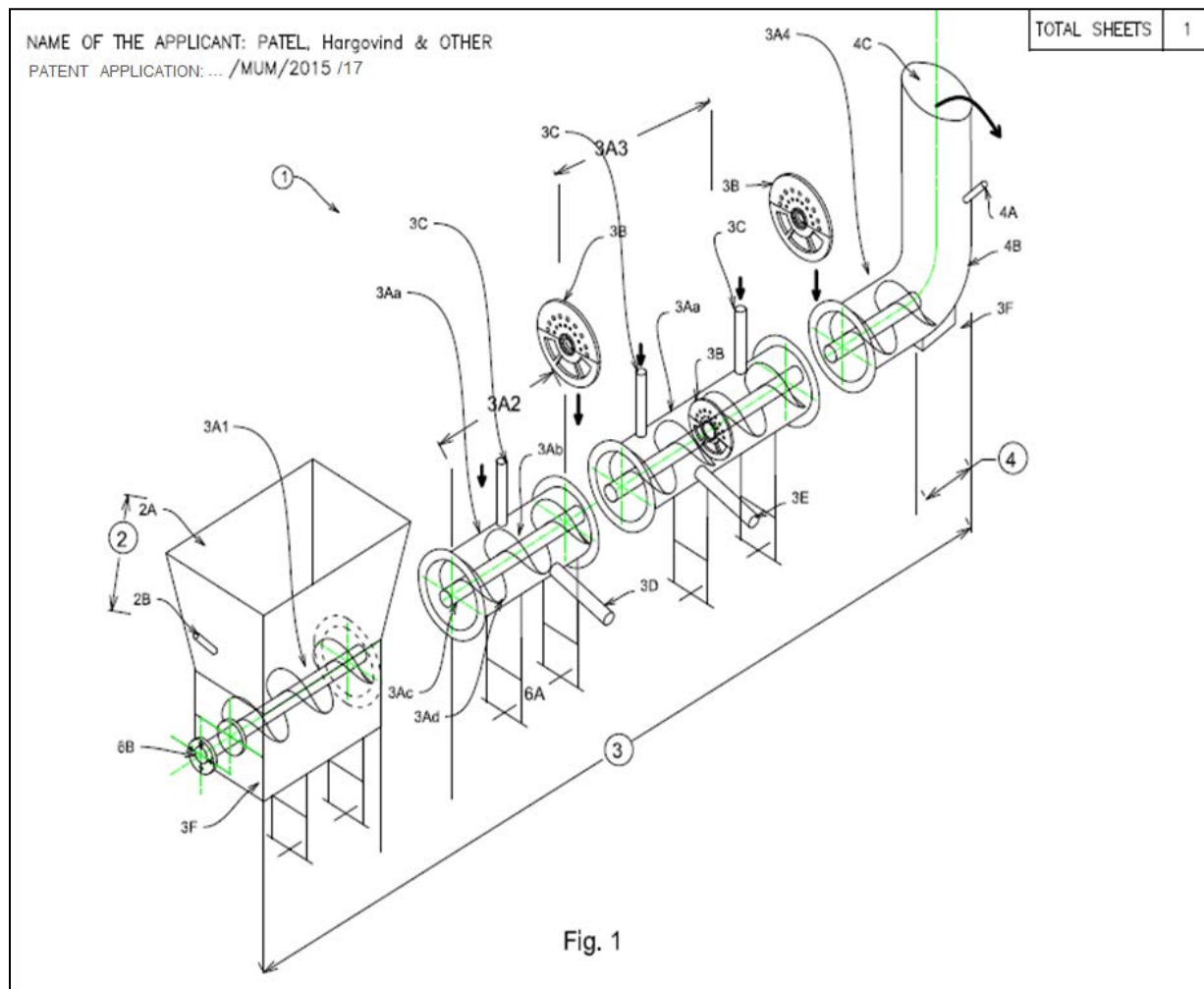
Size reduction of salt in classifier depends on the provision of number of baffles. Similarly different impurities removal depends on the provision of number of step washing zones and its length. Washed salt rate of classifier is on raw salt feed rate reduced by optimum dissolution loss, impurities loss, finer salt loss and moisture. The power consumption is proportional to the capacity of classifier. Eventually, all design parameters of classifier follow the site specific salt type and selected washing pattern.

Thus; up-gradation of salt is achieved by operating a single horizontal classifier. The impurity removal of salt measures around 65 to 85 % in bench scale model. Washing cost comes down for the quality it produces. As a result, all user countries will achieve productivity gain. This technique is affordable by any small to large salt works. Poor salt becomes good and good one gets improved further.

The unit is made up of fully corrosion resistant stainless steel. Life of this plant is increased compared to usual washery, as this classifier is drip-less neat and clean. It is also useful for washing of Gypsum that produced in salt farm.

The horizontal classifier is also called salt washery that compensates the performance of 'inclined screw conveyor and inclined wired drip-off conveyor belt' type salt washery.

Fig. 1. Indicates 'assembly drawing and part list' of "An Improved Horizontal Screw Classifier".



1 : An Improved Horizontal Screw Classifier

2A : Feed Inlet Spout

2B : Wash liquor inlet

3C : Clean Liquor inlet

3D : Wash Effluent Outlet

3E : Clean Effluent outlet

3F : Sweeper Window

3 : Washing Assembly

3A : Segments titled includes following

		4	: Outlet Assembly
3A1	: First segment	4A	: Drain liquor inlet
3A2	: Second segment	4B	: Inclined Outlet Trough
3A3	: Intermediate segment	4C	: Product Discharge Outlet
3A4	: Last segment		
		5	: Joining Assembly
3Aa	: Tubular Trough	5A	: Shaft coupling
3Ab	: Rotating Staggered Flight Screw	5B	: Flanges
3Ac	: Screw Shaft	5C	: Lugs to centralize baffles
3Ad	: Staggered Screw Blade		
		6	: Structural Assembly
		6A	: Support structure
3B	: Stationary Baffles		
3B1	: Primary Perforations	6B	: Thrust bearing housing
3B2	: Secondary perforations	6C	: Hanger bearing
	: Hanger Bushing		

Table 1. Compositions are of Trial runs in Horizontal Screw Classifier: (Mesh size:-5 to 8)

Period 2016	Raw Salt Source	Unwashed Salt %		Washed Salt %		Impurity Removal %		
		Ca ⁺⁺	Mg ⁺⁺	Ca ⁺⁺	Mg ⁺⁺	Ca ⁺⁺	Mg ⁺⁺	(Wash Liquor)
Jan	Solar Salt, (Datar) B.	0.22	0.27	0.04	0.06	81.6	77.8	(5, 25° Be')
Jan	Solar Salt, (Datar) N.	0.53	0.42	0.15	0.07	70.8	83.1	(5, 25° Be')
	" Incline Washery N.	0.48	0.39	0.22	0.10	54.2	74.7	(5, 25° Be')
Jan	Solar Salt, (Old Raw) C.	0.23	0.20	0.13	0.10	43.5	50.0	(0,7,25° Be')
Feb	Subsoil Salt, (Datar) C.	0.70	0.35	0.18	0.09	74.3	74.3	(0,7,25° Be')
May	Solar Salt, (Datar) T.	0.15	0.95	0.07	0.12	56.6	87.3	(7° Be')

Note::

- (1) Trial run model is made up of SS Tube=76mm dia with SS Shaft Tube=25mm dia.
- (2) The washing Liquors used in above trial run were 25°Be' and 6°Be' Brine.
- (3) Analysis Conducted by "Scientific and technical Consultancy Service"
- (4) Salt Samples collected from Salt Manufacturers.

Conclusion: Raw Salt, (/Gypsum etc.) is upgraded by horizontal screw classifier that works on gravity separation in presence of different wash liquors, where optimum energy is spent with freedom to control different washing parameters to achieve upgraded salt quality produce; economically.

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