Development of Pilot Plant–Lateral-Flow Rock Salt Dissolver

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ABSTRACT

During the normal operation of rock salt mines large quantities of virtually unsalable "mine fines" are produced. These mine fines are dissolved at the mine site to produce brine which is then used in the production of evaporated salt. However, because of the physical nature of the fines and the large amount of impurities present, the efficient dissolving of mine fines is more difficult than the same operation with course grades of salt.

Dissolving of the salt by a lateral flow of water through the salt bed eliminates some of the problems encountered when the flow of water is vertical.

The development of a continuous, lateral-flow pilot-plant dissolver and its operation using Louisiana rock salt are discussed.

INTRODUCTION

For quite some time the Research and Development Department of Diamond Crystal Salt Company has concerned itself with the development of salt dissolvers. Initially the aims were to develop improved dissolvers for commercially available grades of rock and evaporated salts. When this had been accomplished, our thoughts turned to Jefferson Island mine fines, known as "C" tailings, which are disposed of at the mine and do not enter commercial channels. This is a rather fine salt with a little higher calcium sulfate content than the commercial grades. Screen and chemical analyses of some typical "C" tailings are shown in Table 1.

Table 1. Screen Analysis of Typical "C" Tailings

Screen Tyler	Percentage
+10	0.1
+14	15.9
+20	34.3
+28	20.6
+35	11.2
+48	8.2
+65	2.7
-65	6.6

Approximate Analysis

Sodium Chloride	98.8%
Calcium Sulfate	1.2

Our basic purpose was to develop methods by which this type of salt could be efficiently dissolved, rather than to develop equipment which could be scaled up to commercial use. The dissolver was housed in a 16" diameter by 24" high Plexiglas [R] tank. Plexiglas was chosen because it permits viewing of the process and the tank can easily be modified.

GENERAL CONSIDERATIONS

There are three basic directions in which water can flow through a salt bed in a dissolver: up, down, or sideways. While down-flow dissolvers may produce crystal-clear brine, they have an inherent defect in that brine rather than water passes through the accumulated calcium sulfate residue.

ce calcium sulfate is more soluble in brine than water, this type of dissolver is not particularly irable for salt which has a relatively high calm sulfate content if high-purity brine is rered. Furthermore, with salt such as "C" tailings, ing a large percentage of fines, percolation rates uld be too low to make the down-flow method nomical.

nsofar as up-flow is concerned, we had used the thod successfully for other types of salt so we) turned to it in this case. Unfortunately, bese of the low porosity of the salt bed and the essive tendency to pack, we determined that water and brine tended to channel up through salt. This produced a brine of low saturation. the same time, because of the relatively high id velocity encountered in the channels, the calm sulfate remained suspended and dissolving, ›ducing brine of low purity.

THE LATERAL FLOW DISSOLVER

With both down-flow and up-flow eliminated, only flow direction remaining was lateral. Two ıditions must be met if the flow is to be substanlly lateral through a salt bed. First, the water ›ut must be distributed throughout the entire ght of the dissolver. Secondly, the brine must be noved over the entire height of the dissolver.

Water inlet. The water distribution system ›wn in Figure 1 consists of three concentric ›es. The inner one marked 1 is a vent. It is open the atmosphere at its upper end. Its purpose will discussed later. The second tube is the pressuretributing water inlet. The third and outermost ›e is made of porous plastic. The space between second tube and the third is divided into comrtments by a number of seals. Four such comrtments are shown.

There is a single hole in the water inlet tube for ch compartment. These holes are sized so that ey furnish a greater resistance to water flow than porous plastic tubing and salt bed. As a result this arrangement the water flow is distributed er the entire length of the water inlet system, minating any tendency for a portion of the bed be bypassed.

The arrangement shown worked very well in our perimental model. It would have to be modified, wever, in a commercial model because we would t really want to have the water distributed unirmly. Since the upper portion of the bed would essentially all salt while the bottom would be

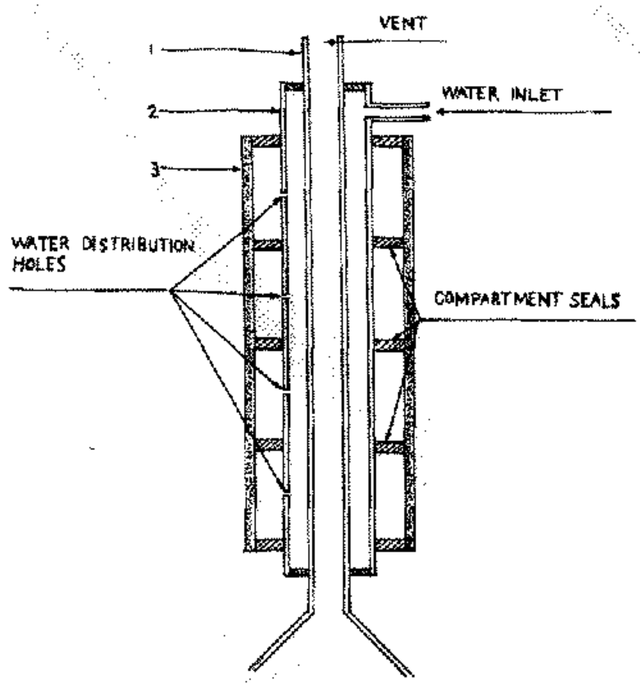

Figure 1. Water distribution manifold.

essentially all calcium sulfate, we would want to have a greater flow at the top than at the bottom. A simple and effective way to accomplish this would be to have a separately valved water inlet for each compartment, so that the amount entering each zone could be individually regulated.

Brine withdrawal. Figure 2 shows the method used for brine withdrawal. The salt bed was contained within a perforated Monel inner tank and a Plexiglas R outer tank about four inches greater in diameter. The brine outlet is near the top of the dissolver. This is necessary because substantially lateral flow is possible only when the liquid between the inner and outer tanks is at maximum height, so that there is no tendency for the water and brine to move downwardly through the dissolver. The perforated Monel inner tank does not extend all the way to the bottom of the dissolver. This was done so that the few larger particles of calcium sulfate which penetrated through the perforations could settle and rejoin the mass of sulfate remaining in the inner tank.

Even though the relatively large area between the two tanks permits most of this sulfate to settle, the very finest particles remain suspended and must be filtered off later.

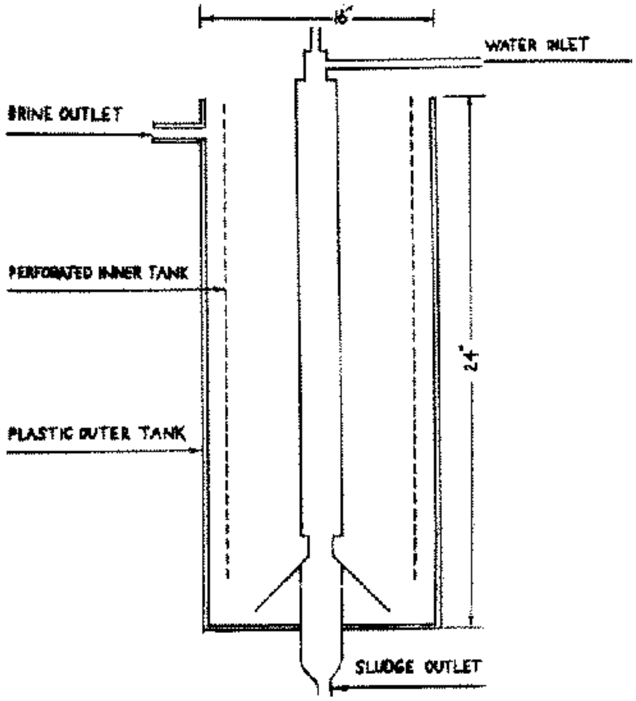

Figure 2. Brine withdrawal system.

Sludge removal. In addition to a water inlet and a brine outlet one more feature is needed in a continuous dissolver and that is a method of sludge removal. There are many ways in which this can be accomplished but they commonly require a conical bottom tank. We had done this previously using a variable-speed screw for sludge removal. In this dissolver, we considered the problem of removing sludge from a flat-bottomed tank.

Table 2 shows the screen distribution of the sludge in some samples of Louisiana "C" tailings and "FC" Northern rock salt. It will be noted that about 76 percent of the sludge particles fall within a rather narrow screen range. The sludge removal system was designed to take advantage of this particular sludge size distribution. While we did dissolve "FC" Northern rock salt during a three day run, some modifications of the dissolver would probably have been necessary to achieve optimum performance.

Figure 3 shows an inverted cone attached to the bottom of the water distribution system. This cone directs the sludge towards a narrow opening between the cone and the perforated Monel inner tank. A tube which runs through the bottom of the tank and serves as a sludge outlet is attached to the inside of the inverted cone. Surrounding this tube and concentric to it, there is a fluidizing ring which is supplied with water through an auxiliary water inlet. Several small diameter tubes arranged around the sludge outlet tube and connecting with it near its top serve as pick-up tubes for the sludge.

Table 2. Size Distribution of Impurities in Southern and Northern Rock Salts

Screen Size (Tyler)	Louisiana "C" Tailings	"FC" Northern
+14	0.4%	1.4
+20	7.6	4.2
+28	5.0	3.7
+35	5.0	3.7
+48	26.4	4.6
+65	30.7	4.1
+115	19.3	6.7
-115	5.6	71.6

Method of operation. When equipped with this sludge removal system, the Lateral-Flow Dissolver

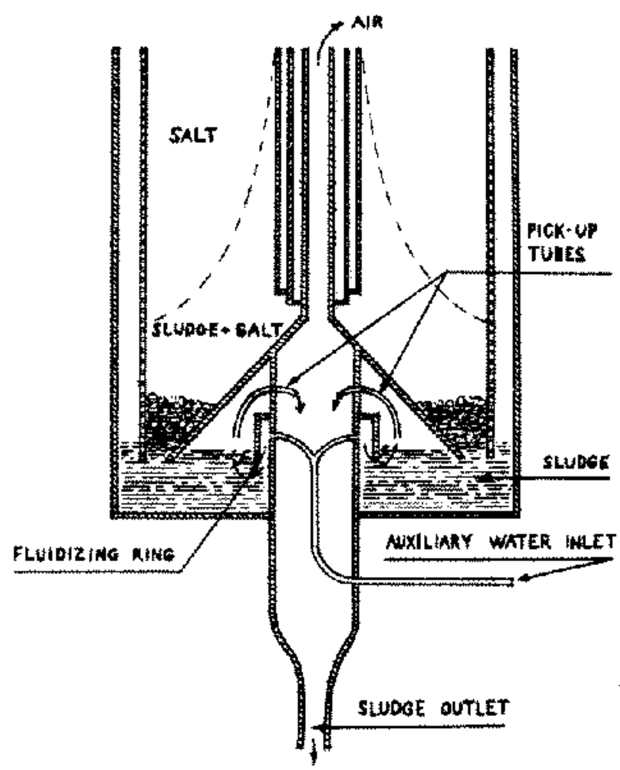

Figure 3. Sludge withdrawal device.

orks as follows. Assume that the dissolver has ached a state of equilibrium and has been tempo-rily inactive but is being put into use again. The ıxiliary water inlet is opened permitting the cape of water through the fluidizing ring. A por-on of the sludge is fluidized and is picked up by ıe small tubes and then drops down the large udge removal tube. The vent tube in Figure 1 rves to remove the air pocket formed in the pper part of the inverted cone. Without it the udge removal is erratic.

As soon as some of the sludge in the center of ıe dissolver has been fluidized and removed, addi-onal sludge moves in from the periphery of the issolver to replace it. Almost immediately after ıe auxiliary water inlet is turned on, the main ater is turned on so that the dissolving of addi-onal quantities of salt refurbishes the supply of udge in the bottom of the dissolver.

Proper operation of this dissolver depends on ıe critical control of the amount of water applied ırough the auxiliary water inlet. If the amount of ater applied here is too great, sludge is forced up ıto the bed and into the space between the inner ıd outer tanks with a resultant decrease in brine urity. On the other hand, if the amount of water pplied is to small, hydraulic pressure forces the udge up into the inverted cone and plugs the nall diameter pick-up tubes. If this surge of sludge oes not plug the pick-up tubes, the excessively ıst removal of the sludge brings salt into the bot-om section of the dissolver. This represents a loss f salt since brine made at this point does not enter ıe product brine stream.

Initially, the 16" diameter dissolver discussed as operated for eight hours producing 99 to 100° alometer brine with a calcium sulfate content anging from 200 to 500 ppm. It was then per-itted to stand idle for 16 days in order to see if ny start-up difficulties would be encountered. here were no start-up difficulties and the results chieved during the second day of operation are hown in Table 3.

CONCLUSIONS

This paper would be incomplete without some ort of explanation as to why this dissolver worked atisfactorily while others did not. Anyone who as ever observed the upward flow of liquid hrough a column of fine material has noticed that niform flow is impossible as long as air pockets

Table 3. Results Achieved After a 16 Day Lay-up of Dissolver

	Salinity	Calcium Sulfate Content of Brine (PPM)
8:00 A.M. Start-up		
8:30	85	478
9:00	90	271
10:00	96	288
11:00	100	407
12:00 Noon	95	376
1:00 P.M.	100	453
2:00	100	450
3:00	100	557
4:00	100	374
5:00	100	409

are present. When salt dissolves, air is released. Normally there is only one direction for the air to move and that it up. On the way up the tiny bubbles of air formed initially coalesce and form larger bubbles. The larger bubbles manage to escape readily in a bed of coarse salt. With fine material, such as mine fines, large air pockets are formed. These bring about non-uniform flow and channeling.

In the lateral-flow dissolver the small air bubbles are swept along laterally by the flow of liquid. They have only a short distance to go to the inner perforated Monel tank. At this point they are released and move upward through the liquid without hindrance.

Some of the pertinent data in regard to this dissolver are given in Table 4. The reader should particularly note that the dissolver operated continuously for hours at a time with all the sludge being removed through two ¼" copper tubes. If such a dissolver were scaled up to a commercial unit some sort of scalping screen would be required to insure that oversize insoluble particles did not enter the dissolver.

In addition to its particular use for fine rock salt, a lateral flow dissolver could conceivably be used for commercial grades of rock salt in installations where floor space is at a premium but considerable amounts of head-room are available. Portions of the above subject matter are proprietary and covered by U.S. Patent No. 3,385,674 (May 28, 1968) and Canadian Patent No. 786,726 (June 4, 1968).

Table 4. Specifications of Model Dissolver

Outer tank, Plexiglas®	16" diameter, 24" high
Inner tank, Monel	12" diameter, 22" high
Perforations of inner tank	0.050" Holes spaced 1/8" apart
Porous Plastic water distributor	1 1/2" diameter 15" long
Main water flow	35 g.p.h.
Salt consumption	100 lbs. per hour
Water flow for sludge removal	4 1/2 g.p.h.

SUMMARY

Both up-flow and down-flow methods of operation were unsatisfactory for the production of high-quality brine from the type of salt known commercially as Louisiana "C" tailings. A lateral-flow dissolver which overcame the defects of the other two methods was designed, built and operated successfully. While this dissolver proved particularly suitable for this type of salt it could also be used for a coarser rock salt.