Controlling Harvesting Efficiencies

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ABSTRACT

The harvesting phase of solar salt production consists of varied operations to pick up and load salt on a transportation system for stockpiling or washing. These operations can be controlled by a report system designed to identify production losses and their reasons in pond operations and transportation. These losses are measured by carrier haul rates.

These rates (R) are a function of distance and can be determined for each pond by knowing the haul distance and using the equation $R = W/T_t$, where W is the carrying capacity of the unit and T_t is the total time required to make a complete trip. (R) is ideal and is the tonnage expected with no times losses other than $t_l + t_{ul}$ which are carrier load and unload times.

Efficiency is determined from the ratio of actual output production to ideal input production capacity. From these values performance can be measured and then controlled with the reporting procedure developed for pond operations and transportation.

INTRODUCTION

The solar salt plant at Exportadora de Sal has grown from an annual production in 1957 of 70,000 metric tons to over 4,500,000 metric tons in 1972. With an expanding world market, plant capacity is progressing to 6,000,000 metric tons per year. This greater production has required a major investment in special carriers and other equipment to be used in the harvesting phase of operations.

To obtain the most efficient harvest and use of equipment, management raised many questions concerning harvesting in general, but foremost was "What is our efficiency and how do we evaluate performance?" This answer required a field study which began with the pond operations during harvesting and then focused on the carriers or transportation. From these studies, data were taken and a report system designed. These reports would also show where daily production losses occurred so that effective controls could be established on inefficiencies.

HARVESTING

Harvesting refers to all pond operations to pick up and load salt to a carrier or transportation system for stockpiling or washing. For clarity, this paper will refer to harvesting as those operations involved in the pond to enable the harvesting machines to pick up salt for loading. Carriers will be discussed separately.

The operations in harvesting begin with drainage of the crystallizers, scarification to loosen salt, and windrowing for the harvester. These were observed for a period of time to detect any delays that would affect production or poor methods that could be improved. The types of delaying factors were recorded over a period of time and production losses were measured by the carrier production rate. This rate will be explained in the next section of this report. The harvesters employed are wheeled and driven by two 400 and 180 horsepower motors for the tractor and flight conveying system respectively. Their load time averages 15 minutes.

A few examples of losses identified and factors causing them are given in Table I. These are recorded only if carriers are delayed. Losses may vary and be specific to each salt plant, but the general report system can be useful to detect them.

From this particular study a report procedure was developed for the pond foremen so that daily losses occurring in the ponds were accounted, reported and remedial action taken whenever possible. Pond foremen at this locality not only supervise the activity in the pond, but are also responsible for the varied equipment operations. In cases where two ponds are in harvest simultaneously, the

TABLE I

Pond Operation Losses

Carrier No. (Delayed)	Loss Contributing Factor	Time Loss (Minutes)	Causes
2	Scarifying	15	Mechanical, grader broke down delaying windrowing and subsequently harvester loading
4	Harvester	30	Harvester got stuck in poorly drained area in loose scarified salt
2	Windrow Machine	15	Windrowing got behind production rate delaying harvester
5	Harvester	10	Mechanical, overheating

job of supervising is even more demanding. Therefore, the report is kept simple to minimize his administrative work, but sufficiently accurate to account for losses.

One particularly sensitive area in harvesting is equipment downtime. Wherever machinery is used it will break down and delays will occur. This particular report can and has improved communications between shops and production. The losses resulting from mechanical causes are reported at the end of each workday so that repairs or neglected maintenance can be performed overnight. In an operation as large as Exportadora's, much equipment is used and it does happen that downtime the following day can occur because of failure to report some defect.

TRANSPORTATION

The carrier units powered by 1000 hp engines, measure 200' long, 18' wide, and 16' high. They consist of a tractor unit and three trailers or boxes, each with a haul capacity of 122 metric tons. The average haul distance one way (to the washing plant where salt is unloaded) is 8 miles with minimum and maximum distances of 5.0 and 10.6 miles.

The first phase of this study was to determine velocity of the units to make a complete trip. As these units do not have speed indicators, velocity was determined simply from the equation V= Distance/Time. Units were timed repeatedly over given distances until a good average value was obtained. Unload time at the washing plant and load time values were rechecked also. All these values were considered ideal as drivers drove at maximum velocity and loading and unloading operations were performed in the minimum possible time.

Once these timings were well established, distances from each pond were determined and carrier haul rates calculated from these factors:

R = haul rate in metric tons/hour to be determined
V = average velocity of carrier in miles/hour
t_l = harvester to carrier load time
t_{ul} = carrier unload time at washing plant
D = round trip distance carrier travels
W = weight hauled per carrier
T_t = total time to make one complete trip
t_h = haul time

$$T_t = t_l + t_{ul} + t_h$$
$$t_h = D/V$$
$$R = W/T_t$$

A reference table was then constructed giving all haul rates. An example is given in Table II.

TABLE II

Carrier Haul Rates
Five Units

Pond	Distance Round Trip, Miles	W/Tt = R Metric Tons/Hour	Daily Production Metric Tons
1	17.42	1,680	23,400
2	15.74	1,800	25,300
3	15.46	1,820	25,600
4	13.80	1,980	27,600
7	10.00	2,430	34,000
8	12.80	2,100	29,100
9	13.96	1,960	27,400
10	19.50	1,540	21,600
33	14.08	1,950	27,300
34	15.60	1,810	25,400
35	16.20	1,760	24,600

As in pond operations, the second phase was to account for real losses occurring during hauling. Carriers were followed daily and a listing was made of those factors producing losses as exemplified in Table III. A standard report system was developed from Table III for road foremen, who maintain carrier fleet movement.

Using the total time loss for each carrier from both reports, pond operations and transportation, the produc-

TABLE III

Transportation Losses

Carrier No. (Delayed)	Loss Contributing Factor	Time Loss (Minutes)	Cause
1	Mechanical	60	Power loss
3	Washing Plant	10	Washing Plant, unloading delayed due to full hoppers
3	Service Stop	8	Service stop, excess delay over permissible time
2	Road	10	Pond Operations, ramp entrance to pond in poor condition slowing carriers and subsequent loading

tion loss in metric ton quantities is estimated from the haul rate value for each carrier as: Loss = R × t (where t is total time loss for each carrier). Total daily loss is the carrier sum.

EVALUATING PERFORMANCE

The daily production quantities given in Table II represent ideal haul rates without delays other than those allowable (loading and unloading). These ideal values can also be referred to as a 100% efficiency case, which means simply that no more production is possible unless more carriers are added or harvesting capacity increased. Performance is then determined simply by comparing actual tonnage for a given day with the ideal case and expressing the results in % efficiency. For example, 21,000 metric tons were harvested in Pond 35 in one day's production, no overtime. Efficiency then is

$$\frac{21{,}000}{24{,}500} \times 100 = 85.6\%$$

Alternatively, a graphical estimate can be made by preparing a graph as in Figure 1.

Efficiency then is simply the ratio of output production to ideal input production capacity. Using this procedure, efficiency is determined for a specific period, either weekly or monthly. An accounting is made also for all production losses indicating areas of occurrence. A report is issued including this information as shown in Table IV. The reference efficiency referred to in Table IV is that level of work established before any changes in harvesting or hauling were made. This value is then used to determine if gains or losses are realized. At this facility, the reference level was used to plan a production increase to a point considered realistic and achievable.

Once the final report is finished and reviewed, individual departments are informed of losses attributed to them so that corrective action can be taken.

Harvesting is a major factor in the plant's operating cost, but controlling this large operation can be difficult unless management can use some report procedure to evaluate performance and detect poor efficiencies that raise costs. This general report and evaluation procedure described here can be a useful tool in achieving controls in harvesting.

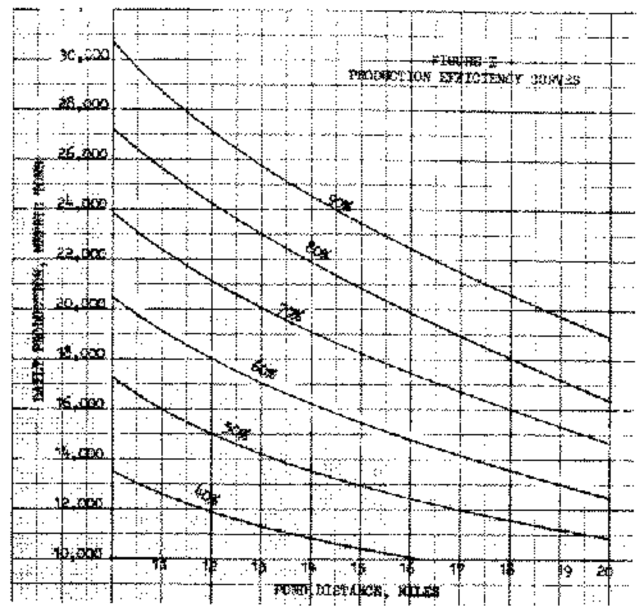

Figure 1. Production efficiency curves.

TABLE IV

Production Performance—January

Average Month's Efficiency	________	%
Daily Production Average (Present Efficiency)	________	Metric Tons/Day
Daily Production Average (Reference Efficiency)	________	Metric Tons/Day
Gain/Loss	________	Metric Tons/Day
Monthly Production	________	Metric Tons
Production Loss Factors: (Metric Tons)		
Carriers	________	
Harvesters	________	
Pond Operation	________	
Washing Plant	________	
Port Loading	________	
Others	________	
Ideal Total	________	
(Losses ÷ Monthly Production)		
Ideal Efficiency	________	