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Management of RO reject water from the tannery industry by solar tunnel dryer

Roopa D.[1], Divya R.[2], Nathiya S.[3]

[1]*Assistant Professor, Gnanamani College of Technology, Namakkal, Tamil Nadu*

[2]*Student, Gnanamani College of Engineering, Namakkal, Tamil Nadu*

[3]*Assistant Professor, Knowledge Institute of Technology, Kakapalayam, Tamil Nadu*

ABSTRACT

Reverse Osmosis is a water purification technique performed to remove the dissolved solids from the tannery wastewater thereby reducing the water scarcity. This process produces two types of water namely pure water and RO reject water. The former can be applied for useful purposes in the same industry while the latter did not find any useful application as it contains a high amount of salt content like TDS.TSS, chlorides, sulphates etc. This reject water is conventionally evaporated by solar evaporation pond almost in all the industries of Tamil Nadu. This method has many demerits like large area requirement, water seepage, and dispersal, inefficient during the rainy season, odour, labour requirement, and maintenance. In order to overcome these issues, the solar tunnel dryer has been designed, constructed and observed for its performance.

Keywords— *Reverse Osmosis, RO reject, Evaporation, Temperature, Total dissolved solids*

1. INTRODUCTION

Tannery industry is one of the oldest industry where skins and hides are processed to produce leather. The various process involved in the industry is curing, soaking, liming, Unhairing, deliming, bating and pickling. All these processes involved, the usage of salt like lime, sodium sulphide, sodium hydroxide etc. The wastewater coming from the various process of industries contain a large amount of salt content. In early days, these wastewaters had been disposed of in land and water with or without treatment. As these industries are increased in magnitude, the pollution caused by the industries also increases.

In order to control the pollution and to reduce the water scarcity, the process called Reverse Osmosis (RO) is introduced in the tannery industry for removing the dissolved solids thereby reusing the water. This RO process produces pure water and RO reject. The former can be applied for useful purposes in the industry while the latter contain TDS (10,000- 15,000mg/l), pH (7 – 7.5), TSS (100-200mg/l), Na (1000-3000mg/l), Cl (3000-5000mg/l) and Sulphate (4000-7000mg/l). Because of these parameters, the RO reject cannot be applied for useful purpose where a part of RO reject water is used in the soaking process of the tannery industry. The remaining RO reject are disposed of either by means of evaporation or mechanical evaporator.

In Tamil Nadu, the mechanical evaporator is not used because of some demerits like scaling formation, cost ineffective, and requirement of a trained person, fuel etc. The conventional method used for RO rejects disposal is a solar evaporation pond which is an open sun drying method. In this method, the RO reject is sprayed into fine droplets by a sprinkler system in the open space. This method is cost effective compared to mechanical evaporator but has some issues like water seepage, ineffective during the rainy season, dispersal, materials damage etc. The proposed method is the solar tunnel dryer which looks like a house overcomes all these issues of the conventional method. This dryer is the modular type uses the direct solar drying technology to evaporate the water.

2. MATERIALS AND METHODS

The solar tunnel dryer of 17.22 meters long and 4.86 meters width and upper triangular part is 1.58 meters height with the 33˚ inclination and lower rectangular part is 1.23 meters height was designed to evaporate about 3000 to 4000 litres of RO reject per day. The materials used in the dryer are UV stabilized colourless polyethylene sheet, Steel frame, HDPE sheet, PVC and UPVC pipe with FRP lining, UV protected the black net, sprinklers etc. The UV protected polyethylene sheet of 0.2mm thick is used to cover the whole structure. The steel frame which is given asphalt coating is used to support the outside transparent sheet with the help of spiral spring. The base was concreted and overlaid with black HDPE sheet (industrial rubber mat) to prevent seepage to the ground. The pipe of 100mm dia is filled with concrete to support the rectangular portion of the dryer. UV protected black net (50% shaded) of 50 meters length and 3 meters width is completely suspended over the 10mm dia FRP coated PVC pipe at 0.1 meters interval by hooks as shown in Figure 5(a) to increase the surface area and to hold the salt content. The sprinkler pipe is FRP lined and arranged in such a way as shown in figure 3 (top view) & 5(b) to spray the RO reject over the black net. The blower pipe is

used to remove the water vapour and to maintain the positive pressure. The sample view of the solar tunnel dryer is shown in Figure1. The original view is shown in figure 2. The top view and front view diagrams clearly show the materials inside the dryer as shown in figure 3.

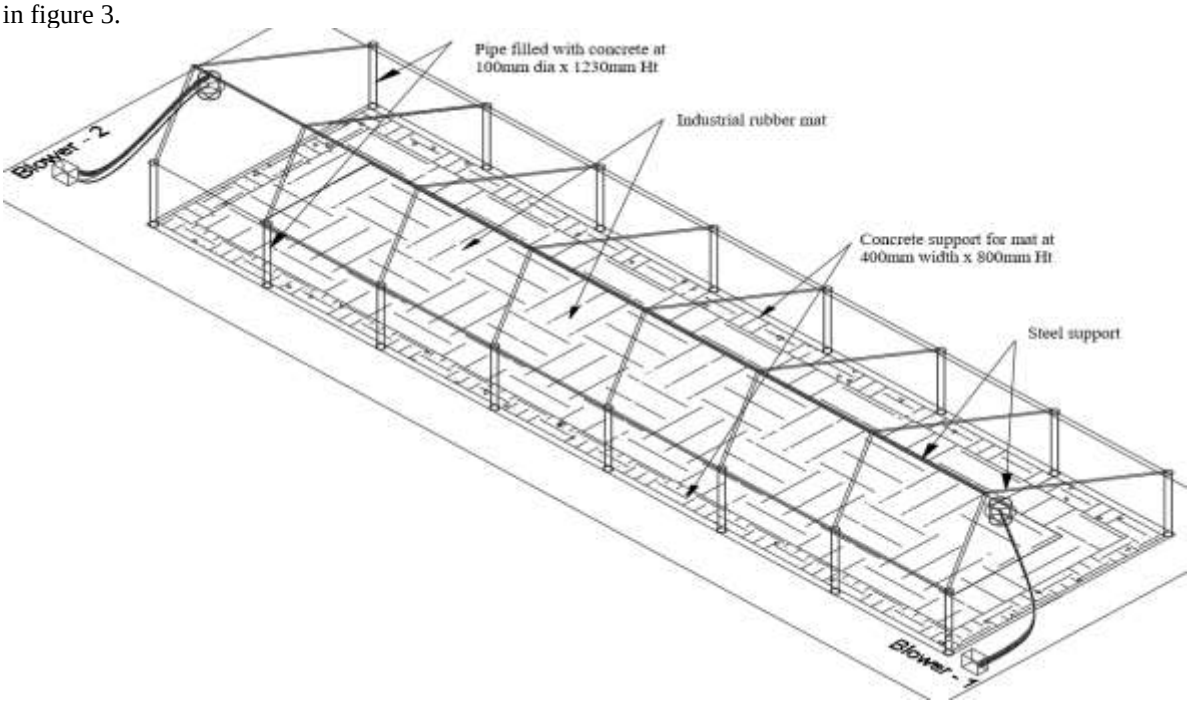
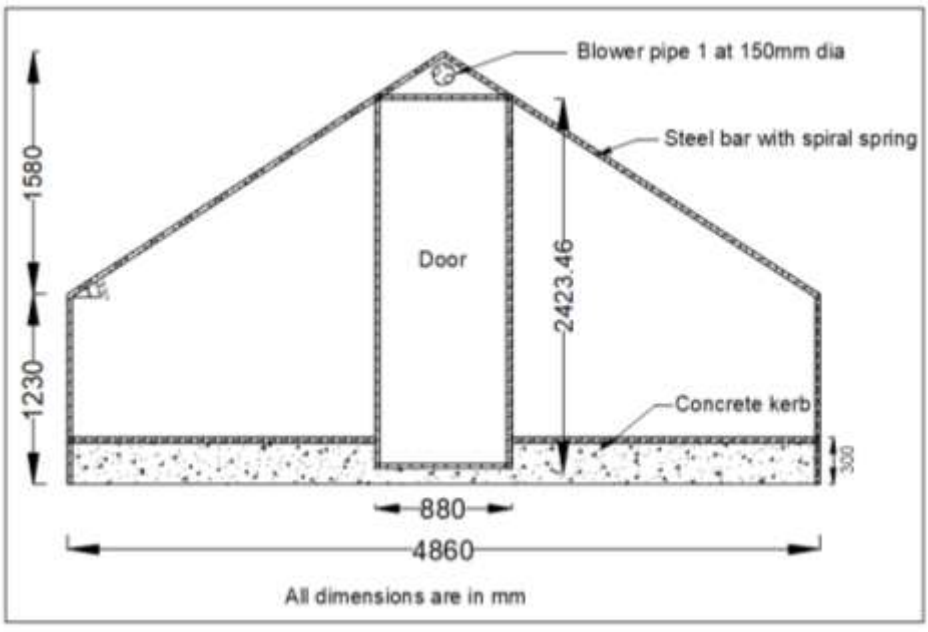


Fig. 1: The sample view of solar tunnel dryer

Fig. 2: The original view of the solar tunnel dryer



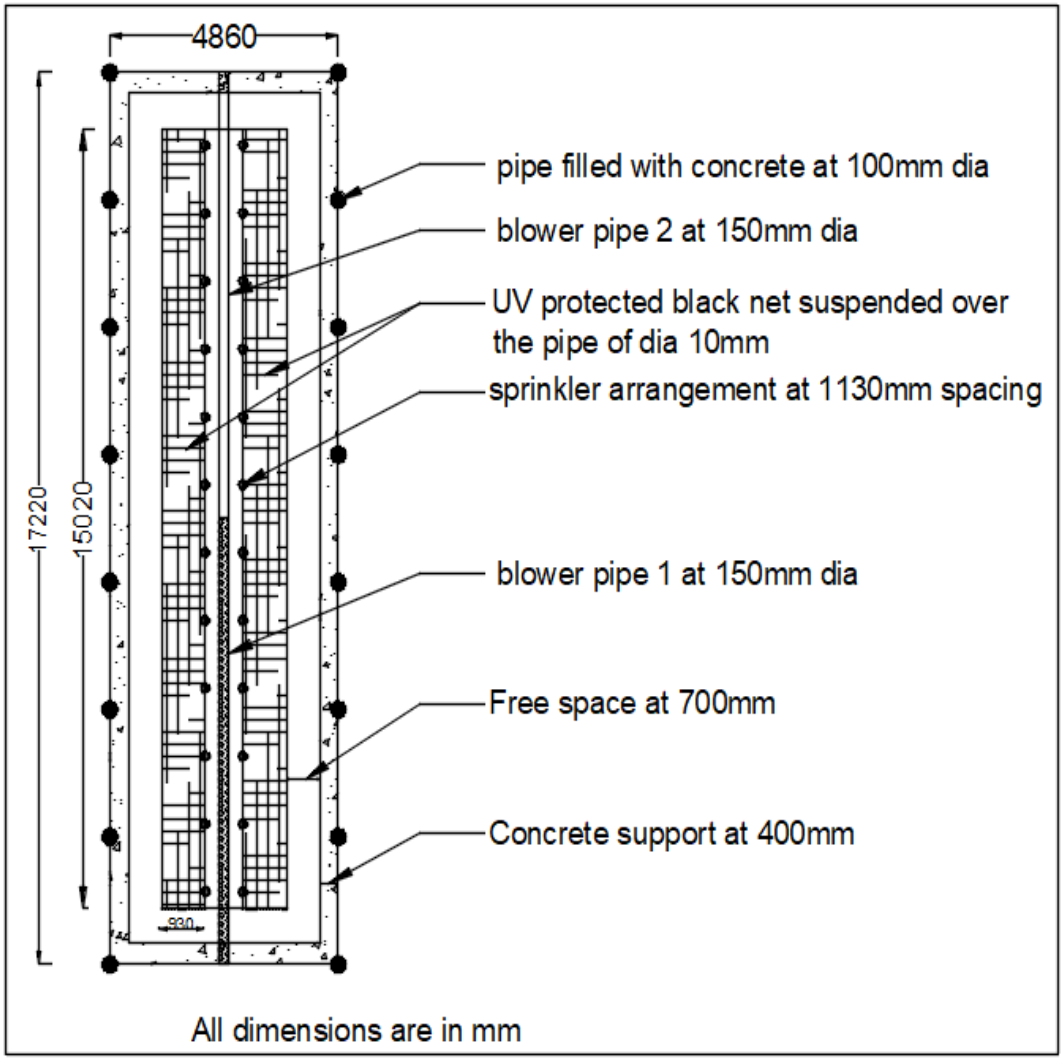


Fig. 3: Front view and top view of the tunnel dryer

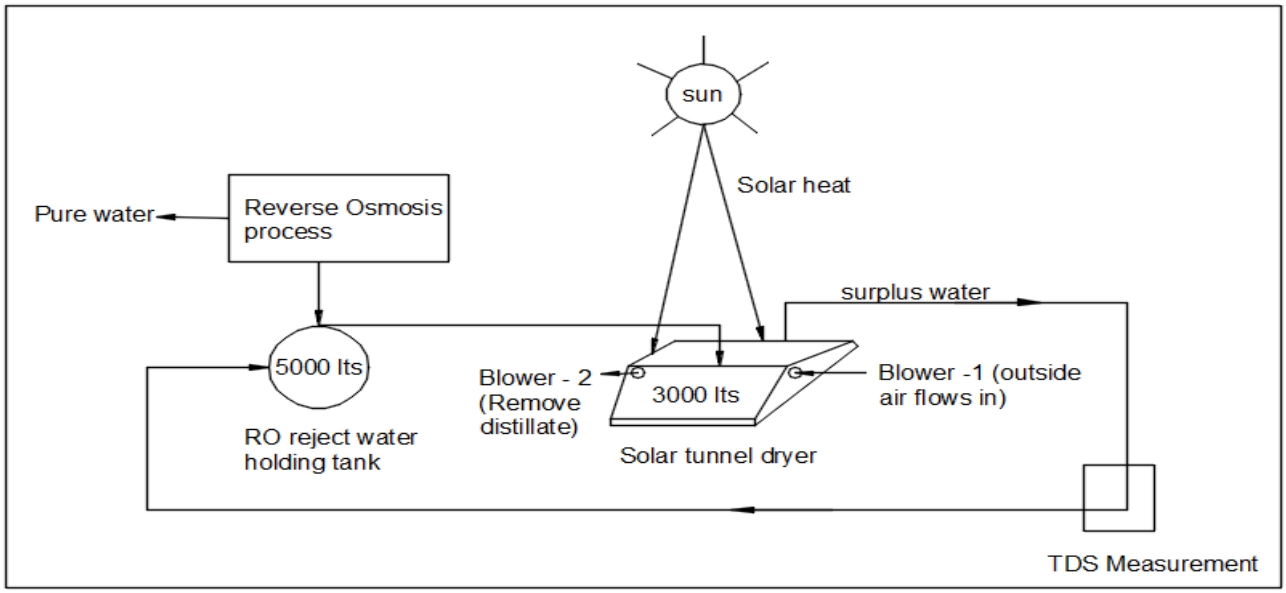


Fig. 4: The flow diagram for the working of the solar tunnel dryer

The process of solar tunnel dryer is explained by the flow chart as shown in figure 4. The RO reject water from the reverse osmosis process is collected in the syntax tank (Holding tank) of 5000litres capacity. From the holding tank, the water flows into the sprinkler arrangements of solar tunnel dryer through the pipe with the help of motor (2HP) at 3 to 4 kg of pressure. The RO reject water is sprinkled slowly over the black net which increases the surface area of the water for evaporation. The UV protected polyethylene sheet absorbs the solar heat and maintains the high temperature about 20 to 25% higher than the outside temperature. The temperature inside and outside the dryer is measured for every one hour by the temperature meter. The temperature meter has a sensor by means of which the temperature is measured. Two blowers have been used where the blower 1 (7.5hp) is used to produce the positive pressure inside the dryer and the blower 2 (12.5hp) is used to remove the moisture content and condensed water from

the tunnel dryer. The surplus water from the dryer again flows into the holding tank by the opening provided at the back of the dryer through the piping system. A few amounts of surplus RO reject is collected in a container for TDS measurement by TDS meter.

(a)

(b)

Fig. 5: (a) Black net arrangements (b) the sprinkler arrangements

3. EXPERIMENTAL STUDY

The solar tunnel dryer is observed for the following parameters namely inside and outside temperature of the dryer, the water level in the holding tank, and an increase in Total dissolved solids and Blower running time. The observation is done for about seven hours of a day about seven days (i.e. one week) in the month of January for 5000 litres capacity. The temperature is slightly low and humidity is more during the observation. The blower 1 and 2 is constantly running between 1 PM to 2 PM and Blower 2 is again run from 5 PM to 6 PM. Blower 1 is running to maintain the positive pressure and 2 is running to remove the distillate formed on the side of the tunnel dryer due to evaporation. The solar evaporation pond (open sun drying) is also observed for the evaporation rate for 5000 litres capacity. The approximate evaporation rate per day for solar tunnel dryer is 1000 to 2000 litres and for solar evaporation pond is 2000 to 2500 litres as tabulated in Table 1.

The observation clearly shows that the conventional method evaporates slightly more water than the proposed method. But the effort to evaporate more water is being in research. The investigation says that the evaporation rate is maximum between 12 pm to 2 pm as there is hot sunlight during this time of observation. The TDS gradually increases as shown in table 1, which proves the evaporation rate increases over time. The comparison of the evaporation rate between solar evaporation pond and solar tunnel dryer is shown in figure 6. The comparison between the two is made for alternative timings to understand clearly.

Table 1: Comparison of the evaporation rate of solar tunnel dryer and solar evaporation pond

Day of observation	Temperature (˚c)			The Water level in holding tank (ltrs)	TDS increase (ppm)	Solar Evaporation pond (Litres) – Open sun drying
	In	Out	Diff			
	Solar Tunnel Dryer					
DAY 1						
10 am	29.5	36.8	7.3	5000	38.5	5000
11 am	32.6	42.0	9.4	4850	40.7	4650
12 pm	36.9	52.8	15.9	4650	42.8	4250
1 pm	38.8	62.2	23.4	4400	45.7	3800
2 pm	38.5	65.6	27.1	4100	48.9	3450
3 pm	35.5	63.3	27.8	3800	52.4	3150
4 pm	32.9	59.3	26.4	3450	53.6	2900
5 pm	30.0	56.0	26.0	3150	55.7	2700
DAY 2						
10 am	25.5	33.9	8.4	5000	38.5	5000
11 am	27.0	39.8	12.8	4800	43.5	4700
12 pm	28.9	45.6	16.7	4600	45.8	4350
1 pm	32.5	49.9	17.4	4500	45.9	3950
2 pm	32.4	54.0	21.6	4300	47.6	3550
3 pm	30.6	55.8	25.2	4000	50.4	3200
4 pm	27.5	54.0	26.5	3750	53.9	2950
5 pm	24.2	50.4	26.2	3500	55.9	2750

DAY 3						
10 am	28.6	35.6	7.0	5000	37.2	5000
11 am	30.5	45.5	15.0	4750	39.7	4650
12 pm	33.9	50.9	17.0	4550	41.4	4250
1 pm	35.6	59.8	24.2	4300	43.7	3850
2 pm	38.4	65.4	27.0	4000	46.9	3500
3 pm	37.6	64.8	27.2	3750	47.4	3300
4 pm	35.5	61.9	26.4	3450	49.8	3100
5 pm	32.9	58.3	25.4	3150	52.4	2950
DAY 4						
10 am	22.6	30.5	7.9	5000	38.4	5000
11 am	24.5	38.6	14.1	4800	41.7	4800
12 pm	27.8	45.4	17.6	4650	43.4	4550
1 pm	33.9	52.4	18.5	4500	45.7	4250
2 pm	34.8	57.9	23.1	4300	48.9	3850
3 pm	34.6	59.8	25.2	4050	52.4	3500
4 pm	32.6	57.6	25.0	3800	54.8	3200
5 pm	29.8	54.0	24.2	3500	57.6	3050
DAY 5						
10 am	20.4	27.8	7.4	5000	38.5	5000
11 am	22.5	35.4	12.9	4850	40.6	4800
12 pm	25.6	42.9	17.3	4700	42.7	4550
1 pm	29.9	49.8	19.9	4500	45.9	4250
2 pm	29.7	52.4	22.7	4300	47.6	3900
3 pm	27.6	53.0	25.4	4000	50.2	3550
4 pm	24.2	50.1	25.9	3650	53.4	3300
5 pm	21.0	45.6	24.6	3300	56.9	3100
DAY 6						
10 am	31.5	37.2	5.7	5000	37.4	5000
11 am	32.9	45.6	12.7	4850	39.7	4800
12 pm	33.2	49.8	16.6	4650	42.6	4550
1 pm	35.6	55.4	19.8	4450	44.4	4150
2 pm	35.4	57.6	22.2	4250	46.7	3750
3 pm	33.6	59.8	26.2	4000	48.7	3400
4 pm	31.8	57.8	26.0	3700	51.1	3150
5 pm	29.8	55.2	25.4	3350	54.9	2950
DAY 7						
10 am	21.5	27.5	6.0	5000	38.9	5000
11 am	21.7	32.4	10.7	4850	40.4	4800
12 pm	22.4	35.6	13.2	4700	43.7	4600
1 pm	22.7	39.4	16.7	4500	43.9	4350
2 pm	22.4	42.5	20.1	4400	45.6	4100
3 pm	21.7	42.7	21.0	4250	46.7	3900
4 pm	20.6	42.4	21.8	4050	48.0	3750
5 pm	20.5	41.3	20.7	3850	49.9	3650

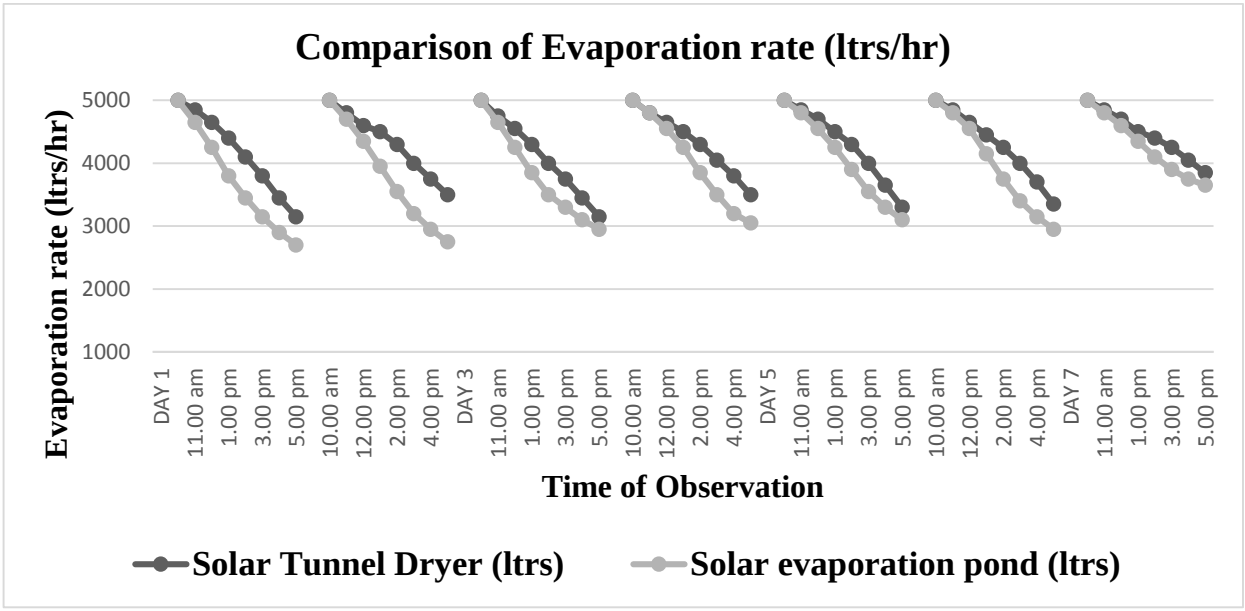


Fig. 6: Comparison of evaporation rate between solar tunnel dryer and solar evaporation pond

4. CONCLUSION

These investigations clearly show that the solar tunnel dryer is the best alternative to overcome the demerits of the conventional method. It is found that the evaporation rate of the solar evaporation pond is slightly more than the proposed method. But to improve the evaporation rate, the proposed method must be installed with the indirect tunnel drying system where the hot air is given inside the dryer externally. The research is going on to improve the rate of evaporation by means of an integrated tunnel drying system.

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