Zero Liquid Discharge ETP – A Case Study (Part III)

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Abstract

The treatment steps like primary, secondary, and advanced filtration in Textile ETP are already discussed. After advanced filtration, the reject effluent management and the salt recovery are the important steps to achieve complete ZLD. Multiple effect evaporation, crystallization, Nanofiltration, and Agitated Thin Film Drying are the equipment used for this purpose. The changing TDS mass balance at each stage has been discussed. The experimental initiatives to use recovered Glauber salt and mixed salt are necessary and expected from dyers.

Key words

Textile, ZLD, ETP, RO reject TDS mass balance, MEE, crystallizer, ATFD, salt recovery.

1.0 Introduction

In the part I&II of this article series, we have understood the characteristics of the influent and basic effluent treatment scheme, components of ZLD, and advance filtration techniques including nanofiltration and reverse osmosis technique to get ur water from the textile effluent. Here, as we are discussing a case study of 600KLD (600000 liters of the effluent/day) effluent from a yarn dyeing plant. The described treatment scheme is as per the case study. We have also studied the effect of these processes on the effluent and accordingly actual test results of inlet and outlet effluent characteristics were discussed stagewise. A complete treatment scheme to achieve Zero liquid discharge was shown with mass balance. Now in this last and III part, we will be discussing the multiple-effect evaporation, mass balance, salt recovery, Sludge generation, and disposal part so that complete ZLD is achieved

2.0 RO Reject characteristics and Nanofiltration output

For 600 KLD plant with 4 stages RO, the RO reject volume will be 51-54 KL with a TDS level of 67000 mg/lit.

Thus for RO reject quantity of 50 KL with TDS level 68000 ppm, the total salt content in the reject is approximately 3400 kg. In this 3400 kg salt, approximately 2550 kg will be common salt with other mono-valent salt and approximately 850 kg will be the Glauber salt.

When this RO reject effluent is further passed through nanofiltration then in the permeate common salt and other monovalent salts will be allowed and Glauber salt and some quantity of mono-valent salt will be in the nano reject

The mass balance observed during nanofiltration is as given below in table 1.

Table 1 – The TDS mass balance during nanofiltration

Particulars or operations	
RO reject and feed to Nanofiltration	50 KL
Nano permeate quantity	25 KL
Nano permeate TDS level	68000 ppm
The common salt and other monovalent salt quantity in nano permeate	1700 kg
Nano filter reject quantity	25 KL
Glauber salt and other mono-valent salt quantity in Nano reject	1700 kg

This Nano reject quantity is taken for Multiple effect evaporation (MEE)for further product concentration

3.0 Salt recovery and its ZLD need

We know that two types of salts are used in the textile dyeing process i.e. Common salt and Glauber salt depending on the shade type, depth, and dyes criticality. Generally, this ratio is 3:1 to 4:1. Additionally, during the neutralization process, the salt is generated due to acid and base reaction, and thus

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the salt burden and hence toxicity is more in the textile effluent. Due to salt and other toxicity, the environmental issues being occurred are as below

3.1 The adverse impact of salt on land or soil

- The fertility of the soil is decreased and after a certain time it is useless for agriculture purpose
- Acidification of land increases
- The porosity of land reduces and the underground water level also decreases
- The crop taken from such land is contaminated

3.2 Adverse impact on a water body

- It is toxic to fish and reduces dissolved oxygen levels in the water
- Endocrine disruption of fish and thus reproductive system is hampered
- Increases algae growth and dead zones are developed in the sea

3.3 Concept and Need of ZLD

ZLD means Zero liquid discharge i.e. Zero discharge of wastewater from Industries. Zero Liquid Discharge (ZLD) is a treatment process designed to remove all the waste/pollution from water In other words while running any textile production activity, you will not discharge water (waste or pollutants) to the environment.

A ZLD system involves a range of advanced wastewater treatment technologies to recycle recovery and reuse the treated wastewater and thereby ensure no discharge of wastewater to the environment.

ZLD concept is not only treatment of wastewater, but it also talks about 3R i.e. Recover, reuse, and recycles. To make the above things successful and economical to the business module we should also focus on 4th R i.e. Reduce use at source. In short:- The focus of ZLD is to reduce wastewater economically and produce clean water that is suitable for reuse (e.g. irrigation, production), thereby saving money and being beneficial to the environment as well as business.

3.4 Economy Process sequence followed

The following process sequence is used to achieve complete ZLD, as shown in figure 1

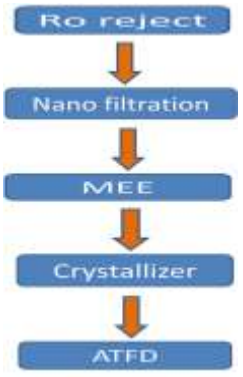

Figure 1 - Salt recovery process sequence

4.0 Multiple Effect Evaporation (MEE)

4.1 *MEE parts and working:-*

The evaporator consists of a large cylindrical body with a dome-shaped top and bottom. Inside, calandria are fitted.

Calandria consists of the number of vertical tubes (diameter 5-9 cms and length 3-7 meters).

When such evaporators are arranged in sequence it is called MEE. Multiple effect evaporators each is held at a lower pressure than the last. The vapor from 1st evaporator is a heating media for 2nd evaporator. Similarly, vapor from the 2nd evaporator serves as heating media for the 3rd evaporator and so on. Generally, 4 to 5 stages of MEE are used in the ZLD plant. The last evaporator is collected to cyclone separator (for gas separation). The steam economy increases as the stages are increased. For 4 stage MEE, to evaporate 4 liters of water, the steam required is 1 kg. For evaporation falling film-type evaporator is used. The typical diagram and its parts are shown in below figure1.

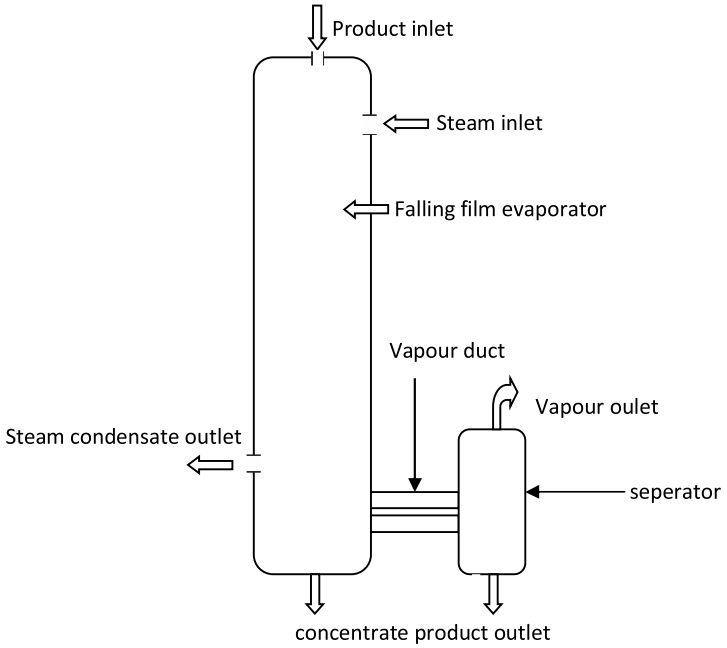

Figure 2- Evaporator machine parts [1]

The mass balance after MEE operation observed is as given in table 2

Table 2 - The TDS mass balance after MEE operation

Particulars or operations	
MEE feed	25 KL
Feed rate	5 KL/hour
MEE concentrate /product quantity	6 KL
MEE concentrate /product TDS level	280000 ppm
MEE condensate water from effluent with TDS level 100 ppm	19 KL

4.2 Preventive Maintenance of the MEE:-

To achieve desired machine operation efficiency and cleaning, the preventive maintenance schedule followed in the mill is as below in table 3

Table 3- MEE Preventive maintenance schedule

MULTIPLE EFFECT EVAPORATOR		
Maintenance Schedule		**Agency**
Daily	The specific gravity of effluent from last Evaporator/Calendria Steam pressure, Vacuum & Temperature calandria, Flow of effluent (to know chock-up of tubes)	Own team
Weekly	Flushing by water & chemical if needed	Own team
Yearly	Cleaning of tubes by motorized scrubber & high-pressure pumps (Jet pump)	Outside team

4.3 Cleaning of MEE

During the evaporation, the scale is formed inside the tube due to the deposition of insoluble salts/ hard scale (ex. sodium carbonate and bicarbonate). The higher the scaling lower is the efficiency. Hence the cleaning is required. The following figure 3 explains the sequential chemical cleaning method and steps used in industry.

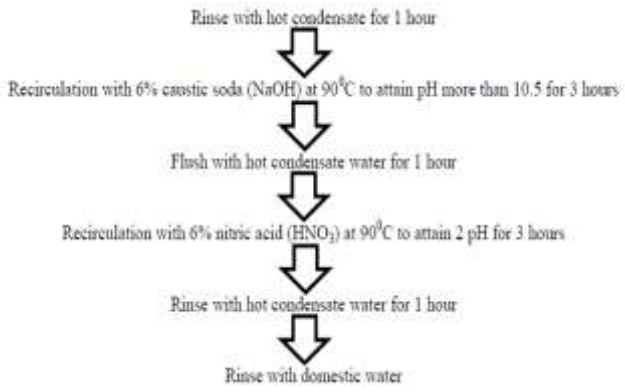

Figure 3:- Sequential chemical cleaning procedure of MEE [2]

5.0 Crystallizer

5.1 working of crystallizer

The MEE concentrate product is then fed to the Crystallizer unit. Crystallization refers to the formation of solids crystals from a supersaturated homogeneous solution

Crystallizers are used for recovering salts from wastewater (concentrated form) that can be reused in the process or sold in the market. Mainly two types of crystallization processes are used i.e 1) Concentration method (example Forced circulation crystallizer) and 2) Cooling (under vacuum or with a heat exchanger)

Vacuum cooling crystallization is mainly used for salts with a decreasing solubility at decreasing temperatures. By lowering the temperature, the salt crystallizes. This is held in suspension by air sucked in at the bottom of the crystallizer (air agitation) and is transported to the outlet

Economy process sequence:-

RO reject Nano filter (to separate common salt etc) MEE crystallizer ATFD

After Crystallizer, the produced Glauber salt is pure form, and mother liquor containing mixed salt is further transferred to ATFD for drying.

By flashing the solution (with sp gravity 1.2 – 1.25) in a vacuum, the solution temperature is reduced. This reduces the solubility of the Glauber salt and causes crystallization. The resulting vapor steam can be used for preheating. The crystallizer is working under vacuum 750 mmHg (1 kg/cm2) and 10 to 15°C temperature to recover Glauber salt(Sodium Sulphate), Temperature is maintained with the help of the chiller plant.

Output Glauber salt is with moisture about 50 %.which be dried with the help of ATFD type dryer or so that powder form Glauber salt can be achieved with 10 % moisture level. The % purity of Glauber salt obtained is >90%

The mass balance during the crystallization process is given in table 4

Table 4 - The TDS mass balance in crystallization

Particulars or operations	
Crystallizer feed	6 KL
Glauber salt quantity	2 KL
Obtained Glaber salt concentrated product purity	50%
Glaber salt weight on a dry basis	1000 kg
Mother liquor quantity	4 KL
Mother liquor TDS level	175000 ppm

5.2 Preventive maintenance of crystallizer:-

The preventive maintenance schedule for crystallizer followed is given in table 5

Table 5- Crystallizer : Preventive maintenance schedule

Crystallizer and pusher		
Maintenance Schedule		**Agency**
Daily	The temperature of the vessel.	Own team
Weekly	Vacuum	Own team
Monthly	Cleaning & Flushing	Own Team
Yearly	Cleaning by chemicals Overhauling	Outside team

6.0 Reuse of recovered salt

6.1 Common salt

It is recovered from nanofiltration and is in the highly concentrated form (TDS level generally is 50-70000 ppm). It can be used directly in the form of liquid by considering the % purity.

6.2 Glauber salt

It is recovered in the form of crystals (moisture content is about 45-50 %) It can be reused for dyeing purposes by considering its moisture content. Even if recovered Glauber salt with a moisture content level of 50 % can be used in the dyeing as a brine solution. Only one should look into bath volume and salt solution to be added. Recovered brine quantity to be added< dyeing bath volume. So, it is proffered to use the recovered brine solution as it is instead of dry powder. This saves the drying cost of salt recovered. For your ref, please note that almost all the shades can be dyed with this recovered salt. The only dyer has to take experimental based initiative for this.

7.0 Final drying by ATFD

7.1 ATFD machine parts and working

The mother liquor coming from the crystallizer and pusher system is taken to the ATFD (agitated thin film dryer) for further concentration from 20 % to 90% TDS level so that almost complete water evaporation is achieved ATFD-agitated thin film dryer – is used for evaporation of water to make concentrated liquid to dry powder form-continuous process.

ATFD consists of a cylindrical vertical body with a heating jacket and rotor inside the shell- equipped with row and pendulum blades all over the length of the dryer

The hinged blades spread the wet, feed liquid in a thin film over the heating wall

The turbulence increases as the product pass through a clearance before entering calming zone situated behind the blades as the heat will transfer from jacket to wall under the smooth agitation

Water evaporates and liquid converts to slurry to cake to dry powder

The vapors move upward and pass through the cyclone separator at the top. These vapors are condensed to form condensate water

The liquid is fed from Top. The ATFD Temp is approx. 150 deg C. The mother liquor from crystallizer is converted to powder form & is continuously scrapped with help of blades in ATFD and dry salt with moisture level 8-10 % is produced. This salt is called mixed salt

The following figure no.4 shows the different parts of the ATFD machine.

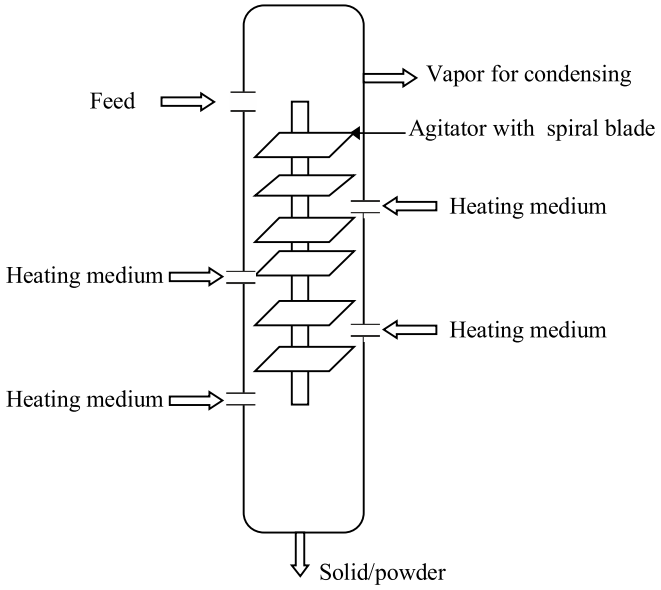

Figure no.4 - Agitated thin film dryer (ATFD) machine parts [3]

7.2 Preventive machine maintenance of ATFD:-

The preventive maintenance schedule for the ATFD machine followed is given in table 6

Table 6- ATFD machine Preventive maintenance schedule

ATFD		
Maintenance Schedule		**Agency**
Daily	Steam Pressure and temperature	Own team
Weekly	Cleaning & Flushing	Own team
Monthly	Cleaning & Flushing	Own Team
Yearly	Over-hauling	Outside team

8.0 Mixed salt Management

As of today, ATFD mixed salt is not used for dyeing purposes in wised scope. Generally, it is being discarded to waste management system i.e. Common Hazardous Waste Treatment, Storage and Disposal Facility (CHWTSDF) in your state /city/area. For example in the Mumbai zone, it is Mumbai waste management ltd is the agency working for this. But, a negative costing commercial is involved in dispatching such mixed salt to CHWTSDF. To save this cost dyer may take in experimental initiatives to use such salt for non-critical shades like black and navy etc.

9.0 Do's and Dont's in ETPP

a. Use safety shoes or boots with non-slip soles
b. Wear personal protective equipment and chemical resistant clothing to avoid exposure of skin or eyes to corrosive and/or polluted solids, liquids, gases, or vapors
c. Do not mix chemicals without the supervision of a qualified chemist or safety professional.

d. Obey all safety instructions regarding the storage, transport, handling, or pouring of chemicals. – as per MSDS
e. Check electrical equipment for safety before use; verify that all-electric cables are properly insulated; take faulty or suspect electrical equipment to a qualified electricity technician for testing and repair
f. Wear safety goggles in all cases where the eyes may be exposed to dust, flying particles, or splashes of harmful liquids
g. Wear a respirator, or gas mask, when exposed to harmful aerosols, dust, vapors, or toxic gases
h. Take extreme care when handling highly corrosive agents such as liquid or gaseous chlorine, concentrated acids or alkalis, etc
i. Obey all safety instructions concerning entry into confined spaces, e.g., check atmosphere for oxygen or for poisonous gases, use respiratory protection equipment if needed, have a co-worker stand guard in case of need for help, etc.
j. Do not smoke, eat or drink in areas where chemical or biological contamination may be expected
k. Use non-latex gloves if the sensitivity to latex has been diagnosed
l. All operators should undergo periodic examinations by an occupational physician to reveal early symptoms of possible chronic effects or allergies

Conclusion

ZLD concept is not only treatment of wastewater, but it also talks about 3R i.e. Recover, reuse, and recycle. This is not only applicable to water but also the salt and other toxicity in the effluent. To make the above things successful and economical to the business module we should also focus on 4th R i.e. Reduce water and chemicals used at the source. In short:- The focus of ZLD is to reduce wastewater economically and produce clean water that is suitable for reuse (e.g. irrigation, production), thereby saving money and being beneficial to the environment as well as business.

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