IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 5, May 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

Optimization of Water Resource at PV Cell Manufacturing Industry

Sindhura S[1] and Dr Sampath Kumar M C[2]

[1] Department of Civil Engineering, B M S College of Engineering, Bengaluru, Karnataka 560019, India

[2] Professor Department of Civil Engineering, B M S College of Engineering, Bengaluru, Karnataka 560019, India

Abstract

Nowadays, since the renewable resources are being exploited the use of sustainable resources like photovoltaic cell and its manufacturing has become a future. Hence the manufacturing of these cells is occurring at a higher rate and hence use of natural resources has been increasing with advancement of technology. Here in this paper it is discussed about the process of manufacturing, types of effluent, optimizing the existing operational treatment plant to higher efficiency is discussed hence cutting down the utilization of natural water by proposing to implementation of Zero liquid discharge treatment plant.

Keywords: *Photovoltaic cell, Treatment of concentrated effluent, Zero Liquid Discharge plant, Silicon wafers.*

1. Introduction

The sun being non-renewable energy and most sustainable form of energy is becoming the future. Capturing this energy and utilizing it in the form of electricity is becoming a challenge. Photovoltaic cell manufacturing industry is growing rapidly and advancement in the production and efficiency of the cell is also rapidly increasing. Hence the concerned environmental aspects are also increasing with the technology advancements.

As the production of photovoltaic cell is increasing there is an increase in consumption of water resource. Hence implementation of ZLD plant might thrive the thirst of water requirement as well optimizing the existing water treatment plant might increase the efficiency of the treatment plant. This paper includes the brief production process of solar cell then followed by the types of effluents generated and its characteristics then the three phase design criteria for a 250KLD plant and its efficiency.

2. Production Description

Production of PV cell process includes following wet chemistry process mainly saw damage removal followed by texturing finally followed by cleaning. The sequential study on following order of the process is important for us to know about the effluent generated at various stages of the process which would help us modify and bring in zero liquid discharge (ZLD) plant and optimize the water utilization for the production purpose.

2.1 Process of PV Cell Manufacturing

Photovoltaic cell manufacturing process follows

i. Removal of saw damage and texturing in H_2O, HNO_3, and HF
ii. DI water rinse
iii. KOH to etch porous silicon off that was formed during acidic texture
iv. DI water rinse
v. HCl cleaning
vi. DI water rinse
vii. Air Drying

Saw damage has to be removed from the wafer surface, since it has it effect on the mechanical strength of the wafer and also increases recombination feature in the surface region. Also, the alkaline or acidic solutions and the plasma etching can be used for removal of saw damage from surface.

The wafer is cleaned to expel metal and natural contaminants that would cause an expansion of surface recombination. A mixture of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and water is ordinarily utilized for soluble saw harm evacuation on the multi-crystalline silicon wafers. To enhance the horizontal consistency and the anisotropy of the carving procedure, isopropyl liquor (IPA) is added to the scratching arrangement. the wafers are flushed in deionized (DI) water, cleaned in hydrochloric acid (HCl), washed in DI water, cleaned in hydrofluoric acid (HF), washed in DI water, lastly dried in hot air. HCl expels metal contaminations from the wafer surface. HF carves the local silicon dioxide off, expels metals with this surface, and structures a hydrophobic surface.

2.2 Types of Effluent and Characteristic

The effluent generated from the photovoltaic cell manufacturing process can be differentiated as

Rinsing effluent where the concentration of the chemical components is lower and which can be treat with a basic process.

Concentrated effluent which consists of concentrated acids and bases. Characteristics of effluent is mentioned in Figure 1.

2.3 Design criteria for a ZLD plant

The design criteria include a four-phase treatment process for different effluents generated from the photovoltaic cell manufacturing process. Design criteria is proposed for a 250KLD.

- Phase-1 includes following treatment procedures
  i. Batch treatment process
  ii. Multimedia filtration
  iii. Fluoride polishing
  iv. Softening
  v. Ultra-filtration
  vi. RO process
  vii. Regeneration and chemical dosing
  viii. Sludge treatment and handling system
  ix. Treatment of MMF, ACF backwash water, WAC regeneration waste and RO effluent

The rinse water effluent mainly consists of Fluoride, Silica and TDS. In the batch treatment tank effluent is added with chemicals like Lime, Aluminum Oxide, Dolomite and Polymer. At high elevated pH Silica and Fluoride react with lime and dolomite to form Calcium Fluoride and Calcium, Magnesium Silicate. Polymer is added to create flocs which are settled down in the form of sludge. The clear water is decanted for further treatment steps. The sludge is transferred to sludge thickener and later fed to centrifuge decanter. Due to centrifugal action water is separated from sludge and then dry solids are collected in cake cart for external disposal. Decanted water is fed to batch treatment tanks for treatment.

The decanted water mainly consists of high TDS and some amount of fluoride and hardness. Water is passed through multimedia filter to remove suspended solids present due to carryover of flocs. It is then passed through Weak Acid Cation to remove hardness present in water due to excess calcium from lime. Fluoride polisher removes residual Fluoride which could not be precipitated in chemical process. Ultra-filtration removes fine suspended particles (colloidal silica) to achieve desired silt density index by RO plant (SDI value <3), so that water can be fed to RO system which removes TDS.

There are two stage ROs to achieve overall recovery of 90% for phase -1. Permeate water is fed to existing raw water tank to be further fed to Ultrapure Water System as raw water. RO reject is fed to Multi Effect Evaporator to burn water molecules to form vapor and later condense it. The condensate will have suitable TDS and it also can be reused as raw water for process. This becomes true Zero Liquid Discharge System. The MMF backwash waste water shall be collected in tank and transfer to batch treatment tank for further treatment.

- Phase-2 includes following treatment process
  i. Multi effect evaporator

In Phase 2, RO2 reject water and treated water from batch treatment tank containing high TDS is fed to evaporator to burn water molecules to form vapor and then condense it to form condensate to be reused as raw water for existing DI plant. Dry salts are collected in cake cart and disposed of externally.

- Phase-3 includes following treatment process
  i. Batch treatment for concentrated effluents.
  ii. Lime powder dosing system.

In Phase –III, Concentrated effluents like HF, HF+HCl, HF+HNO3, NaoH/KOH are treated in Batch Treatment Tank to precipitate fluoride and silica the same way as in phase – I. Lime powder hopper system with screw pump and conveyor system is used to dose lime powder in batch treatment tank. The sludge is taken to sludge thickener and then fed to centrifuge decanter to form dry sludge. The decanted water containing high TDS is fed to batch treatment tank.

Sewage treatment plant of 100 KLD capacity with conventional biological process to remove BOD/COD. Membrane bioreactor process will further remove suspended solids to achieve SDI <3. Treated water is ozonated to kill bacteria’s and then RO process removes TDS. The permeate water is once again ozonated before sending it to raw water tank to be reused again. Partial water is used for gardening. RO reject water shall be fed to phase – I(RO1) for treatment. Figure2 represents the process flow diagram along with mass balance chart for the above discussed design.

ISSN (Online) 2348 – 7968
www.ijiset.com

3. Tables, Figures and Equations

3.1 Figures

Parameter	Rinse Water 1	Rinse Water 2	HF 1	HF 2	HF+HCl 1	HF+HCl 2	HF+HNO3 1	HF+HNO3 2	NaOH 1	NaOH 2
pH	2	2.3	3	2.5	2.20	2.20	3.02	1.68	12.10	12.30
Turbidity	<1	<1	70.6	4.3	55.00	15	89.00	69.00	168.00	90.20
Total Soluble Solids	8,566	7,389	16,300	28,000	157,900	139,600	38,500	16,600	20,900	21,100
Calcium	4	5	0.54	2	11.00	12.30	6.30	3.30	0.17	0.35
Magnesium	1	1.3	0.81	0.5	1.00	2.08	1.30	0.46	LOQ	LOQ
Sodium	44	52	70.00	34	180.00	25.00	7.00	13.30	5,062.00	6,154.00
Potassium	0.41	0.7	0.92	0.86	3.80	2.00	1.00	1.60	24.00	19.41
Hardness	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	3,289.00
Chlorides	496	326	6,800	2,522	36,800	23,000	NIL	NIL	149	99.20
Sulphates	LOQ	LOQ	616	610	102.00	251	1,005	640	284.00	149.00
Nitrates	1,314	1,120	9	0.5	209	65	9,134	4,389	629.00	654.00
Acidity %	0.3800	0.24	7.9	6.8	6.02	5.98	35.40	38.05		
Alkalinity									1.45%	1.27%
Carbonate	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	10,600	8,300
% of Acid w/v			7.9	6.8	6.02	5.98	35.40	38.00		
% of Alkali w/v									1.45	1.27
TDS	8,566	7,389	16,300	28,000	157,900	139,600	38,500	16,000	20,900	21,100
Reactive Silica	47	75	0.14	0.36	0.90	6.74	39.00	0.73	505.00	575.00
Colloidal Silica	95	27	74.3	141	405	825	2,705	2,591	199.40	137.00
Total Silica	142	102	77	142	406	831	2,744	2,591	704.00	712.00
Fluorides %	0.26	0.22	7.5	6.4	1.58	2.2	1.96	0.60	0.051	0.048

Figure:1 Design effluent water analysis

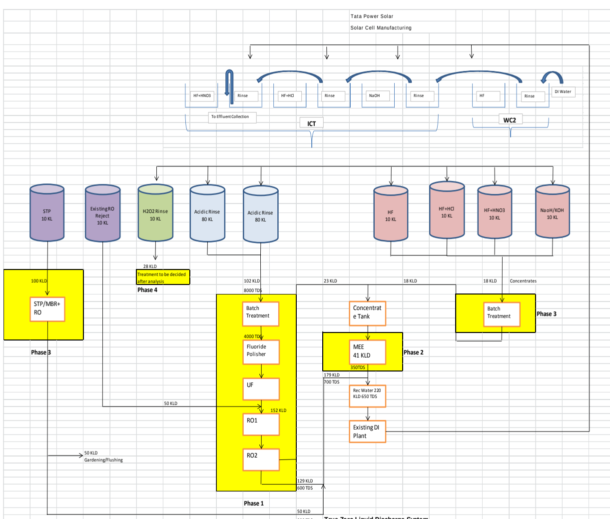

Figure:2 True Zero liquid discharge mass balance process flow chart

4. Conclusions

We know PV cell manufacturing industry is a future scope and will be playing a major role in sustainable resource management. Hence bringing in suitable environmental measures to make it more likable in an environmental aspect by implementation of zero liquid discharge plant. From the above design implementation, we can see that there is 95% efficiency achieved and 30% of water is recovered compared to previous effluent treatment plant. Hence optimizing precious water resource is achieved.

References

[1] M. Schleef, D. Worf, R. Bartels, M. Kostieva, Waste water treatment for crystalline silicon solar cell production, Photovoltaics International (PV-Tech) 11 (2011) 20

[2] Nadjib Drouiche , Fadila Djouadi-Belkada , Tarik Ouslimane , Aissa Kefaifi ,and Jihane Fathi , "Photovoltaic solar cells industry wastewater treatment", Desalinization and Water treatment, 08 Mar 2013

[3 E. Billenkamp, Water and wastewater treatment for solar industry, Trade J. Water Wastewater Manage. 16–18 (2011).

SINDHURA S pursuing MTech in Environmental Engineering from BMS College of Engineering, has been awarded a degree in Bachelor of Engineering in Civil Engineering in the year 2016. current research interests; association with any professional associations. Do not specify email address here.

Dr M C Sampath Kumar professor Department of Civil engineering at BMS College of Engineering