A STUDY REPORT

ON

EFFLUENT TREATMENT PLANT

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Prepared in fulfillment of the

Practice School-I Course No.

BITS C221/BITSC231/BITSC241

AT

Century Rayon, Mumbai

A Practice School-I Station of

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

May 22-July 14 2017

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Acknowledgements

Firstly we would like to thank **Mr. O.R. Chitlange**, President, Century Rayon, for giving us this wonderful opportunity to pursue Practice School-I at Century Rayon, Mumbai.

We are grateful to **Mr. Rajaram Rao**, General Manager, Auxiliary Plant for providing valuable guidance and all resources needed.

Our thanks to **Mr. Kishore Shewkani**, Head of Department, Sulfuric acid plant, WTP plant and Effluent Treatment Plant (ETP) for extending constant technical support and helping us through plant operation technicalities.

We are indebted to **Mr. Abhijeet Ithape**, **Mr. Abhijeet Bali** and **Mr. Gaurav Mishra** for helping us out whenever needed.

Our heartfelt appreciation goes to **Mr. Leonardo D’Souza** and **Dr. Neetu Yadav** for being a competent and highly supportive instructor for Practice School-I.

Abstract

Century Rayon mainly produces high tenacity tyre cord and viscose rayon filament yarn. Both the process require an enormous amount of water in the production process. The water exiting from these plants is high in zinc content, acidic in nature, and exhibits high BOD. Before dumping the water in river, the water needs to be treated to bring the zinc, BOD and pH levels in accordance with that stated by the Maharashtra Pollution Control Board. Earlier the norms were 100ppm of BOD level, pH of 7 and 30ppm of zinc. Hence the company treated the used water only for pH and zinc content. After the modification of norm to BOD level under 30ppm and zinc level under 5ppm, a new BOD treatment plant is installed. The project mainly focuses on the analysis of the ETP (Effluent Treatment Plant) and BOD (Biological Oxygen Demand) and compare the efficiency of the old and new ETP plant. Furthermore suggest possible improvements that can be made in the plant.

Keywords: Lamella, ETP, Clarifier, BOD, MLSS

The main objectives of this project are:

1. To study the pre, primary, secondary and tertiary treatment of waste water and significance of each processes.
2. To study the construction and design principles of lamella clarifiers.
3. To study the relationship between retention time of sludge and area of the clarifier.

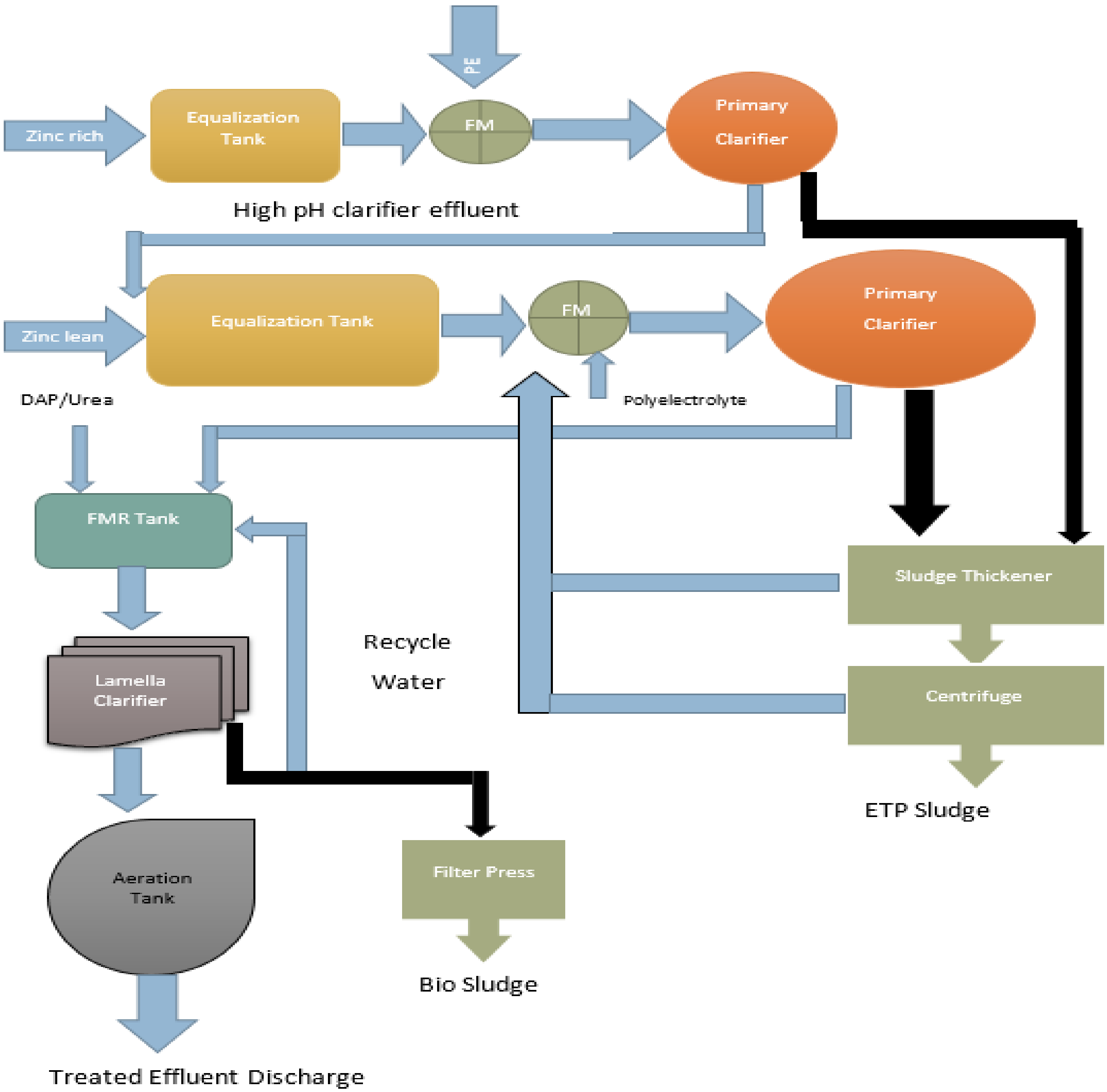
The effluent water flow of around 12000 m^3/day from various departments is first collected in a common chamber having the pH probe which reads the inlet pH of the incoming effluent. The pH of the incoming effluent is mostly acidic in nature and is neutralized by addition of lime solution in equalization tank. The effluent water from equalization tank is pumped by neutralized effluent pump to flash mixer.

Pumping of effluent water in flash mixer is followed by addition of poly-electrolyte and then to Clariflocculator where flocculation and settling occur. The clarified water overflows to the aeration tank before final disposal of effluent. Part of Rayon After Treatment and Tyrecord spin bath effluent rich in zinc is separately in Clariflocculator tank where pH is maintained between 9 to 11. Overflow of clarifier is taken back to inlet of equalization tank.

The settled sludge of both clarifiers are taken into thickener for concentrating the sludge and then pumped to super decanter for separation of solids and liquids. This wet sludge is passed through dryer to reduce the moisture content of the sludge. Solid sludge is collected in a trolley kept below machine and separated liquid goes to flash mixer of zinc clarifier and then it is disposed in a pit. The pit is an HDPE (High Density Polyethylene) lined as per guidelines of CPCB and then sent to Mumbai Waste Management Ltd., Taloja, regularly.

Sr. No.	Control System	Mode of treatment
1	Screening heavy / suspended particles	Wire mesh in every department effluent outlet point
2	pH control at 6 places, continuous pH monitoring of final discharge point	Lime solution Automatic control system and feeding
3	Screening- Heavy object	Wire mesh
4	Equalization and hydraulic mixing	Recirculation of effluent for hydraulic mixing
5	Flash Mixer	Electrolyte for suspended impurities
6	Clariflocculator	Settlings of suspended particles
7	Aeration	2 surface aerators and 2 submersible aerators
8	Final Discharge	Close pipe- 48”Ø long conduit
9	Thickener	Thickening of sludge
10	Centrifuge	For separating sludge and water
11	Zinc reduction system	For reducing zinc
A	Segregation of Zn rich stream	Automatic high and low pump level in Rayon AT
B	Flash Mixer	Automatic mixing. Addition of lime
C	Clariflocculator	Settlings of suspended impurities

After the modified regulations by the Control Pollution Board, Century Rayon has installed a new BOD plant setup to reduce the BOD level under 30ppm.



The new BOD plant consists of a Fluidized Media Reactor (FMR) followed by Lamella Clarifier and Aeration tank. The Effluent Treatment Plant consists of 2 clarifiers based on Zinc content- zinc lean and zinc rich. The zinc rich flow stream is low in pH (3-5) and is treated with lime in equalization tank to make it mildly basic and passed on to clarifier to settle the sludge in the settling clarifier. The overflow from the settling clarifier is used to treat the Zn lean flow line to bring the pH to 7. Additional lime can be added according to the requirement. The treated Zn rich flow is mixed with the Zn lean flow and the combined flow sent to the settling clarifier for further sludge settling. The output flow from settling clarifier is the inflow for FMR.

Figure 1: Fluidized Media Reactor

Figure 2: Media used for cultivating bacteria

Figure 3: Lamella Clarifier

Pretreatment

Pretreatment removes all materials that can be easily collected from the raw water before they damage or clog the pumps and lines of primary treatment clarifiers. Objects commonly removed during pretreatment include trash, tree limbs, leaves, branches, and other large objects.

Pretreatment In the ETP Plant of Century Rayon

The water which comes from the different departments is usually acidic (with pH ranging from 2-3) .This is measured with the help of accurate pH meters. At the point where the water is exiting the corresponding departments, lime ($CaCO_3$) solution of concentration of about 200 ppm is added by pipelines to maintain a basic pH of 9-10.

In addition if the pH gets out of range then a separate lime addition point is placed just outside the ETP plant. There are a total of 5 points of lime addition in the zinc-lean stream. For the zinc-rich stream, lime is added in the agitator vessel.

Other than that, a screening turbine is placed for the water coming out of the rayon After-Treatment department. A tube-type skimmer is placed to skim off the oil which is coming along with the water but it will be upgraded to a belt-type skimmer.

Primary Treatment

Primary wastewater treatment uses screening to remove large objects, grit chambers to remove smaller particles, and sedimentation tanks to separate solids from liquids. Primary treatment consists of temporarily holding the water in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment.

Primary Treatment In the ETP Plant of Century Rayon

3500 m^3 of water rich in zinc (80-100 ppm) comes from Tyrecord Spinbath and Rayon After-Treatment. It is passed to an equalization tank where it is kept for 1.8 hours. Next polyelectrolyte is added to this water which goes to the zinc clarifier where the residence time is 1.8 hours. Sedimentation occurs and the solid sludge gets separated after passing through the D-Canter. This sludge is consequently passed onto thickener. The liquid sludge is dipped into a HDPE (High Density Polythene Pit). The clarified water is added to the inlet to the zinc-lean equalization tank. The water (12000 m^3) from all the departments of the company except Rayon After-Treatment and Tyrecord Spinbath with low zinc content (20-40 ppm) is collected by a common line in an equalization tank where the post-clarified zinc-rich water with pH 9-10 is also collected. A part of this water is driven through a pipe to create a hydraulic pressure to facilitate sedimentation.

This water is then pumped by neutralized effluent pump at the rate of 400m^3/hr to the flash mixer. There are 4 pumps out of which 1 is on standby and 1 is automated.

In the flash mixer an anionic polyelectrolyte is added to aid in flocculation in the flash mixer. Next the water is added to the clariflocculator where the sludge is sedimented out. The residence in this clarifier is around 4 hours. The sludge is concentrated and is passed through a D-Canter to separate the solid and liquid sludge. The liquid sludge is dumped in HDPE pit and the solid sludge is collected in trolley and dumped.

The clarified water is partly fed (10%) to the FMR (Fluidized Media Reactor) to undergo further treatment; but in the future, entire water flow from conventional clarifier can be fed to secondary clarifier before releasing it to the saline region of the creek. The remaining water is fed to the aeration tank where further treatment like addition of antifoam is done, from where it is recycled back to the departments and the rest is dumped into the saline region of the creek.

Secondary Treatment

Secondary treatment is a treatment process for wastewater to achieve a certain degree of effluent quality by using a treatment plant with physical phase separation to remove settleable solids and a biological process to remove dissolved and suspended organic compounds. After this kind of treatment, the wastewater may be called as secondary-treated wastewater.

Secondary Treatment In the ETP Plant of Century Rayon

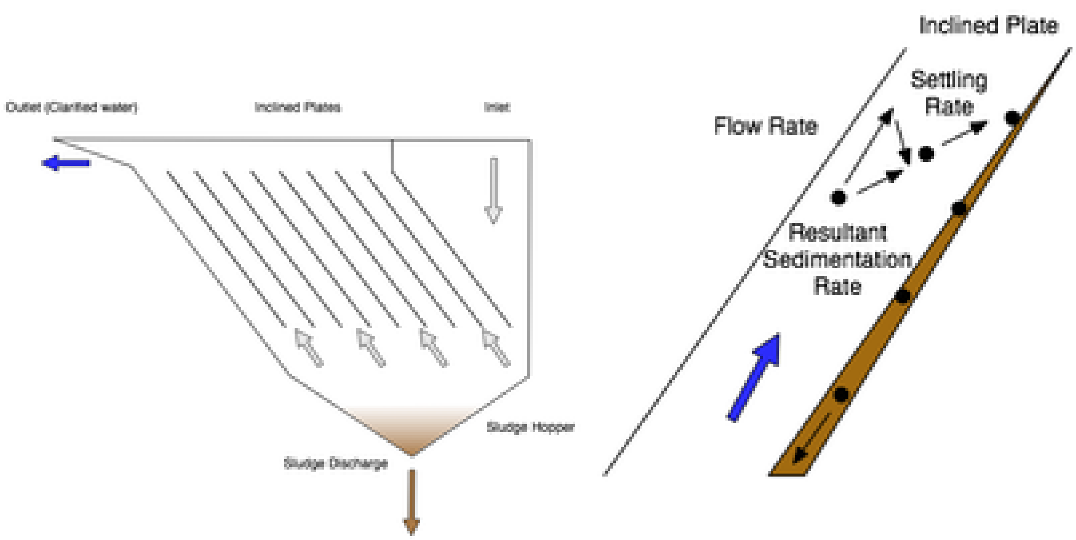
The clarified water is passed to the FMR which has a capacity of 700 m3. Diammonium Phosphate (DAP) and urea is added to the FMR. The residence time in the FMR is 1 hour. Here the water is mixed with bacteria which has been specifically cultured to release oxygen from the organic and inorganic compounds present in water thus decreasing BOD. There are 2 FMRs in parallel.

This water is passed onto the lamella clarifier. There are 12 lamella clarifiers in total and the residence time here is 30 minutes. The clarified water is again passed to the aeration tank from where it is either recycled back or thrown out into the saline region of the creek.

The remaining water which was not completely clarified is again recycled back to the FMR.

EQUIPMENT	DIMENSIONS (M)	HOLDING CAPACITY (M^3)
EQUILISATION TANK FOR NORMAL EFFLUENT	43.75 x 11.12 x 2.43	1200
CLARIFIER FOR NORMAL EFFLUENT	Ø33 x 3.2 SWD	2800
THICKENER	Ø13 x 3 SWD	400
AERATOR	30.1 x 7.5 x 2.6	600
EQUALISATION TANK FOR ZINC RECOVERY	12.8 x 12.8 x 2.25	370
CLARIFIER FOR ZINC RECOVERY	Ø18 x 2.8 SWD	730
	TOTAL	6100

Design of Lamella Clarifier



Lamella clarifiers can be used in a range of industries including mining and metal finishing, as well as to treat groundwater, industrial process water and backwash from sand filters. Lamella clarifiers are ideal for applications where the solids loading is variable and solids sizing is fine and are more common than conventional clarifiers at many industrial sites due to their smaller footprint.

Keywords: Equipment Footprint: It refers to the physical space a computing device or equipment requires when being placed or deployed within a home, office or computing facility.

Lamella clarifiers are generally employed with primary water treatment in place of settling tanks. They use a series of inclined plates that provide a large effective area for settling of sludge for a smaller footprint.

Advantages

- Large effective settling area caused by inclined plates which improves operating conditions.
- Unit is more compact usually requiring 60-80% of area of clarifiers operating without inclined plates.
- Reduces problem of algae growth.
- Operation within an enclosed area provides better control of operating temperature.
- Can operate with flow rates 2-4 times of traditional clarifiers.
- Settling can be improved by putting flocculants and coagulants. They optimize the settling process.

Assessment of characteristics

Sedimentation effectiveness $\eta = (c_1 - c_2)/c_2$

C1: inlet concentration

C2: outlet concentration

Total surface area required for settling can be calculated for a lamella plate with N plates, each plate of width W, with plate pitch Θ and tube spacing p.

$$A = W \cdot (Np + \cos\theta)$$

Design heuristics

- Rise rate: Rise rates can be between 0.8 and 4.88 m/h from different sources.

- Plate loading: Loadings on plates should be limited to 2.9 m/h to ensure laminar flow is maintained between plates.
- Plate angle: The general consensus is that plates should be inclined at a 50-70° angle from the horizontal to allow for self-cleaning. This results in the projected plate area of the lamella clarifier taking up approximately 50% of the space of a conventional clarifier.
- Plate spacing: Typical spacing between plates is 50 mm, though plates can be spaced in the range of 50–80 mm apart, given that the particles > 50 mm in size have been removed in pre-treatment stages.
- Plate length: Depending on the scale of the system, total plate lengths can vary, however, the plate length should allow for the plates to rise 125 mm above the top water level, with 1.5 m of space left below the plates at the bottom of the clarifier for collection of sludge. Most plates have a length of 1–2 m.
- Plate materials: Plates should be made of stainless steel, with the exception of situations in which the system has been dosed with chlorine to prevent algal growth. In these circumstances, the plates may be plastic or plastic coated.
- Feed point: Feed should be introduced at least 20% above the base of the plate to prevent disturbance of the settling zones at the base of the plates.

Main characteristics

Lamella clarifiers can handle a maximum feed water concentration of 10000 mg/L of grease and 3000 mg/L of solids. Expected separation efficiencies for a typical unit are:

- 90-99% removal of free oils and greases under standard operation conditions.
- 20-40% removal of emulsified oils and greases with no chemical amendment.
- 50-99% removal with the addition of chemical agent(s).
- Treated water has a turbidity of around 1-2 NTU.

Initial investment required for a typical lamella clarifier varies from US$750 to US$2500 per cubic meter of water to be treated, depending on the design of the clarifier. The surface loading rate (also known as surface overflow rate or surface settling rate) for a lamella clarifier falls between 10–25 m/h. For these settling rates, the retention time in the clarifier is low, at around

20 minutes or less, with operating capacities tending to range from 1–3 m^3/hour/m^2 (of projected area).

Design of settler

Primary clarifiers can potentially remove more TSS and COD or BOD for less operational cost than any other treatment process in use today. Primary clarification, depending on wastewater characteristics, can have a profound effect on the size, capacity, and performance of downstream treatment processes. As a unit operation, physical forces predominate in the removal of TSS in primary clarifiers. The process objective of primary clarifiers is to remove settleable TSS, whether these solids already exist in the raw wastewater or if they are precipitated solids generated as a result of chemical addition for enhanced suspended solids, phosphorus, or heavy metal removal. Despite the fact that primary clarifiers remove only *settleable* TSS, performance historically has been quantified based on the removal efficiency of *total* suspended solids,

$$E_{\mathrm{TSS}} = 1 - (\mathrm{TSS}_{\mathrm{PE}}/\mathrm{TSS}_{\mathrm{PI}})$$

Where

E_{TSS} = TSS removal efficiency (often reported as a percentage),
$\mathrm{TSS}_{\mathrm{PE}}$ = primary effluent TSS concentration (mg/L), and
$\mathrm{TSS}_{\mathrm{PI}}$ = primary influent TSS concentration (mg/L).

In removing settleable TSS, primary clarifiers fortuitously remove the COD (or BOD) associated with them. Because downstream biological processes are sized based on the amount of biodegradable material there is in the primary effluent, the performance of primary clarifiers also is often quantified based on the COD (or BOD) removal efficiency

$$E_{\mathrm{COD}} = 1 - (\mathrm{COD}_{\mathrm{PE}}/\mathrm{COD}_{\mathrm{PI}})$$

Where

E_{COD} = COD removal efficiency (often reported as a percentage),

COD_{PE} = primary effluent COD concentration (mg/L), and

COD_{PI} = primary influent COD concentration (mg/L).

$$TSS_{PE} = TSS_{non} + (TSS_{PI} - TSS_{non})e^{-n\tau}$$

Where

TSS_{non} = nonsettleable, influent TSS concentration (mg/L),

n = a constant (1/d), and

τ = hydraulic residence time (d).

$$\tau = V_{PC}/Q_{PI}$$

Where

V_{PC} = primary clarifier volume (m^3) and

Q_{PI} = primary influent flow (m^3/d).

The volume is equal to the surface area times the average depth:

$$V_{PC} = A_{PC} \cdot d$$

Where

A_{PC} = primary clarifier surface area (m^2) and
d = average primary clarifier depth (m).

Influent flow divided by surface area is equal to the surface overflow rate (SOR, $m^3/m^2 \cdot d$ [gpd/sq ft]):

$$SOR = Q_{PI}/A_{PC}$$

and the remaining product, n times depth, can be replaced with another constant:

$$\lambda = n \cdot d$$

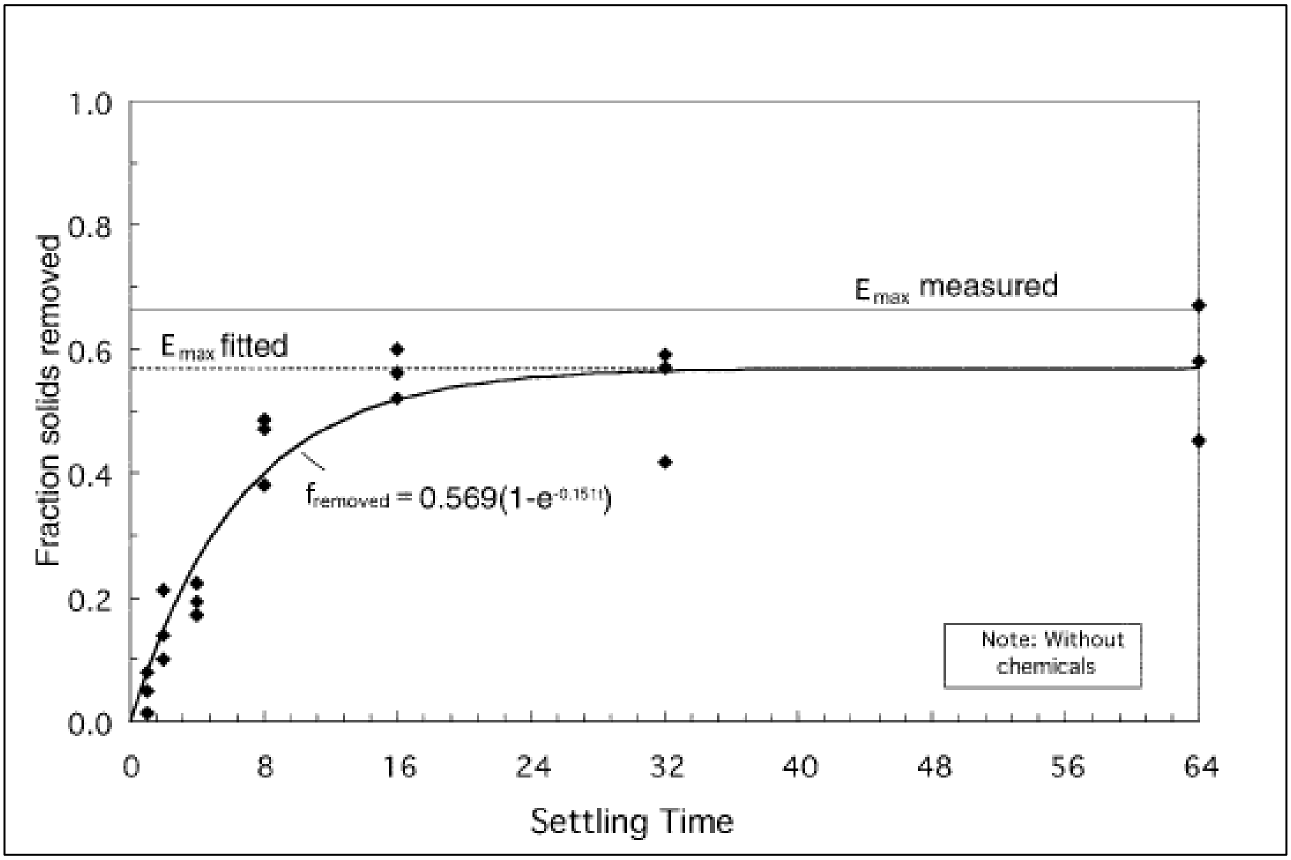
Where

λ = settling constant (m/d or $m^3/m^2 \cdot d$ [ft/d or gpd/sq ft]).

Therefore, eq 2.3 becomes

$$TSS_{PE} = TSS_{non} + (TSS_{PI} - TSS_{non})e^{-\lambda/SOR}$$

$$E_{TSS} = [1 - (TSS_{non}/TSS_{PI})] - [1 - (TSS_{non}/TSS_{PI})]e^{-\lambda/SOR}$$



Clarifier Design Heuristics

1. Characterize the settling velocity or settling velocity distribution of waste-water the settled.
2. Select design settling velocity V_d (m/h).
3. Calculate the ideal clarifier area A_{ideal} (m^2):

$$A_{ideal} = Q_m / (V_d \times 24)$$

where Q_m is the maximum wastewater flow to clarifier (m^3/d).

4. Determine degree of nonideality expected and express it as a DE.

5. Determine design surface area A_d:

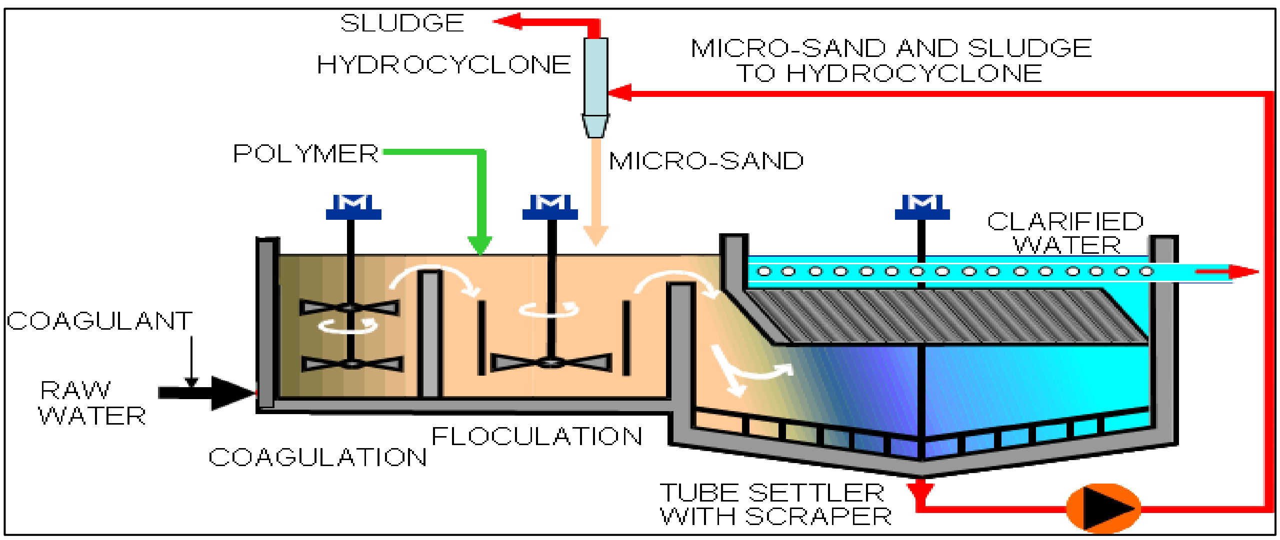
$$A_d = A_{ideal} / DE$$

where DE is a characteristic of the particular clarifier design details.

6. Select depth and design details (inlet and outlet designs, baffling, collectors, etc.) to achieve the most cost-effective design.

Alternatives for Lamella Clarifier

Sand ballasted clarifiers



Characteristics

- Economy:

  Micro sand vigorous mixing considerably reduces coagulation and flocculation time and, consequently, the overall footprint of mixing and flocculation time and, consequently, the overall footprint of the mixing and flocculation chambers. High flow rates produce compact installations and low civil costs, ideal for upgrading existing plants. Efficient use of chemical dosage produces an important reduction in operating costs.

- Stability and Flexibility:

Changes in raw water characteristics (turbidity, pH, temperature) do not significantly affect the clarified effluent quality. The process will accept wide swings in flow rates, between 0-150% of the nominal flow, with no effect on effluent quality. The stability of the process simplifies the operation.

- Water of Superior Quality:
  The coagulation phase produces a consistent clarified water of superior quality for all raw water conditions.
- Responsiveness:
  The Actiflo® is capable of very rapid start-up and responds quickly to changed operating conditions. Effluent turbidity exceeding accepted standards will be attained in less than 30 minutes after start-up

Bibliography

1. Water Environment Federation, (2005). *Clarifier Design, Second Edition*. Alexandria, USA
2. Actiflo®. http://technomaps.veoliawatertechnologies.com/actiflo/en/
3. http://web.cecs.pdx.edu/~fishw/UO_Ballast-Actiflo.pdf
4. Wikipedia, 2013. Industrial Waste Water Treatment https://en.wikipedia.org/wiki/Industrial_wastewater_treatment
5. Simon Judd, 2013. *The MBR Book, Principles and Applications of Membrane Bioreactors in Water and Wastewater.* ISBN: 978-0-08-096682-3