Review on Integrated effluent treatment plant

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Abstract- C*overs the mechanisms and processes used to treat wastewater that is produced as a by-product of industrial or commercial activities. Petroleum refineries are complex systems of multiple operations that depend on the type of crude refined and the desired products. The integrated effluent treatment plant revamps the traditional effluent treatment plant, as it consists of an additional membrane bio reactor along with a bioremediation tank.*

Keywords: *Membrane, Waste water, Sludge, Reverse osmosis, oil.*

I. INTRODUCTION

The high rate of urbanization and Industrialization give rise to the water pollution problem. All over the laws are passed to to protect the environment. So,All the industries should treat waste water in treatment plants. The main treatments are : primary, secondary and tertiary.This paper relates to waste water treatment in major factories especially the petroleum refineries. Water treated from effluent treatment plants, is not treated for microbial components. Thus, use of such water is harmful and needs further treatment. This problem is solved by the use of few additional components such as MBR (membrane bio reactor) and bioremediation tank.

II. STREAMS TO BE TREATED

A. Stream Description

- Process (Oily) Effluents
- Spent Caustic Effluents
- Contaminated Rain Water
- Sanitary Waste

B. Major operations involved

- Free Oil Removal
- Emulsified Oil Removal
- Sulphide Treatment
- Biological Treatment
- Reverse Osmosis Treatment
- Sludge Treatment
- Bioremediation

III. FREE OIL REMOVAL

Oil & grease in the wastewater can be present in essentially two main forms namely "FREE OIL" and "EMULSIFIED OIL". Generally, oil globules of above 60 micron are removed by API Oil Separators and less than 60 micron by TPI Oil separators.

A. API Oil Separator

The separation of oil from water by gravity differential is based on the rise rate of oil globules. Since the oil globules present will have varying sizes, for practical purposes the design is based on the rise rate of globules having a diameter of 60 microns. The separation basins are designed to have low velocity (0.6 m/s) and minimum cross or eddy currents, and sufficient retention time to permit the globule to coalesce and rise to the surface. During its upward travel to the surface, particles coalesce to form a film of oil, which is mechanically skimmed and recovered.

B. TPI Oil Separator

The current trend is to satisfy the increased separating area requirements by providing a number of stacked plates. Thus, the separating surface area is increased vertically. The area is further increased by selecting corrugated plates. The plates are located one on top of the other at specific distance from one another. The entire plate pack is placed in a tank at an approx. angle of 45 degrees. Hence the unit is called as "Tilted Plate Interceptor (TPI)". The wastewater enters the plates either parallel to corrugations in "Counter Current Flow" or at right angles to the corrugations in "Cross Flow" under laminar flow conditions.

IV. EMULSIFIED OIL REMOVAL

An intimate, two - phase mixture of two immiscible liquids with one phase dispersed as minute globules in the other phase are defined as an EMULSION. In the case of refinery wastes, the oil phase is intimately dispersed in the water phase. Various factors contribute to the stability of this dispersion. The minute globules are stabilized by an interfacial film or stabilizing agent such that the globules do not coalesce and do not respond to gravity settling. A major factor contributing to the formation and stability of emulsions is the electrical charge carried by the emulsified particles. In general, globules of oil in an oil-water emulsion may be broken by an electrical current or by electrolytes supplying a sufficient concentration of effective ions which neutralize the surface charges on the emulsified oil globules, permitting them to coalesce into larger globules.

Dissolved Air Flotation (DAF) is a process commonly used in refineries to remove emulsified oil and suspended solids from gravity separator effluent. The process involves pressurizing the influent to DAF Unit and then releasing the pressure, which creates minute bubbles that float suspended and oily particulates to the surface. The floated material is collected by a mechanical froth skimmer.

V. SULPHIDE TREATENT

Sulphur is an inherent impurity in most crude oils, and its concentration depends on the source of the crude. During the crude refining process, this impurity is separated from the product and discharged as a liquid effluent. During the processing step the Sulphur is converted to sulphide.

Sulphides are removed by chemically oxidizing them to elemental Sulphur or Sulphate using strong oxidizing agents such as Hydrogen Peroxide ($H2O2$), Ozone & Chlorine. In view of its various advantages, Hydrogen Peroxide is normally the preferred chemical.

The reactions involved are as under:-

Acidic Range / Neutral Conditions

In acidic range and neutral conditions, sulphides in the effluent are mostly present in the form of Hydrogen sulphide. The hydrogen peroxide reacts with Hydrogen Sulphide to give products of oxidation – water and elemental Sulphur as shown below:

Hydrogen peroxide + Hydrogen sulphide → Water + Sulphur

Alkaline Range

In alkaline range, sulphides present in the effluent are generally in the form of sodium sulphide. The Hydrogen peroxide reacts with sodium sulphide to give end products as water and sodium sulphate (relatively harmless and impose no oxygen demand), as shown below.

Hydrogen peroxide + Sodium sulphide → Water + sodium Sulphate

VI. BIOLOGICAL TREATMENT

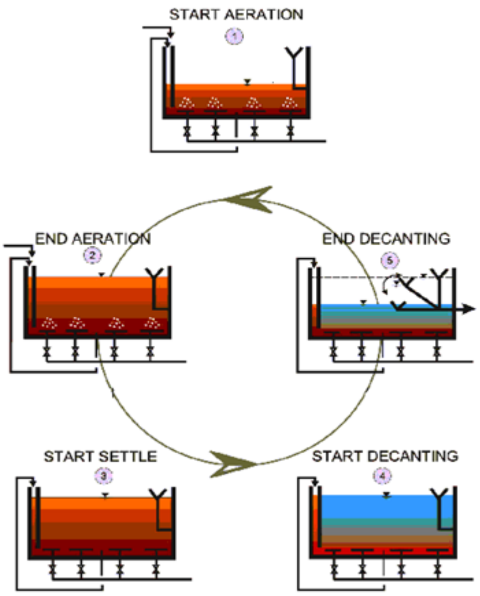
Organic matter, phenols, residual sulphides, non-recoverable oil and hydrocarbons contribute to the effluent's Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). BOD is indicative of the quantity of oxygen required to biologically stabilize the organic matter present in the waste water, while the COD indicates the oxygen requirement for oxidizing the organic matter by a strong chemical in an acidic medium, at elevated temperature. In order to stabilize the organic matter, biological treatment of waste water is to be accomplished by aerobic digestion of the organic matter. Most modern effluent treatment plants (ETP) in refineries employ Sequential Batch Reactor (SBR) followed by Membrane Bio Reactor (MBR) systems for treatment of organics.

Sequential Batch Reactor (SBR)

In Sequential Batch Reactor system a Cyclic Activated Sludge Treatment (C-Tech) technology is used. It provides highest treatment efficiency possible in a single step biological process. The C-Tech system is operated in a batch reactor mode. This eliminates all the inefficiencies of the continuous processes. A batch reactor is a perfect reactor, which ensures 100% treatment. Two or more modules are provided to ensure continuous treatment. The complete process takes place in a single reactor, within which all biological treatment steps take place sequentially as described below.

STEP 1: Fill-Aeration (F/A)
STEP 2: Settlement (S)
STEP 3: Decantation (D)

These phases in a sequence constitute a cycle, which is then repeated. During the period of a cycle, the liquid volume inside the Reactor increases from a set operating bottom water level. During the Fill- Aeration sequence mixed liquor from the aeration zone is recycled into the Selector. Aeration ends at a predetermined period of the cycle to allow the biomass to flocculate and settle under quiescent conditions. After a specific settling period, the treated supernatant is decanted, using a moving weir Decanter. The liquid level in the Reactor is so returned to the bottom water level after which the cycle is repeated. Solids are wasted from the Reactor during the decanting phase.

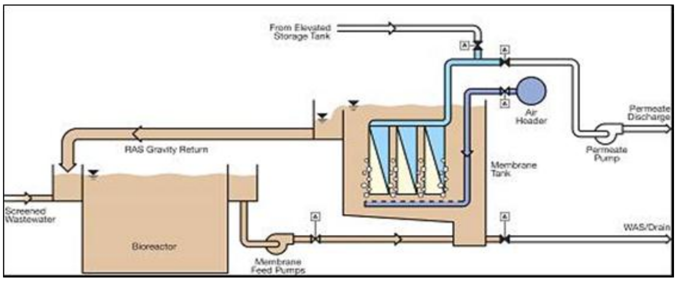


Membrane Bio Reactor (MBR)

Based on the process requirements and influent characteristics,a Modified Ludzack-Ettinger (MLE) process was selected for Membrane Bio Reactor system.

This design consists of the influent being fed into an anoxic zone followed by an aerobic zone. Nitrate formed in the aerobic and membrane zones, is recycled back to the anoxic zone where it is denitrified. Having the anoxic zone as a first zone, allows for maximum influent BOD utilization for denitrification (maximized the C:N ration).

The effluent of the SBR treatment will be collected in an MBR feed tank where submersible pumps will transfer wastewater into the Bioreactor Splitter Box. Wastewater is combined with the recycled mixed liquor from the membrane trains and is equally distributed into two biological trains. Supplemental carbon will be added in the Splitter Box should the influent carbon be insufficient for the biological process. Sodium hydroxide and antifoam agents will be added if required. A bypass of the SBR is included should the influent to the MBR be deficient in nutrients which will affect the biological process.Mixed liquor flows through each biological process train by gravity from the anoxic to the aerobic zone and into the Bioreactor Collector Channel. Foam and scum are collected in a foam trap located at one end of the overflow channel via a motorized downward opening gate. Dry-pit centrifugal pumps will transfer foam, scum and waste activated sludge to the sludge handling facility.



Mixed liquor recirculation pumps will transfer mixed liquor from the Bioreactor Collector Channel into the Membrane Tank Splitter Channel. Mixed liquor flows by gravity into (4) parallel ZeeWeed® membrane tanks via partially submerged sluice gates, which are designed to ensure equal flow distribution to all the membrane tanks and same water level in all tanks. The mixed liquor overflows to the Membrane Tank Collector Channel and it flows by gravity to the Bioreactor Splitter Box where it is combined with the influent before entering the anoxic zones.Clean water is withdrawn from the mixed liquor through the membrane using a dedicated permeate pump and is discharged to a common collector header discharging to the Treated Effluent Tank for RO feed. Permeate will be used from this tank for backpulsing and cleaning the membranes. The system is completed with membrane tank drain pumps. These pumps are common to all membrane trains and will drain the membrane tanks when required.

The treated effluent from SBR System is collected in MBR Feed Tank. It is then pumped to Membrane Bio Reactor (MBR) System.

VII. REVERSE OSMOSIS TREATMENT

The treated effluent after Membrane Bio Reactor is taken for the tertiary treatment. The tertiary treatment mainly consists of Reverse Osmosis System.
The Reverse Osmosis (RO) unit essentially works at the molecular level. It separates the molecular impurities from the water thus making one stream rich in salt molecules and other stream lean in salts thus reducing the TDS and silica of the water.

Reverse Osmosis System:

The treated water from MBR is further polished into RO plant to get the product water which can be use as feed to plant, floor wash etc.

In order to prevent the precipitation of the salts on reject side, an antiscalant is added at the inlet of the cartridge filter, which will result in inhibition of scales. Furthermore Sodium bisulfite shall be dosed to remove free chlorine present in the feed water. Presence of free chlorine in the feed water will irreversibly damage the RO membranes. 30 - 33 % HCl acid is also continuously dosed inlet of the cartridge filter to adjust the pH of the feed water.

Micron cartridge filter is provided in order to remove micron size particles, which is additional safety. Water is then pumped using high-pressure pumps through R.O. module for removal of TDS. Reverse Osmosis module consists of thin film composite Polyamide Membranes. On continuous running the R.O. membranes get fouled with fine colloids, bacterial debris or some times carbonate scales. These need to be removed and cleaned from the surface of the membrane.

VIII. SLUDGE TREATMENT

Biological sludge generated from SBR & MBR is thickened for volume reduction. Thickening is done by gravity belt thickener and then dewatered by centrifuge operation. Polyelectrolyte is used to increase efficiency of the centrifuge operation. The dewatered sludge send for further treatment and secured landfill.

IX. BIOREMEDIATION

The Bioremediation process is a biological method to reduce the Total Petroleum Hydrocarbon (TPH) level in the oily sludge to make it suitable for non-hazardous land fill site.

The process involves biological processing of the oily sludge in a confined Bioreactor using specially designed bacterial columns and advanced fermentation methods to degrade the petroleum hydrocarbon in the sludge producing a non-hazardous sludge with very low level of hydrocarbon. The TCLP analysis of the remediated sludge is within US EPA guideline for land fill in a non-hazardous site.

The Bacterial mass is naturally selected and acclimated with a careful blend of nutrients and surfactants. The reactor conditions promote growth of highly active microbial population which rapidly converts the TPH into carbon dioxide and water.

The contents of the bio reactor are closely monitored for temperature, pH, aeration intensity and nutrients. Each batch is treated for approximately 10-15 days after which the bio remediated sludge is removed from the reactor using discharge pumps.

The oily & chemical sludge generated from API, TPI Oil Separators, DAF, and RO & DM plant is thickened in a gravity thickener. The thickened sludge is dewatered by centrifuge operation. Polyelectrolyte is used to increase efficiency of the centrifuge operation. The dewatered sludge is send to bioremediation unit for further treatment.

X. CONCLUSION

The addition of membrane bioreactor along with a bioremediation tank ensures thorough treatment of waste water. The cost and maintenance of both these tanks are highly economical. Hence, does not hinder the efficiency of the plant.
These added plants also ensure complete biological purification of water.
Application of these systems in petroleum refineries would make the waste water highly potent to use.

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