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Effluent Treatment in LPG Bottling Plants
A Study on Mysore LPG Bottling Plant

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Abstract:- Effluent treatment has these days become very critical everywhere right from giant manufacturing units to mini household. Water being the precious resource, several attempts are being instigated to promote usage of treated water. A study is made on plant operations at one of the LPG Bottling plants in India at Mysore of Hindustan Petroleum Corporation Limited (HPCL). This paper discusses the treatment mechanism that is needed to be adopted at LPG Bottling plants for proper processing of hazardous wastes that come out as byproducts at these factories. This also compares the effectiveness of traditional treatment mechanism with SBR. Measures that are needed to be taken to increase water reusability and the various processes in which the treated water can be used are elucidated.

***Keywords**:- MDT, Organoclays, SBR, Degassing, Adsorption.*

I. INTRODUCTION

Liquefied Petroleum Gas (LPG) is a flammable mixture of saturated & unsaturated hydrocarbons, majorly propane & butane. The usage of it is widespread in various locations as aerosol propellant, refrigerant and predominantly in heating appliances, cooking and as fuel for motor vehicles. The salient feature of LPG is that it will transform into liquid state if compressed moderately at room temperature. There are many advantages of LPG over other sources of energy i.e when compared to oil combustion, LPG releases only 81% of CO_2 and when compared to combustion of coal, it releases only 70% CO_2 also sulphur content in LPG is very less which marks it most environmental friendly.

Density	0.525-0.575 g/cm^3
Auto Ignition Temperature	410-580^{0}C
Calorific value	11000-16000 Kcal/kg
Viscosity	0.3cSt@45^{0}C

Table 1. Properties of LPG

LPG in India is primarily used as cooking fuel. This is supplied in cylinders which are properly designed pressure vessels. LPG is filled into these vessels at LPG bottling plants. Owing to the hazard associated with the product, many safety precautions are adopted at these factories. Any factory has byproducts which come out as waste and are supposed to be treated to meet the standards set by the state before disposal.

An LPG Plant typically has following operations going on:

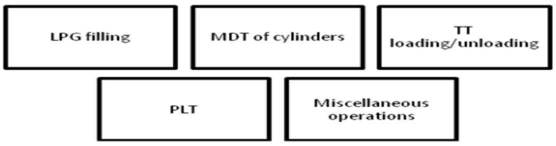

Fig 1:- LPG Plant Operations

II. LITERATURE REVIEW

A. Organoclays

This is an advanced method developed to separate out oil from water. These are prepared by modifying Bentonite with quaternary amines. They've got hydrophobic chains with large surface area emerging from clay surface. They are also used in paint formulation and as viscosifiers.

B. Sequencing Batch Reactor (SBR)

As the name suggests, it has sequence of several reactions happening in the same reactor. It is a 3 in 1 tank that can perform operations in treatment like equalization, aeration & clarification. It is a sound solution where there is a space constraint with an activated sludge system that follows fill and draw procedure. Inlet and outlet are separated for influent and effluent. Oxygen is bubbled through the mixture of waste water & activated sludge to reduce BOD & COD. Flocculating & Coagulating agents are then added to separate out colloids in form of flocs or flakes. Sediments are separated out by removing the clear water.

C. Mandatory Due for Testing (MDT)

LPG cylinders are typically pressure vessels specially designed to withhold the product at required pressure. Design bearing pressure of an LPG cylinder is 16.7kg/cm^2. Every pressure needs to undergo pressure test in stipulated time to remain fit for regular usage. In many cases this is achieved by the method of hydro testing (as name implies pressurizing the vessel with water). A new LPG cylinder will remain due for hydro testing after 10 years whereas a cylinder that has undergone hydro testing previously will be rechecked after 5 years. LPG cylinders are subjected to hydrostatic pressure of 25kg/cm^2 for 30 seconds while testing. Steps involved in this process are:

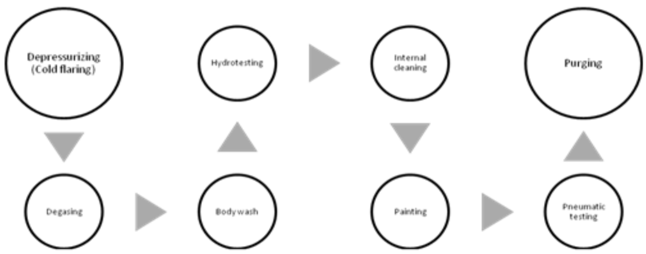

Fig 2:- Sequence of steps in MDT

D. Degassing

Degassing is the process of removing any traces of gas from the containing vessel. As LPG is very explosive in nature, it needs to be removed without any trace in order to work with its containing vessel. Once the cylinder that is due for pressure testing is segregated, it is depressurized by letting out the LPG. Further the valve is removed and the vessel is filled with water till the neck. This is kept undisturbed for 1-2hrs and then the water is let out. This removes any other wastes present inside the cylinder (especially pyrophoric iron that is formed as result of iron water reaction).

III. METHODOLOGY

Water is used for several purposes inside the plant. Water usage at a moderate demand plant has been studied. This plant bottles about 25000 cylinders per day.

Purpose	Quantity in lit
Degassing	17000
Hydro testing	2000
washing unit	4000
Test Bath	3000
Gardening	5000
Cleaning	1000
Office use	5000
Misc	1000
Total	38000

Table 2. Water usage at LPG plant in various processes

The effluent generated comes to around 25000litres per day. Majority of which is contributed by degassing. In all the processes happening inside plant (except panting), there are not many hazardous chemicals generated. Thus, if the water is treated properly with appropriate procedure, more than 20000litres can be reused, that brings down the daily water requirement of plant from outside. It is high time to incorporate the following steps in LPG plant operation to keep the process sustainable and economically viable.

A. Water treatment

In order to make the water reusable, it needs to be treated. In general treatment of water occurs in following phases.

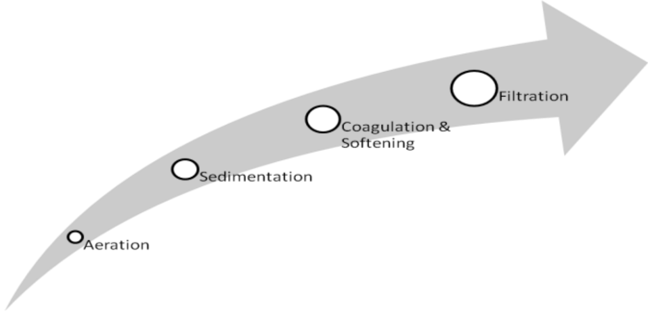

Fig 3:- Water treatment phases

There are also other intervening processes involved in treatment of water depending on prevailing water condition for eg. Dechlorination, Deflourination etc.

B. Water characteristics

There are certain standards up to which water needs to be treated in order to make it reusable. The aim of water treatment is to ensure water meets following standards. The procedure needs to be adopted appropriately to maximize water reusage. Following table enumerates the set parameters.

Parameter	Value
pH	6.5-8.5
TDS (mg/L)	2000
Chloride (mg/L)	250
Fluoride (mg/L)	2
Turbidity NTU	<30
BOD (mg/L)	<8
Sulphate(mg/L)	250
Hardness(mg/L)	60-120

Table 3. Safe water parameters

IV. WATER TREATMENT

The set up as shown in fig has been made. The process and the outcome are discussed in detail step by step.

Composition of wastewater:

As mentioned earlier, there are many types of wastes generated from various processes happening inside the plant. Majority of these include:

- Pyrophoric iron from Degassing
- Oils (Conkote) that are used as lubricants
- Chemicals used during body wash
- Miscellaneous wastes

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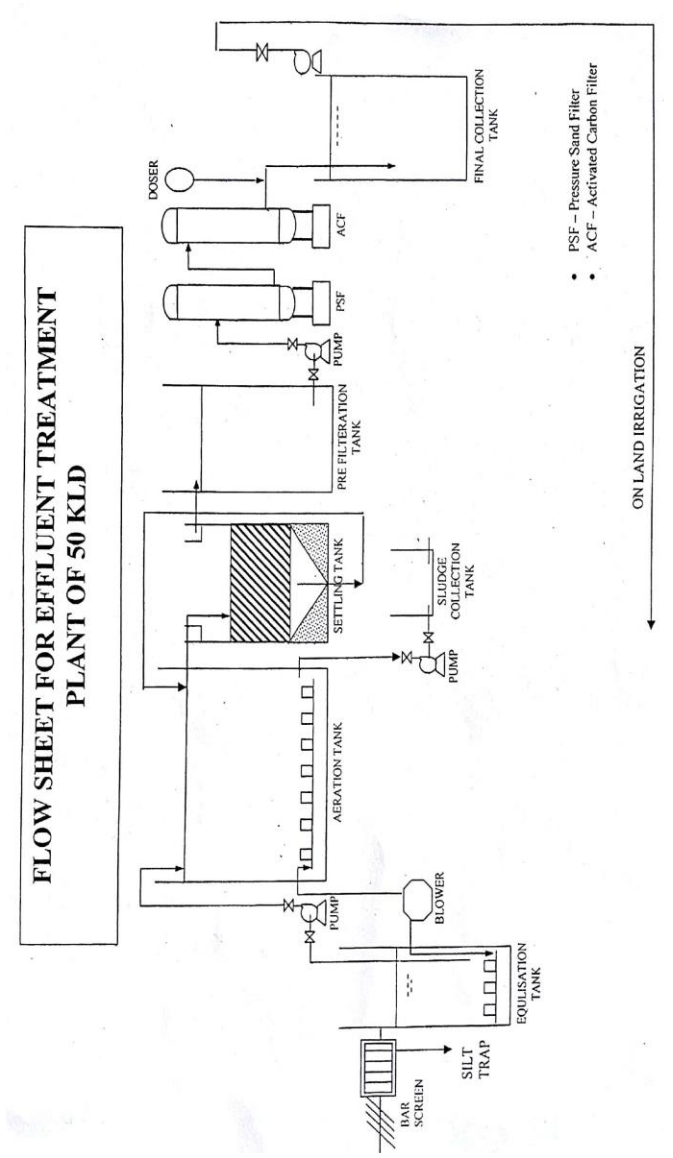


Fig 4:- ETP schematic

Influent Characteristics:

Waste water generated from all the operations happening inside the plant has been collected. Following values are observed against each entity:

Parameter	Value
BOD	50 to 100 mg/L
Suspended solids	100 to 200 mg/L
COD	250 to 350 mg/L
TDS	1000 to 1200 mg/L
Turbidity NTU	90 to 200 NTU

Table 4. Influent characteristics

There are also various other parameters which are outcome of innate nature of used water like chloride, fluoride, sulphate content etc. These are not taken into account as neither of the processes generate them as by products or wastes. Available methods to tackle them if present have been discussed in coming sections.

Each and every step involved in treatment has been enumerated below:

1. Screening & Oil separation:

Effluent generated is collected through sanitary sewers running across the plant and transported to equalization tank. Before the water is discharged from sewer to tank, it is allowed to pass through bar screen which separates out massive particles. Water is then kept undisturbed allowing the oil to separate out and float. The oil is now removed by an overflow weir and a skimmer.

The tank is lined up with Chemie range's organoclay coating at the bottom. This ensures the absorption of remaining oil droplets inside the water. Organoclay coating needs to be changed once in one or two months depending on the oil it has absorbed and its remaining capacity.

2. Aeration:

The purpose of this process is to bring water in contact with the oxygen so as to promote oxidation which converts undesirable substances to manageable forms. CO_2 & H_2S are removed from water. Aeration is achieved through diffusion with the help liquid gas contact systems. In this case air into water is adopted by introducing submerged air blowers. This process helps in prevention of formation of corrosive water. After aeration the water is then pumped into sedimentation tank.

3. Sedimentation:

After aeration the water is left out to settle in this tank. Heavy particles & compounds that are formed during aeration settle down in this tank. Although heavy particles are allowed to settle, there are some colloidal particles that do not settle. The clear water after sedimentation is pumped into pre filtration tank. Sediment is manually removed and disposed of in sludge drying bed.

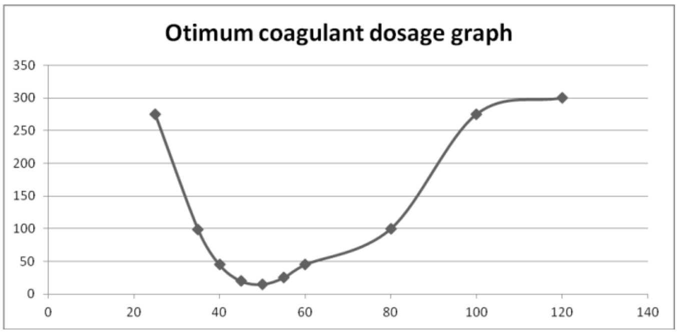
4. Coagulation & softening:

This process is carried in pre filtration tank. As mentioned earlier, colloidal particles settle very slowly or may not settle at all. The reason for this is the presence of electrical charge around the particles that repel each other hampering agglomeration. Colloidal stability is because of excessively large surface to volume ratio resulting from their very small size. In water treatment trivalent metallic salts are used such as $Al_2(SO_4)_3$ or $Fecl_3$. Alum on addition to water hydrolyses as follows:

$$Al_2(SO_4)_3.14H_2O \text{ -> } 2Al(OH)_3\,(s) + 6H^+ + 3SO_4^{2-} + 8H_2O$$

These form as flocs and settle down due to gravity. Coagulant dosage is added depending on the colloidal particles present inside the water. This was determined using Jar test experiment and the dosage as shown in fig. is being considered optimum.

Softening removes the hardness of water which is caused due to presence of multivalent metallic cations. This can be achieved with lime soda ash or caustic soda. In this case caustic soda (NaOH) is used as softening agent owing to its flexibility in removing all forms of hardness.



On Y-axis : Turbidity in NTU
On X-axis : Dose rate in ppm/v
Fig 5:- Optimum coagulant dosage graph

5. Filtration:

This is the polishing step. Its primary purpose is remove any leftovers of the previous processes. Many pathogenic organisms are also removed by filtration. In our case there is no organic waste involved and thus filtration need not be followed by disinfection before reuse. Two types of filters are made available here. They are:

- Rapid sand filter
- Activated carbon filter

Rapid sand filter uses bed of silica sand of depth 0.6 to 0.75m with rate of filtration from 2.5 to 5m/h. Several modes of operation are possible like upflow, biflow, pressure and vacuum filtration. In our case gravity filtration is used. The filter is designed in such a way that it has got large pores on the top and pore size reduces on moving down gradually. This helps in stopping bigger size particles on the top. After filtration, filter is cleaned by back washing.

Activated carbon filter is mainly used for removing organic constituents & residual disinfectants. The two principle mechanisms involved in this filtration are adsorption & catalytic reduction. Organics are removed by adsorption and disinfectants by the other one. It has an added advantage of removing chlorine (if present) by adsorption. As per reports 1 pound of carbon reacts with 6 pounds of chlorine. Due to non polar - non polar forces existing between carbon surface and contaminant, polar forces are overcome and adhesion on surface takes place. The water is then let out for normal usage.

6. Handling of sludge:

Wastes that are separated out in process are diverted into sludge drying bed before disposal. These include sediment in sedimentation tank, flocs in pre filtration tank, wastes that are obtained during back washing of filters. After drying these are disposed of into a safe place where they're buried underneath. As the organic content is very low, it cannot be used as manure for fields, also the quantity of sludge is less when compared to sludge obtained in any sewage treatment plant.

7. Miscellaneous operations:

Apart from the process stated, there also some intervening obstacles encountered depending nature of water obtained from various sources prior to usage. These include chloride, fluoride contents, presence of heavy metals, Ammonia etc. At LPG plants it is commonly observed that fluoride or chloride content is high after treatment. In order to account for it Calcium Chloride (Cacl2) can be used for removing fluorine hwereas sodium sulphate, sodium bisulphate, sodium sulphate or sodium metabisulphate can be used for removing excess chlorine.

V. RESULTS

After the treatment is over, water standards that were mentioned in table-3 were met. This is the evidence to show that treatment remained effective and that it is a sustainable approach to go for. Results are listed in the table-5.

Parameter	Value
BOD	<30 mg/L
Suspended solids	<100 mg/L
COD	<250 mg/L
TDS	1500 to 1800 mg/L
Turbidity NTU	<25 NTU

Table 5. Effluent characteristics

Out of 25KLD waste water generated, with the incorporation of a treatment plant, 20KLD of water was made available for reuse. This has drastically cut down the reliability of plant on other sources of water. This treated water can now be used for gardening and degassing which are major water consuming areas. The quantity recycled can be enhanced if the water losses that are occurring due to evaporation, improper placement of sewers, inefficient diversion of waste water is addressed.

Scope for introduction of SBR

Sequence Batch Reactor (SBR) is a new technique developed these days to improve the quality of treatment besides addressing space constraint and speed of the entire process. 3 processes are performed inside one tank i.e equalization, aeration & clarification. SBR serves great purpose when organic content in the waste water is high i.e. in cases like sewage. It can be used at LPG bottling plants as well owing to its innocuous nature and whenever there is a space constraint. Installation and operational costs are higher for SBR in this case. In the ETP schematic (fig 4), SBR replaces equalization, sedimentation & aeration tanks which keeps the setup minimal. Treatment time will be optimized as the time involved in transfer from one to other is reduced.

VI. CONCLUSION

As discussed in earlier segments, effluent treatment at LPG plants has got paramount importance especially in this modern era where the water crisis is growing day by day. It is pathetic to notice that many LPG plants are still functioning without an ETP and consuming enormous amounts of water regularly. As water consumption is inevitable, it is therefore very critical to treat the used water with stated techniques and promote reuse of water to maximum extent possible.

REFERENCES

[1]. Howard S Peavy, Donald R Rowe, George Tchobanoglous, Environmental Engineering, Indian Edition, pp. 11-182.

[2]. M A Aboulhassan et.al, "Treatment of paint manufacturing wastewater by the combination of chemical & biological processes"International Journal of Science Environment and Technology, Vol.3, No.5, 2014, 177-1758.
[3]. Robert A Corbitt, Standard Handbook of Environmental Engineering, 2nd edition, pp. 50-850.
[4]. R C Gaur, Basic Environmental Engineering, pp. 30-86.
[5]. S V sahni, LPG Operations Manual, Hindustan Petroleum Corporation Ltd, pp.1-372.
[6]. Punmia, B.C.,Jain, A and JainA, Water supply Engineering and Waste water Engineering. Laxmi Publications (P)Ltd., New Delhi, pp. 30-350.