Global Journal of Researches in Engineering
Industrial Engineering
Volume 13 Issue 2 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 Print ISSN:0975-5861

An Approach to Reduce Waste in Lead Acid Battery Industries

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Abstract - The following paper aims to inform the readers about various hazardous wastes like solid waste, liquid waste and air pollutant generated in lead acid battery industries, harmful effects of those wastes and necessary treatment needed to neutralize those hazardous wastes. Efficient methods of neutralizing those hazardous wastes to reduce the harmful effects on both human and nature are shown here. Considering ISO 14001:2004 some treatment plants like effluent treatment plant (ETP), air treatment plant (ATP), and Fume Neutralizer Plant are essential for neutralizing those hazardous wastes. The performance of those treatment plants are evaluated by checking out important parameters like PH, total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), chlorides and other heavy metals. Here the limits of those parameters of effluent both before treatment and after treatment are shown and finally some recommendations about waste management are given in the conclusion section.

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GJRE-G Classification : FOR Code: 660401

AN APPROACH TO REDUCE WASTE IN LEAD ACID BATTERY INDUSTRIES

Strictly as per the compliance and regulations of :

An Approach to Reduce Waste in Lead Acid Battery Industries

Md. Jasim Uddin [α], Pritom Kumar Mondal [σ], Md. Atiqur Rahman [ρ] & Md. Hasibur Rahman Lemon [ω]

Abstract - The following paper aims to inform the readers about various hazardous wastes like solid waste, liquid waste and air pollutant generated in lead acid battery industries, harmful effects of those wastes and necessary treatment needed to neutralize those hazardous wastes. Efficient methods of neutralizing those hazardous wastes to reduce the harmful effects on both human and nature are shown here. Considering ISO 14001:2004 some treatment plants like effluent treatment plant (ETP), air treatment plant (ATP), and Fume Neutralizer Plant are essential for neutralizing those hazardous wastes. The performance of those treatment plants are evaluated by checking out important parameters like PH, total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), chlorides and other heavy metals. Here the limits of those parameters of effluent both before treatment and after treatment are shown and finally some recommendations about waste management are given in the conclusion section.

Keywords : lead acid battery, effluent treatment plant, biological oxygen demand, waste management.

I. Introduction

Battery industry represents an important and growing sector where the uses of toxic and hazardous materials are quite frequent. By visiting some renowned lead acid battery industries like Abdullah Battery Company Pvt. Ltd, Electro-battery industry and 'RAHIMAFROOZ' battery industry we have come to know that the substitutions of toxic and hazardous materials by non-toxic and non-hazardous materials are not totally developed yet. Lead is one of the vital ingredients of the lead acid batteries.

Global lead consumption was exceeded 10 million tons in 2011 and approximately 80% of the lead produced is used in manufacturing lead acid batteries [1] [2].

There is immense growth in the demand for the lead batteries. Lead poisoning is the most serious environmental health threat to children and one of the most significant contributions to occupational disease. Lead causes symptoms ranging from the loss of neurological function to death depending upon the extent and duration of exposure both children and adults can suffer from an illness including effects on central nerve system, kidneys , gastrointestinal tract and blood forming system. Lead also affects the reproductive system in both men and women [3]. The annual cost of lead poisoning in children in the U.S. alone is estimated to exceed $43.4 billion, worldwide estimates are not available, but would greatly exceed this figure, as exposures are known to be significantly higher in developing countries [4]. The average blood lead level among children residing near battery plants in developing countries is 13 times the average level observed for children in the United States and the average workers blood lead level in battery manufacturing plant in developing countries is over 4 times the level considered to be elevated by the U.S. CDC for the purpose of surveillance.

In production of lead acid battery huge amount of sulfuric acid (H2SO4) is used. It lowers the PH value of water when mixed up with water which raises the acidic property of water [5] [6]. If lead acid batteries are disposed of in a solid waste landfill or illegally dumped the lead and sulfuric acid can seep into the soil and sulfuric acid contaminated ground water, potentially affecting the quality of our drinking water supply.

Government has taken steps to ensure the proper management of this hazardous waste and safety of both human and environment because of so many disaster and environmental impacts in the last few years. Battery waste water is characterized by its PH, BOD, TDS, COD, Sulphate, Chlorine and heavy metals like Arsenic, Lead [7]. The levels of pollutants in lead acid battery wastewater also vary depending upon the process adopted in battery manufacturing. Liquid wastes are neutralized by proper ETP system, the pollutants of the air are removed by ATP and solid wastes are reused in production process by recycling [8]. The purpose of this waste management is not only to keep the environment sound but also to make the production process economical.

II. Methodology

After visiting some renowned battery industry then their existing waste management system was studied by discussing with concern personal. From battery waste management literature and consulting with industry waste concern person and discussing with some chemist some proposed ETP, ATP, fume neutralizer plant and recycling plant was developed.

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Here methodology includes the treatment of liquid waste, air pollutant and solid waste. The treatments are possible by the proper functioning of ETP, ATP, Fume Neutralizer Plant and recycling plant. The performance of those treatment plant were judged by differentiating the values of different parameters like PH, BOD, TDS, COD, TSS, Chloride and Sulphate before treatment and after treatment. The samples were collected at inlet and outlet of the effluent treatment plant units and analyzed as per Standard Methods for the Examination of Wastewater. The samples were analyzed for various parameters like p^H, BOD, COD, TSS, and TDS.

a) Effluent Treatment Plant

ETP has designed to provide chemical processes and these processes are needed to balance the PH level of waste water. Separation of oil from wastewater to purify it is also another purpose of ETP. Lead acid batteries are obtained through the chemical processes by using Lead, PbO, sulfuric acid and other chemical substances. The unwanted residue obtained at the time of preparation of acid forming, jar forming and other processes which contribute to major amount of COD, TDS, TSS and leady effluent and other heavy metals. Here the designed ETP consists of all component units such as oil separation tank, neutralizing tank, Alum dozing tank, NaOH dozing tank, one step purifier, Sedimentation tank, pure water tank, PH and TDS test units etc. A Schematic block diagram of the treatment plant is shown in the Fig.1.

At first effluent is taken to the oil separation tank where oily substances are separated from the waste water which can also be called heavy water. Then it is taken to the heavy water tank through a pipeline. Then heavy water is taken to the neutralizing tank where Alum and NaOH are dozed from alum dozing tank and NaOH dozing tank respectively to balance the PH level. Then PH is used to test the PH level of the water in the neutralizing tank. The activities in the neutralizing tank will be repeated until the PH level reaches to the acceptable limit. When the PH level is okay then TDS test will be conducted. If the result of the TDS is not satisfactory then that water will be experienced a chemical process called Ion Exchange where colloidal particles will become sediment. Then the water will be filtered. Now again TDS test will be conducted. If this time result is okay then the water will be sent to the one step purifier. If the value of TDS is inacceptable limit in the very first time it will be then directly sent to the one step purifier without conducting the process of Ion Exchange. In one step purifier light particles are separated from the water. Then it will be sent to the sedimentation tank for the final separation of the sludge. Then it will be sent to the pure water tank and this water can be reused in production process or it can be allowed to go the environment.

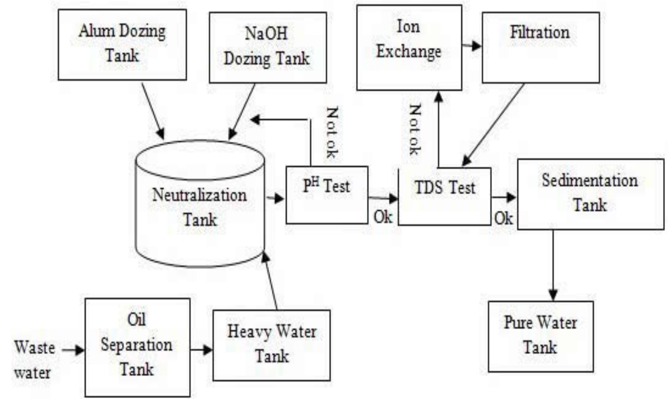

Figure 1 : Schematic block diagram of ETP

We have made estimation about the size and capacity of different units of our designed ETP. The estimation is made by considering that the monthly production is 50000 batteries. The size and capacity can be varied with the frequency of the production.

Table 1 : Size and capacity of different units of ETP

SN.	Unit	Sizes	Capacity (Approximate)
1	Oil Separation Tank	2.5m*2.0m*3.0m=15.0m^3	15000 liter
2	Heavy Water Tank	2.0m*1.8m*2.8m=10.08m^3	10000 liter
3	Neutralizing Tank	1.5m(Diameter)*3m(Height)=5.3m^3	5000 liter
4	Alum Dozing Tank	1.5m*1.0m*2.5m=3.75m^3	3700 liter
5	NaOH Dozing Tank	1.5m*1.0m*2.5m=3.75m^3	3700 liter
6	Rotary Vacuum Filter	Cloth having 10 μ, vacuum create at 500 to 600 mmHg	5 RPM, 75Kg/hr Sludge removal
7	Sedimentation Tank	2.3m*2.2m*2.5m=12.65m^3	12500 liter
8	Pure Water Tank	2.0m*1.5m*2.5m=7.5m^3	7400 liter
9	Sludge drying bed	2.0m*1.75m*2.0m=7.0m^3	7000 kg

b) Air Treatment Plant

There are many air emission technologies like Electrostatic Precipitators, Fabric Filters or Bughouse and Wet Scrubbers. These technologies are commonly installed to reduce the concentration of substances in process off-gas before stack emission. In the case of lead acid battery industries the Bughouse technology is the best suited and economical dust collection process. Bughouse technology has 90% efficiency to separate air pollutant like acid mist, leady fumes and particulate matters. In the case of lead acid battery lead is the most devastating air pollutant.

Our designed ATP is based on Bughouse technology. It consists of rotary unit, separation house, U-shaped condenser chamber, one cone chamber, two cone chamber, bughouse and chimney. The schematic block diagram of our designed ATP is shown in Fig.2.

At first exhaust gas is sucked by a rotary unit and then the gas is forced to strike with the wall of the house where heavy particles like lead will be fallen down. Then the gas will pass the condenser chamber. The condenser chamber consists of four U-shaped condensers where the gas will be condensed to remove the particles. Then the gas will be moved towards the one cone chamber. In one cone chamber, the gas will be circulated and moved downward rapidly and at the bottom, it will face an obstacle. Then the gas will move upward and heavy will be separated because of upward movement. Now the gas will move towards to the two cone chamber and will be divided into two groups for more perfect separation of heavy air pollutant. Then the gas will be sucked by the bughouse for the final separation of the dust from the gas and after this pollutant will be removed. Then the gas will be allowed to go to the atmosphere. This process is very much economical because here huge amount of lead will be recovered in different stages of the process.

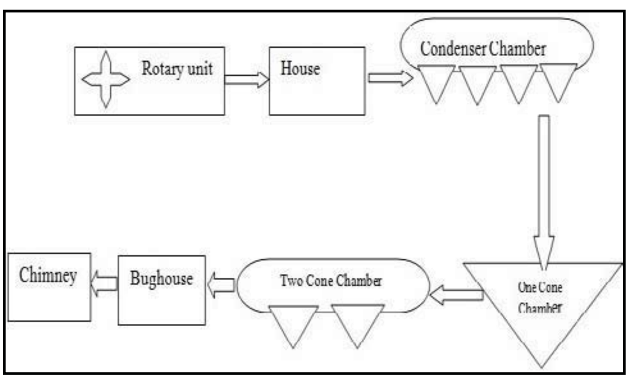

Figure 2 : Schematic block diagram of ETP

c) Fume Neutralizer Plant

Fume neutralizer plant is designed for the treatment of fume to neutralize acidic gasses. In ATP heavy particles like Lead, particulate matter etc. is separated from the fume. In lead acid battery industries huge amount of sulfuric acid (H_2SO_4) is used in electrolysis process. Because of the electrolysis process some acidic gasses like SO_2, SO_3 etc. are generated which increase the acidic property of the air. The increasing acidic property of the air is very much harmful for the environment. So it is very much essential to neutralize the acidic property of the air.

Our designed fume neutralizer tank consists of blower, neutralizing tank, NaOH dozing tank and exhaust chimney. The schematic block diagram of the designed fume neutralizer tank is shown in Fig.3.Fume is sucked by a blower and then forced to go to the neutralizing tank where NaOH is dozed. In neutralizing tank a chemical reaction is taken place between NaOH and acidic gasses. By the chemical reaction the acidic property of the fume will be neutralized. Then the fume will leave the plant and go to the environment through the exhaust chimney.

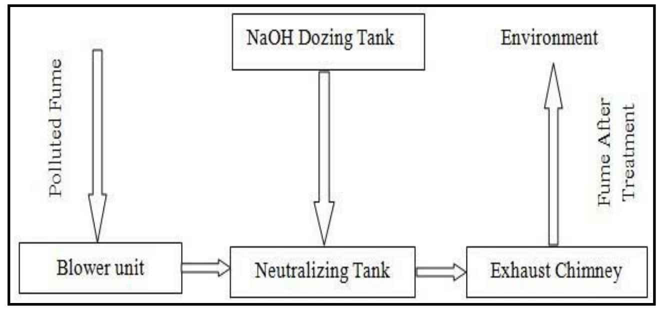

Figure 3 : Block Diagram of Fume Neutralizer Plant

d) Hazardous and Solid waste management

Solid waste, also known as dry refuse and is practically in dry state. Disposal of refuse is depending upon frequency of generation and production of products. Plastic scrape, leady paste, lead oxide paste and glass mats are treated as hazardous waste. Leady paste generated from ETP and dry lead from ATP which are sent for recycling of lead and it has not any direct ill effect to worker. Lead oxide paste from processing reused itself in process. The discarded plastic scrapes are mostly sent it for recycling. Recycling is the recovery of material from waste created in manufacturing and consumption, for reuse in the production of new items [9]. Recycling is very much essential because with the help of recycling we will be able not only to remove reusable materials from the waste which will reduce the environmental pollution due to solid waste but also to utilize recoverable materials as a production input which will help to conserve both nonrenewable resources and energy. Our proposed overall recycling system is divided in to two segments. In-plant recycling and recycling or secondary material industry are these two segments.

In the case of In-plant recycling strategy it is possible at several stages of production to recycle certain materials within the same manufacturing facility. When in-plant recycling is not feasible, it may be possible to recover certain materials from waste by secondary material or recycling industry. Overall view of the total recycling system is shown in Fig.4.

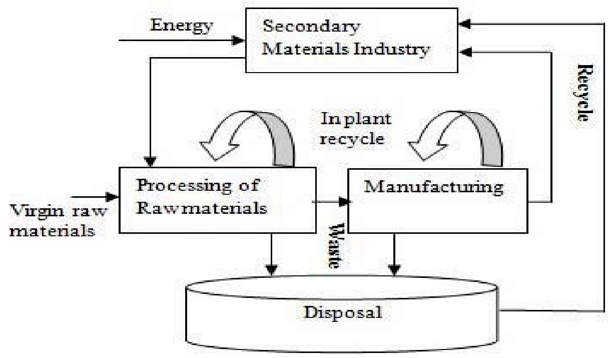

Figure 4 : Overall view of the total recycling system

Here we can see that solid wastes are disposed in the time of processing of raw materials and manufacturing. In-plant recycling is only feasible in the case of processing of raw material and production of final process. If in-plant recycling is not possible then secondary material industry is needed. Then the disposal from different areas like raw material processing area, manufacturing area are collected and sent to the secondary material industry for recycling. Waste can be directly sent to the secondary material processing industry from the manufacturing area. After recycling of the solid waste in secondary recycling industry, we can get our production input. Then these production input will be sent to the raw material processing zone and after processing which will be used in production of the final goods.

III. Result & Discussion

The analysis of wastewater is usually being carried out for pH, COD, BOD, TDS, TSS, Chlorides, Sulphates. The results of treatment for major pollutants in treated and untreated water with respect to each treatment operations are discussed below. The effluent parameters were continuously checked in few lead acid battery industries to know the range of the values of those parameters for obtaining better quality effluent that has to reach the effluent standard limits as prescribed by MPCB. Considering the range of the values of different parameters, the designed ETP will be able to keep the parameters in the standard limit. Daily checking is needed for pH, TDS, TSS, lead for the safety and unit process requirement point of view. Effluent samples were collected from several lead acid battery industries. In laboratory these samples were used to conduct some chemical operations which are specified in the above designed ETP to ensure that whether the ETP is working soundly or not. The average pH ranges for influent waste was 2 to 3 which showed the acidic nature and after the designed treatment it was neutralized. In wastewater, dissolved solids consists mostly of inorganic salts such as, chlorides, sulphates, lead, arsenic etc., and a small amount of organic matter and dissolved gases. The industrial wastewater contains large amount of chlorides, which can cause significant disruption in the ecological balance. Many techniques have been adopted in order to reduce the amount of chlorides in wastewater like demineralization, reverse osmosis, coagulation, precipitation, electro dialysis and so on. In this study, the variations in pH due to acidic waste which generated from jar formation and acid dilution plant had highly acidic in nature. The value of total dissolved solids (TDS) in the wastewater was very high and after lime treatment TDS was standardized. By analyzing the value of TDS in few industries, it was noticed that it ranges from 2800 to 3100 mg/l which had been reduced to 2100 to 2200 mg/l. Wastewater contains considerably high COD due to presence of some organic and inorganic materials. Before treatment, COD had a value ranges from 900 to 1000 mg/l which had also been reduced to acceptable limits 250 to 300 mg/l after designed treatment. Graph shows variation in daily influent and effluent wastewater. Daily fluctuation presented in graph those are given below in Figure no. 5.,6,7,8. Fig.5 shows variation in p^H value against days the variations ranges 2 to 3 and 7 to 8. Before treatment P^H had a low value that means the wastewater was acidic and after treatment it had been seen that P^H value had increased and the acidic property had also been neutralized.

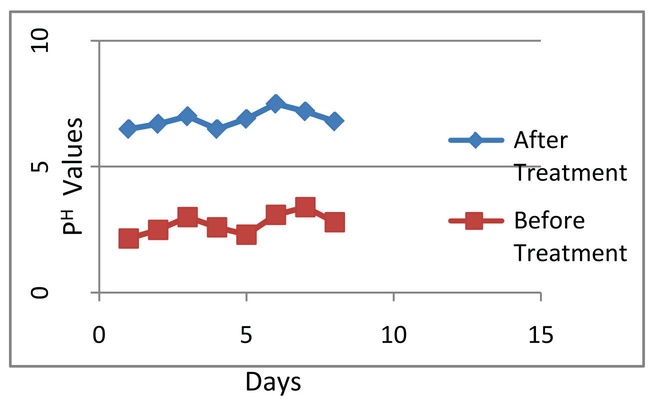

Figure 5 : Variation in pH value against days

Fig.6 shows variation in TDS values against days, the variations in influent TDS due to presence of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular in suspended form. Here it is seen that the value of TDS before treatment was 2800 to 3100 mg\l and after treatment it had been reduced to 2100 to 2200 mg\l.

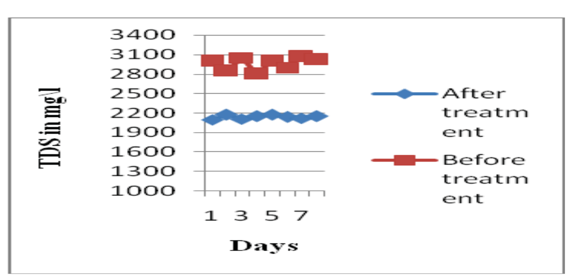

Figure 6 : Variation in TDS values against days

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Fig.7 shows variation in COD values against days, the variations in influent COD due to presence of chlorides, sulphates, heavy metals and other chemicals. Before treatment COD was 900 to1000 mg\l and after treatment it had become 250 to 300 mg\l.

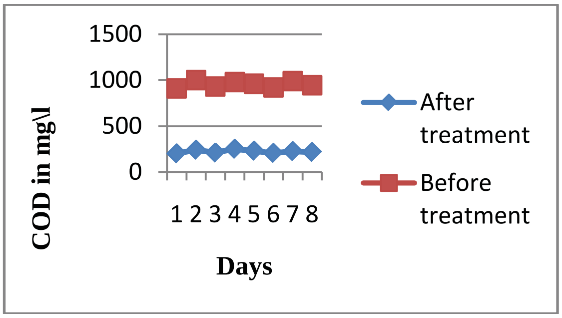

Figure 7 : Variation in COD values against days

Fig. 8 Shows variation in BOD values against days. Before Treatment BOD was 350 to 450 mg\l and after treatment it had been reduced to 50 to 100 mg\l.

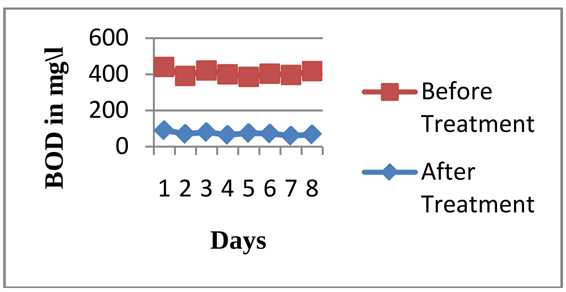

Figure 8 : Variation in BOD values against days

In lead acid battery production, huge amount of lead is needed and a portion of that lead is wasted and mixed with the fume. So it causes air pollution and presence of lead in air is very harmful especially for children. So, an ATP has been designed which has 90% efficiency to reduce the amount of lead in fume. Electrolysis process is needed to be conducted to produce battery. Which causes the generation of acidic gasses and that is very much harmful not only for human but also for environment. Those acidic gasses can be neutralized in fume neutralizer plant by chemically reacting with NaOH. Solid wastes or hazardous wastes are very much frequent in production processes and have a great impact on the atmosphere. Solid waste can be reused by recycling. Plastic scrape, leady paste, lead oxide paste and glass materials are the most common solid waste produced in lead acid battery industry. All these solid wastes can be recycled either by in-plant recycling or by secondary material industry.

IV. Conclusions

The study indicates that all major pollutants including heavy metals will be drastically reduced in the wastewater during the treatment process. The pH, BOD, COD, TSS and TDS of raw influents are generally recorded to pH 2.5, BOD 370 mg/L, COD 950 mg/L, TDS 3100mg/L and TSS 275 mg/L, while the mean values of the same parameters in the treated effluent estimated will be 7.6, 74.6 mg/L, 182 mg/L, 90 mg/L and 1945 mg/L. Generally the ratio of COD and BOD in the raw effluent is found 2.60, which will be significantly reduced to 2.3.The treated effluent results showing that all the inorganic matters will be removed significantly. If all the treatment units run successfully then waste disposal system will be appropriate. It will then not only help to keep the environment green but also help the industry economically by reducing waste and recycling it to make raw materials.

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