Analysis on pollution prevention and control of waste lead battery recycling process

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Abstract. From the perspective of recycling, waste lead-acid batteries have very objective utilization value. However, from the perspective of environmental protection, waste lead-acid batteries contain many pollutants, which will cause serious pollution and damage to the environment if not handled properly. Containing lead, not only has a very high collection value, also is likely to lead pollution and poisoning accidents caused by improper operation, cause a threat to people's life and health, therefore, this text set about from the pollution source analysis, through the way of recycling and pollution prevention and control technology were analyzed, and aims to take certain measures to protect the environment, protect health.

1. Introduction
As far as China is concerned, about 5 million tons of waste lead batteries are produced every year. However, China is not optimistic about the recycling of waste lead batteries at present. More than 80% of the waste lead batteries will flow into the illegal recycling market, and few enterprises can establish the context of unified acquisition. For the recycling of waste lead batteries, there is a great mobility, and individual professionals have become the main body of recycling waste lead batteries. However, due to the lack of professional knowledge and environmental awareness of most individual professionals, in the process of recycling and transportation of waste lead batteries, it often happens that the batteries are disassembled and the protective cases of waste lead batteries are discarded at will. It not only poses a certain threat to the environment and human health, but also causes a serious waste of lead resources, which violates the concept of sustainable development.

2. Waste lead-acid battery pollution tracing
The special structure and composition of lead-acid battery are relatively special, as shown in the table below. The main components of lead-acid battery are lead, plastic, sulfuric acid, glass fiber, copper, etc., among which lead accounts for 70% to 80% and electrolyte accounts for 10% to 20%. Due to its extremely high lead content, it is very valuable for recovery, and the acid can easily cause damage to the environment due to its characteristics. Therefore, it is necessary to pay attention to the recovery rate of resources and prevent waste liquid and waste gas from polluting the environment in the process of transportation and recycling. Based on this, the research on pollution of lead-acid batteries focuses on the following three aspects: pollution in the recycling process, pollution in the dismantling process and pollution in the reuse process.
Table 1. Description of main structure of lead-acid battery

| Main composition | Brief account |
|------------------|---------------|
| Positive and negative plates (1) | It consists of grid and active material, the grid material is generally Pb-Sb alloy, and the maintenance-free battery is Pb-Ca alloy. The active material of positive plate is mainly lead dioxide, and the active material of negative plate is mainly metallic lead. |
| Baffle (2) | It is made of corrosion-resistant insulating materials such as microporous rubber and composite glass fiber. |
| Electrolyte (3) | Is prepared from concentrated sulfuric acid and deionized water. |
| Battery case, cover (4) | Containers containing positive and negative electrodes and electrolyte, generally plastic and rubber materials. |
| Exhaust plug | Generally made of plastic. |
| Other parts | including chain, pole, saddle and page display, etc. |

2.1. Pollution analysis of recovery process

This level mainly focuses on the imperfect recycling industry chain and non-standard recycling mode. Due to domestic has not yet establish a unified, standard of scrap lead-acid battery recycling, at the same time no formal large old lead battery recycling companies on the market, many recycling batteries belong to individual operators, so also did not form a system specification recycling industry chain, and these batteries soho general lack of professional knowledge, has produced many problems in the process of collection and transportation, brought bad effects to the environment, such as the lead in the waste lead acid storage battery acid directly discharged into the sewer, not to deal with. Or in the transportation process did not take measures to prevent leakage of liquid, which caused damage to the environment, also affected people's health. After the waste battery recycling did not take a timely scientific approach, and even some small enterprises will pile up in the open, so that the acid leakage pollution of the environment and water resources. After evaporation of acid solution, acid mist may also be generated, thus causing damage to the air layer [1]. In addition, the wrong choice of recycling mode will not only cause resource waste, but also cause environmental pollution to a certain extent.

2.2. Pollution analysis of recovery and disassembly process

According to relevant national industrial policies and regulations, based on the composition characteristics of waste lead-acid batteries, the dismantling of waste lead-acid batteries must be carried out by enterprises with hazardous waste operating licenses. The disassembly of lead-acid batteries from standardized regenerative manufacturers shall go through the steps as shown in the figure. Under the action of disassembly, rolling and gravity, the waste lead-acid batteries shall be divided into waste acidic electrolyte, electrode paste, metal particles, bake lite and polypropylene, etc. In non-standard regenerating plants, lead acid batteries are generally disassembled manually with tools such as axes. During the dismantling process, a little attention to the battery acid may cause leakage problems, lead paste will also be discarded. But lead paste contains a number of chemicals that can eventually wreaking havoc on the environment. The specific dismantling steps of waste lead battery are shown in Figure.
Figure 1. Disassembly steps of waste lead-acid batteries

2.3. Reuse process pollution analysis
Good and evil people mixed up because waste lead-acid battery recycling industry, some small furnace lead smelting enterprises equipment is adopted by the soil, small reverberatory furnace, etc., these devices are very backward, and the lack of corresponding exhaust gas treatment equipment, resulting in production when not in accordance with the relevant national standards effective treatment tail gas of sulfur dioxide, particulate matter, lead and other harmful substances, such as metals, adverse impact on the human body to the air. [2] so recycling link is the most important thing for recycling waste lead acid battery lead in resources, metal lead, lead paste these sludge is mainly obtained in the process of dismantling waste lead acid battery materials, all these lead and its compounds can be used in the process of production of secondary lead, therefore, based on the regeneration of the recycling process of lead is the key of the waste lead acid battery recycling, this link is the pollution caused by waste liquid, waste gas pollution, etc.

3. Prevention and control technology of waste lead-acid battery pollution
On the basis of proper selection of recycling methods and reasonable utilization of facilities and equipment, the key point of pollution prevention and control for waste lead batteries lies in the combination of source control, pollution monitoring and emergency response.

3.1. The choice of recycling mode
From the perspective of fuzzy evaluation, this paper selects the appropriate recycling methods of waste lead batteries from four recycling methods: battery manufacturers, automobile manufacturers, secondary dealers, industry alliances and professional recycling resource enterprises. In order to achieve this goal, it is necessary to conduct comprehensive evaluation from multiple aspects and the current situation of the industry. In this paper, four factors including recovery efficiency, technical ability, recovery cost and operation scale are selected to constitute the evaluation index system set.
3.1.1. **Objective layer, criterion layer and scheme layer are established.**

![Diagram](image)

**Figure 2.** Target layer, criterion layer and scheme layer

3.1.2. **Criterion layer weight calculation.** According to the target layer, the criteria layer factors are compared in pairs to build a judgment matrix:

\[
\begin{bmatrix}
1 & 1/3 & 1/3 \\
3 & 1 & 3 \\
3/5 & 1/3 & 1
\end{bmatrix}
\]

According to the matrix A, \( CI = (\lambda_{max} - n) / (n-1) \) = 0.095, CR = CI/RI = 0.099 < 0.1, so the judgment matrix consistency test is passed. The weight of each factor in the criterion layer is calculated as: \( W = \) (recovery efficiency is 0.07, technical capability is 0.56, recovery cost is 0.22, operation scale is 0.15).

After scoring by professionals, the scores of various modes are: automobile manufacturer = (70, 70, 75, 80), car dealer = (80, 70, 70, 65), battery manufacturer = (80, 80, 75, 80), trade unions = (80, 90, 80, 95), battery recycling enterprise = (80, 85, 80, 85).

| Table 2. Final score table of five recycling methods |
|-----------------------------------------------------|
| Trade unions | Recycling enterprise | Battery manufacturer | Automobile manufacturer | Car dealer |
|--------------|----------------------|-----------------------|-------------------------|-----------|
| 87.75        | 83.6                 | 78.9                  | 72.6                    | 69.95     |

To sum up, the industry alliance with the highest score has a good development prospect. The industry alliance can be formed by battery production enterprises, automobile production enterprises and battery recycling enterprises. Through the sharing of resources such as equipment, personnel and funds, and the sharing of waste or used battery recycling information logistics network, the operation risk and cost can be reduced and the high-efficiency waste or used battery recycling can be realized. In the other four battery recovery main body modes, the form is a single operating main body. At present, the comprehensive strength of a single operating entity is limited, so many problems will be encountered when recycling waste or waste.

3.2. **Source control**

In order to recycle waste lead-acid battery reasonably and effectively, and ensure safety and environmental protection, it is necessary to choose appropriate facilities and equipment to meet the needs of environmental protection, and to have high efficiency, energy saving, easy to operate and other characteristics.

Collect process control. To prevent waste lead battery electrolyte leakage, appropriate measures should be taken to prevent waste lead acid battery damage and acid leakage at the recovery point. The waste lead battery should be properly placed, such as placed in a special corrosion-resistant container that is not easy to be damaged or deformed, and the acid leakage will cause environmental pollution.
Loading and unloading process control. The handling of waste lead battery shall be handled in strict accordance with the procedure, and handled lightly to avoid leakage of waste lead battery electrolyte caused by wrong operation or collision.

Storage process control. After the admission and loading of lead-waste batteries, the integrity of the batteries shall be checked and sorted carefully. The complete sealed maintenance-free waste lead battery shall be stored on the shelf in the complete waste storage area. If there is any damage, the damaged waste lead battery shall be placed in a special container resistant to corrosion and not easy to damage and deformation.

3.3. Pollution prevention and control in the process of recycling lead

At present, hydrometallurgy and fire-gold metallurgy are mainly used to finish the metal lead treatment. There are two modes of fire metallurgy. The first mode is pre-desulfurization followed by reduction of lead by low-temperature smelting. In the process of pre-desulfurization, sodium sulfate solution is easy to be formed and high-purity salt is produced. The second method is to recycle lead by melting reduction to avoid the problem of sulfur pollution. It needs to produce acid in the flue gas containing sulfur dioxide during smelting, and the exhaust gas must be treated before it can be discharged. When using these two methods, blast furnace and reflector without direct coal burning can be used. Meanwhile, reasonable control should also be carried out on the melting medium and other medium, so as to eliminate all the sulfur and lead oxides in the battery debris. Because the whole process is closed, so also want to use airtight short kiln, avoid harmful material, pollution composition to discharge. The gas must be treated before it can be discharged.

There are also two models of hydrometallurgy, one is the solid-phase electroreduction of lead, the other is the pre-desulfurization - electrolytic precipitation. Among them, the lead paste will be attached to the cathode plate after the lead reduction by solid phase electrolysis is treated with sodium hydroxide, and the lead bloom of solid phase in the electrolysis process will gradually be reduced to metallic lead. Because of the presence of pollution elements, this process must be closed, and the gas can only be discharged after treatment. The second kind of pre-desulfurization needs to be treated with ammonium carbonate and alkali metal carbonate to finally make the lead in the lead paste into lead compounds. The desulfurization materials generally choose silofluric acid. After obtaining the electrolyte, it is necessary to conduct electrolytic precipitation, and then promote the desulfurization solution to be evaporated after leaching, and finally recover.

4. Conclusion

With the concept of sustainable development and the introduction of an environmentally friendly society, China has issued a number of relevant laws and policies in recent years to standardize the management of lead battery recovery, and strive to establish a perfect waste lead battery recovery system, to solve the problem of recycling. In order to alleviate the shortage of resources in China, reduce the pressure on the environment and strengthen people's awareness of environmental protection in the treatment of waste lead-acid batteries, stricter and more environmentally friendly requirements are put forward for participating enterprises. The pollution problem of waste lead-acid battery recycling process restricts the development of the industry, so it is necessary to improve the current situation through technology upgrading and concept transformation, in order to essentially improve the recycling efficiency and reduce the generation of harmful substances.

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