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RECYCLING AND REUSING OF BATTERIES AND ITS COMPONENTS: A REVIEW

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1. ABSTRACT

This paper checks out the way toward reusing batteries particularly lithium-ion batteries. As we are drawing nearer towards electric vehicles, lithium-ion batteries are to be utilized. Their accessibility is less and costly. Likewise, this paper centres on strategies for reusing difficulties that are being confronted. Likewise, what activities can be begun for reusing batteries and finding reasonable and efficient ways when a battery is at end of its life.

1.2 Introduction

As recycling of all the materials is somewhat not good nor bad. For automotive batteries we have a clear vision of the materials used and their toxic nature. It only may depend on the various battery types and the recycling method. If the reusable material can be removed from the used or dead batteries then extraction of raw material should be practiced. Recycling of the batteries will also reduce the costs which are involved in the import duties of materials that are not available in the country. And also help the environment by reducing the SOx, smelting nickel, copper, cobalt in the atmosphere as mining extraction of materials will be less practiced. Also helps in reducing payments that are involved in the waste management of hazardous materials. As the need for an electric vehicle is being increased the demand for lithium-ion batteries is also being increased and fewer lead-acid and nickel batteries are be took used. Recycling methods should safe, economical, environmentally safe and transportation should be taken care of. And also recycled batteries should be of fine quality so that they can find a useful place in the market for their optimum purpose.

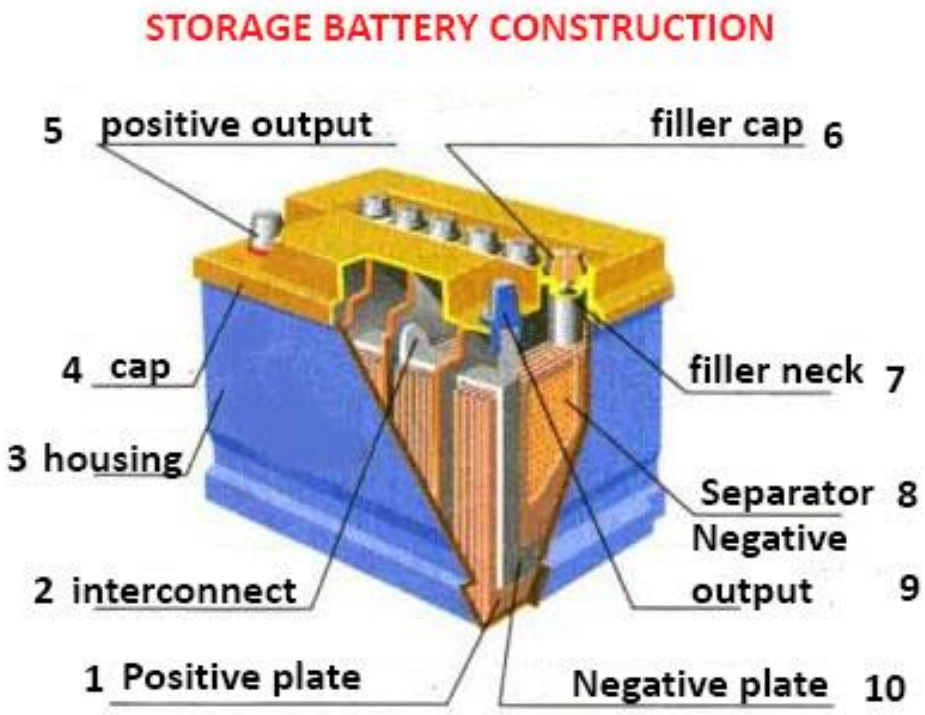
1.3 Comparison of automotive batteries

Before understanding the subject altogether, it is a lot of imperative to comprehend various sorts of car batteries which are by large significantly utilized. Lead acid, nickel hydride, and lithium-ion are the batteries generally utilized in vehicles, half and half vehicles, and plug-in and some crossover vehicles separately. It is imperative to comprehend the physical and compound structures of these batteries. These previously mentioned batteries genuinely to some degree same yet are very extraordinary synthetically. Comprising of terminals (anode and cathode) which are the dynamic materials which both go as the current gatherers with the terminal which conveys between the two anodes (the cathode and anode). The table that appeared beneath tells how these batteries extraordinarily very artificially and genuinely both.

Table of different types of battery components

Battery Type	Cathode	Anode	Electrolyte	Separator	Casing
Lead Acid	PbO_2	Pb	H_2SO_4	PE,PVC or Silica	PP
Nickel Metal Hydride	$NI(OH)_2$	MH(AB)s	KOH	Polyolefin	Stainless Steel
LITHIUM - ION	$LiMO_2$	Graphite	Organic solvent	PP/PE	Metal or Laminate

Recycling becomes more difficult and complex as more diverse materials are being used.



2. Recycling of batteries

As the above table characterizes their various kinds of batteries have distinctive material. Reusing measures are very comparable however various ways and strategies to play out the reusing cycle have.

2.1 Lead Acid Battery Recycling

Lead acid batteries are significantly utilized in cars uncommonly in IC motor vehicles and have a huge interest. Discarding the Lead acid batteries straightforwardly can hurt the climate that is the reason discarding these batteries is illicit in certain nations. Anyway, reusing Lead acid batteries is a serious cycle. Right off the bat, the packaging of the battery is broken and the electrolyte is emptied and gathered. Plates and connectors are currently eliminated and are then entirely recuperated. At that point, the recuperated lead is re-dissolved and sifted for making new battery parts. The plastics are softened and formed into new housings. The acids recuperated can be killed and are utilized in assembling the cleansers.

The high quality of the lead is obtained as recovered lead firstly taken back to the elemental form and is again purified. Recycling lead-acid batteries are considered as profitable. As mostly all lead-acid battery manufacturers use the same raw material lead oxide (electrodes), sulphuric acid (electrolyte), and polypropylene (casing). Lead-acid recycling is simple and profitable but cannot be disposed of without being recycled and if not, it may be considered illegal. No segregation is required for battery chemistry and the recycling process is very simple.

2.2 Nickel-metal-hydride Recycling

Nickel metal hydride batteries are generally used in little gadgets power apparatuses structure numerous previous years which have short lives and they are been reusing for a long time. Additionally, in half-breed vehicles for a very long time. The nickel and iron are recuperated through electric circular segment heaters and rotating hearth. The recuperated iron-nickel is sent for the creation of hardened steel as this material is having appeal in the market for different fields. Reusing

these batteries is useful because they can re-utilized from numerous points of view. Indeed, even the batteries that were utilized in cross-breed vehicles have generally excellent resale esteem. All the nickel-metal hydride batteries have nearly a similar science (AB) 5. In the end reusing of nickel-metal hydride has been discovered a lot of fruitful.

2.3 Lithium-ion recycling

Presently a day's most test thing is reusing of lithium-ion batteries, these lithium particles reusing batteries lessens the dangers to natural contamination like soil contamination and diminishes the utilizing non-renewable assets like metals (Nickel, cobalt, manganese) and so on and most noxious acids are not store in the earth. All these dangerous factors to conquer then the main arrangement is reusing of the batteries, for utilizing these reusing of the batteries it will help the lessening the expense of the new batteries and there diminishes the weight to the production more batteries and they are not utilizing more extraction metals from the mining. Battery science and plan in the lithium-ion batteries comprises of five segments they are:

i. Cathode

ii. Anode

iii. Electrolyte

iv. Separator

v. Casing

In the lithium-ion battery, the electrolyte is comprised of the lithium salt is broken down in natural dissolvable rather than watery dissolvable because when the lithium salt responds with water to deliver combustible gasses and the separator is comprised of polypropylene and the packaging is comprised of plastics, aluminium, and steel. In the lithium-ion batteries, the cathode is an aluminium plate which is a lithium metal oxide is LICO2, LiNiO 2, LiMn2O4 is utilized and the anode material is copper plate covered with graphite. The synthesis of lithium-ion battery.

Table 2: Composition of lithium-ion batteries

Components	Composition (Mass %)
LiC_oO_2	27.5
Steel /Ni	24.5
CU/Al	14.5
Carbon	16
Electrolyte	3.5
Polymer	14

The recycling of lithium-ion batteries can be classified into two types they are:

(i) Physical process

(ii) Chemical process

In the physical process, the actual cycle includes the dismasting of the battery and partition of the battery segments and in the synthetic cycle incorporate draining, arrangement, refining in the actual cycle the strategy is pyro metallurgical cycle or pyrolysis and the compound technique is hydrometallurgical measures.

2.3.1 Pyro metallurgical process or pyrolysis

When we see that meaning of the pyrolysis mean pyro means fire and lysis means decompose and this is a full emission release process through the air it requires the air filter to filter the polluted air and this process requires more amount of energy and more high temperature.

This process does not require any chemical compositions and the outcome products from this process are cobalt, lithium, Nikhil, and copper, and these metals are extracted from the slag. The pyro metallurgical process is a high-temperature smelting process and, in this process, involves

Step 1: In this process, the lithium-ion batteries are dismantling to the module level and these are fed into the high-temperature furnace

Step 2: The organic materials like plastic and separators are burned in the furnace and the new alloy is formed

Step 3: By adding some slag forming agents like sand, coke, and limestone in the heating furnace

Step 4: In the high-temperature furnace, the plastics and electrolyte burn to supply energy for smelting, and these valuable metals are reduced.

Step 5: During the smelting process Cao-Sio2-Al2O3 and Feo-Sio2-Al2o3 were participated in the slag system, in this slag system the recovery of metals are cobalt, copper is extracted and other manganese and lithium are formed their efficiency is low.

Step 6: Later their metals are extracted there is the formation of the novel slag is there. In this slag system (mno- Sio2-Al2o3) and further leaching to this rich manganese slag there where extraction of the LI and MN is a possible extract from this slag. The efficiency of lithium and manganese is 94.85% and 79.86%.

Step 7: After that, the recovery maximum amount of lithium from slag by evaporation during chlorination rating and there is maximum possible extract lithium efficiency is 97.45.

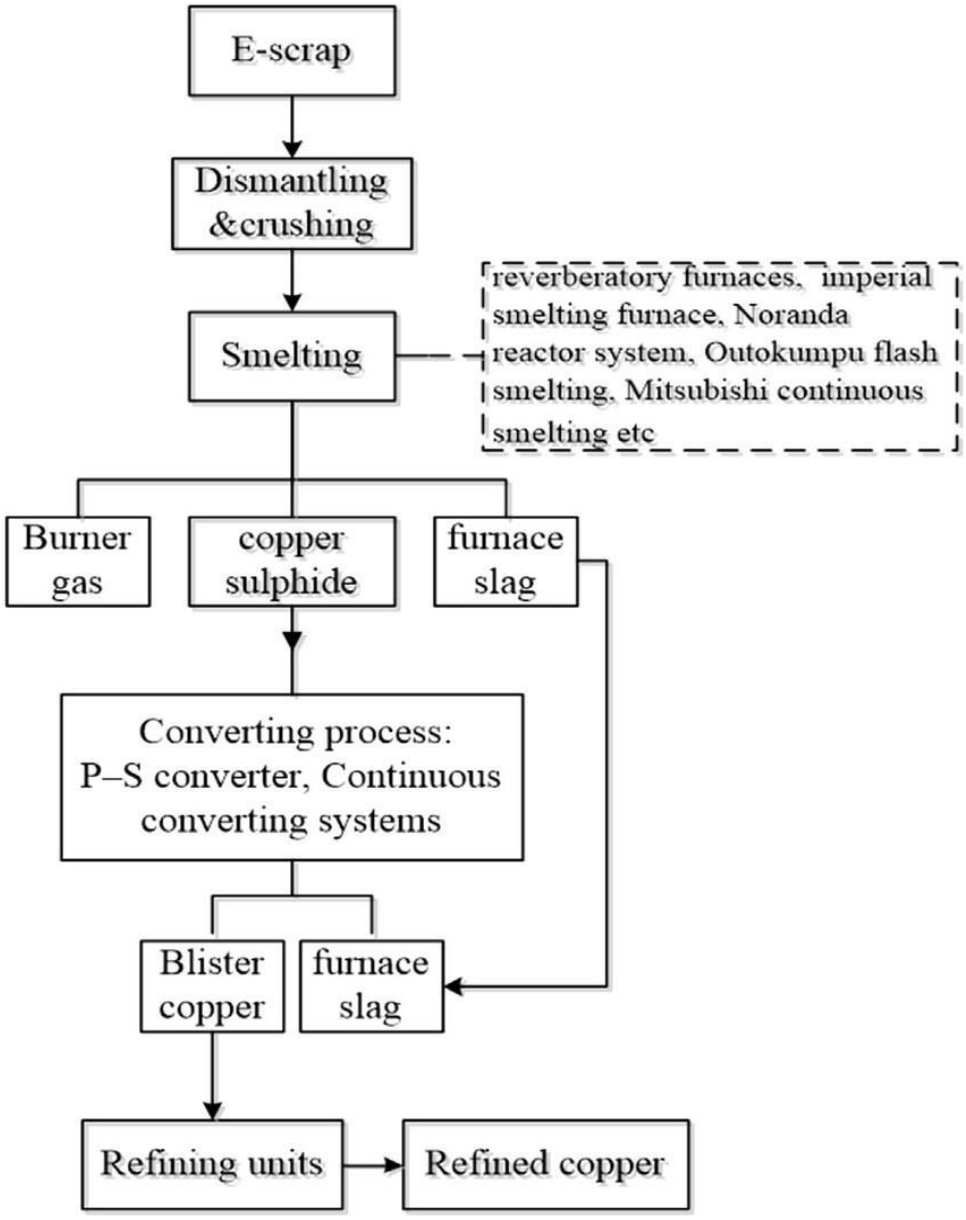


Figure 2 Flow chart of pyro metallurgical process

2.3.2 Hydrometallurgical process

This hydrometallurgical process uses mainly chemical solvents or reagents and this process consumes less amount of energy and this process not requires high temperature and the hydrometallurgical process is an environmental eco-friendly and the pollution-free process

This process mainly looking together to recover the anode material, electrolyte, and cathode material and the hydrometallurgical process is a chemical solution that is used to extract the metals like Lithium, Cobalt, Nikhil, and Copper.

Recycling process:

Step 1

In this process, the battery is crushed into small amounts of scab or tiny particles and all these battery particles are fed into the acid or alkaline solution to dissolve the metallic fraction of batteries to recover the main components.

Step 2

In step 2 the process is we used the chemical solvents like H2SO4 and H2O2 are added to the lithium-ion battery solution to recover the components or metals like lithium (Li) and cobalt (co) to achieve the full recovery of metals in 10 minutes at 75o degrees centigrade.

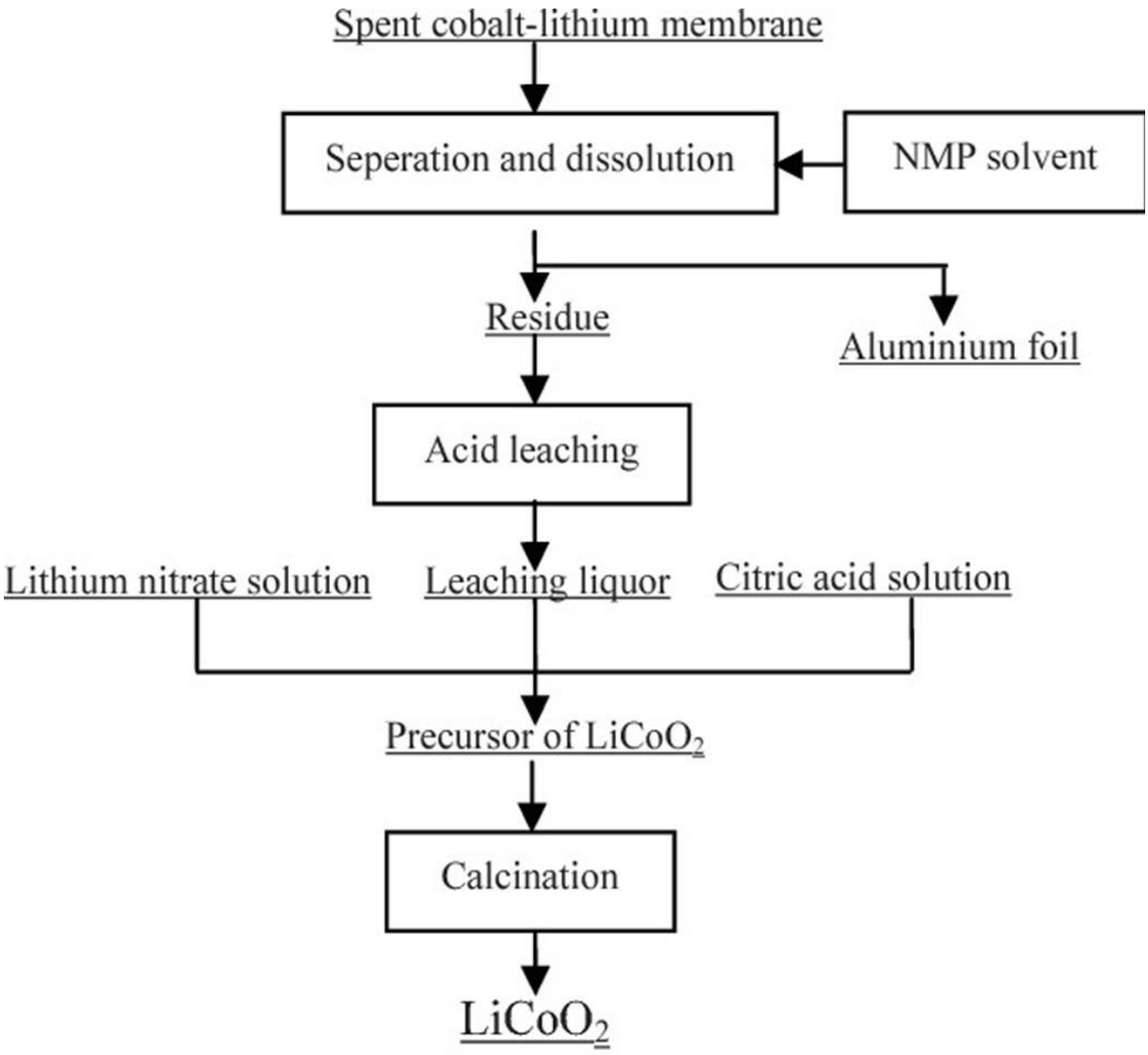
After that, the thermal pre-treatment of LiCOO2 is done to reduce the carbon and organic binders from the chemical solvent.

Step 3

In this step, the leached cobalt-containing powder from LIBS with H2SO4 and H2O2 to recover the cobalt sulphate and the addition of oxalic acid to this cobalt sulphate and from mixing of two powders to produce another powder and the cobalt sulphate is heated to produce Co3O4 and from this compound to recover the Co (cobalt) and Li (lithium) by using the HCL solution and the cobalt is extracted with a high amount of purity.

Step 4

In this step, the combination of ultrasonic washing and acid leaching and precipitation is used to extract the purity of the cobalt and this ultrasonic washing recover efficiency of co and reduce the environmental pollution and consumes less energy.



Recycling of batteries for commercial process worldwide

Table 3 Manufacturing of lithium-ion batteries in world wide

Components	Composition (Mass %)
$LiCoO_2$	27.5
Steel /Ni	24.5
CU/Al	14.5
Carbon	16
Electrolyte	3.5
Polymer	14

4. Problem faced in recycling system

Ongoing occasions have caused challenges with the ideal framework on which future li-particle reusing could be demonstrated. Inconvenience is caused at auxiliary lead smelters when the reusing of li-particle batteries alongside Lead acid batteries is finished. The utilization of li-particle batteries is straightforward for SLs, cruisers as it is undefined from Lead acid batteries. However, consideration of li-particle batteries in the info stream of auxiliary lead smelter has brought about flames and blast.

Substance responses that are happening are muddled. Vaporization of the unpredictable natural electrolytes causing the lithium-ion cell to detonate .such occasion is perilous and must be forestalled. The same number of recyclers pay for their ideal info material, for example, Lead acid battery recyclers, a few elements may shroud diverse battery types in beds of Lead acid batteries to try not to need to pay for their manner.

COMPANY LOCATION MATERIAL RECYCLE CAPACITY (TONNES/YEAR)

1 Sonny and Sumitomo Metals Japan Li-ion 150

2 Dowa ecosystem Japan Li-ion 1000

3 Taxco Canada Li-ion 4500

4 Umicore Belgium Li-ion 5000

5 Chemetall Germany Li-ion 200

6 Sarp France Li-on 7000

7 Revatec Belgium Li-ion 3000

Punishment is forced by recyclers for sending defiled burdens. The pre-owned batteries are frequently conveyed to recyclers in enormous burdens and it's unthinkable for plant staff to do a cautious visual screening of the heaps on the transport lines. Before getting to their plants, lead acid batteries recyclers need li-particle batteries to be taken out. Li-particle producers are pushing toward more affordable material which compounds the issue. We ought to forestall Lead acid batteries from entering the input stream for fruitful lithium-ion reusing. For huge arrangement batteries, isolation frameworks are needed. Li-particle batteries are lighter than Lead acid batteries.

5. Vision for future Recycling System

The vision and its beneficial outcomes won't be acknowledged whether the worth chain creates along its present direction. Batteries need to turn out to be more reasonable through lower creation cost, higher use, and improved business cases for end clients. To create and reuse the batteries reasonably implies bringing down emanations, taking out basic freedom's infringement, guaranteeing safe working conditions over the worth chain, and improving repurposing and reusing.

6. Conclusion

The same number of various techniques for reusing has been talked about, there favourable circumstances and detriments, correlation of various sorts of reusing measure and their delayed consequences. Giving data about specialized and conservative correlations of the reusing cycle with the goal that issues confronted can be recognized and be unravelled structure all perspectives. It has been seen that reusing of the Lead acid and nickel-metal-hydride is very simple when contrasted with and lithium-ion battery. As there is no simple method to reusing Li-particle batteries as they are confounded and chomped in costly ways. As the interest in lithium-ion batteries expanding reusing may turn into a need. A new plan and demonstrating of the reusing cycle can truly assist with improving reusing measure or may present another technique for reusing.

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