# OBSERVERSHIP REPORT

**Secondary lead smelting and battery recycling — Gravita India Ltd, Jaipur**

Prepared by Harshdeep · Visit date 25 June 2026 · Focus: the reduction chemistry of lead recovery

I visited Gravita India Limited's secondary lead smelting and battery-recycling plant at Jaipur, Rajasthan. I was shown the route from used lead-acid batteries through breaking, smelting and refining to cast lead ingots and alloys, together with the laboratory. The plant recovers lead, polypropylene and acid from spent batteries, so it is a working example of circular, resource-recovery chemistry. This report focuses on the chemistry behind that recovery.

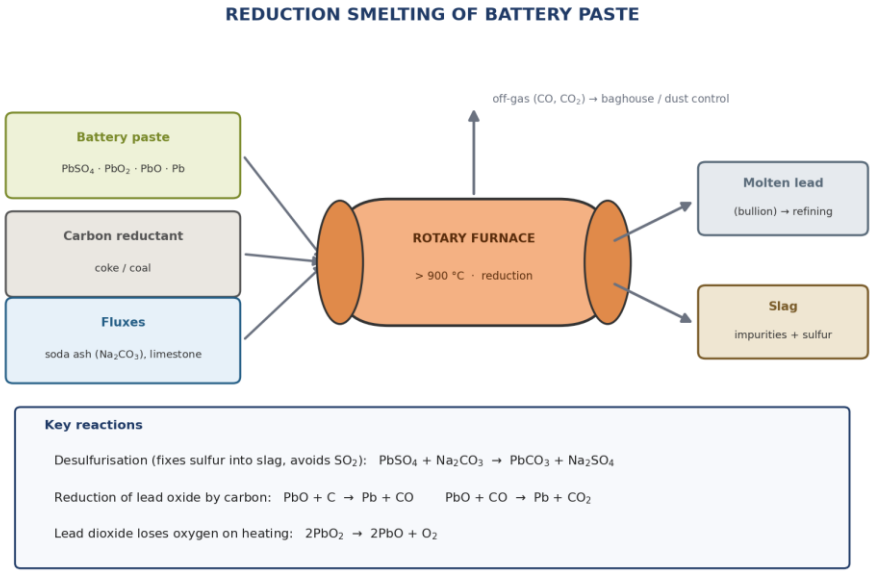
## What is inside a used battery

A used lead-acid battery is not one material but a set of components that have to be separated before any lead can be recovered. A polypropylene casing holds lead grids, a lead-rich paste and a sulfuric acid electrolyte. The grids are lead or a lead alloy containing antimony or calcium. The paste, which comes off the plates, is a mixture of lead compounds: lead sulfate (PbSO4), lead dioxide (PbO2) from the positive plate, lead oxide (PbO) and some metallic lead. Recovering the lead means turning all of these back into the metal. The battery is first broken and the plastic, acid, grids and paste are separated, and the sulfuric acid is collected and neutralised before reuse or disposal.

## The chemistry of reduction smelting

The lead paste and metallic scrap are charged into a rotary furnace together with a carbon reductant (coke or coal) and fluxes (soda ash and limestone), and heated to above about 900 degrees Celsius. The furnace does two chemical jobs: it deals with the sulfate, and it reduces the lead compounds to metal.

Sulfate is a problem because heating lead sulfate on its own would release sulfur dioxide, which is a pollutant. To prevent this, soda ash (sodium carbonate) is added; it reacts with the lead sulfate and fixes the sulfur into the slag as sodium sulfate, PbSO4 + Na2CO3 → PbCO3 + Na2SO4. The lead is then left as a carbonate or oxide that is easy to reduce. The lead oxides are reduced by carbon and by the carbon monoxide it forms, PbO + C → Pb + CO and PbO + CO → Pb + CO2. The lead dioxide from the positive plates first loses oxygen on heating, 2PbO2 → 2PbO + O2, and is then reduced in the same way. In every case carbon is the reducing agent and the lead ends up as molten metal. The fluxes also gather the remaining impurities into a slag that floats on the dense molten lead, so the two separate by density and are tapped apart.




*Reduction smelting: soda ash fixes the sulfur into slag, and carbon reduces the lead oxides to molten metal.*

## Refining and alloying

The lead that leaves the furnace is crude, so it goes to refining kettles. There, impurities such as copper, antimony, arsenic and tin are removed in controlled steps. Copper is taken off as a dross, and elements such as antimony, arsenic and tin are removed by oxidation, because they oxidise more readily than lead and rise into a dross that is skimmed off. Once the lead is pure enough, alloying metals such as antimony, tin and selenium are added to the melt in set amounts to make the lead alloys the customer needs; antimony, for example, hardens the lead. The composition is checked before the metal is cast.

## The manufacturing process

The full sequence I observed is set out below. Batteries are collected and broken, the acid is neutralised, and the paste and scrap are smelted, refined and alloyed before the metal is cast, tested and dispatched.




*Flow of the secondary lead recycling process observed during the visit.*

## Quality-control chemistry

The laboratory controls the composition of the metal. Molten samples are taken before casting and finished products are sampled as well. An optical emission spectrometer and an X-ray fluorescence analyser measure the lead purity and the levels of alloying elements and impurities, so each batch meets specification. This matters because a small amount of the wrong element changes the properties of the alloy, and lead alloys are supplied to tight chemical limits.

## Safety and environment

Because lead and its compounds are toxic, control of dust and fume is central to the plant. Lead dust and furnace fume are captured by dust extraction and baghouse filters, chimney emissions are monitored continuously, and workers use respirators and have their lead exposure checked. The recovered polypropylene is recycled, the neutralised acid is treated, and slag and other residues are handled as hazardous waste. The operation is a form of circular manufacturing, since it returns lead, plastic and acid from spent batteries into use rather than mining new lead.

## What I learned

The plant showed me reduction metallurgy applied to recycling. The chemistry is a clear sequence: separate the battery, fix the sulfur so it does not escape as sulfur dioxide, reduce the lead compounds to metal with carbon, and then refine and alloy the metal to specification. Seeing how a single equation such as $PbO + C \rightarrow Pb + CO$ sits inside a real recovery process, and how much of the plant is built around handling a toxic element safely, made both the chemistry and its responsibilities concrete and strengthened my interest in chemistry and materials.