RECYCLING magazine

Materials handling for waste electrical and electronic equipment

Waste Electrical and Electronic Equipment (WEEE) is one of the fastest-growing waste recycling streams. It covers anything with a plug, power cord or battery that has been disposed of.

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Materials handling equipment for WEEE, Copyright: Clyde Pneumatic Conveying Ltd

For environmental and economic reasons, WEEE recycling is essential. It contains toxic metals such as lead and mercury, industrial metals like aluminium and copper and precious metals, notably gold and silver.

Additionally, lithium ion batteries (LIBs) are often present in WEEE. They contain strategic and critical materials and metals such as graphite, lithium and cobalt, in addition to copper and aluminium foils.

Given the importance of materials recovery and the tangling nature of the cabling used in electrical goods, WEEE and LIB recycling requires a specialised processes and materials handling equipment.

Taming tanglers

Cables, wires, carrying straps and irregular shaped plastics are renowned tanglers. When they bridge together they block the flow of the WEEE through the process. And, worse, they wrap around rollers, star screens and screw conveyors causing process downtime and reactive maintenance to remove the clogging.

Richard Sims of Clyde Pneumatic Conveying Ltd, based in the UK, says that "conveying of irregular shaped flakes and foils can be achieved using our RotoScrew Technology."

Depending upon the size and shape of material the discharge of conveying vessels can be fitted with either one or up to 3 screw feeders giving a 'live' bottom discharge into the conveying pipe.

He adds that "fitting negative rake flow liners or internal agitators are additional features that we can add to our conveying vessel to prevent with any flow issues."

LIB recycling regulatory growth drivers

There are many types of LIBs, each with different active materials in the LIB anode. At the end of life, valuable industrial metals such as lithium, cobalt, nickel and manganese are recovered during LIB recycling using hydrometallurgy and CO2.

The highest energy density is achieved with Nickel, Manganese, Cobalt (NMC) LIBs. These are favoured in premium automotive applications and are displacing Lithium Cobalt Oxide (LCO) LIBs in premium mobile phones to extend their battery life.

NMC and LCO LIBs contain large amounts of cobalt, manganese and nickel. In the EU cobalt and manganese are both recognised as both strategic and critical materials. Nickel is regarded as strategic. Recovery of these metals during LIB recycling is therefore of paramount importance.

Reflecting these points, the EU Battery Regulation (2023/1542) is now in force. It states that in 2026, at least 65% of the total mass of an LIB must be recycled. That requirement rises to 70% in 2030. Zooming into cobalt and nickel, the reprocessing recovery at the end of 2027 must be at least 90%. By the end of 2031, that increases to 95%.

The same regulation currently requires 50% of the lithium to be recycled and this jumps to 80% for 2032 and beyond. This increase will force the industry to invest in new recycling processes.

Foils and flakes

After discharging residual electricity the LIB, the initial stages of recycling are brutally mechanical. LIBs are shredded to open up the battery housing. This releases the liquid electrolyte solvent.

Plastic flakes, shredded copper and aluminium foils are then separated from the powders used in the anode and cathode using a Zig-Zag Air Classifier. Separation of the plastic flakes from the metal foil shreds is performed using an electrostatic separator.

Copper and aluminium foils have very different densities and can easily be separated with a densimetric table or fluidised bed. In these machines, gravity and air flotation work in harmony to achieve the separation of the two metallic foils.

The resulting powder, called black mass, is a mixture of anode and cathode materials. It is composed of cobalt, nickel and manganese oxides, lithium and graphite.

“For powder handling Clyde has a range of dense phase conveying vessels”, confirms Sims. “Included in the range are vessels designed especially for fine powders, others designed for coarse materials or variable particle size powders and granules.”

Pneumatic dense phase conveying systems can move materials a few meters to over a kilometre. Transfer rates of up to 500 Tonnes per hour can be achieved in single pipes.

Powder processing

Black mass powder is approximately 50% mixed metal oxides / carbonates and 50% graphite by mass. Graphite separation can be achieved by flotation in an aqueous liquor. This is effective because graphite is hydrophobic whilst the metal powders are hydrophilic. When gas bubbles are sparged into the liquor the graphite is floated out, whilst the metal powders remain suspended.

Alternatively, an acidic liquor is used to dissolve the metallic compounds and the insoluble graphite is filtered from the solution.

Pyrometallurgical and hydrometallurgical techniques can be used to recover critical materials from the black mass to enable their recycling.

Clyde’s RotoScrew and RotoFeed injection technologies can pneumatically convey and inject materials directly into processes and furnaces or smelters.

Sims explains that “our injection equipment can operate at pressures up to 30 barg and elevated temperatures. If required, they can achieve submerged injection under molten metal.”

Source: Stephen B. Harrison, sbh4 consulting