ELV RECYCLING STEPS UP A GEAR

Development of improved sorting technologies for the non-ferrous fraction of auto-shredders

Although the number of end of life vehicles (ELVs) needing recycling is growing, due to processing limitations aluminium recycling rates are being hindered. A European-funded project -- ShredderSort -- aims to contribute to new solutions to the aluminium recycling industry.

By LNEG and Instituto Superior Técnico, Univ. Lisboa, Portugal

More than 10 million tons of automotive waste from end of life vehicles (ELV) are generated yearly in the EU and the values are continuously increasing. ELV wastes are managed by the auto-shredder plants which process ELVs through a series of mechanical and physical operations in order to separate the materials into different streams: ferrous, non-ferrous, heavy non-metal and fluff. Ferrous materials, constituting more than 60wt% (percentage by weight), are sent to steel-making plants, while the non-ferrous (NF) fraction, rich in aluminium and representing slightly less than 10wt%, is processed to separate some alloys.

Copper alloy fragments are usually obtained by hand sorting, heavy media separation and even by color sorting devices. The aluminium rich fraction obtained contains a wide range of Al alloys with different chemical compositions due to the presence of different alloying elements (e.g. Si, Mg, Mn, Cu, Zn). The different concentrations of such metals confer specific properties to each alloy, which are arranged within a standard series classification.

Several Al alloys are difficult to separate due to their similar physical-chemical properties. Some technologies have been proposed to separate them using vision/colour sorting systems, but requiring firstly a surface cleaning and a chemical treatment by etching in baths in order to modify the surface colour of some alloys. However this kind of technology becomes expensive since is highly intensive regarding water, chemicals and energy consumptions and subsequently has not been successfully applied.

As a result, aluminium fragments containing several alloys are still downgraded to produce some types of cast alloys, hindering the recycling rates of aluminium, mainly in what respects to the manufacture of wrought alloys from secondary materials. Moreover since the separation processes being used, like hand picking, are labour-intensive, aluminium scrap continues to be exported from the EU to foreign countries, increasing the European dependence on raw-materials. The improvement of recycling of the NF fraction can have important implications in the recycling efficiency, with subsequent advantages from the economic, environmental, and resources conservation point of view.

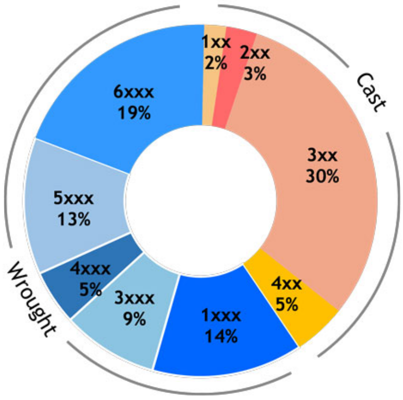

Figure 1 – Typical distribution of main aluminium alloy series of NF fractions of shredders

Aluminium Alloys in NF

In the NF fraction, Al alloys can constitute more than 75wt% of the flow, while Cu alloys account for nearly 15-20wt%. Regarding aluminium, Figure 1 shows the typical distribution of the alloys that can be found in the NF fraction of a shredder plant. These values are based on the experience gathered in the activities of the ShredderSort project, although varying from plant to plant and from time to time in each plant, depending on many factors namely from the type of scrap processed in each batch and the market profiles of consumers.

Currently most shredders receive and treat many other scraps than ELV's, namely electric waste, aircraft and ship waste, metal residues from demolishing and other general waste materials. However, the most important Al alloys used in automotive applications are present in the waste. That is the case of cast alloys of series 3xx used in many vehicle components such as engine blocks, pistons and heads, as well as in subframes and wheels. Axles and subframes can also be constructed using stampings and extrusions from wrought series 5xxx and 6xxx.

These two alloy types have also common applications in other car components, such as in inner and outer panels, and space frames. Forgings made of 6xxx alloys have also applications in car construction namely in suspension parts.

Wrought alloys from series 1xxx and 3xxx have usually other applications than cars, the former being mainly applied in electric wires and foil, while the latter are commonly used in utensils and beverage cans.

ShredderSort Project

During the last decades automatic sorting technologies have emerged for several applications, including metals separation. These are based on a flow of fragments transported by a conveyor and passing by a sensor/detector that measures a property of the materials, which can be easily distinguished from other materials in the flow. The system is connected to an actuator (commonly pneumatic ejectors) that removes from the circuit some pieces and leaving others to proceed in the belt.

Today, some technologies of this kind already exist such as those based on vision analysis, X-rays, electromagnetic, colour detection, among others. Nevertheless, all of them still have limitations. Concerning aluminium alloys, there is no proved technology that can systematically sort fragments with different concentration of alloying elements.

The ShredderSort project aims at further improving existing scrap sorting technologies based on combined electromagnetic and spectroscopic principles, in order to achieve a successful recovery of some different alloy groups in the NF shredder fraction. To start, the process separates heavy metals (copper alloys, including brass and bronze) by means of advanced multifrequency electromagnetic sensing principles - Electromagnetic Tensor Spectroscopy (EMTS) combined with Vision Image Analysis (VIA).

In this system, a high speed vision system enables to determine the position, size and orientation of the fragments, followed by detecting the characteristic conductivity tensor of the fragment through modelling the response of electromagnetic sensors. The process allows separating Cu-based fragments from light metal fragments. In sequence, the LIBS technique allows discrimination between different light alloys based on their chemical composition, which, when assembled with a sorting device (sensor/detector/actuator), can provide separation of alloy groups.

The technique consists of a shot of a high power laser beam focused on the surface of the particle/fragment, inducing a plasma which when cooled emits the atomic spectra of the constituting elements. By means of spectra treatment and an adequate definition of regions of interest in the spectra, different alloys can be distinguish and subsequently separated. Both EMTS-VIA and LIBS methods avoid any complex pre-treatment or any kind of sample manipulation, and provides an easy and speedy analysis. It is therefore appropriate to be applied in a sensor/detection sorting device.

The technology is still in development but the results achieved so far are promising. The EMTS-VIA and LIBS sorting techniques are currently being developed at the lab scale. Laser design and spectrometer construction (for LIBS) is also running. Integration of the several systems is an important task to proceed. The project will also involve the design, construction and operation of pilot sorting lines where the technologies will be assessed and demonstrated.

C.A. Nogueira, F. Pedrosa and F. Pedrosa are from LNEG – Laboratório Nacional de Energia e Geologia, I.P., Lisboa , Portugal. F. Margarido, R. Novais Santos, F. Durão, and C. Guimarães are from the Instituto Superior Técnico, Univ. Lisboa, Portugal. www.shreddersort.eu.

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