A circular approach for recovery and recycling of automobile shredder residues (ASRs)

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In June 2018 the European Circular Economy Package (CEP) was published in the Official Journal of the European Union. The European CEP's intent is to ensure the European Union's transition to a circular economy. As opposed to the typical linear economy - in which resources are created, used, and disposed - a circular economy is one in which resources are used for as long and as productively as possible, and at the end of their useful life, their products and materials are recovered and regenerated.

Among others, the European CEP includes Directive 2018/849 of May 30, 2018 amending the directives that regulated waste electrical and electronic equipment (2012/19/EU), batteries and accumulators and waste batteries and accumulators (2006/66/EC) and end-of-life vehicles (ELVs, 2000/53/EC). Specifically, for what concerns ELVs, the amendment Directive requires Member States to, as well as the original requirements, take the necessary measures to ensure that all end-of-life vehicles are stored (even temporarily) and treated in accordance with the waste hierarchy. It also requires Member States to electronically submit a report on reuse and recovery targets for each calendar year to the Commission. However, the amending Directive did not change the targets for reuse, recycling and recovery of the ELVs and their components originally stated by Directive 2000/53/EC.

In this work we carried out a complete and thorough characterization of ASR samples with the aim to check the suitability of ELV waste products to be recovered and recycled in the form of material – for the production of new plastic composites – or energy, through a thermal valorization process in incinerator or cement plants. This forms of recovery and recycling of waste products from ELVs are important steps in the gradual transition of the automotive industry towards a circular economy.

ASRs samples were collected in two positions of a dismantling plant located near Turin (Italy) during two sampling campaigns carried out in 2017. Two samples went from the output of the aspiration system that intercepts the light waste materials liberated by the main crusher, in the follow named as “light fluff”. The other two samples were collected at the end of a series of separation phases, the main aim of which is the recovery of non-magnetic metals. One of the main refuse from this series of operations is a waste product, in the follow named as “heavy fluff”, that contains rubber and plastic as principal components. The tests for the valorization of the ASRs in the form of material were specifically carried out on the fraction made of plastic extracted from the samples of light and heavy fluff. The plastic fraction accounted for 14.3±0.7% and 16.4±5.2% in light and heavy fluff, respectively.

Tests for material recovery and recycling included a densimetric separation at the density value of 1 kg/dm^3 and a subsequent set of sequential operations of separation carried out on the basis of the softening temperature values. The combination of the two tests allowed to separate the single polymers that made up the plastic fraction extracted from the ASR samples. The tests revealed that polypropylene was the most representative polymer in light ($\rho < 1$ kg/dm^3) plastics and that the heavy plastic extracted from the light fluff samples contained approximately 75% of a polymer that softens at approximately 160°C, that, according to ASTM D 1525 rule (Vicat softening temperature), it could be polycarbonate or polyammide-6. Conversely, the heavy plastic extracted from the heavy fluff samples contained, other than polycarbonate or polyammide-6 and PTFE, a material that did not soften at 180°C; it could be polyammide-66 or some kind of thermoset resin. Separation in single polymers may help in finding dedicated recycling solutions for a specific polymer or for a blend of thermoplastic polymers.

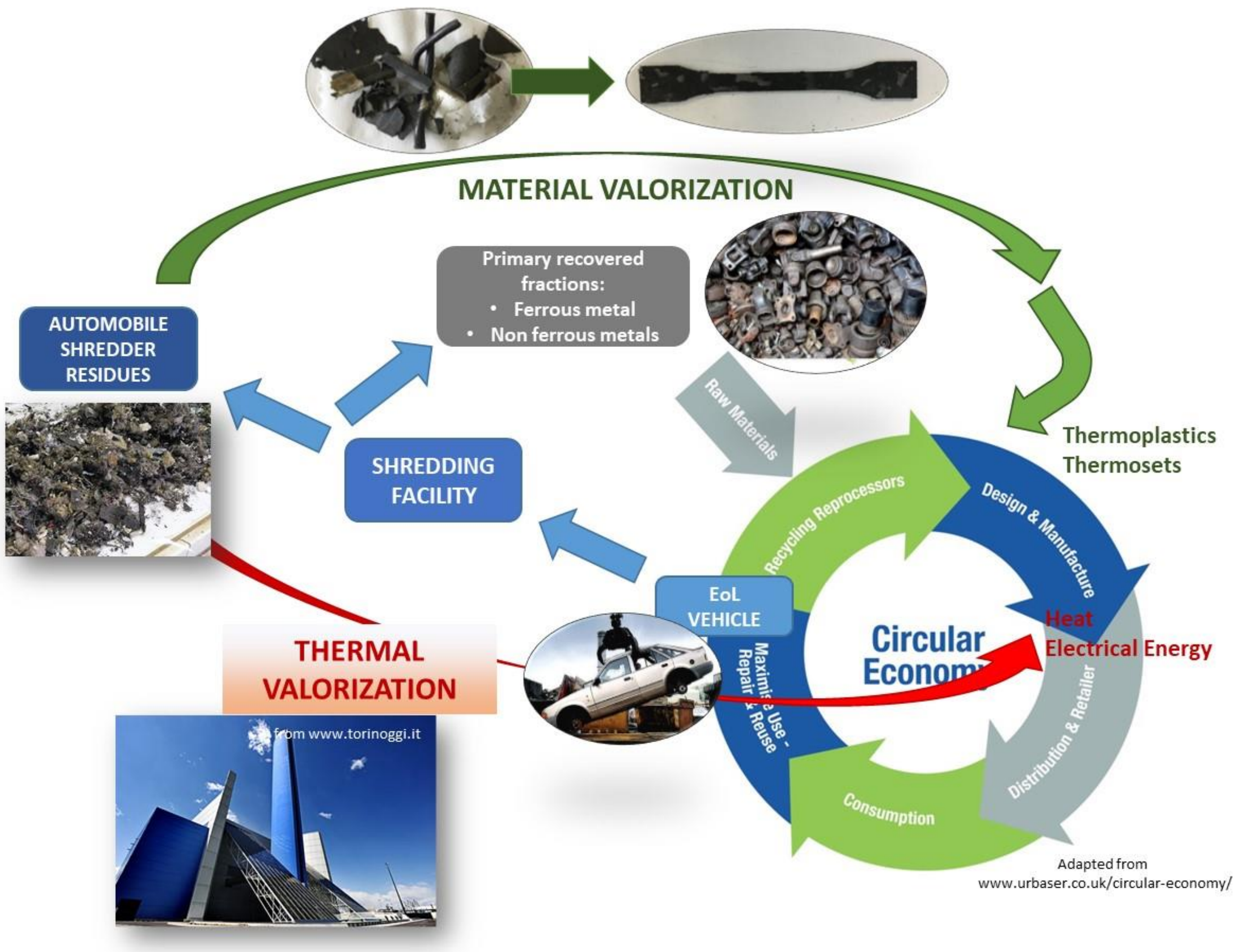

Figure 1. Conceptual scheme of the work

Tests for thermal valorization were aimed to verify if the fluff samples had the requisites to be assimilated to solid recovered fuels according to Italian regulation 14/02/2013 n.22. Tests were focused on the determination of the caloric value and chlorine and sulfur content. The caloric value (lower heating value, LHV) of the four ASR samples was determined, after a product composition analysis, by carrying out a weighted average of the LHVs of each fraction that compose the sample. Both samples fell into class 1 of Table 1 of the decree (LHV > 25 MJ/kg). Chlorine and sulfur were determined according to a procedure that modifies and improves the method described in UNI EN 15408_2011 rule for the determination of sulfur, chlorine, fluorine and bromine in solid recovered fuels. The method employed in this work used an acid digestion (in the presence of nitric acid, 65% and oxygen peroxide, 30%) to liberate and transform sulfur and chlorine to sulfate and chloride, respectively, and a subsequent spectrophotometric determination of the generated ionic species.

Even in this case, the determination of chlorine and sulphur content was focused (and limited) on the plastic fractions, because, especially chlorine, is contained in the PVC polymer. The results of the analysis revealed that the content of chlorine and sulphur in the ASRs samples was well below the detection limits, $<2.5\cdot10^{-3}$ % for chlorine and $< 2.5\cdot10^{-2}$ % for sulfur, respectively. The high caloric value and the low content of chlorine and sulfur made the samples of ASRs suitable for thermal valorization in incinerator or cement plants under the limitation (10%) imposed by the EC Directive on ELVs.