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TECHNICAL AND ENVIRONMENTAL ASSESSMENT OF CURRENT OPPORTUNITIES AND TREND IN END-OF-LIFE VEHICLES DISPOSAL

Abstract:
The paper deals with the analysis of state of art in end-of-life vehicles recycling in the European Union and worldwide, descripts briefly the legislation on ELVs recycling, ELV material composition and current technological processes for car disassembly and shredding. The objective is to depict the problems connected with the waste prevention, re-use, recycling, and recovery of the end-of-life constituents; automobile shredder residue disposal. Based on analyses, the optimum shredding facilities are shown. At the conclusion, technical and environmental aspects of ELV recycling are evaluated.

Keywords:
end of life vehicle (ELV), shredder, automobile shredded residue (ASR), recycling

INTRODUCTION

Vehicles, essential to society, are continually increasing in use. However, throughout their life cycle vehicles impact the environment in several ways: energy and resource consumption, waste generation during manufacturing and use, and disposal at the end of their useful lives. About 75% of end-of- life vehicles, mainly metals, are recyclable in the E.U. The rest of the vehicle is considered waste and generally goes to landfills. Environmental legislation of the E.U. requires the reduction of this waste to a maximum of 5% by 2015. [1]

Every year, end of life vehicles (ELV) generate between 8 and 9 million tonnes of waste in the Community which should be managed correctly. [2]

Automobile manufacturing has increased in the last 20 years, reaching about 58 million units (excluding commercial vehicles) in 2000. According to estimates by the OECD, the total number of vehicles in OECD countries was expected to grow by 32% from 1997 to 2020. Automobile production is more or less equally distributed between North and South America, Europe, and Asia. [3]

LEGISLATION ON END-OF-LIFE VEHICLES RECYCLING

The main document is the Directive 2000/53/EC of the EP and of the Council on End of Life Vehicles. ThE Directive lays down measures which aim at the prevention of waste from vehicles and at the reuse, recycling and other forms of recovery of ELVs and their components so as to reduce the disposal of waste, as well as at the improvement in the environmental performance of all of the economic operators involved in the life cycle of vehicles and especially the operators directly involved in the treatment of ELVs. The ELV Directive states, that no later than 1 January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Within the same time limit, the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year. The Directive also defines the minimum technical requirements for ELV treatment. [2], [4].

CURRENT ELV RECYCLING IN THE E.U.

Considering the material composition of a car, it is necessary to take into account the average lifespan of a car; ELV in the recycling chain today were manufactured in the 1980s–1990s.

An overall schema [5] of the vehicles' paths starting from automakers to disposal of the shredder residue is shown in Figure 1. The last car owners (i.e., users) are the starting point for the ELV chain. After de-registering the vehicles, the users can deliver their old cars to the dealers and/or to used-car dealers. The dealers, in turn, deliver the used cars to collectors/dismantlers. Deregistration of used cars can be done by users, dealers, collectors, and/or dismantlers, depending on the regional rules. [4]

PROBLEMS RELATED TO ELV SHREDDING

Collecting and dismantling companies focus on removing valuable spare parts and other components such as engines, batteries, oils and fuels, and airbags. These companies are mostly interested in ELV parts that are suitable for reuse, recycling, or sale. The ELV dismantling is often done improperly, increasing the amount and toxicity of ELV waste. After dismantling, the remainders of the ELV are processed by shredding companies. [2]

After the hulks are shredded, the obtained materials undergo a series of mechanical and physical separations in order to recover the ferrous and non-ferrous metals. The residual of the shredding process, automobile shredder residue (ASR), represents about 20–25% of the ELV weight. Its average composition is given in Figure 1. [5]

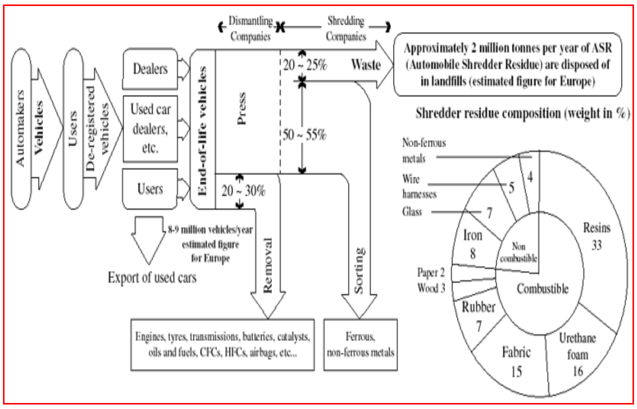

Fig. 1 The disposal route for end-of-life vehicles [5]

The ELV recyclable rate of 75–80% is higher than that of simpler products such as glass containers, newspapers, and/or aluminium beverage cans. [6]

The ASR is the weak point of ELV recycling not only in the E.U. but also in the worldwide automobile industry. About 2 million tonnes of ASR are generated per year in E.U. countries. In fact, it represents less than 1% of the total waste generated in the E.U. The ASR, while toxic enough to be classified as hazardous waste in many countries, could be considered an energy source as it contains more than 7% combustible matter. [1], [3]

Two options will be considered for the ASR: recycling/recovery and waste disposal. Although many alternatives have been researched (physical separation, incineration, pyrolysis, and composite materials), it seems that the landfilling of ASR was the most appropriate option.

Shredding and separation line is a device for ELV bodies processing in the original or pre-pressed form (Fig. 2). The material is shredded into pieces of 150 - 200 mm in size, and is partially compacted and got rid of dust, other impurities and non-ferrous metals. The final product of the line is a block of steel waste containing 92% of iron with a specific weight of 1.0 to 1.1 $t.m^{-3}$. [7]

By further separating, two types of grain can be achieved (as required by customers) – with the average diameter 4 cm and 9 cm. Hourly output of the equipment is dependent on the type of processed material and varies from 20 - 40 $t.h^{-1}$ of pure steel waste.

Fig. 2 Car bodies before and after shredding [8]

Shredding and separation unit is a facility that treats steel waste hitherto bundled in the original form, which was of very low quality due to its impurities content. Shredding and separation line is a system of several individual technological units that are interconnected by conveyer belts. The principal activity is the grinding of light steel waste, which is performed in enclosed hammer crushers. Material is inserted into crusher by means of two cylinders with the power of up to 20 t, and it is gradually chipped by rotating hammers made of special steel. Hammers are fit radially on the rotor and create a circle with a diameter of 1900 mm (Fig. 3).

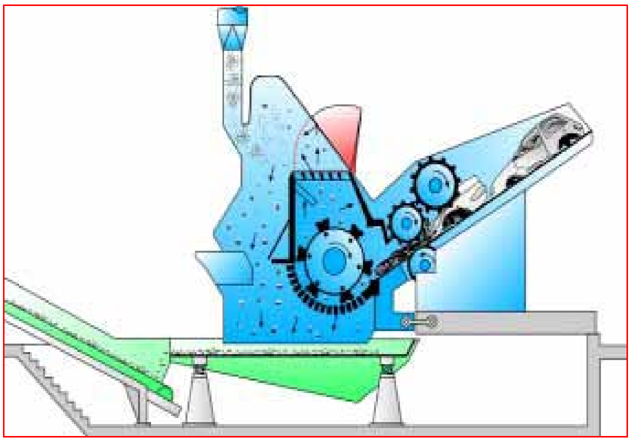

Fig. 3 Top and bottom discharge shredder [9]

At the process, certain amount of dust is produced, which is collected by radial fan already in the shredder unit itself. Fine dust fractions are drawn by pipe into a wet scrubber (with water content of 18 m^3), where the dust is sprinkled with water and incurred sludge is carried by special conveyor into the container. Heavy fraction of the dust is collected by dry precipitator and delivered by conveyor into container.

Another device, where the coarse and light impurities are separated, is the device placed after the shredder. It is a cyclone, where all the shredded material falls through. Light fractions, i.e. non-metallic fraction are exhausted into the same dry precipitator as the similar fraction from the shredder. Thus, the shredded steel material is separated from dust and light impurities such as parts of rubber, wood, plastics etc. The material is then supplied by conveyor to further separation equipment - magnetic separation. This is a rotating magnet, which sorts shredded material into magnetic (containing Fe) and nonmagnetic portion (containing non-ferrous metals and heavy impurities). The device works automatically. [7]

Magnetic portion is then transported by conveyor to the sorting workplace where they are manually picked pieces of shredded waste, which visibly contain non-ferrous metals. Furthermore, the magnetic portion is transported to the rotating sorting drum, which is located at the end of the equipment and serves only to further sorting of the material (by means of a sieve). The processed steel waste is collected by the conveyor under the crane line and can be immediately dispatched.

After the magnetic separation, the second fraction arises, which contains non-ferrous metals, wood, rubber etc. This is transported by conveyor to a rotating separation drum. The sieve separates the material into three fractions (up to 15 mm, 15 - 80 mm and above 80 mm). Fractions up to 80 mm are stored in the stack. The fractions of above 80 mm are separated manually where non-ferrous metals are visually selected. [7]

The whole device works automatically (except for two manual sorting departments) and is operated from the driving cab by machine operators. They are able to control the light signalling of the individual nodes of technological units and if the failure of the *equipment occurs, the operator disables the equipment. Similarly, the operator controls the dangerous places at the displays. The design of the main shredder section is derived from the Hammermills shredding system. [7]*

ASSESSMENT OF CURRENT OPPORTUNITIES AND TRENDS IN ELV DISPOSAL

In general, the industry is interested in increasing the ELV recyclability. In compliance with this, it is necessary to adopt the vehicles design and construction modifications, such as elimination of a non-recyclable and potentially hazardous materials, reducing the diversity of plastic products used as vehicle components, thus increasing the potential recyclability of plastic components, or reduction of parts, consisting of incompatible materials, such as plastics and metals, or ensure that these different materials are used so that they can be easily separated from each other etc.

In the area of ELV recycling, there is a space for modern separation technologies, which will allow separating mixed plastic waste components from impurities. The application of conventional physical separation technologies used for ore and non-ore raw materials, however, encountered in the plastic waste to its specific physical and chemical properties. Here opens the way for the subsequent use of physical and chemical separation methods, such as flotation, which allows separation of all types of plastics. [10], [6]

FUTURE APPROACH TO ELV RECYCLING

The directive of European Parliament and of the Council of 18 September 2007 organized former national policies and voluntary agreements. It was aimed to harmonize these existing rules and to push the E.U. governments and automobile industry to comply fully with the directive and to translate its key requirements into national law. The ultimate goal of this directive is to put only 5% of ELV residues (ASR) into landfills. [4]

The main actor in the ELV chain, according to the E.U. directive is the producer, a vehicle manufacturer or professional importer of a vehicle into a member state of the E.U. The producer links the upstream (supplier) and downstream in the ELV chain (collector, dismantler, and shredder). On the other hand, collaboration between collector, dismantler, and shredder are necessary to successfully meet the directive goals. [1]

The vehicle produced has to at least meet the following goals: low energy consumption, easy dismantling, suitable recycling, and less toxic metals. To fulfil these goals, the producer has to know the technical and economical facilities, recyclability rate, and efficiencies of the downstream ELV chain. On the other hand, the producer will provide the dismantling information for each new type of vehicle put on the market. The design of vehicles appropriate for dismantling, recycling, and re-use, and free of some hazardous substances (Pb, Hg, Cd, and Cr VI) will significantly improve the cooperation of the supplier-producer chain. [11]

CONCLUSION

The objective of the paper was to evaluate the shredding process and assess the possibilities for performance improvement in ELV recycling. At ELV recycling, it is necessary to comply with exact environmental and technical demands. Separated materials after shredding go to automakers for use in the production of the same components from which they are issued. Energy can be recovered from combustible parts of ELV by using them instead of fossil fuels in industrial operations, such as cement plants. The remaining part of the vehicles, ELV waste, goes to a landfill under strict waste control.

In an increasingly global economy, the goals of the E.U. directives are becoming a sensitive issue for worldwide vehicle production. The car manufacturers have an essential role in the infrastructure system of waste prevention, collection, and treatment of ELV.

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