DISPOSAL OF AUTOMOBILE SHREDDER RESIDUE, CONSIDERING MIXED PLASTIC PART OF THE LIGHT FRACTION

Zsofia Ujsaghy

Budapest University of Technology and Economics, Department of Automobiles
Stoczek Str. 6, J. bld. 024, H-1111 Budapest, Hungary
tel.: +36 1 4632388, fax: +36 1 4632599
e-mail: ujsaghy.zsofia@auto.bme.hu

Abstract

In the last few decades the number of vehicles on the roads increased in a great extent and not surprisingly also the number of car wrecks increased simultaneously. These car wrecks representing a significant gross and volume of garbage contain hazardous materials among others, hence it needs to be handled. That requires a complex processing system.

European Union directives and home regulations (in Hungary) give the adequate legal background to handle this special and problematic waste effectively. The technological background for recovering and reusing as clear substance and as much component as possible is provided by the development of the shredder and the after-coming separator technology. This technique is undergoing constant development. Disposal must in the first place be organized in such a way as to create environmentally-friendly solution opportunities, in compliance with the statutory requirements using the latest state of the art, in order to close the relevant material cycle.

The most problematic fraction is shredder light fraction, it is about 20% of the grinded wrecks. The purpose of this paper is to present the environmentally-friendly disposal of vehicle wrecks, in particularly such disposal of non-metallic automobile shredder residue (ASR). ASR consists essential of plastic materials (60%), glass/sand, i.e. mineral substances, textiles/leather/wood, together with paint dust/rust and residual metals. The main aim is to change the present practice: lower the volume of waste getting into the landfill.

Keywords: *recycling, automobile shredder residue, shredded light fraction, energy recovery, pyrolysis*

1. Introduction

About eight to nine million tons of waste is created only from car-wrecks in the European Union annually. In Hungary, about 100-120 000 vehicles are discarded every year, which means nearly 100-120 tons of waste. After the accession to the European Union, the harmonisation of compliance with the directives regarding car-wrecks became compulsory in Hungary as well. One of the most important aims has become to reduce the amount of waste due to car-wrecks landing in depots. Waste treatment rates from car-wrecks have also been tackled. [1]

2. EU Commission directives

The environmental laws concerning the recycling of vehicles and their aggravation have effected that the value of all organic materials (plastic and rubber parts) found in cars has gone up considerably. Although the primary goal would be the mass reduction of cars, due to the emission directives, traffic safety, reuse and comfortability demands, there has been a mass increase in the last few decades. The materials used are now influenced not only by design and economic but also by environmental factors.

The 2000/53/EC Commission Directive on the end-of-life vehicles prohibits the application of certain materials in car manufacturing. Moreover, it determines certain rates in the course of recovery. According to this, as of 1st January 2006 the reuse and recycling has been increased to

80% by an average weight per vehicle and a 5% energy recovery must be performed on these vehicles, thus the recovery rate comes to 85% all together. No later than 1st 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, from which 85% will be reused in material, while 10% in energy. For vehicles produced before 1st January 1980, Member States may lay down lower targets, but not lower than 75 % for reuse and recovery in a ratio of 70%/5% [2].

3. Current technologies

Nowadays, the most widely-used recovery method of car wrecks is the so-called shredding. In the hammer mill comminution works dismantled and dried car-wrecks and body elements are ground to fist-size pieces, then the various materials are separated based on material features like density, magnetic and electronic conductivity. After this separation the various materials are taken to recycling plants.

The residue that remains after the separation of all metals, the so-called shredder light fraction, which consists of the mixture of plastic, rubber, glass and fabric, is 18-22% of all problematic wastes. It mainly consists of polluted, mixed plastic and rubber waste. Even though there would be enough processing capacity in Hungary, the material recovery of plastic and rubber waste does not work sufficiently. This is due to the lacking economic and legal initiatives, which would promote recycling, and to the market's rejection of secondary raw material. The best solution would be to reuse the raw materials, or to recycle them after use or at least recover the invested energy, but by no means, to continue the present practices of depositing the crashed waste in monodeponies. Since a big part of these materials is plastic, whose weight-volume percentage is high, they break down slowly. For this reason, it would be essential to reduce the amount of car-wrecks landing in monodeponies.

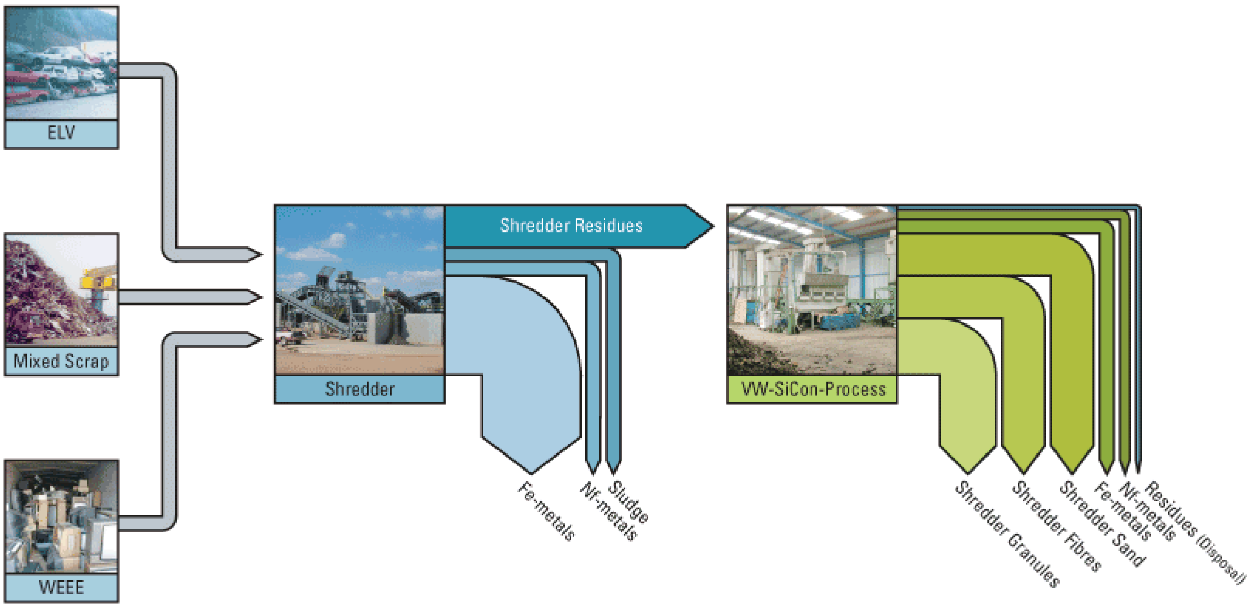

Fig. 1. VW-SiCon technology, an advanced technology to separate waste fractions [3]

Presently, the metal content (which is 70-75% of vehicles) goes through material recovery as heavy fraction in the shredding process, while the burning of the light fraction (the previously gained plastic and rubber parts) in cement works effect an energy recovery rate of about 4-5%, due to which the recovery rate will be only 80% instead of 85% prescribed in the above-mentioned directive. Similarly to the directive on „end-of-life vehicles", the directive on depositing waste greatly influence car manufacturing. According to this, the deposition (or general discarding) of organic waste deriving from car-wrecks is prohibited. As a consequence, car manufacturers are forced to search for new alternatives in the development of the recovery of comminutional light fractions.

In Hungary vehicles wear out much more easily than in other countries due to bad-quality roads. The average age of the three million vehicles used in Hungary is also much higher than abroad. Furthermore, due to the problems in waste treatment and reuse possibilities- which reflect the general lack of environmental awareness in the population- the situation is worse in Hungary than in other countries. Currently, there are about 280 legal car-wreckers and waste treatment plants, which is an insignificant number compared to the illegal car-wrecker plants (which is about five times as many) and which take about half of the car-wrecks in Hungary.

In Budapest there are two shredder works, and now a third one has been built in Fehérvárcsurgó in Fejér country thanks to the ALCUFER group. Figure 2 depicts the shredder works in the middle of processing car-wrecks.

Fig. 2. The shredder works in Fehérvárcsurgó

4. Developments in material recovery

4.1. The magnetohydrostatic technology

With the increase of the body mass of vehicles, also the ratio of plastic and elastomers in them becomes higher, due to the constructional advantages of light structures. Currently, 11-12% of vehicle-parts contain plastic, whose majority is polyoelfins (Polypropylene, Polyethylene) and styrole-based materials (Polystyrole, Acrylnitril-Butadien-Styrol). Despite the EU-directives, the comminuted organic ground materials from various wastes and car-wrecks deriving from shredding are deposited in depots, which contradicts the relevant directives and as a consequence, the required recovery rate is not reached. As a role model Austria could be mentioned, where the prohibition on depositing waste applies to the entire amount of organic waste, and the light fraction is taken by specialised burning works from the shredder works to energy recovery for the cost of 180 EUR/ton. Our goal is to start, as it is in other countries, development processes, by which the rates required by the EU can be complied with. As a response to that, the project W2Plastics sponsored by the EU7 K+F framework is developing a separation technology that, with the help of connected ultra-sound quality assurance system, separates polyelfines from the shreddered light fraction thanks to the magnetohydrostatic separation technology. A further advantage of the system is that it can separate as many as eight homogenous fractions from each other in one step, which can be significant for the reuse in car industry as well. A material separation can be executed by the modifiable density of the separation fluid.

The 4-year long, 13-member development project coordinated by the Delft University of Technology commenced in January 2009 have the following Hungarian participants: ALCUFER Kft., the Departments of Automobile Engineering, Polymer Technology and Organic Chemistry at the Budapest University of Technology and Economics.

ALCUFER Kft. is in charge of the development of the energy recovery and reuse of the organic parts of the light fraction (which cannot undergo material recovery) coming from Fehérvárcsurgó Shredder Words. The Budapest University of Technology contributes to the project with market analysis, the mechanical examinations of the materials of separated structures, the improvement of material quality by chemical additives and new product ideas [4].

4.2. The recovery of the obtained plastic and created products

The recovered plastic waste is normally sold as granulate or cast plastic straight after grinding. These products often lag behind those made from original material not only in quality but also in appearance. At the same time, the marketing of granulates made from secondary raw material is very difficult. A solution for this could be the creation of blendings and composite matrixes which can be marketed as opposed to the original material, and instead of the usual down-cycling (the deterioration in quality) there could be an up-cycling (improvement in quality). This process is hindered by the fact that the heterogeneous plastic mixture binds loosely at the boundaries of the various materials. To improve this, secondary bonds are created by the addition of chemical additives and compatibilisers. Secondary bonds can be replaced by much stronger covalent bonds by a so-called electron irradiation technique. With the help of glass-fibre supported polymers, the connection between blends can be strengthened, in which the glass-fibre is connected to the elements of the material with various chemical additives. Another problem of plastic recovery is aging. Plastic that is to be recycled will be worn out even more in the course of the recovery process. Further additives are necessary to strengthen the stability against UV-radiation. Car industry is not yet ready to apply recycled plastic, however. For this reason, other industries have to be found to complete the recycling process [4].

5. Developments in energy recovery

The two most important thermic procedures from all thermochemical methods involving heat transfer are: waste burning and pyrolysis. In these cases material transformation comes about mainly as a result of heat.

- Burning: Oxidative decomposition with the addition of air stoichiometrically or repeatedly.
- Pyrolysis: Reductive decomposition while providing oxygen less than in a stoichiometrical amount or under circumstances lacking oxygen entirely [5].

5.1. Burning

In the course of burning the organic components of waste react with the oxygen of the air and are turned into gases, steam and are released from the system as fume, while the inorganic unburnable inorganic matter stays in the form of scum and scale.

Advantages:

- It reduces the volume and mass of waste significantly,
- Burning produces energy and the obtained heat can be used,
- From the perspective of sanitation it is the most efficient since all bacteria and other causative agents are killed.

Disadvantages:

- It results in secondary pollution (air pollution, scales, cinder and the deposition of these),
- Non-beneficial from the perspective of ecology: materials decomposed thermically leave the natural cycle,
- Its investment and operational costs are much higher than those of traditional technologies.

5.2. Pyrolysis

In the course of pyrolysis, organic waste is chemically decomposed under regulated circumstances in an adequately designed reactor at a high temperature, in a closed environment poor at or lacking in oxygen – or under inert gas atmosphere. During this process from the organic waste we gain pyrolysis gas, fluids (oil, tar, water containing organic acids) and solid final products (pyrolysis coke), whose composition, ratio and amount depend on the composition of waste, the operational circumstances and the structural solutions of the reactor. The final product can be primarily used as energy source (fuel gas, fuel oil, coke), and more rarely as chemical secondary raw material (e.g. it can be used to create methanol by converting the gas products into syngas.

In pyrolysis the circumstances of the chemical reactions are determining: temperature, warm-up time, reaction time, size of grits and pieces, the extent and efficacy of mixedness. The applied temperature ranges from 450 till 550°C, but with certain processes it's higher than that. Reactors to be used are vertical or shaft reactors, horizontal fixed-bed reactors, rotary drum reactors and fluidised reactors.

Following the separation phase in water-bath, the solid rest can be processed in several ways. For the separation of gas- and steam-state products various gas-steam purification and separation methods and combinations (cyclones, electrostatic filters, gas washing devices, post-burning chambers and cracking reactors) are used.

Advantages:

- Its products are alphatic and aromatic hydrocarbons,
- Its air-polluting effect is much lower than that of waste burning.

Disadvantages:

- Material must be thoroughly prepared,
- In the processes with lower temperature, gas purification is more complex and complicated, and the highly polluted washing water has to be cleaned in a very complex manner,
- Compared to burning, there is a higher chance for incomplete and hardly decomposable products.

From the successful processes four technologies are have been put to use: the Siemens-, the Lurgi-, the Noell- and the Thermoselect technologies. These technologies effect a multi-step thermic waste-treatment, so providing a better controllability of the part processes and by the pre- and inter-selection, they bring about the reduction of the inert materials. In the Siemens and the Lurgi-technologies the complete combustion of the gas phase occur in the device itself, while in the Noell and Thermoselect technologies create a kind of gas that can be burned outside the device as well [5].

A Hungarian initiative has also appeared in 2009 as part of the National Technological Programme of the National Office for Research and Technology. Its goal is to develop an optimal separation technology, by which the unusable organic components of a material are put to use by pyrolysis. Under the coordination of ALCUFER Kft. in the consortium called RECYTECH the following participants are present: the Departments of Polymer Technology, Organic Chemistry, the Advanced Vehicles and Vehicle Control Knowledge Centre, E-Elektra Inc. from Dunaújváros, the Bay-Logi Institute from Miskolctapolca, the Institute of Raw Material Processing and Environment Process Engineering at the University of Miskolc and Powerenergy Kft. from Solt. Powerenergy Kft is in charge of the technological development of pyrolysis. Their task is to produce two separators and pyrolysators which could locally contribute to the energy recovery of the light fraction produced in the Fehérvárcsurgó Shredder Works and the Electronic Waste Processing Plant in Dunaújváros [6].

6. Summary

In the course of pyrolysis, waste can be decomposed practically without side-products into materials that can be used and sold one by one. The operational costs of pyrolysis can be covered by the profitable marketing of the final products. Compared to burning, pyrolysis allows less emission of harmful substances and provides a much higher amount of useful materials, yet its profitability depends greatly on the marketing of the final products. Currently, it seems to be the best solution to use pyroil in internal combustion aggregates to produce „green electricity” because this state subsidised energy source results in the quickest economic return of the technology. At the current oil prices it could be worthwhile to hand over pyroil to oil companies for further refinement. Pyrogas could be exploited to produce electricity in gas turbines or for heating works, while pyrocoke can be used as colouring substance or as filtering material in the paint industry.

The residue of pyrolysis can be used as oil or the mixed plastic waste could well be taken to the burning plant as part of the waste and be used as energy source. The energy content of the major components of plastic waste, pure PE, PP, PS, PET, are roughly equivalent to the calorific value of 44 MJ/kg of fuel oil and is exploited completely. It is only PVC whose calorific value is lower (22 MJ/kg) because of its high chlorine and „petroleum” content [7].

No matter how waste has been treated so far, our goal must be – supported also by the EU – the higher and higher rate of material recovery of waste.

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