FACTSHEET

EUROPEAN DIISOCYANATE & POLYOL PRODUCERS ASSOCIATION (ISOPA)

End-of-life Vehicles Recovery and Recycling – Polyurethane Car Components Options Analysis

Introduction

Although the End-of-Life Vehicle (ELV) Directive 2000/53/EC came into force in October 2000, national implementation in some Member States is still in progress. Since the Directive leaves to European Union Member States to define how to finance and monitor to organise implementation, the regulatory options will vary a great deal from country to country.

{PRIVATE}According to the Directive, car manufacturers are responsible for the disposal of all ELVs which they produced after July 2002 and from January 2007 for all cars. The legislation also stipulates that carmakers must re-use and recover 85% of ELVs by weight by 2006. At least 80% of that weight must be re-used and recycled while up to 5% can be dealt with through energy recovery operations. In 2015, this target rises to 95% of ELVs by weight, 85% of which must be re-used and recycled.

Uncertainty prevails around the real costs and benefits, technical feasibility and economic viability of recycling and recovery options. The total weight of cars is increasing and the percentage of plastics materials in cars is also increasing. Both factors make the 2015 quota very challenging.

Polyurethane (PU) is a highly versatile plastic material that is commonly used in the automobile industry because of the many economic and ecological benefits it provides. PU applications lower the environmental impact of cars by reducing vehicle weight and improving fuel efficiency. At the same time, the excellent sound-absorbing, vibration-dampening and shock absorption qualities of PU contribute to higher comfort and safety levels. On the basis of the performance/weight ratio, polyurethane is very often the best available material.

PU is recyclable and recoverable through a range of different methods (www.isopa.org for fact sheets). There are varying external factors such as local conditions, market capacities and the amount and quality of reclaimed material. These should be considered when determining which option is preferable in relation to environmental considerations and technical and economical feasibility .

ISOPA and Euromoulders are working together to analyse the viability of various recycling and recovery options for car seats from end-of-life vehicles and the following options are discussed in this fact sheet:

- Dismantling of car seats and material recycling of PU foam.
- Shredding of complete car seats and use of the organic-rich shredder residue light fraction for feedstock recycling
- Separation of the flexible PU from the shredder residue to use as a secondary raw material after clean up from contamination

Because of the difference between various countries in infrastructure, shredders and dismantling operations, existing recycling industry and recovery operations, it is expected that many different schemes will develop across the European Union.

Dismantling of PU seat cushions

Under today's existing and up-coming national ELV legislation, dismantling embraces a number of important steps such as depollution and removal of parts for reuse. In the future the activity may expand to removal of parts for material recycling depending on cost efficiency or mandated dismantling of selected parts such as the seat cushion by, in a few cases, national legislation.

In Europe, both in Italy and in the Netherlands selected dismantling is already taking place. In Italy the decision to dismantle seat cushions depends on market conditions such as the revenue received for the baled PU by the dismantler. The Fiat Auto Recycling (FA.RE) system does not provide any continuing subsidy. In the Netherlands the total chain from dismantling, the logistics and the sales of baled PU is subsidised by Auto Recycling Netherland (ARN).

The dismantling of the PU seat must be cost efficient when judged on the basis of the value generated from the baled PU as compared to PU trim foam available in the market place from bedding & furniture production. Besides the understanding and knowledge of this cost efficiency the aspect of quality of 12 year old post consumer foam has been researched. In addition to the dismantling step the aspects of collecting and transporting large amounts of foam have been estimated [1].

The dismantling of PU seat material was analysed using information received from ARN in NL and FA.RE in Italy. Large amounts of foam (about 10 tons) from the FA.RE and the ARN systems were used for visual, physical and chemical analysis.

The results (see Table 1) showed that the contamination of the PU seating material is rather low when compared to PU foam in shredder residue. The total amount of heavy metals is rather high in PU [2] and above 1000 ppm for As, Cr, Co, Cu, Mn, Ni, Pb, V, Sb and Sn of the regulated heavy metals.

A comparison of the average analytical results from the ELV PU foam from dismantled seats and from shredder residue (SR) PU foam is given below:

		PU (1) Foam Dismantled	PU (2) Foam in SR
Hu	GJ/t	25.6	16.7
Ash	wt%	0.9	21.3
Cl	wt%	0.11	0.91
Hg	mg/kg	<0.1*	0.8
Tl, Cd	mg/kg	<1.0*	1.2
As to Sn	mg/kg	200	1200
Zn	mg/kg	50	5340

* < means below detectable limit

Table 1: Compositional comparison [1]

The end-of-life characteristics of dismantled PU foam are extremely different from and significantly better than foam from SRs. This is not surprising as the PU foam absorbs a large amount of heavy metals and other liquid components still present in the ELV when its goes through a shredder. The contamination of the SR foam with other constituents is extremely high and makes any kind of cleaning very costly and carries a high risk for the final customer of this PU foam from SR for applications such as re-bonding.

Different scenarios have been considered [1] in order to make an estimate of additional logistic costs of dismantled PU cushions. These are (a) each dismantler has invested in his own baling press and compresses the PU cushions before transportation to the recycler; (b) the dismantler collects PU cushions in containers and transports them to a nearby baling center or (c) there is transport of uncompressed PU cushions from dismantler to recyclers. The detailed results can be seen in reference [1] for Germany.

Depending on scenarios an optimum cost between investment cost for the baler and running cost for the actual transport have been determined. The costs can vary between 1,10 €/kg and 0,75 €/kg for the PU foam.

Feedstock recycling

Gasification

Of all the feedstock recycling processes, the gasification process is likely to prove to be the one of most interest for polyurethane materials. In a two stage process, mixed plastics are heated and then combined with air or oxygen. A synthesis gas, consisting of carbon monoxide and hydrogen is produced. This gaseous product can be used in a wide range of refinery processes as well as the production of methanol, ammonia and oxo-alcohols.

In trials, with polyurethanes materials forming a small part of the mixed plastics waste feed, the nitrogen inherent in polyurethanes has proved to be beneficial in the acid gas neutralisation process and thus improved the economics of the process.

There is already an industrial scale plant [2] in operation as shown in Figure 1.

Commercial gasification units, running on a range of feed sources, are in operation all over the world. This method is also acknowledged for packaging waste and automotive shredder residue as recycling by German authorities.

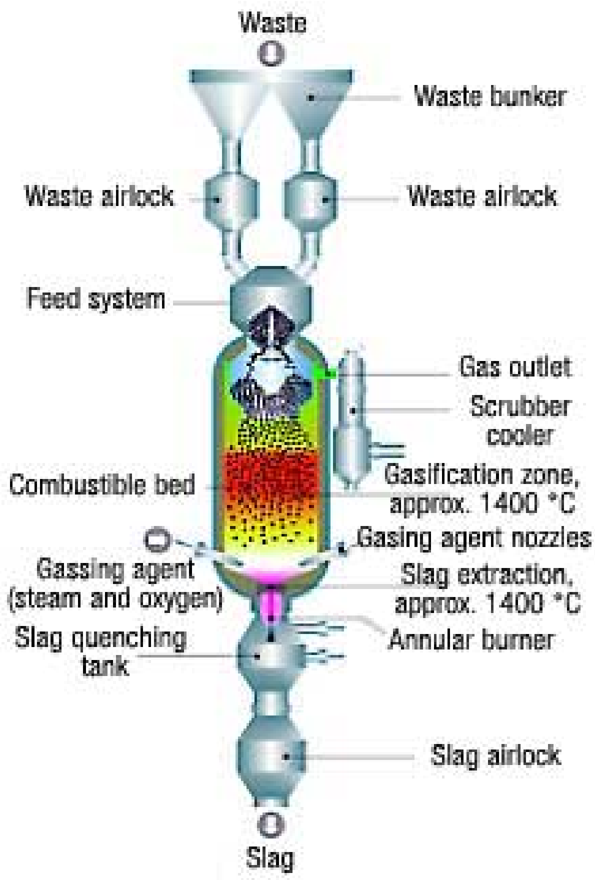
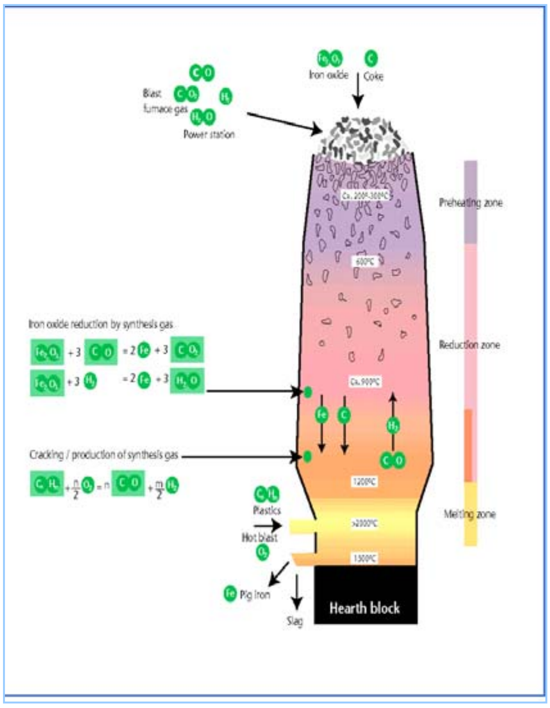


Figure 1 – Gasifier for pretreated solid waste
Source : www.svz-mbh.de

Blast Furnace Reducing Agent



The most recently developed option has been spearheaded by the Bremer Steelworks in Germany, using mixed packaging plastics.

In the past, heavy oil or coal dust has been used as a reducing agent in a blast furnace for converting the iron ore to metallic iron. Currently, up to 30% of these materials can be replaced by mixed plastics, which are injected into the furnace. At temperatures in excess of 2000ºC, the plastics are broken down, mainly into carbon monoxide and hydrogen. These capture the oxygen from the iron ore, producing carbon dioxide, steam and pig iron.

Other blast furnace operators are now showing an interest in a range of mixed plastics waste streams. It is likely that this option will provide a large volume solution for much of the waste which will become available in the near future.

This method is acknowledged for packaging waste as recycling by German authorities [3]. Currently, it is in use in two large plants in Germany.

Volkswagen [4, 5] has, together with others, developed a process where the plastic fraction of shredder residue, is used in blast furnaces. Earlier trials have shown that PU alone can also be used.

Chemolysis

Chemolysis of polyurethanes is a depolymerisation process where the PU macromolecules are broken down into smaller units by means of reactive agents. Water (hydrolysis), glycols (glycolysis), acids (acidolysis) and amines (aminolysis) typically serve as reagents to break the urethane bond (4, 6). The resulting products may be reassembled into polyurethane polymers which are suitable for re-use in applications similar to those for which the original components were employed. However, it is necessary to process feedstock of known composition in order to obtain consistent and predictable regenerated products and that is not the case for PU seats in old cars that vary significantly in their composition, especially over a long period of years. Moreover, it has been demonstrated that chemical recycling can only be cost efficient with sufficiently large scale (30,000 to 50,000 tons per year) and with a well specified input stream. These are difficult criteria to meet for post consumer waste. Due to high total chain costs, chemical recycling of post-consumer PU seat cushions is not seen as an economically viable option.

Washing of polyurethane foam removed from the shredder Residue

One option for polyurethane applications to meet the recycling targets in cars (i.e. mainly car seats) could be the separation of PU foam from the shredder residue. Due to the heavy pollution of these PU pieces a washing process has to performed before the material can be applied to any subsequent use.

In a study by Euro-Moulders and ISOPA, PU foam pieces were manually selected out of the light shredder residue fraction of two important shredder companies: Galloo in Belgium/France and EMR in the UK. In each case 450 kg of foam were handpicked in three portions of 150 kg each. These foams have been washed in equipment that the Belgian company Salyp had built in Ieper based on a license of the Argonne National Laboratory in the US. Any secondary application of PU foam requires minimum levels of impurities and emissions. The goal of the study was to obtain information about the performance of the washing process in terms of dirt (silica, iron oxide and oil), heavy metals, polychlorinated biphenyls (PCB's) and volatile organic compounds (VOC).

Starting from typical dirty PU foam pieces, contaminated with oil, sand and mainly iron oxide, the washing process delivered a visually clean product. Dirt was obviously effectively removed. The detailed analysis, however, proved that PCB levels remain rather high after the washing process and will hence be of concern in terms of the UNEP (United Nations Environmental Programme) Protocol. Some heavy metals show concentrations that will inhibit a number of potential further applications. Finally the emissions (VOC and FOG – fogging behaviour) exceed levels that have been agreed to by the automotive industry.

Figure 3 – Unwashed foam

In summary, it can be concluded that the Salyp washing technology, which is currently the best available technique for such cleaning processes, is not yet capable of creating a really clean PU product out of the shredder residue. The current European markets for recycled PU products are supplied mainly by clean post industrial waste streams (today 50 – 60.000 tons) in a good quality at a reasonable cost. Large amounts of this foam are exported outside Europe. Hence, potential applications for re-bonded foam made from washed post-consumer PU are very limited. As a consequence, PU separation from automotive SR and subsequent washing today cannot be regarded as a realistic solution.

Figure 4 – Washed foam

Conclusions

The implementation of the ELV Directive will, most likely, result in different approaches across the European Union. This is due to existing national schemes, such as in the Netherlands, to varying labour costs for dismantling, to different geographic conditions with respect to demographics such as population density, to existing operating plants for energy recovery and feedstock recycling and to slightly different landfill phase-out timing and other factors more related to the investment in new plants.

The PU seat foam cushion can contribute to the requirements on recycling and energy recovery. The choice of the route to contribute to these quotas depends very much on the various national or local conditions. The decision which way the compliance will be met will be mostly influenced by the OEMs and national ELV Directive implementation. Euro-Moulders and ISOPA have spent considerable efforts to analyse the different options for PU seats and propose best practices. The choice of best solutions for PU has to reflect the following criteria:

- Market and quality of product
- Environmental aspects
- Investment and monetary deficit

Euro-Moulders and ISOPA will participate within the industry at large to make sure that PU specific aspects are understood and taken into consideration in the overall ELV recovery schemes.

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