TwinRec - Bridging the Gap of Car Recycling in Europe

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Abstract

Shredding of the dismantled wreck will remain the key process of End-of-Life Vehicle (ELV) recycling. The resulting shredder residue (SR), currently landfilled, requires appropriate treatment in the near future.

TwinRec, EBARA's gasification and ash melting process, can handle that residue in one integrated process, recycling the materials and recovering the energy. The world-wide largest installation for thermal treatment of SR is in operation since 2000, and has to date treated more than 170'000 t of that waste material.

In the meantime, a total of 14 TwinRec process lines have started operation, generating a unique reference basis and experience in waste gasification with integrated ash melting. Very recently, the largest ever waste gasification and ash melting plant was ordered from Malaysia.

Applied to the EU directive ELV, the recycling and recovery targets of 2006 and 2015 are met efficiently and transparently, as TwinRec is able to gasify the SR as delivered from the shredder.

1 Automotive Shredder Residues: hazard or resource?

Except for Japan and Switzerland, automotive shredder residue (ASR) is currently still landfilled all over the world. Therefore, until recently, the composition of ASR was of subordinate relevance and the amount was merely a cost factor in terms of landfill fees.

This situation has dramatically changed: Like already enforced in Switzerland, landfill bans for combustible waste or at least drastically rising landfill taxes are installed in a growing number of countries, i.e. Austria, Germany and the Netherlands. Furthermore, the EU Directive ELV has set recycling and recovery targets which require new measures to deal with ASR for current and future EU member countries.

Consequently, the whole process of ELV recycling is receiving great attention from all involved parties. Standards for dismantling of cars are installed, with detailed requirements for removal of liquids and hazardous components and selected parts for material recycling. However, shredding of the dismantled car will remain the key process for the recycling of the largest material fraction – the metals.

Safety, comfort and fuel efficiency of modern cars result in a growing percentage of non-metallic materials used in cars. On the other hand, efforts are ongoing to improve the dismantling of parts, where economically feasible and ecologically desirable.

We estimate an average of 180-250 kg shredder residues (SR) per car for the future. Their composition will vary not only due to differences in the preceding dismantling and shredding process, but also because most shredders recycle other materials, too.

Table1 compares average composition of SR with municipal solid waste (MSW). The concentrations of pure metals, but also halogens and heavy metals are about 3-10 times higher in the ASR compared to MSW. Together with the risks originating from toxic organic compounds, this has led to the classification of SR as a hazardous waste in individual countries like Switzerland and Sweden, in the Basel Convention and by OECD and EU (“amber waste list”).

		ASR	MSW
Fe	metallic [%]	7.5	1.5
Cu		2.5	0.15
Al		2.0	?
Cl	mg/kg	17000	6000
Br		400	80
F		300	120
Zn	mg/kg	10000	1600
Pb		4000	700
Cr		800	350
Ni		600	60
Cd		50	10
Hg		1.5	0.25

Tab. 1 Composition of ASR and municipal waste (Average of multiple sources)

On the other hand, SR has a calorific value of 13-20 MJ/kg and contains several percent of metals available for recycling, like aluminium, copper, brass, zinc, stainless steel and lead. While any treatment of SR must primarily address the hazardous potential of the material, a use of the recycling and energy recovery potential is an additional important goal.

2 TwinRec is the all-in-one post-shredder process

2.1 Process description

In 2000, EBARA has introduced TwinRec for SR treatment, which is based on fluidised bed gasification in combination with ash melting. The following description is focused on the core components of the TwinRec system: the fluidised bed gasifier and the cyclonic combustion chamber.

Shredder residues are fed to the gasifier without any additional preparation, just as delivered from the shredder plant. The gasifier is a proprietary internally circulating fluidised bed of compact dimensions, operated at temperatures between 500 - 600°C. Together with the resulting fuel gas, fine particles are entrained into the gas flow leaving the gasifier. The low gasification temperature in the fluidised bed leads to easily controllable process conditions.

The gasifier's main function is separation of the combustible portion and the dust from the inert and metallic particles of the SR. Metals like aluminium, copper and iron can be recycled as valuable products from the bottom off-stream of the gasifier as they are neither oxidised nor sintered with other ash components. Together with these metals, larger inert particles are removed. Smaller inerts are returned to the gasifier where they serve as bed material. The fine inerts are blown out of the gasifier to enter the next stage.

Fuel gas and carbonaceous particles, both produced in the gasifier, are burnt together in the cyclonic combustion chamber at temperatures between 1'350-1'450 °C by addition of secondary air. Here, the fine particles are collected on the walls, where they are vitrified and proceed slowly through the furnace.

The molten slag is quenched in a water bath to form a granulate with excellent leaching resistance, meeting safely all common regulations for recycling in construction.

The high combustion temperature ensures that the most stringent dioxin emission regulations down to 0.1 ng TE/Nm3 are met with minimal additional measures.

Gasifier and ash melting furnace operate at atmospheric conditions, without consumption of fossil fuels (except for start-up) and oxygen. Due to the low excess air ratio, only a compact sized steam generator and air pollution control unit are required. The energy content of the waste is converted into electricity and/or district heat with high net efficiency.

Figure 1 shows schematically the gasifier and the ash melting furnace.

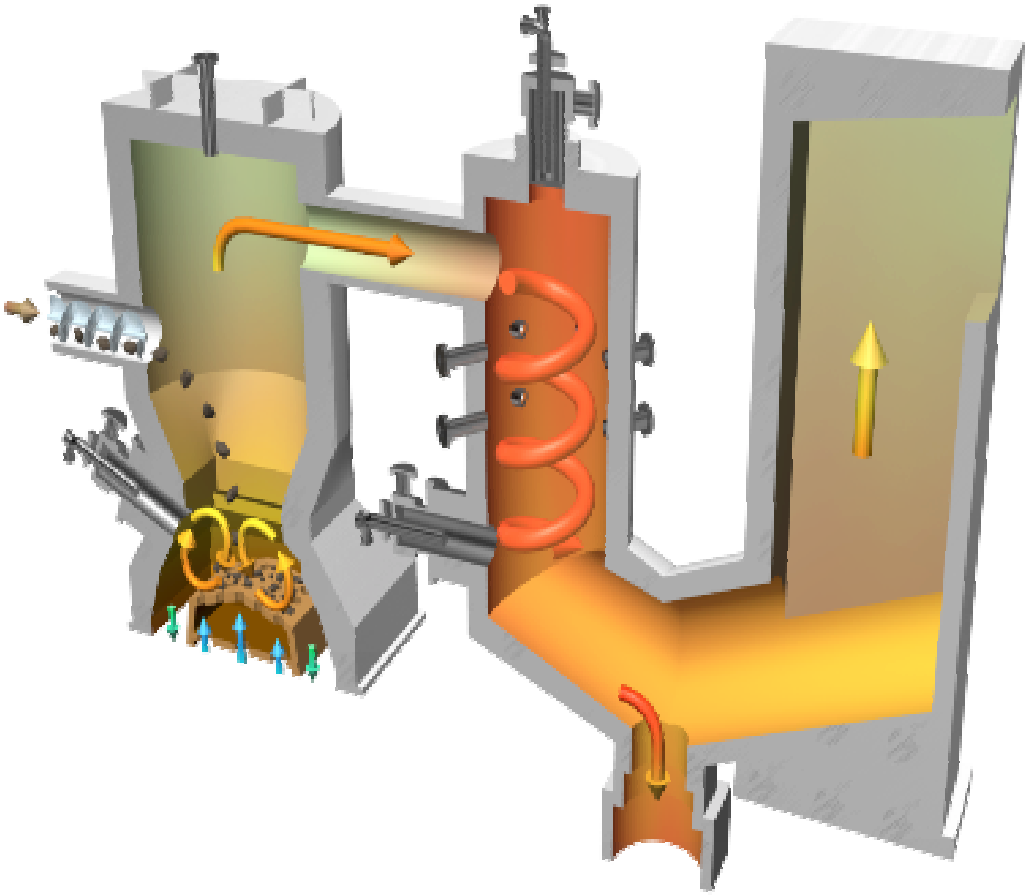

Fig. 1 TwinRec core components – Gasifier and ash melting furnace

2.2 Recycling and recovery results

Looking at the wide range of SR components, TwinRec generates product streams which fit to their characteristics and enable the best use of them:

- Pure metals and alloys are recovered in superior quality from the gasifier and are recycled
- Inert mineral material is cleaned from dust and organic matter to make it suitable for recycling
- Mineral dust and metal oxide powder is vitrified into the glass granulate and recycled afterwards
- Any harmful organic substances are completely destroyed and the total organic content is transformed into energy
- Volatile metal salts are concentrated into the secondary fly ash and available for zinc, lead and copper recycling in the zinc industry.
- The amount of final residues for landfill is can be reduced as desired from ecological and economical targets.

The energy efficiency of TwinRec is better than in thermal waste treatment processes which require oxygen and consume therefore a good part of the energy internally. Also, the ash melting furnace is integrated into the water steam cycle, making use of the highest temperature level for steam production.

2.2.1 Recycling of the glass granulate

The glass granulate is the largest fraction for recycling. For a successful application in the construction industry, it must satisfy technical criteria and pass the respective environmental certification.

Technically, the granulate qualifies for various applications, replacing cullet, gravel or sand. It can be applied as loose bulk material, or as filler in combination with inorganic or organic binders. In Japan, the granulate is used as a filler in asphalt.

The main environmental test is usually a leaching procedure, with specific requirements of maximum concentrations in the leach ate. The harmonization of these leaching procedures between EU countries or even internationally is still in a very early stage. As a result, different sets of rules are applied in each country.

Fortunately, the TwinRec glass granulate has proven to comply easily with all kinds of leaching tests:

Germany

Besides individual regulation in the German countries, recycling of waste materials in construction is subject to LAGA Z2 compliance, based on the DEV S4 (DIN 38 414-4) leaching process. Leaching of the TwinRec glass granulate (original or after grinding) is a below detection limit for the metals, and for halogen ides a few percent of the limit. Of course, no ageing is necessary before recycling.

Switzerland

In Switzerland, recycling of residues from waste treatment in generally discouraged. Instead, a special (low-cost) category of landfill is announced for high-quality glass granulates. An extensive study was sponsored by the Swiss Agency for the Environment, Forests and Landscape (SAEFL) to investigate the long-term behaviour of such glass materials. TwinRec glass was provided for this study. The result was, that the glass (like others) has excellent properties for a safe, long term storage.

„ [..] All investigated samples turned out to be good „glasses“ from mineralogical viewpoint. The vitrified residues are obviously stable in their thermodynamical behaviour. The samples show good leaching properties. In a rather aggressive test (ground samples, 10 days leaching in 90 °C water) only a comparatively small amount of the contained heavy metal was leached. These positive properties should be considered when landfilling, in that way that only minimum demands shall be required in terms of location and landfill technology. Providing, that [..] also in the daily routine residues of comparable quality as in this investigation are produced, we could imagine to landfill such residues on a new “glass landfill”, with similar demands as for today’s “inert materials landfill” [..]”

Tab. 2 Translated letter excerpt from H.-P. Fahrni, SAEFL (March 2001)

Netherlands

The Dutch building materials decree prescribes a column leaching test (NEN 7343). Again, most parameters are below detection limits for the TwinRec glass granulate or at a small fraction of the category N2 limits.

Japan

The Japanese leaching test is similar to the German, but the material is ground to 2mm first. All parameters are found below detection limit. As mentioned below, the TwinRec glass granulate is already recycled in large quantities by the construction industry.

3 TwinRec experience

3.1 Aomori ASR plant in commercial operation since 2000

The Aomori plant has a thermal capacity of 2 x 40 MW, corresponding to 2 x 60'000 t SR per year. The SR is delivered from 5 shredder plants (input to shredder: cars and brown/white goods) and by 2 non-ferrous separation plants. All shredder residues are fed to the gasifier without pre-treatment. After the shredder process, the waste size fits perfectly with the waste specification for the TwinRec technology.

In addition the SR, the plant is treating mechanically dewatered sewage sludge, in amounts from 0-30% of the SR amount. Other waste plastic materials are treated at times. Recently, a hospital waste feeding system was installed, which is now feeding sealed boxes of hospital waste directly into the TwinRec gasifier.

Commissioning started in February 2000. Until January 2003, more than 170'000 t of SR and 30'000 t of sewage sludge were treated. The flexibility concerning sewage sludge co-treatment was demonstrated with various amounts of sludge, including SR treatment alone.

Fig. 2 summarises the dual energy and material recycling as it is demonstrated in Aomori: Magnetic metals, after their separation at the TwinRec plant, are delivered to the shredder plant and recycled to the scrap industry. Non-ferrous metals (mainly copper and aluminium, and also stainless steel) as well as the gasifier bottom ash fraction are pre-separated on the plant, then processed to a specialised non-ferrous separation plant. With that scheme, the existing equipment optimised for metals separation can be used. Copper, aluminium and stainless steel of good quality are sold to the respective metal markets.

The molten glass product fulfils the stringent Japanese soil standard. After grinding, it is sold to the construction industry, where it is currently used as a filler in asphalt. The zinc-rich filter ash is recycled in the zinc industry.

The energy content of the SR is converted to electricity, which is used to operate other plants of the same company; the excess is fed to the grid.

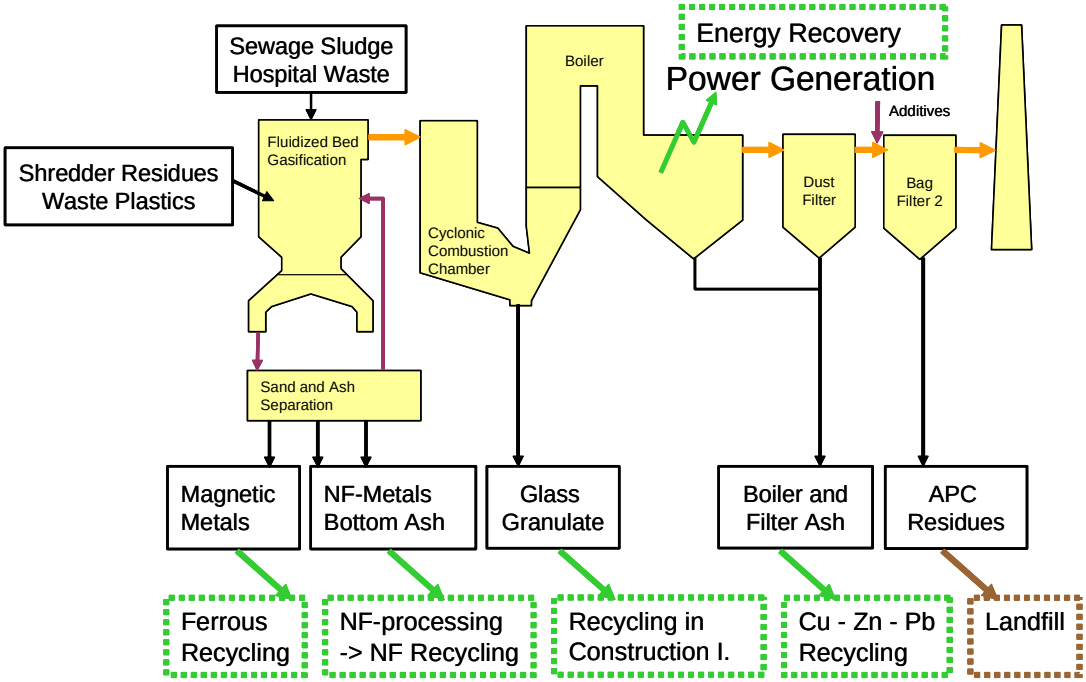

Fig. 2 Combined energy and material recycling at the Aomori plant

3.2 Experience from 14 commercial process lines

Since the start-up of the Aomori plant, several more TwinRec plants have been started, resulting in the experience from 14 process lines in operation to date.

Fig. 3 TwinRec plants in Aomori, Kawaguchi, Kurobe, Sakata and Joetsu

A variety of wastes is treated, from waste plastics, SR, sludges, industrial waste, WEEE and slags to municipal solid waste (MSW).

Different as the wastes treated and the capacity of the plants is also the appearance of the plants, as depicted in Fig. 3.

Most recently, the Kawaguchi plant was started, treating 18 t/h of municipal solid waste in three process lines (3 x 21 MW).

In addition to vitrification of its own ashes, bottom and fly ash of another incinerator is vitrified in the ash melting furnace. Additionally, some of the secondary fly ash is recirculated and even the inert gasifier bottom ash, after metals separation, is ground and fed back to the ash melting furnace. This way, more than 97% of the waste input are turned into energy, metals and glass granulate for recycling!

Figure 4 shows the performance of the plant since the first day of commercial operation (status Jan 20th).

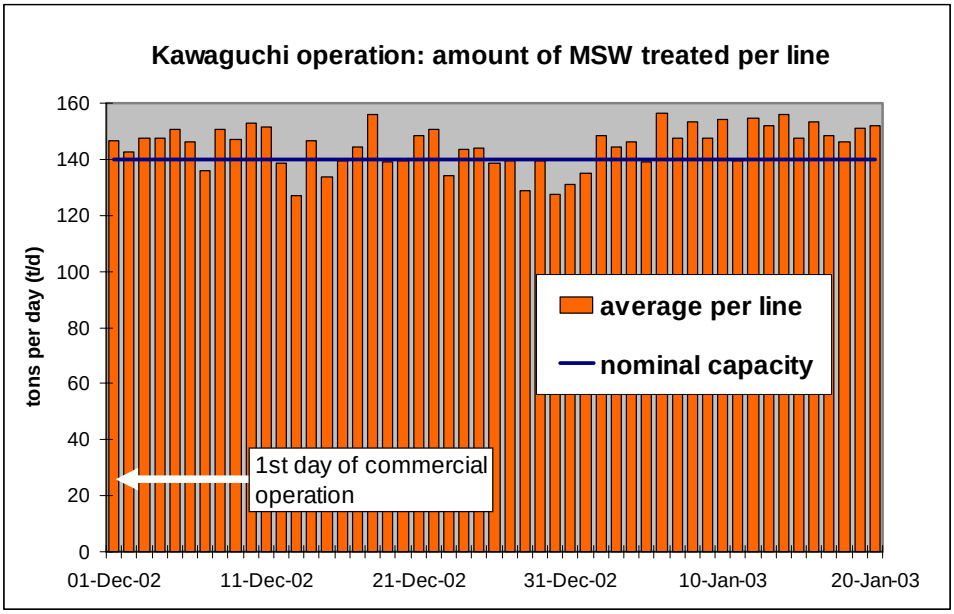

Fig. 4 Kawaguchi plant operating continuously at over 100% from day one.

3.3 World's largest waste gasification and ash melting plant

On February 7th 2003, EBARA announced that it has acquired a major project against serious international competition:

Malaysia's Ministry of Housing and Local Government has decided on EBARA's TwinRec technology for the first thermal waste treatment plant of the country.

The plant, which will be located in Kuala Lumpur, has a total capacity of 1500 t/d (62.5 t/h) MSW in 5 process lines of 300 t/d each. After 38 month of construction, the plant will be world's largest waste gasification and ash melting plant.

4 The gap is closed – EU directive compliance at minimum cost

TwinRec is designed to combine material recycling (metals, mineral components, ash) with energy recovery. This concept fits ideally to the goals set by the EU Directive ELV, which requires in its final stage 95% of recycling and recovery of the car.

The TwinRec gasifier, besides detoxification of the organic material, separates the remaining metals and large inert particles from the combustibles and fine ash, therefore maximizing the total metal recovery from the end-of-life vehicles.

The combustible gas and the fine char are used to vitrify the ashes and fine particles, turning these into a recyclable, inert construction material.

Of course the excess energy is recovered with a steam boiler, available either for direct steam and heat use, or for power generation in a steam turbine.

If desired, the recycling percentage can be further increased by recovering zinc, lead and copper from the secondary fly ash. In total, the amount of SR left for landfill can be reduced to less than 5% of the SR amount, resulting in a total recycling and recovery of the ELV of 99%!

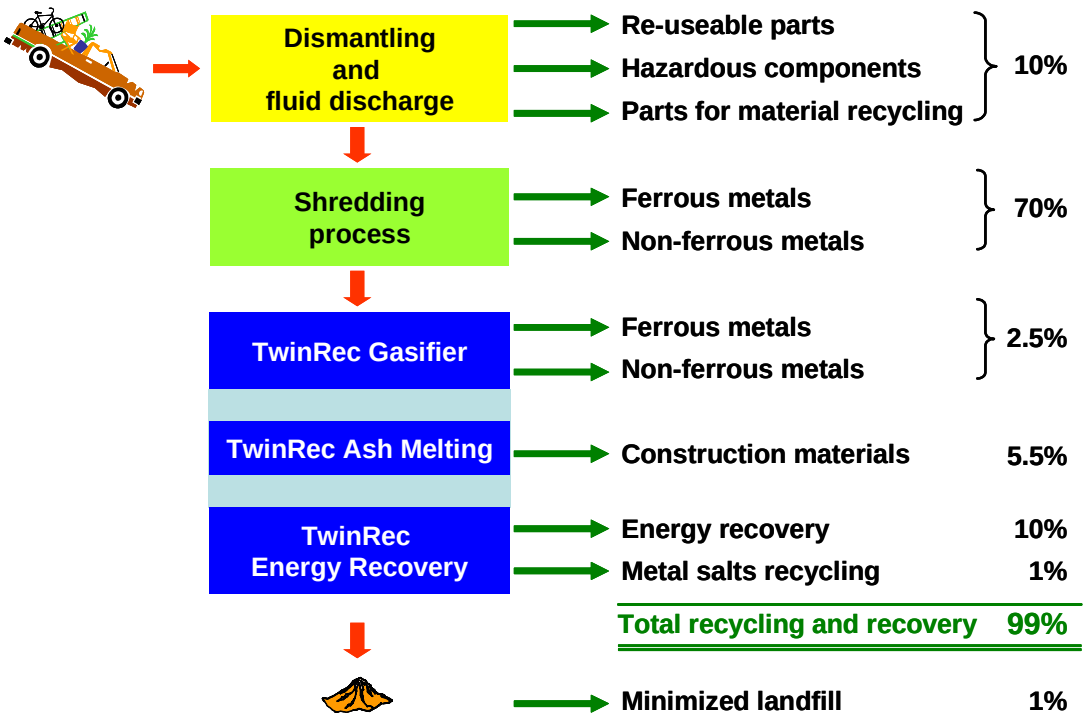

Fig. 5 Stepping up to 99% recycling and recovery with TwinRec

The TwinRec concept bridges the gap between current and future car recycling with one single process. This avoids waste dissipation, but also intransparent cost structures. The gate fee of a TwinRec plant for SR will be in the range of 20-50 € per car, which corresponds to the cost of just half a tank filling of gasoline.