

NADA ŠTRUMBERGER, D.Sc.
JASNA JURUM KIPKE, D.Sc.
GORDANA ŠTEFANIĆ, D.Sc.
Fakultet prometnih znanosti
Zagreb, Vukelićeva 4

Traffic Safety and Ecology
Review
U. D. C. 629:620.284
Accepted: Mar. 2, 1999
Approved: Oct. 5, 1999

MATERIAL RECYCLING IN TRANSPORT

SUMMARY

Recycling means re-introducing waste material into the production process, as addition to primary resources. The use of waste as secondary raw material is economically justified. By using old material not only primary raw material is saved, but energy as well.

The paper presents the most frequent materials, the ways in which they are collected, and subsequent classification. The sorting procedures have been mentioned, with throughput capacity an important parameter expressed in tonnes per hour. The higher the throughput capacity, the better the effect of sorting.

KEY WORDS

transport, material recycling, savings, sorting, collecting

1. INTRODUCTION

Recycling means re-introduction of waste material into the production process as addition to primary raw materials. The definition of waste here may be: "Waste is the raw material in the wrong place."

The use of waste as secondary raw material is justified from the economic point of view, since primary raw materials are more expensive and their reserves are getting depleted in nature. The re-usage of production waste in the production of new kinds of goods is common in the paper and glass industries. The usage of old materials means not only savings in the reserves of raw materials, but also savings in the consumption of energy. Thus, e.g. the production of glass from broken glass requires only two thirds of energy for melting, required otherwise for production from primary raw materials. In the production of iron or aluminium the relevant values show the same relation.

Waste is also raw material with regard to precious materials. These materials have to be separated by sorting. When waste is collected already separated regarding sorts, it is easier to carry out the sorting process. In some European countries rules have existed already earlier, about collecting certain types of waste (in Sweden e.g. separately newspapers and separately journals have been collected since 1980).

2. OBTAINED MATERIALS AND THEIR USE

2.1. Paper and Cardboard

The most widespread types of waste are paper and cardboard. In Germany, the share of old paper in the paper industry is the largest in the world. Old paper provides 50% of paper raw material. In Sweden, rich with wood, the percentage of using old paper is at the moment 10%, and only after the act on preventing tree felling will have been accepted, will the paper industry be forced to take a part of old paper. For such usage in paper industry, it is necessary to perform certain technical modifications since waste paper is not clean.

There is also an additional possibility that paper and cardboard are added as the middle layer in the industry of plywood or as fuel. Fuel is produced from light fraction by air separation, and it consists of paper and traces of artificial materials. After cutting into pieces, it is pressed into cubes which are easily stored and transported.

2.2. Foils of Artificial Materials

With the rising price of oil, artificial materials are becoming interesting as old material. The best organised waste collection is in bags of artificial materials. The production of artificial material uses 50% of old collected raw materials - waste. It is important to determine what kind of artificial material is involved and this is defined by designations.

2.3. Ferrous Waste

Ferrous waste can be sorted by means of a magnet. Steel production waste is very useful because there is no sorting. The problem arises with old cans which have one side coated with tin. This coating hinders the recycling process and it has to be chemically or thermally removed.

2.4. Glass

Glass recycling is best organised in Switzerland, where 35% of old broken glass is used in the production of glass. Glass industry has to consider the purity of broken glass. Even very slight impurities, a little stone or metal cap reduce the quality and cause difficulties in the re-production.

Glass is produced in white, brown and green colour. While being collected, old glass should be separated according to the colour in order to simplify its use in reproduction.

Table 1 - To add broken glass of another colour in the production of a certain colour of glass

Addition of foreign broken glass	Production		
	brown glass	green glass	white glass
brown	–	≤ 15%	≤ 0.01%
green	≤ 5%	–	≤ 0.005%
white	≤ 10%	≤ 10%	–

Table 2 - Allowed values of impurities in broken glass

organic matter	0.05%
magnetic metal	0.005%
non-magnetic metal	0.0015%
non-magnetic solid material	0.01%

3. METHODS OF SORTING

3.1. Screening

Fine parts can be separated by means of a strainer, which is especially important for precious raw materials. Grains of up to 50 mm can be screened. Bigger parts are sorted manually or mechanically.

Manual sorting is the longest applied sorting method. Many materials can be identified optically and mechanically and they are easy to sort.

3.2. Crushing

Materials that cannot be screened are crushed. In the earlier phase crushing creates waste of energy with subsequent undesired poor sorting results. Pre-action for air separation is crushing with limited grain sizes. The type of pre-crushing is important for the success of air separation. In air separation, specifically lighter materials are separated from the heavier ones. Light fraction consists mainly of paper with the traces of plastic foils. Heavier fraction con-

tains damp materials of organic origin, as well as glass and metal. According to purpose, light and heavy fractions can be further separated. The up to now mentioned sorting methods depend on the level of technology.

3.3. Separation of Paper and Artificial Material

For separating paper from the artificial material, wet and dry separation are used.

Wet separation

The mixture of paper and artificial material is moistened. Paper absorbs water and deposits on the artificial material. The damp mixture can be recycled by air separation. Herewith, artificial material is separated as light fraction, and paper as heavier fraction.

The damp mixture can be processed in the crushing device. It consists of a strainer drum lined from within with knife rollers of counter-direction. Damp paper is torn into pieces and screened through the strainer holes. Artificial materials are crushed once again and removed as the strainer overflow.

Wet separation methods are performed with satisfactory effects. They can be applied where damp paper is directly recycled in the paper industry.

Dry separation

In cheap sources of energy, the mixture of paper and artificial material can be separated by hot "shock". Paper does not change its form and the foils of artificial material gather into a ball. In air separation, paper is separated as light fraction, and the artificial material as heavy fraction. In many places, the principle of different strength is applied. The mixture of paper and artificial material lies on a grate, where scrapping and stretching are performed. Paper gets torn and falls through the grate. Artificial material sticks to the grate and is later removed.

A more efficient way is hot treatment separation. Both methods provide the possibility for the paper to be stored over a longer period of time without changing its properties in a dry room.

3.4. Separation of Heavy Fractions

Separation of floating organic materials can be performed by streaming in water. For glass and non-metal separation, gravitation separation is applicable. Glass can be sorted in the devices according to the colour.

4. SORTING PROCEDURES

4.1. Sorting Procedure R-80

R-80 was the first pilot plant in Munich. The sorting plant has been used in Sweden since 1979. The procedure is as follows:

The waste is fed from the dosage collector tank over a conveyor belt into the mill with cutting rollers for crude crushing. Prior to entering the mill, ferrous metals are separated by a magnet. Other compact heavier elements are separated ballistically on a fast discarding belt conveyor. Following crude crushing, iron is separated on a belt magnet. Then, fine particles of up to 60mm in diameter are separated on a tight shaft strainer, for composting. The strainer overflow gets into the horizontal current of the air separator, which operates pneumatically and ballistically. Here,

heavier fraction occurs, medium and light fraction. Medium fraction is subsequently cleaned at the second tight shaft strainer. The overflow consists of cardboard, and light paper and impurities pass through. In a zigzag separator the impurities are screened through a strainer and they belong to the heavier fraction.

4.2. Sorting Procedure by the Fläkt Company

Crude crushing is performed in a double-rotating mill with hammers. Fine material for landfills and composting is screened into the strainer drum. In a zigzag air separator, heavy items are separated from the light ones. Heavy items are not processed further. Light items are crushed and cleaned on a fine strainer of adhering sand. Then light fraction is subjected to hot "shock" in a drier, so as to shrink the artificial ma-

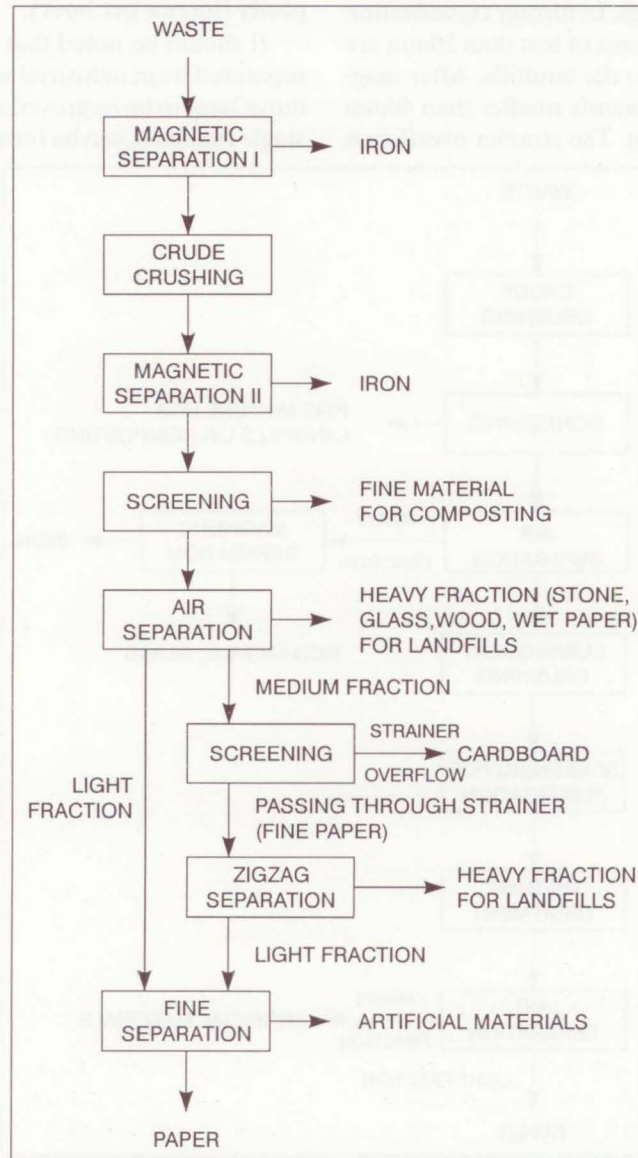


Figure 1 - Scheme of R-80 Procedure

material. In a further zigzag air separator paper is separated as light fraction, and foils of artificial materials as heavy fraction.

Fläkt-procedure has been performed in Sweden for several years already, with a throughput capacity of 10 tonnes per hour. In the Netherlands, a plant has been operating since 1980 with a throughput capacity of 25 tonnes per hour.

4.3. TH-Aachen Sorting Procedure

This procedure has been developed at the Institute for briquette manufacturing of the Technical College in Aachen (TH-Aachen).

It consists of the dry part with throughput capacity of one tonne per hour and a wet part with the throughput capacity of 0.1 tonnes per hour. The waste is first conducted in the direction of tearing, releasing the waste materials from the bags. In further classification stage, first the fine components of less than 20mm are screened and transported to the landfills. After magnetic separation, the components smaller than 40mm are screened for composting. The strainer overflow is

crushed to under 100mm in a crusher with knife rollers.

In a subsequently turned on zigzag air separator, three products are separated: light load (paper and artificial materials), medium fraction (organic materials and wet paper) and heavy fraction.

Heavy fraction is conducted to stream classification, separating organic materials as floating fraction. Non-metals are separated separately. Mixed glass is crushed subsequently and separated according to the colour in the optical/mechanical sorting devices.

5. CONCLUSION

European countries have increasing requirements for the development of waste sorting technologies. The aim is to increase maximally the throughput capacity (tonnes per hour).

It should be noted that domestic refuse should be separated from industrial waste. The described procedures have to be improved all the time so that waste, as single fractions, can be reusable. The bonds on bags or

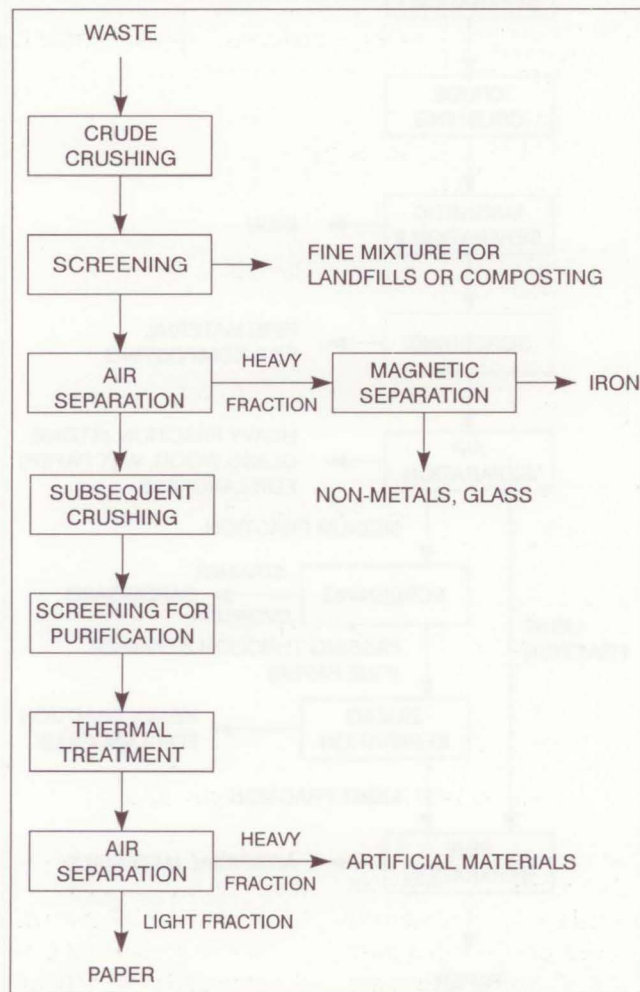


Figure 2 - Scheme of the Fläkt company procedure

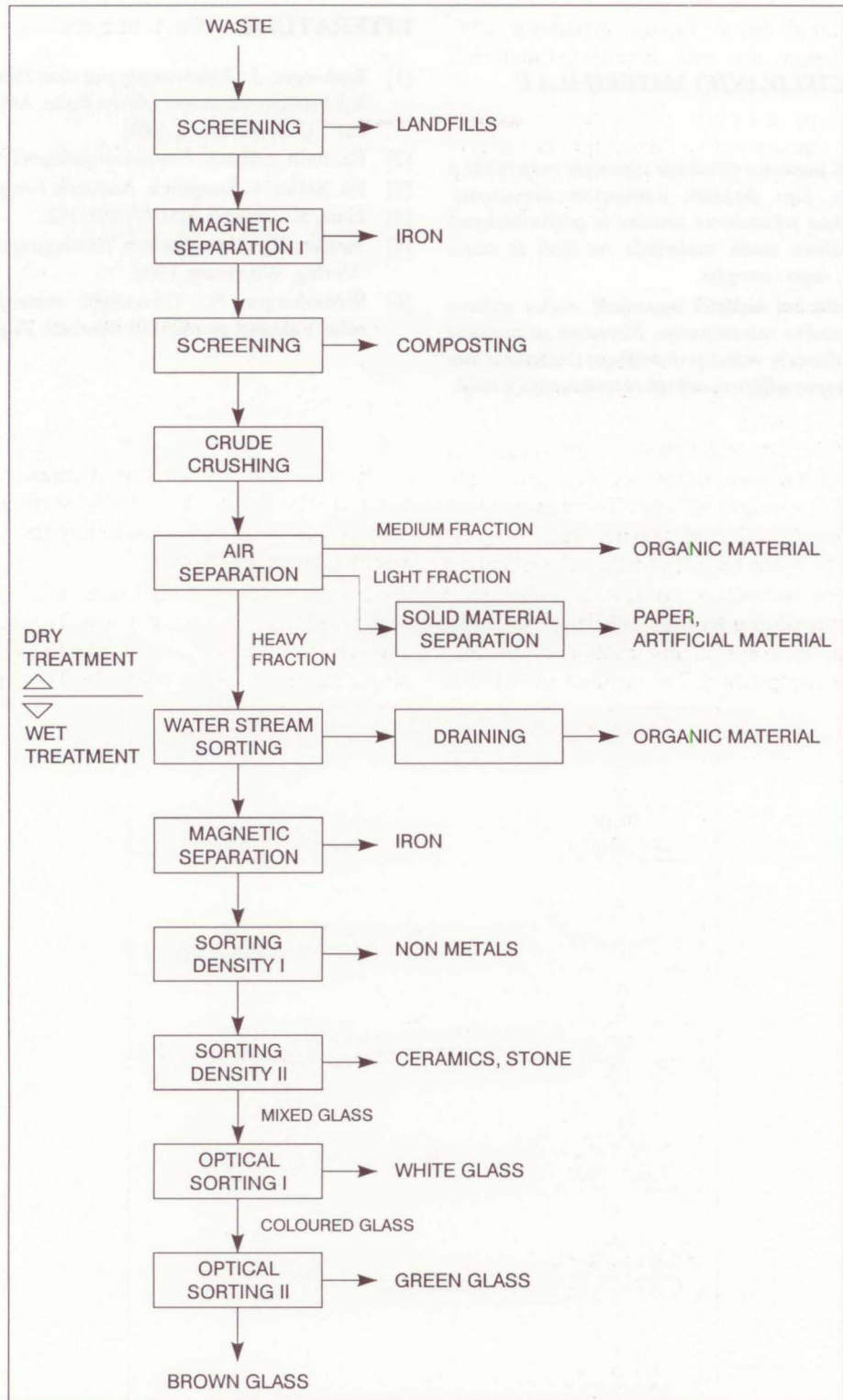


Figure 3 - TH-Aachen sorting procedure

boxes have to be easily opened so as to release the contents. Separation is performed on a strainer drum with 40 and 80mm size holes, followed by the treatment in the air separator. In strainer overflow the separation can also be performed manually. Ferrous metals are separated by means of a magnet. The remain is cut

into pieces and conducted to an air separator. Light fractions separate paper and artificial materials, and heavy fraction is subjected to damp procedure.

The waste sorting itself is successfully reflected in the obtained new materials from waste, and the sorted waste can substitute also the primary sources.

SAŽETAK

OPORABA (RECIKLIRANJE) MATERIJALA U PROMETU

Oporaba znači ponovno uvođenje otpadnih materijala u proizvodni proces, kao dodatak primarnim sirovinama. Primjena otpada kao sekundarne sirovine je gospodarstveno opravdana. Uporabom starih materijala ne štedi se samo primarna sirovina, nego i energija.

U radu su prikazani najčešći materijali, načini njihova skupljanja te naknadno razvrstavanje. Navedeni su postupci razvrstavanja, pri čemu je važna provodljivost izražena u toni po satu. Što je veća provodljivost, učinak razvrstavanja je bolji.

LITERATURE

- [1] **Emberger, J.:** *Erfahrungen mit dem Betrieb einer natürlich belüfteten statischen Mieten Rotte.* Abfallwirtschaft an der TU Berlin Bd. 6. 1980.
- [2] **Fa. Beth, Lübeck:** *Prospektunterlagen.*
- [3] **Fa. Keller + Knappich, Ausburg:** *Prospektunterlagen.*
- [4] **Lenz, S.:** *Umwelt 4* (1979) 291-292.
- [5] **Sattler, K.:** *Umweltschutz Entsorgungstechnik.* Vogel-Verlag, Würzburg, 1982.
- [6] **Štrumberger, N.:** *Tehnologija materijala u prometu roba.* Fakultet prometnih znanosti, Zagreb, 1997.

