DRY DENSITY SEPARATION OF MIXED CONSTRUCTION AND DEMOLITION WASTE

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Abstract

The effective sorting of mixed construction and demolition waste (CDW) is a significant prerequisite for obtaining high recycling rates of building and construction materials. A mixed sample of CDW typically consists of wood, brickwork, concrete, gypsum, roof material, paper, plastics and remaining metals. In this work the separation efficiency of air jig, dry sand fluidised bed, air table, windsifter, ballistic separator, colour sorting and dual-energy X-ray transmission sorting were systematically investigated in the “KRINGBOUW” project, in which several industrial partners, TU Delft and TNO cooperate. The tests resulted in a defined basis to carry out tailor made techno-economic analyses and when feed characteristics are known, the plant output can be accurately predicted. In this way the process can be optimised for the best match between feed and product markets.

Introduction

Construction and Demolition Waste (CDW) is produced when buildings and structures are constructed, renovated or demolished. The main components are soil, ballast, concrete, asphalt, bricks, tiles, gypsum, masonry, wood, metal, paper and plastic. Selective demolition, sorting and crushing enables a high recycling rate for minerals, metal, wood and plastics.

Fig. 1 – 20-40 mm light fraction from mixed CDW at the Vlaardingen plant of Van Gansewinkel, The Netherlands, where the samples were collected.


Fig. 2 – 20-40 mm heavy fraction aggregate.

A large part of the CDW can be kept separate and reused directly, especially CDW arising from larger projects and in those cases when selective stripping of buildings is possible. Despite this, a significant part of the CDW is collected as mixture and successive separation is a necessity. Today numerous CDW sorting facilities are in operation, which rely on techniques such as crushing, screening, magnetic separation, sifting and handpicking. Materials such as wood, gypsum and brick can be separated by Heavy Medium Separation and jigging. They also affect washing and wetting of the processed material. This wet processing is efficient, but washes off all fine dirt and sand which accumulates in the water circuit. It makes the aggregate cleaner and dirt free, however the washed fines add up in the water circuit and need to be removed continuously. As a consequence they cause a considerable additional waste stream of high moisture content that is difficult to dewater.

Density separation alone is useful but has fundamental limitations. Several components in CDW show a considerable spread in density instead of a single value. An example is brickwork showing different levels of porosity. These may overlap with the spread of the lighter component, such as gypsum or wood. In these cases, pure fractions can never be obtained by density separation alone. Light materials like wood and gypsum are affected by moisture and loose value after wetting.

As part of the “Kringbouw” project, which aims to close the cycle of building materials, the combination of dry separation and automatic sorting are now systematically investigated by Delft University of Technology. The project that is managed by TNO is carried out by a consortium of Dutch companies and institutes and supported by the Dutch Government. The dry separation methods investigated included air jigging, air tabling, ballistic separation and dry sand fluidised bed separation. Further automatic sorting based on colour was investigated. Work on X-ray and inductive sorting is in progress.

Table 1. Composition of samples used for the tests.

	Composition [%]	
	5-15 mm	30-40 mm
Stones	46.96	41.79
Tiles	6.46	20.44
Glass	26.28	14.56
Gypsum	5.28	2.75
Plastic	2.08	2.89
Metals	3.71	0.76
Wood/Paper	7.83	15.28
Bitumen	1.05	1.54

Polystyrene	0.13	0
Textiles	0.03	0
Dust	0.20	0

Dry density separation

In the project the efficiency of a variety of dry density separation systems was systematically investigated with the sample shown in Table 1. Only systems were investigated that are industrially applied in comparable mineral processing or waste treatment applications.

Air jigs

Air jigs were invented in the early 20th century and are in use for the separation of stones from coal in the mining industry (Fig. 3a). The allair jig, developed by RWTH Aachen and allmineral, is a recent improvement and employs a pulsating air current that causes a stratification of a bed of mixed material through which the air passes (Fig. 3b). This transfers the energy for the formation of the layers inside the bed, while a constant air current causes a differential displacement of light and heavy particles, bringing the energy to break the inter-particle friction. The machine has a minimum feed size of 1 mm, top feed size of 50 mm and a maximum capacity of about 50 tons per meter width per hour. Advantage is that the jig does not require a classified feed and this full size range can be fed to a single unit.

During tests with the sample of Table 1 using a pilot scale separator at the Minerals Processing laboratories at RWTH Aachen it was found that also lights and heavies from CDW can be separated (Fig. 4). The products are a light product containing mainly wood, plastics, porous masonry and gypsum, and a heavy aggregate fraction. Besides the entirely dry processing, its main advantages are the possibility to feed material of a wide size range, high capacity and compact design.

Fig. 3a – 50 t/h air jig for the cleaning of coal (Allmineral, RWTH Aachen).

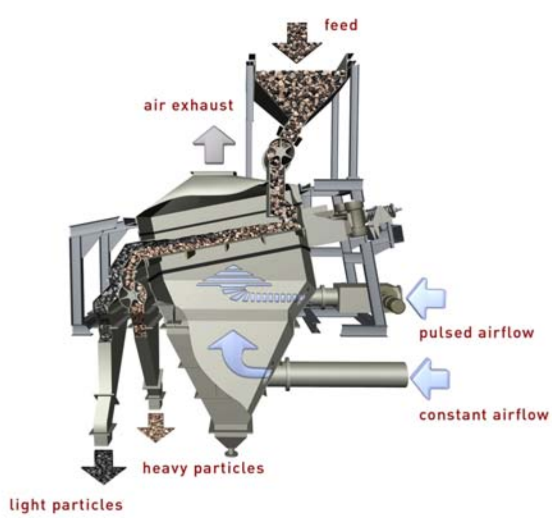

Fig. 3b – Principle of Allmineral air jig (www.allmineral.com).

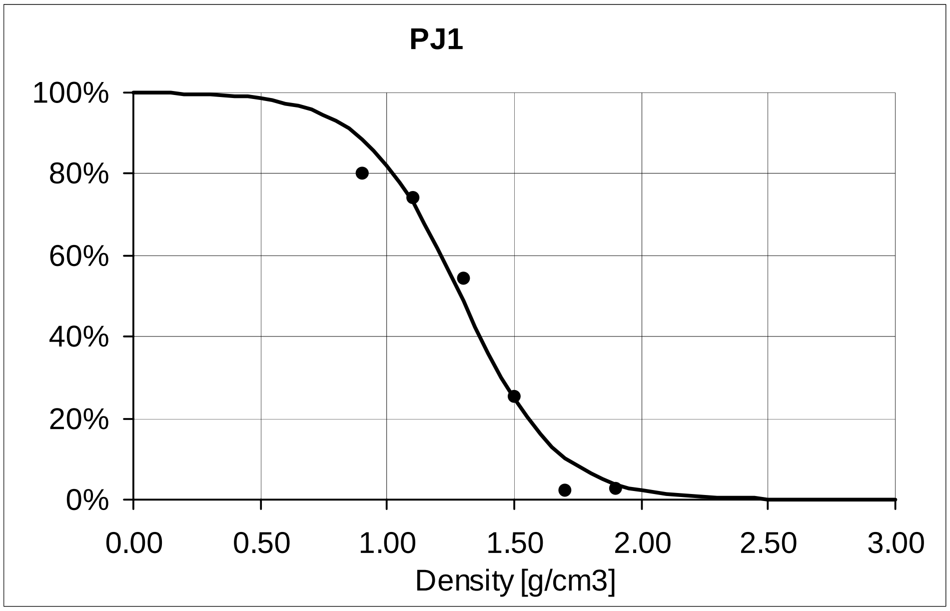

Fig. 4 – Results of the air jigging showing the percentage in the light product as function of density. The dots indicate measurements and the curve a mathematical fit.

Dry heavy medium separation

For 20 to 50 mm sized feed the air-fluidized bed appeared the best dry density separation process in terms of separation efficiency (Fig. 5). It can be considered as a "dry" Heavy Medium Separation. A gas passes upwards trough a layer of dry sand, when the drag of the flow on the particles counterbalances the weight of the particles the bed is said '*fluidised*'. A particle placed in the fluidised sand settles if its specific gravity exceeds the density of the fluid suspension or floats when its specific gravity is lower. Some of the most efficient fluidised bed separations for coal cleaning have been developed particularly in Canada and China. A system commissioned in 1997 processes 700 kt/y of 6 to 50 mm coal feed. The separation efficiency is comparable to wet jigging and the highest of all dry density separation techniques so far investigated. Air pressure and flow volume, and hence energy use, are relatively low compared to air jigs and tables. Disadvantage is that there is some sand loss that can exceed 1% of the feed when it is not properly dry, but for mixed CDW a moderate sand loss can be tolerated. The system is suitable for 20 mm oversize and there is no principle top feed size, which is only limited by practical design limitations of the system.

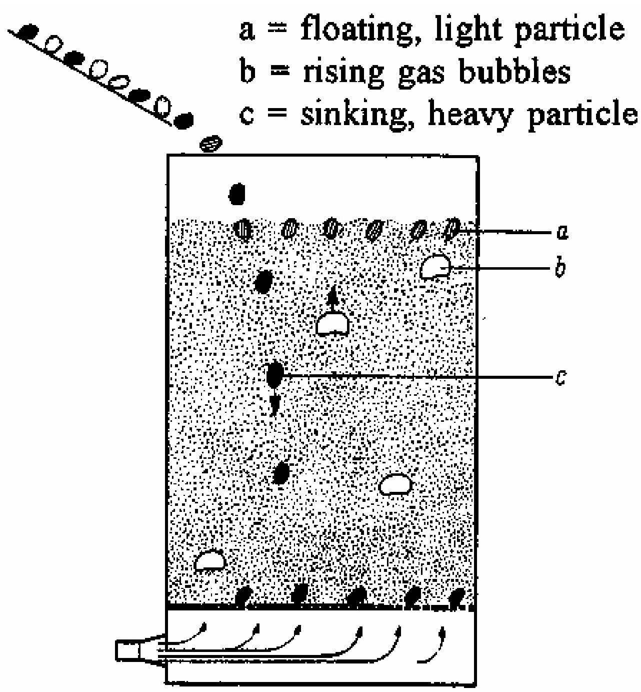

Fig. 5 – Dry sand fluidised bed principle.

Pilot scale separator at TU Delft

Tests were carried out with the air fluidised bed separator installed at the Department of Applied Earth Science, Delft University of Technology, the Netherlands (Fig. 5). The material to be separated is fed at the beginning of a separation chamber made up by a narrow vibrating deck, containing sand and crossed by an airflow, which causes the fluidisation of medium sand to occur. Vibration pushes the feed towards the end of the separation chamber. Particles heavier than the apparent bed density sink, while light particles float on the dense medium. The two fractions leave the deck in two different streams and are discharged and collected into separate containers. The sand at the output is screened off and re-circulated. The experiments with the same sample as shown in Table 1 showed the steepest density partition curves of all dry density separators investigated in this project (Fig 6).

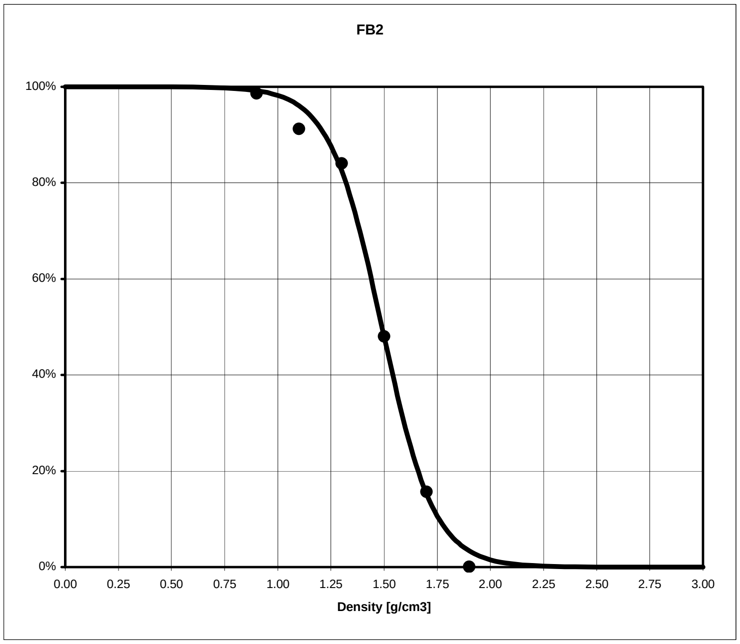

Fig. 6 - Results of the sand fluidised bed showing the percentage in the light product as function of density. The dots indicate measurements and the curve a mathematical fit.

Other techniques

In addition air tabling, ballistic separation and windsifting were tested using the same methodology. The results are intermediate between the two techniques above, on condition a narrower classification has been done before.

Automatic sorting

Automatic sorting is a separation process based on measured properties of the particles. As a consequence, the distinctive properties are not directly related to the magnitude of the separating force, as in the case with conventional physical sorting processes. Together with recently developed new sensors and advanced industrial image processing the possibilities in automatic sorting have been widened significantly in recent years. In the project the efficiency of X-ray, optical and electromagnetic sensors were investigated.

Colour sorting

Automatic colour sorting from the light and heavy fraction was investigated with the Scan & Sort CombiSense 1200 at the Department of Mineral Processing at RWTH Aachen, Germany. Its optical system incorporates a high-speed camera with 1 billion colours recognition and a special conductivity sensor permitting the identification of a variety of metals (Fig. 7, 8). It can handle mass streams of up to 10 tons per hour. Computer controlled nozzles blow out the detected materials. The camera is analyzing size, shape, colour and position of particles on the belt. The information is then used to generate impulses instructing the nozzles to blow out single particles or allow them to pass.

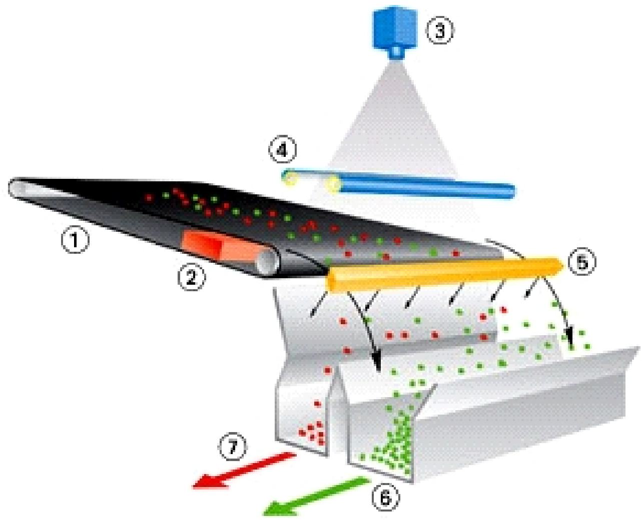

Fig. 7 – Principle of colour sorting (Scan & Sort). 1=conveyor, 2=metal sensor, 3=colour camera, 4=lighting, 5=blow bar, 6=main stream, 7=reject

Fig. 8 – The Scan & Sort CombiSense 1200 at RWTH Aachen.

The results gained with the CombiSense exceeded expectations. It could well be used to increase product quality and avoid the presence of unwanted materials in the stream to be recycled.

Total **wood** recovery and grade from the light fraction are high, reaching values of 83% and 92% respectively. 3% of stones and tiles are separated with wood; by more effective density separation a large proportion of this heavy material could be removed and grade would be about 95%. It can be concluded that colour sorting can be effectively used for wood removal from mixed CDW.

The **red brick** grade is 77% and recovery is 16% related to all stones, including brick and concrete. This result is not bad considering that the machine was set in order to remove only the red coloured brick. Tiles with one side red at a grade of 18% end with red brick. Total red brick and tile grade is around 95%.

Colour sorting allows also a good removal of **gypsum** form the heavy fraction showing a recovery of 94%. This is a good result because in recycle aggregate the presence of that mineral should be avoided due to its sulphate content. The grade is only 5.6% because of the presence of stones and tiles of similar colour in the concentrate. These could be easily removed by density separation in a second stage.

Glass recovery and grade are 96% and 56%. Thus the CombiSense separator would be also useful for glass removal from mixed building waste, where glass comprises the disturbing component.

X-ray sorting

Current investigations focus on the possibility to sort components from CDW using X-ray sensors. An example is the MikroSort AR 1200 (CommoDaS / Mogensen) that was introduced in 2004 (Fig. 9). These are expected to further increase the quality of sorting and extend the possibilities. An example is shown in Fig. 10, where each dot in the graph represents a measurement on a single particle. As can be seen, an effective split between organic and inorganic materials can be made, as well as an effective metal recognition in the same pass. Utilising dedicated imaging software specific components such as gypsum or asbestos can be removed as well (Fig 13). The capacity of the current machines is similar as those in use for optical sorting.

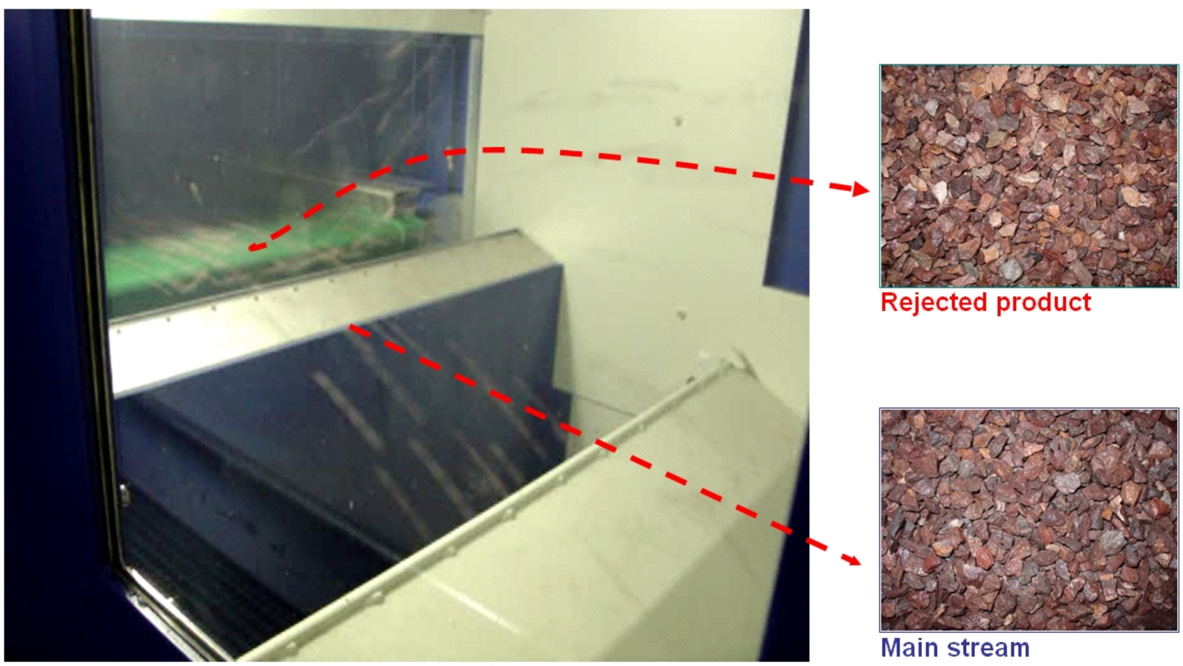

Fig. 9 – X-ray transmission sorting of 20 mm rocks

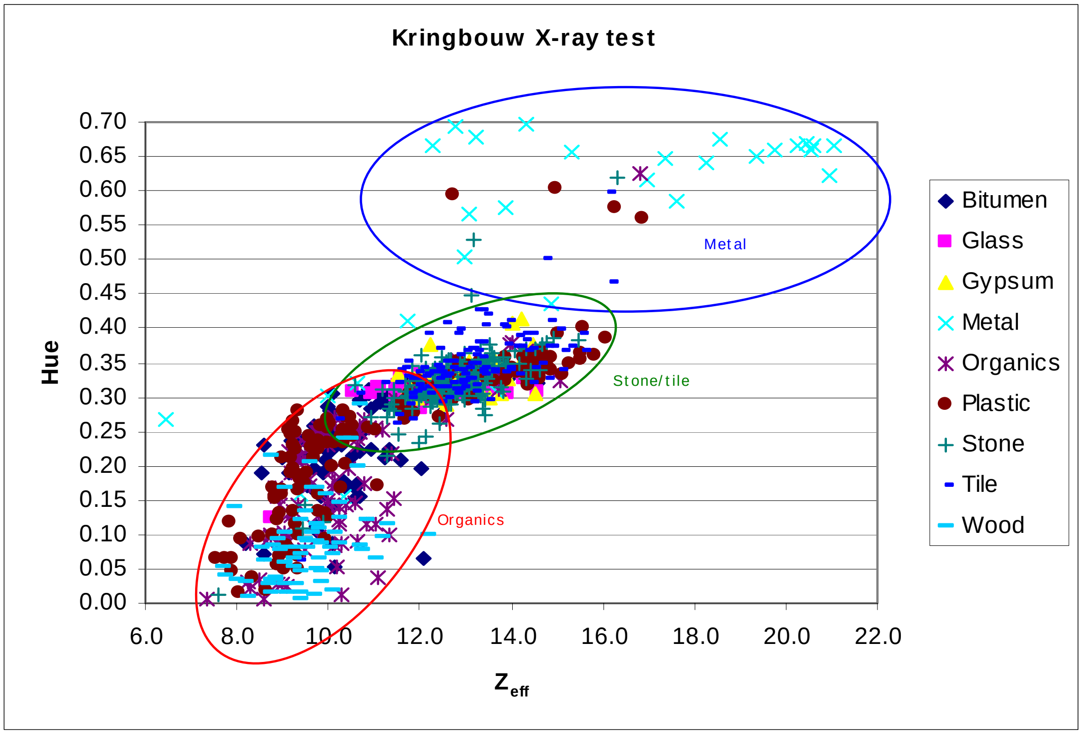

Fig. 10 – Concentration of components in CDW using X-ray transmission imaging (TU Delft).

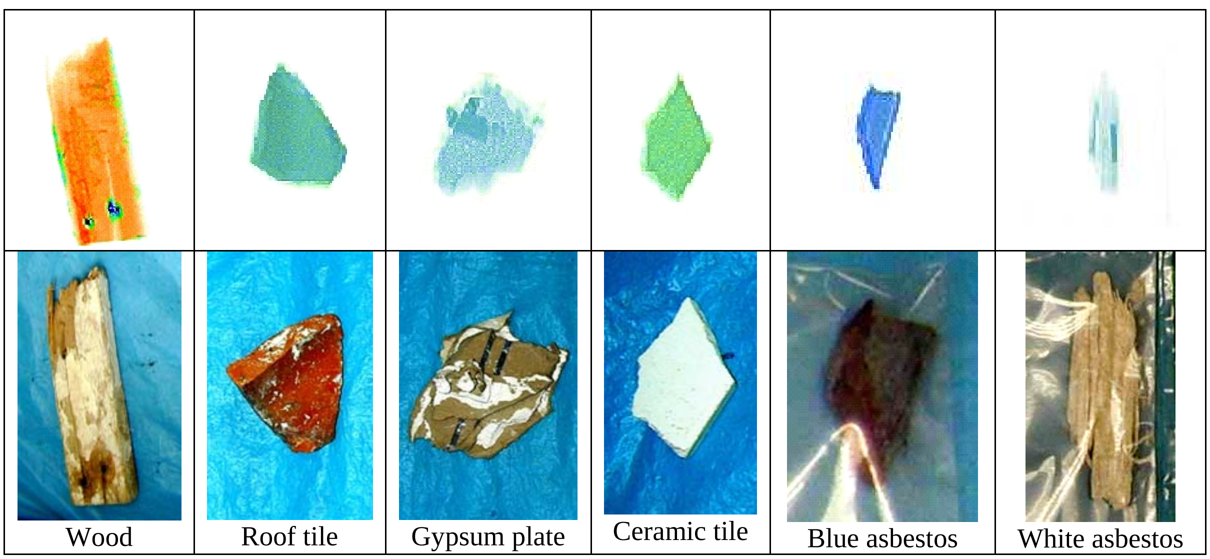

Fig. 11 – DE-XRT images (top) and camera images (bottom) of various CDW components and asbestos

Combinations of sensors

Dual-energy X-ray transmission is capable of removing PVC from mixed combustibles and a combination of X-ray and optical sorting is expected to enable a significant decrease in remaining asbestos fragments (Fig. 11). Another aspect is the suitability to detect and separate coarser material. The present generation of colour sorters enables separation of boulders of 250 mm and exceeding 30 kg each, e.g. the MikroSort Solid CDX -12. With coarse feed mainly comprising crushed concrete and masonry throughput is about 100 t/h.

Conclusions

There is no single best dry CDW plant layout. It depends on a trade off between economy, product markets, and on factors such as space requirements, capacity requirements, whether or not classification in narrow size fractions is practical, or the need to connect to existing treatment operations. The tests resulted in a well defined basis to carry out tailor made techno-economic analyses of a given operation. In the remainder of the project in 2005 this approach will be followed in a pilot scale demonstration project involving automatic sorting of mixed CDW. A possible concept is shown in Fig. 12, where a cost effective pre-concentration is done based on physical concentration, followed by automatic sorting for obtaining high quality aggregate and solid recovered fuel.

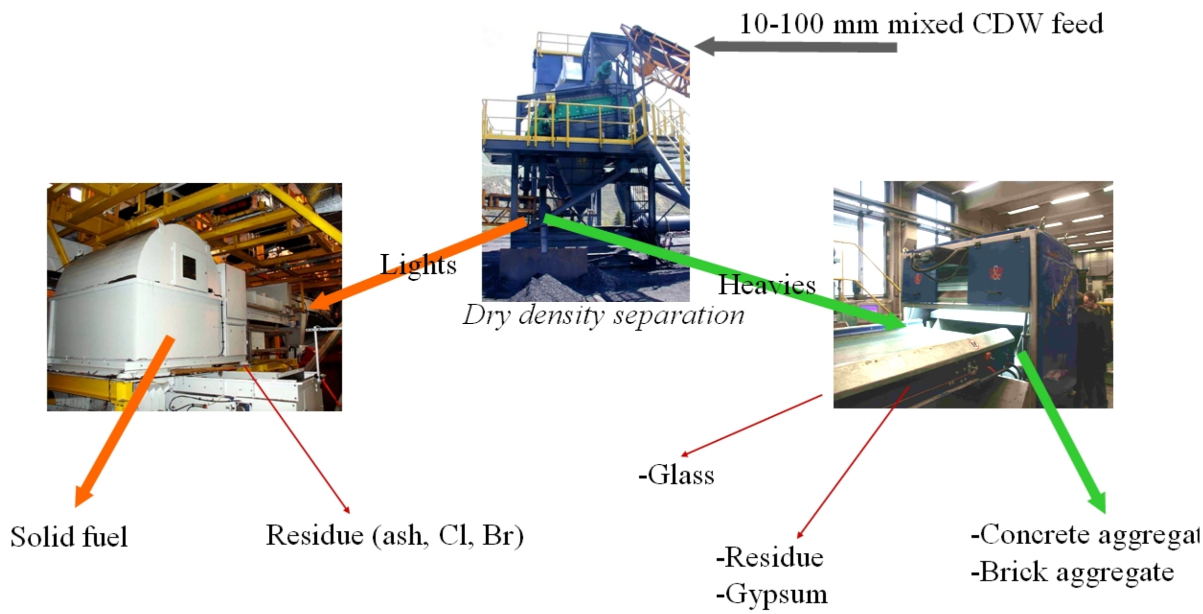

Fig. 12 – Dry processing scheme for the production of high quality aggregate and solid fuel from mixed CDW