Dry separation of mixed constr

As part of the Kringbouw project designed to close the building materials loop, combinations of dry separation and automatic sorting of construction and demolition waste have been systematically investigated by Delft University of Technology in The Netherlands. The pros and cons of air jigs, air tables, air fluidised bed separation, ballistic separators and colour sorting methods are discussed in the article, which also includes some analysis of relative costs.

figure 1

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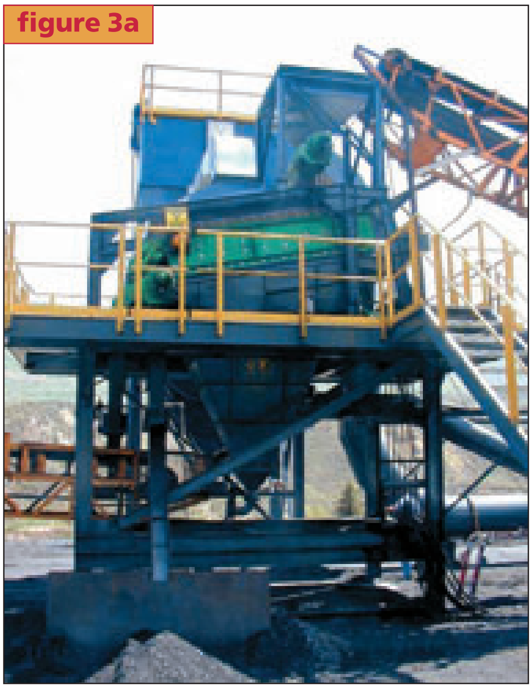
figure 3a



A 50 tonnes per hour air jig used for cleaning coal. *(Photo: Allmineral/Technical University of Aachen, Germany)*

Construction and demolition (C&D) waste - which arises when buildings and other structures are erected, renovated or demolished - comprises mainly soil, ballast, concrete, asphalt, bricks, tiles, gypsum, masonry, wood, metals, paper and plastics. In the EU, C&D waste constitutes the largest waste stream in quantitative terms, and selective sorting and crushing yields a high recycling rate for minerals, metals, wood and plastics. Roughly 75% still goes for landfilling, although countries like Denmark, The Netherlands and Belgium are achieving recycling rates of more than 80%.

A large proportion of C&D waste can be separated and reused directly, especially that arising from larger projects and from selective stripping of buildings. Nevertheless, large volumes of C&D waste are collected in mixed form and require successive separation. The numerous C&D waste sorting facilities rely on techniques such as crushing, screening, magnetic separation, sifting and hand-picking.

Materials such as wood, gypsum and brick can be recovered via heavy media separation and jigging. These also effect washing and wetting of the processed material. Wet processing can be efficient, but washes off all fine dirt and sand which accumulates in the water circuit; this makes the aggregate cleaner and dirt free, but the washed fines mount up in the water circuit and need to be removed on a continuous basis. Thus, they constitute a substantial additional waste stream with a high moisture content that is difficult to dewater. Density separation alone is useful but has fundamental limitations. Several components of C&D waste exhibit a considerable spread in density: for example, brickwork shows different levels of porosity and these may overlap with those of lighter components such as gypsum or wood. In such cases, pure fractions can never be obtained by density separation alone. Light materials like wood and gypsum are affected by moisture and lose value after wetting.

As part of the Kringbouw project designed to close the building materials loop, combinations of dry separation and automatic sorting have been systematically investigated by Delft University of Technology. The TNO-managed project is being carried out by a consortium of Dutch companies/institutes and supported by the Dutch government. The dry separation methods investigated have included air jigging, air tabling, ballistic separation and air fluidised bed separation. Further automatic sorting based on colour was also investigated, while work on X-ray and inductive sorting is in progress.

Air jigs

Air jigs have long been used to separate stones from coal in the mining industry *(see Figure 3A)*. The Allair jig, recently developed by Allmineral and the Aachen technical university in Germany, employs a pulsating air current to cause stratification of a bed

uction and demolition waste

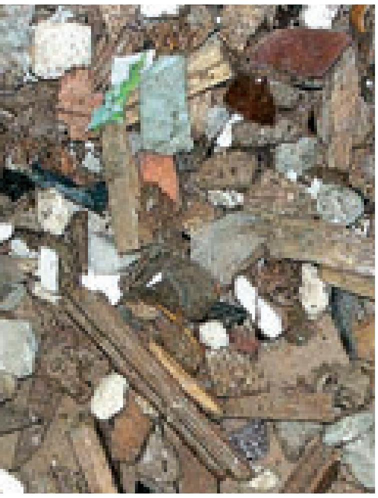
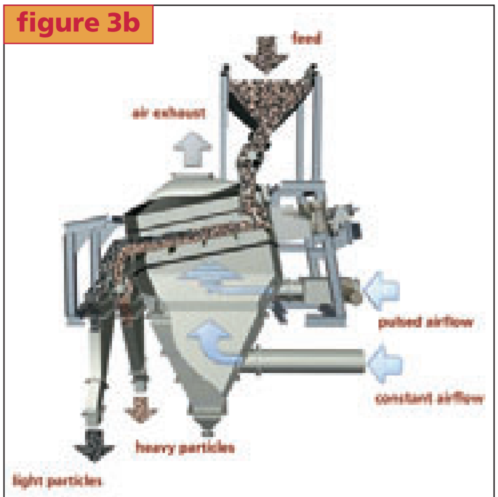


figure 2

Figure 1 Light fraction of 20-40 mm from mixed C&D waste at the plant of Van Gansewinkel in Vlaardingen, The Netherlands, where the samples were collected.

Figure 2 20-40 mm Heavy fraction aggregate.

figure 3b



Principal of the Allmineral air jig.
(For more information: www.allmineral.com)

Table 1: Composition of the samples used for the tests.

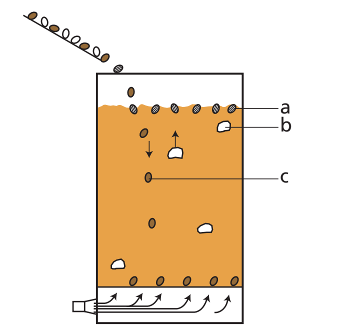
	5-15 mm	30-40 mm
Stones	46.96	41.79
Tiles	6.46	20.44
Glass	26.28	14.56
Gypsum	5.28	2.75
Plastic	2.08	2.89
Metals	3.71	0.76
Wood/Paper	7.83	15.28
Bitumen	1.05	1.54
Polystyrene	0.13	0.00
Textiles	0.03	0.00
Dust	0.20	0.00

of mixed material *(see Figure 3B)*. The machine has a minimum feed size of 1 mm, a top feed size of 50 mm and a maximum capacity of around 50 tonnes per metre width per hour. The jig does not require a classified feed and this full size range can be fed to a single unit. During tests on a sample from Dutch waste management company Van Gansewinkel *(see Table 1)* using a pilot-scale separator at the Minerals Processing Laboratories in Aachen, it was found that lights and heavies from C&D waste can also be separated. The product consists mainly of wood, plastics, porous masonry and gypsum, and a heavy aggregate fraction. Besides being an entirely dry process, its main advantages are the ability to consume a wide size range of feed material, its high capacity and also its compact design.

Air fluidised bed

For feed of 20 to 50 mm, the air fluidised bed approach appeared the best dry density separation option in terms of separation efficiency *(see Figure 4)*. A gas passes up through a layer of dry sand; a particle placed in the fluidised sand settles if its specific gravity exceeds the density of the fluid suspension or floats if its specific gravity is lower. Separation efficiency is comparable to that of wet jigging and is the highest of all the dry density separation techniques investigated to date. Air pressure and flow volume, and hence energy use, are relatively low when compared to air jigs and tables. On the downside, sand loss can exceed 1% of the feed when it is not properly dry, although a moderate sand loss can be tolerated for mixed C&D waste.

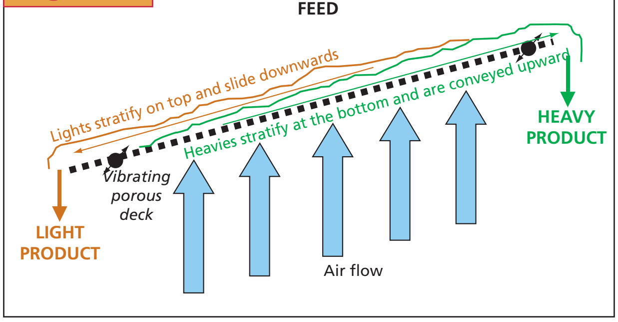
figure 4



a= Floating, light particle
b= Rising gas bubbles
c= Sinking, heavy particle

Dry sand fluidised bed principle

figure 5



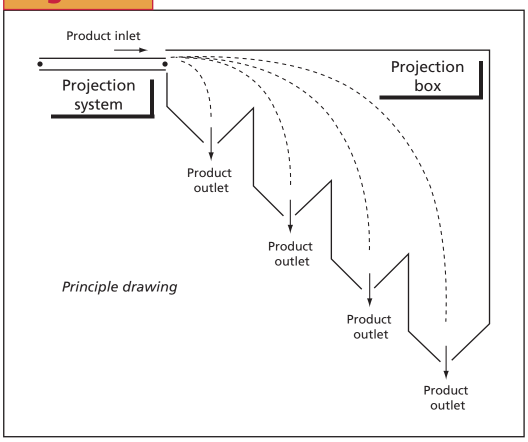
The principle of an air table

Air tables

The principle behind an air table is illustrated in *Figure 5*. The feed is added in the middle and conveyed upwards on an inclined porous deck by means of vibration. An upward-flowing air current loosens the lights and lets them selectively slide downwards to form a layer on top of the heavies nearer to the bottom of the plate.

Air tables are particularly effective in de-stoning a feed consisting mainly of organic material, eg coal or food. They are also used for concentration of metals from ground cable scrap or electronics waste, eg the separation of copper from aluminium or aluminium from plastics in the 2 to 8 mm range at capacities of around 1 tonne per hour. Mixed C&D waste feed requires heavier models with a higher capacity, similar to those used in coal cleaning. In a typical plant, several tables operate each at a maximum feed capacity of around 12 tonnes per hour and are fed with a closely classified feed. Experiments carried out on an air table at the Delft laboratories yielded good separation efficiency provided that the feed was well classified. Efficiency levels fell between those of the air jig and air fluidised bed approaches. However, there is considerable displacement of flat heavy fragments of ceramic tile and glass in the light fraction. These slide down quickly on a thin film of air, ending up in the lights, and are insensitive to the vibration of the porous deck. As a consequence, pure lights were not obtained but the quality of the heavy aggregate was unaffected. Operating an air table requires close monitoring, especially when there are fluctuations in, for example, feed capacity, composition, size and moisture content.

figure 6



Principle of the Aster ballistic separator

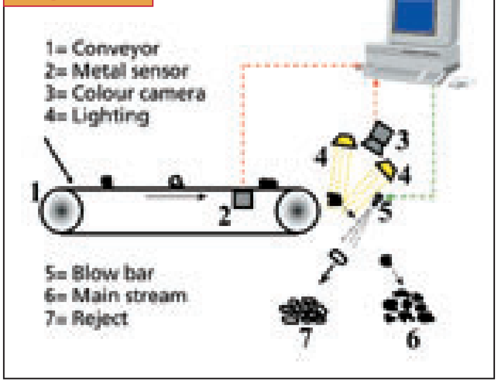
Ballistic separator

The Aster Ballistic Separator has been developed by the TNO Institute for Environment, Energy and Process Innovation in Apeldoorn, The Netherlands. Separation is based on the principle that aerodynamic forces are influenced by particle velocity, size and shape *(see Figure 6)*. The main driving force is gravitation and so energy consumption is less than 0.1 kWh per tonne. Material is fed on to a conveyor belt and falls from a height of approximately 6 to 8 metres into a box with six compartments. For the most effective density separation, feed should be well classified. Results were similar to those achieved with air tabling but this system is easier to operate, has higher unit capacity and is insensitive to moisture fluctuations and related problems such as agglomeration of fines. The ballistic separator has the highest unit capacity of all dry density separators: depending on belt width, maximum capacities easily exceed 100 tonnes per hour.

Colour sorting

Automatic colour sorting from the light and heavy fraction was investigated using the Scan & Sort CombiSense 1200 at the Department of Mineral Processing in Aachen. Able to handle mass streams at up to 10 tonnes per hour, this optical system incorporates a high-speed camera with 1 billion-colour recognition and a special conductivity sensor enabling the identification of a variety of metals *(see Figures 7 and 8)*. The camera analyses

figure 7



Principle of a colour sorting plant

figure 8

Scan & Sort CombiSense at the Technical University of Aachen in Germany size, shape, colour and position of particles on the belt; the information is then used to generate impulses, instructing computer-controlled nozzles to blow out single particles or allow them to pass.

The CombiSense proved that it could be used to increase product quality and avoid the presence of unwanted materials in the stream to be recycled. From the light fraction, the recovery of wood and its purity were both high, reaching 83% and 92% respectively. Some 3% of stones and tiles were separated with the wood but, by more effective density separation, a large proportion of this heavy material could be removed to give a purity of around 95%.

Red brick purity was 77% and recovery was 16% for all stones, including brick and concrete. This result is not bad considering that the machine was set to remove only red-coloured brick and red seramic tiles. Total red brick and tile purity was around 95%. Removal of gypsum from the heavy fraction was around 94% - a good result because its presence in recycled aggregate needs to be avoided due to sulphate content. Purity is only 6% because of the presence of stones and tiles of similar colour in the concentrate. These could be easily removed by subsequent density separation. Glass recovery and purity emerged as, respectively, 96% and 56%. Thus, the CombiSense separator would be also useful in, for example, removal of worrying levels of glass from mixed building waste.

Investigations are currently focusing on the possibility of sorting components from C&D waste using electromagnetic and X-ray sensors. Introduced this year, the MikroSort AR 1200 (CommoDaS/Mogensen) is expected to increase sorting quality and options, for example. 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 reduce remaining asbestos fragments to a significant extent *(see Figure 9)*. Another aspect is the suitability to detect and separate coarser material. The present generation of colour sorters, including the MikroSort Solid CDX -12, enables separation of boulders measuring 250 mm and weighing up to 14 kg. With coarse feed mainly comprising crushed concrete and masonry, throughput is around 100 tonnes per hour.

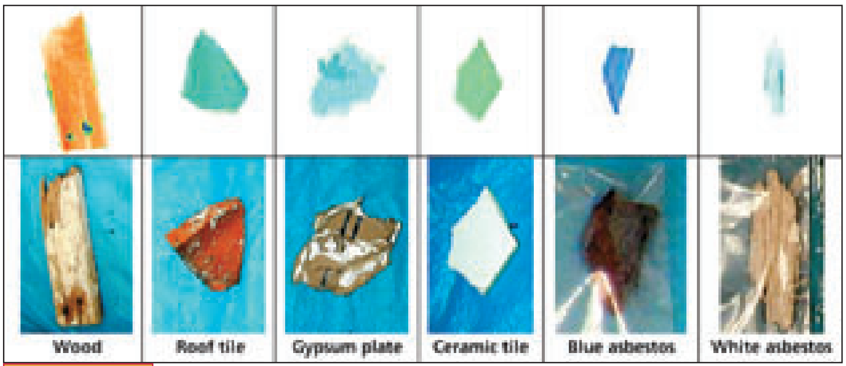


figure 9 DE-XRT images (top) and camera images (bottom) of various C&D waste components and of asbestos

Table 2: Estimate of the processing costs for a 200 h/y plant with a 50 t/h feed capacity *(Estimates in Euro per metric tonne)*

	E/t feed	E/t feed
Front loader operation	2.5	
Air jig plant	1.9	
Ait table plant	2.7	
Sand fluidised bed plant	2.7	
Ballistic separator plant	2.0	
	AVERAGE Incl. front loader	**4.8**
Additional automatic lights sorting	1.4	
Additional automatic heavies sorting	2.4	
	AVERAGE + aut. lights sorting	**6.3**
	AVERAGE + aut. heavies sorting	**7.3**
	AVERAGE + aut sorting both	**8.7**

Processing costs

The figures in *Table 2* are drawn from Allmineral and TNO cost estimates, and from coal processing data. These were based on a five-year depreciation period, 10% interest, a € 0.10 per kWh electricity price, and supervision costs of € 50 per hour for a full- time job. Although these estimates cannot be precise at this stage, they indicate that the handling costs (front loader operation), dry density separation costs and automatic sorter costs are each of the same order of magnitude (between € 2 and 3 per tonne). The added value of the products should exceed selected processing costs, which are at least € 4.50 per tonne for a simple dry density plant, rising to over € 9 per tonne for a plant with advanced after-sorting of heavies and lights. Using cost assumptions and considering the already-determined quantitative performance of the chosen units, an optimised process can be selected to give required product quality in the cheapest way.

Conclusions

No single plant lay-out can be said to be the best since this depends on a trade off between economics, product markets, space and capacity requirements, the need to link up to existing treatment operations, and on whether classification in narrow size fractions is practical. The tests provide a basis for carrying out tailor-made, techno-economic analyses of a given operation. Next year will see a pilot-scale demonstration project involving automatic sorting of mixed C&D waste. □

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