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Refuse sorting plant

Introduction

With progressing civilization the amount of refuse is also increasing drastically. It is collected by refuse trucks and transported to the rubbish dump. The volume of dumped material is constantly increasing. The refuse collected from households and general trade consists of many different materials, kitchen waste; paper; cardboard; textiles; leather; rubber; metal; glass; ceramics; plastics; etc. Of these materials, quite a number can be utilized or recycled, the precondition is, however, their separation from the other refuse and the existence of markets into which they can be absorbed.

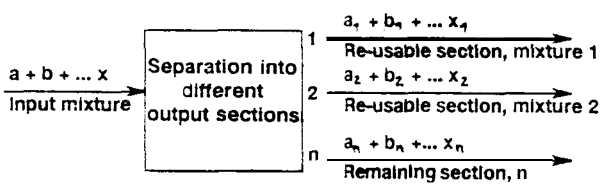
This separation can be carried out by conventional methods, i.e. in central or decentral sorting plants after collection and transport, or by new methods, i.e. the refuse is pre-sorted in the households or general trade into the desired groups of materials and then transported to special user or recycling firms.

In the latter case, a considerably smaller amount of refuse remains, which may be suitable for further separation, the type and extent of which, however, depending on the already separated usable materials.

The separation of the refuse can be carried out manually or mechanically, but an optimal separation is desirable. Against this, however, are economic as well as separation efficiency aspects. Separation efficiency not only depends on the separation aggregate but also on the characteristics of the materials.

Both from an ecological and an economic point of view, simple mechanical sorting plants seem to be the most sensible option, perhaps supplemented by manual sorting. Not only can the volume of refuse be diminished considerably, but a regaining of important valuable materials is also possible. This means schematically, that the input mixture can be separated into different output sections'(see figure 1).

Figure 1. Scheme for separating waste



The output sections consist of product streams enriched with reusable materials and the remaining rubbish. Separation aims at diminishing as far as possible the number of remaining impurities in the reusable products. Possible reusable products for sorting are: paper and cardboard, tins, non-ferrous metals. glass, ceramics, paper and plastics usable for energy, composting materials.

It is very difficult to separate glass and plastics mechanically at a reasonable expense and with an acceptable quality of the product. The quality of the paper and cardboard is much lower in the case of collective refuse collection as against separate collection.

The use of mechanical sorting plants is, of course, only reasonable from a certain minimal collection amount onwards; below that level, pure manual sorting is the most sensible method.

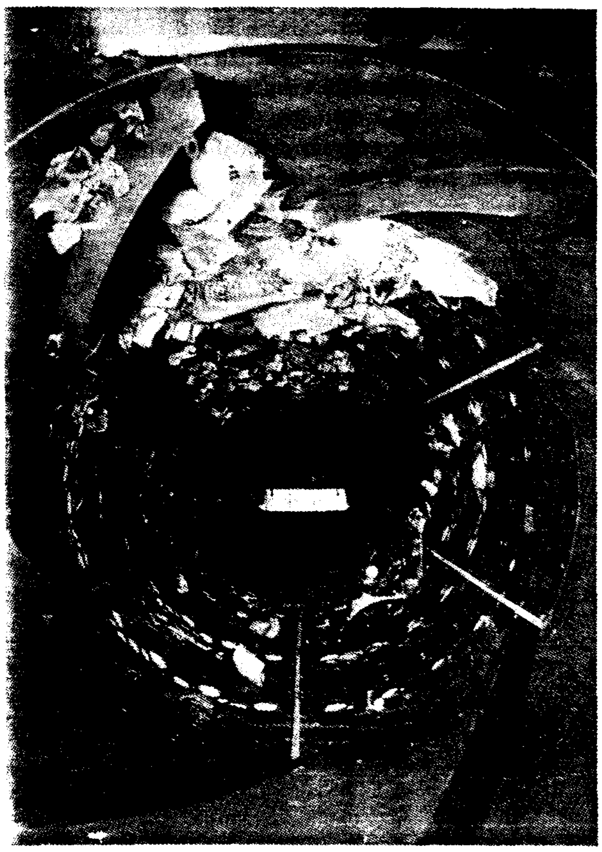
Basic process and machine arrangement

Strictly speaking for the sorting of reusable materials and reusable material mixtures, not only are sorting processes necessary, but also screening, cornminuting, consolidating and even drying processes might be necessary. In addition to this, transportation. feeding and transfer equipment play an important role.

Comminuting steps are essential in the mechanical treatment of unsorted household refuse, whereas in the treatment of pre-sorted, reusable material mixtures they are only necessary under certain preconditions. As cornminuting belongs to the cost, repair and maintenance-intensive process steps, this is avoided as far as possible. The following types of machines are basically used for comminuting:

Slow revolving cutting-shearing rollers;

Light hammer mills;



Specially prepared hammer mills (selective comminuting);

Cylinder mills.

Screening is an unavoidable part of sorting. Screening is necessary, for example for the separation of contaminating fine grain before sorting, or for the division of the reusable material streams into more easily sorted grain classes. Screening classification can be done by screening drums, grizzlies, and flat screens (vibration, swinging, cascade screens).

For the treatment of refuse, screening drums are mostly used as they can easily dissolve agglomerations, easily free single particles for screening, and are suitable for mixtures with round and plane parts.

Screening drums, however, require a lot of space and are relatively expensive. Furthermore, they create large amounts of broken glass, making it impossible for the glass to be sorted according to colour. Should the latter be required, flat screens have to be used.

A basic part of each refuse treatment plant is the ***magnetic separation*** of ferrous metals, mostly tins. For this separation magnetic rollers, and top belt magnets, crossways or parallel to the direction of flow are used.

For an efficient magnetic separation, it is important to lift out loose material, i.e. at the point of discharge from a device or at the point of transfer. Even then it cannot be avoided that some parts of rubbish are entrained with the removing of tins. This contamination can be diminished by a sensible arrangement of the single magnets within the top belt magnet separator as follows. The ferrous piece of metal to be removed is taken by the first magnet, but released again after a certain distance to a second magnet, which attracts the piece of metal immediately after its release. By this procedure, any loose contaminations can be removed to a certain degree from the piece of metal.

Depending on the field strength and the distance of the magnetic separator from the material to be sorted, different sorting aims can be achieved, as e.g. tins, crown caps, batteries or others.

Simple ***blow-out processes*** against or with the flow of material, e.g. at transfer points, at the screen discharge or at suction devices, are suitable to separate materials like plastic foils or sheets.

The separation of other sections, as for example, plastics and paper or glass and paper as well as the separation of paper/cardboard, plastic mixtures and non-ferrous metals can still best be done manually.

Example of a simple refuse sorting plant

An economical start in the mechanical sorting of refuse should comprise of screening, magnetic separation, and manual sorting.

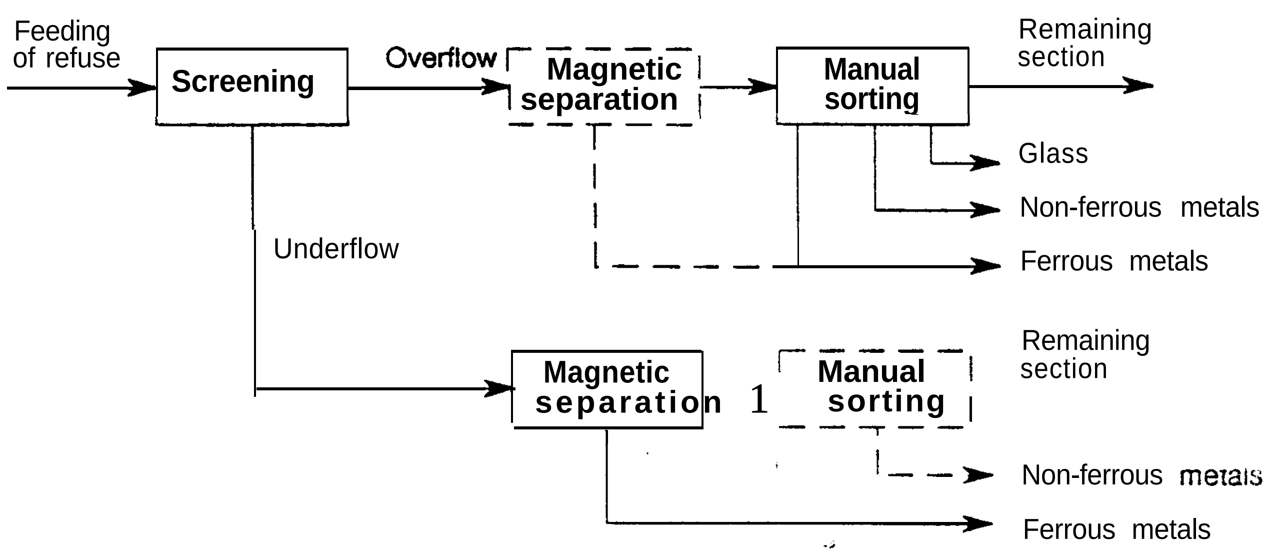
A hail with a width of about 40 metres and a length of about 70 metres is optimal for the arrangement of the machines and offers enough space for deliveries and products.

The sdparation process is shown in figure 2. The plant comprises of a refuse feeding installation which takes up the dumped refuse. This consists of a plane bunker with bunker plate from where a wheel loader pushes the refuse onto an underfloor conveyor belt. The driver of the wheel loader should also have the task of removing bulky parts before they enter the' installation and of loading them into containers set out for this purpose.

The refuse is fed from the underfloor conveyor belt via a following ascending belt to the screening drum: the first separating stage of the plant. Sorting is done by means of the round holes in the drum, the optimal diameters being between 100 and 180 mm, depending on the refuse structure. Through baffles built into the drum, closed bags should be opened during the revolving movement, thus freeing their content. The screening drum has to be dimensioned according to the amount of refuse and the task of separation.

The further treatment of the ovefflow and underflow of the screen is carried out in two parallel processes. The ***overflow section*** is discharged into a sorting station:. a large sorting belt from where glass, ferrous, non-ferrous metals and other inert materials are removed either for re-use or for the dump.

Figure 2. **Refuse sorting plant**



At the point of transfer to the sorting station, a top-belt magnetic separator may be installed for the mechanical separation of ferrous metals.

The remaining stream represents the fuel section, which can, after the necessary further treatment (comminution, packing press), be fed into an incineration plant.

By the installing of further equipment, the sorting plant offers the possibility of aiso separating paper and plastics for re-use.

The *underflow* section, mostly organic material, is taken by means of a conveyor belt to the top belt magnetic separator (possibly muitipole), positioned at the end of the belt, which removes the ferrous metal parts crossways to the conveyor belt and deposits them into a container.

The remaining underflow stream is either transported directly to the dump via open containers or is brought there after passing along a small sorting belt to allow the extraction of the remaining non-ferrous metals.

By extending the plant it is possible to use the underflow of the screen for composting. In this case, a second screening drum is installed behind the magnetic separator. The overflow of this screening process is dumped, while the underflow, representing the compostable material, is transported into composting reactors. The compost produced can, in most cases however, only be used for subordinate purposes (e.g. covering the dump).

According to the structure of the remaining stream of refuse, a comminuting of the material might also be necessary. For this, an impact tearing machine can be used.

Dimensioning

The plant has to be dimensioned according to the amount of refuse to be treated. There is no calculation formula in existence, only figures gained from experience of the different producers. However, these are only guidelines, as not only the volume but also the composition of the refuse play an important role.

Concerning the screening drum, the following dimensions will be necessary for a throughflow of 5-10 t/h:

Length of the drum:	6 m
Diameter of the drum:	2 m
Diameter of the holes:	120 mm (1st half of the drum)
	180 mm (2nd half of the drum)

However, it has to be taken into consideration that, besides the outside dimensions of the drum and the diameter of the holes, the throughflow and the separating efficiency are also determined by the rotating speed, the built-in baffles, the angle of inclination, humidity and the characteristics of the material to be screened. In order to prevent clogging it may be necessary to install certain screening aids, such as brushes or other gadgets.

In order to increase the effective screening area, suitable carrier plates are installed to take the material to be screened as far as possible to the top of the drum. These carrier plates can, with the corresponding construction, also be used for transporting the material through the drum, so that the angle of inclination of the screening drum can be reduced to 0^0.

There are some basic rules which can be given for the technical design of screening drums:

Drum load	≤ 0,1 Mg/m^2
Duration time	25-30 s in the case of un-comminuted refuse
Rotation speed	~ 45 % of critical speed
Hole diameter	> 10 mm

Magnetic separation involves top-belt magnets which extract ferrous metals from the refuse. A precondition for effectiveness is the ferrous metals having been comminuted and thus, to a large extent, separately fed to the magnets. There is no limit to the size of the ferrous metals, since magnets are available for extracting almost all weights. However, the most suitable particle size for magnetic separation of household refuse is 10-100 mm.

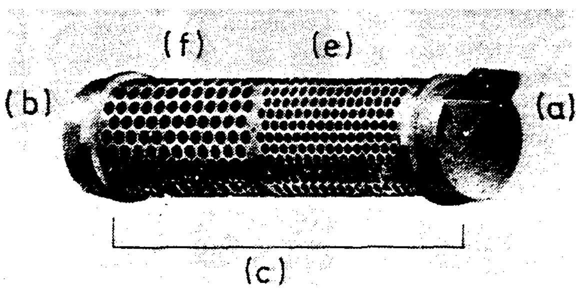
Manual separation takes place on a sorting belt. For the accepted refuse throughflow of 5-10 t/h, 4 to 6 workers are required to remove foreign bodies without hindering the separation process.

Description of the product to be manufactured

As previously mentioned, the classic separating aggregate in a modem sorting plant is the screening drum, the construction of which is outlined in figure 3. A stainless, high-quality steel drum serves as a screen. At one end of the drum is a joining ring (for the driving aggregate and feeding-in of material) (a) and at the other an end ring (for discharge of the screen overflow) (b). The drum is divided into two halves, each with equidistant holes; the holes of the first half being smaller than those of the second half. The screening drum to be constructed requires the following dimensions:

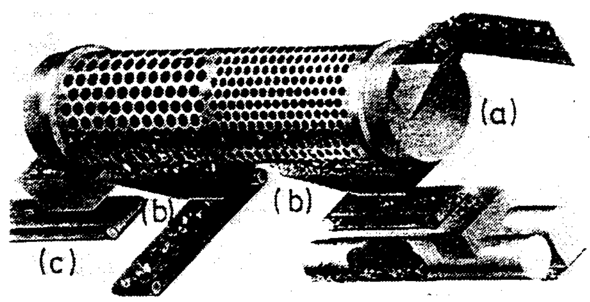
Length of drum:	6 m (c)
Diameter of drum:	2 m (d)
Diameter of holes (1st half):	120 mm (e)
Diameter of holes (2nd half):	180 mm (f)
Steel thickness:	5 mm

Figure 3. Screening drum



The necessary auxiliary equipment for making the drum operational is delivered separately and fitted to the drum at the place of operation. As can be seen from figure 4, this means the driving aggregate and the material feed-in are fitted to the joining ring (a). The refuse to be sorted enters the material feed-in via a conveyor belt. On the underside of the drum, two underflow containers are fitted, one for each of the two sections with different hole diameters. The screened material falls into these containers and is consequently transported by belt on for further processing. The material discharger, into which the overflow falls, is fitted to the underside of the end ring. The overflow is also transported by belt to the next processing stage.

Figure 4. Operation of screening drum



Description of the production process

The first production stage is the exact calculation of the dimensions of the stainless steel plate out of which the screening drum is to be formed. Equally important is the calculation of the number and position of the holes of different diameters which are to be cut out of the drum.

This having been done, the stainless steel plate is cut to the required size with a cutting torch. Subsequently the different sized holes are cut out in the same way. After the steel plate has cooled down it is given after-treatment (smoothing down of any possible burrs) and the holes are inspected to check the diameter and spacing.

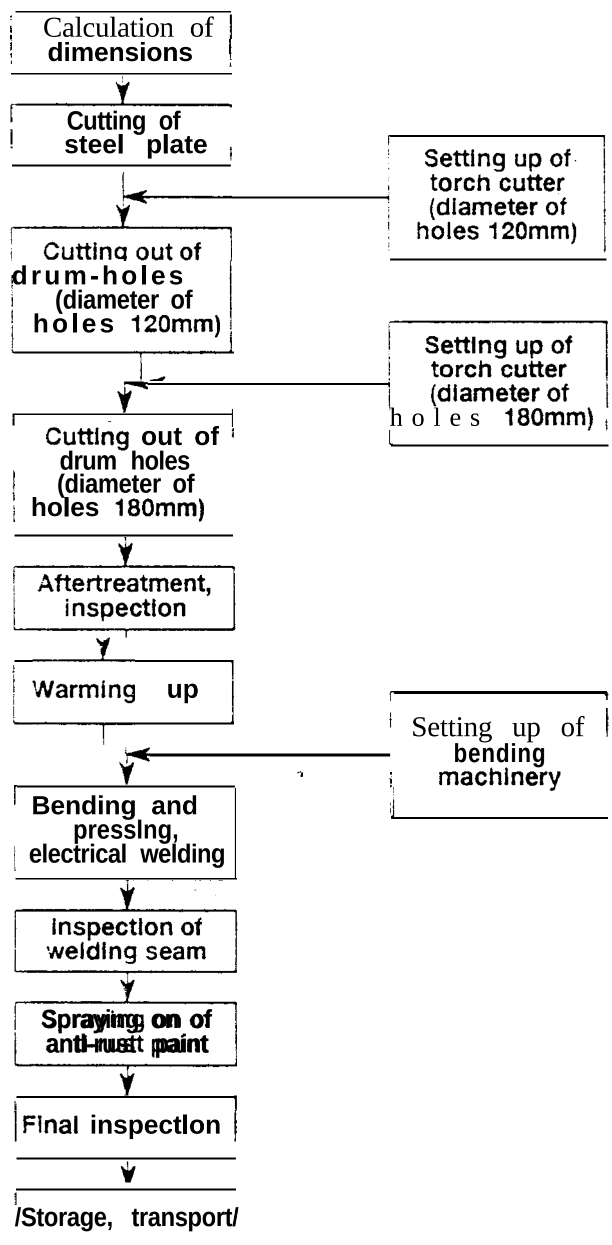
By crane, the steel plate is then lifted to the next processing stage: an electric heating apparatus for warming up the steel in order to increase its bending and tensile properties. This is necessary, since afterwards the steel plate is formed into its cylindrical shape by a bending machine which has been set up to correspond with the dimensions of the drum to be produced. Subsequently, the cylinder is electrically welded along the join of the two long sides.

Before the drum is removed, the welded seam is inspected to ensure perfect cohesion. This being so, the drum is removed by crane and taken to the last processing stage where it is sprayed with a rust-resisting paint. After drying and final inspection, the drum can go to the storage depot or be prepared for transport.

Example of a production plant

Screening drums are produced in the metalworking industry, whereby the relevant firms concentrate more heavily on products other than screening drums. The latter are only produced on special demand and have to be fitted into the regular, daily production programme. For this reason. it is not possible to give exact figures regarding, e.g. personnel and energy requirements for the production of a screening drum. However, in order

Figure 5. Flow chart



to procure reliable data, it is assumed that a firm is producing screening drums only, i.e. 2 units in the course of an 8-hour working day.

Required machinery and equipment

Description	*Pieces*
Autogenous welding and cutting apparatus	1
Electric furnace	1
Bending machine with integrated electric welding apparatus	1
Crane	1
Work benches	3
Drawing table	1
Colour-mixing machine	1
FCB-Price for machinery and equipment: Approx. US$ 3.0 million	

Required manpower

Technical manager	1
Administrative manager	1
Administrative staff	2
Foreman (metalworking)	1
Skilled workers	3
Unskilled workers	5

Required area

	Square metres
Production hall	200
Management and administration	100
Social rooms	120
Storage	300

Required energy

Electricity	60 kW
Water	
Oxygen, acetylene	

Required inputs

Stainless steel plates
Joining ring
End ring
Electric motor
Charging funnel
Discharging section
Underflow containers
Conveyor belts
Electrodes
Rust-resisting paint

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