Crushing technology and sorting system

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I. Crushing technology:
   - Jaw crusher,
   - Gyratory crusher,
   - Cone crusher,
   - Impact crusher:
     - Horizontal shaft impactor,
     - Vertical shaft impactor.

II. Sorting system:
    - Separation:
      - Magnetic separation,
      - Wet separation,
    - Pre-sorting,
    - Hand sorting,
    - Sucking and blowing,
    - Wet sorting.
I. Crushing technology

A key component of the construction is how to reduce the waste once it has been completed. Excavation and land clearing will inevitably result in large piles of rubble, debris and stony materials.

Stony materials/wastes processing can involve four general types of unit operations. They are:
1) comminution – the process of particle size reduction;
2) sizing – separation of particle sizes by screening or classification;
3) concentration by taking advantage of physical and surface chemical properties; and
4) dewatering – solid/liquid separation.

Size reduction is the operation carried out for reducing the size of bigger particles into smaller one of desired size and shape the help of external forces. Size reduction is mainly done through crushers and mills. Crushing and grinding are the two primary comminution processes.

![Diagram of flow by a typical recycling facility]
Crushing

Crushing is the process of transferring a force amplified by mechanical advantage through a material made of molecules that bond together more strongly, and resist deformation more, than those in the material being crushed do. Crushing devices hold material between two parallel or tangent solid surfaces, and apply sufficient force to bring the surfaces together to generate enough energy within the material being crushed so that its molecules separate from (fracturing), or change alignment in relation to (deformation), each other.

A crusher is a machine designed to reduce large rocks into smaller rocks, gravel, or rock dust. Crushers may be used to reduce the size, or change the form, of waste materials so they can be more easily disposed of or recycled, or to reduce the size of a solid mix of raw materials (as in rock ore), so that pieces of different composition can be differentiated.
Jaw crusher

Jaw crushers are mainly used as primary crushers. Their main purpose is to reduce C&DW to smaller sizes for the next crushing stages. Jaw crushers are a popular alternative to primary gyratory crushers, since they can process large amounts of hard material efficiently. Due to their smaller physical size, jaw crushers are also ideal for tight spaces, such as underground mining and mobile crushing applications.

[Image of a jaw crusher]

(https://www.metso.com/products/crushers/jaw-crushers/)
A gyratory crusher is similar in basic concept to a jaw crusher, consisting of a concave surface and a conical head. Both surfaces are typically lined with manganese steel surfaces. The inner cone has a slight circular movement, but does not rotate and the movement is generated by an eccentric arrangement. As with the jaw crusher, material travels downward between the two surfaces being progressively crushed until it is small enough to fall out through the gap between the two surfaces.

https://www.911metallurgist.com/blog/gyratory-crusher
A cone crusher is similar in operation to a gyratory crusher, with less steepness in the crushing chamber and more of a parallel zone between crushing zones. A cone crusher breaks C&DW by squeezing the material between an eccentrically gyrating spindle, which is covered by a wear resistant mantle, and the enclosing concave hopper, covered by a manganese concave or a bowl liner. As material enters the top of the cone crusher, it becomes wedged and squeezed between the mantle and the bowl liner or concave. Large pieces of C&DW are broken once, and then fall to a lower position (because they are now smaller) where they are broken again. This process continues until the pieces are small enough to fall through the narrow opening at the bottom of the crusher.
Impact crusher

The word impact makes sense that in this particular type of crusher some impaction is being used for crushing of rocks. In normal types of crusher pressure is generated for the crushing of rocks. But, impact crushers involve an impact method. There is a hopper one side that takes the crushing material into the machine. All material is carried only within a cage. This cage has an opening on the end, bottom and on the side. These openings help in escaping the pulverized material from the impact crusher. Normally such type of crusher is used for crushing of materials that are not very hard say “soft material” and materials that are non-abrasive. There are two types of impact crushers: horizontal shaft impactor and vertical shaft impactor.
Impact crusher

Horizontal shaft impactor (HSI)
The HSI crushers break rock by impacting the rock with hammers that are fixed upon the outer edge of a spinning rotor. HSI machines are sold in Stationary, trailer mounted and crawler mounted configurations. HSI's are used in recycling, hard rock and soft materials. In earlier years the practical use of HSI crushers is limited to soft materials and non abrasive materials, such as limestone, phosphate, gypsum, weathered shales, however improvements in metallurgy has changed the application of these machines.
Impact crusher

Vertical shaft impactor (VSI)
VSI crushers use a different approach involving a high speed rotor with wear resistant tips and a crushing chamber designed to 'throw' the rock against. The VSI crushers utilize velocity rather than surface force as the predominant force to break rock. In its natural state, rock has a jagged and uneven surface.
Key benefits of size reduction

The key benefits of size reduction in mineral dressing are the following:

1. increased dissolution rate,
2. improved drug delivery,
3. cleaning product health & safety,
4. controlling the rate of reaction,
5. greater density,
6. separating grain components,
7. consistent product appearance,
8. consistent texture.
II. Sorting system

Sorting is a core process in certain separation applications. Separating materials can be used to remove impurities or isolate a higher value product. Due to the rapid technological development in image processing and the supporting hardware, materials which until recently were impossible to sort, can now be sorted in a precise, economical process.

Processing of C&DW has many parallels with processing of other recycling products such as metals, but differs in one essential respect, namely grading of the end products. In the case of C&DW there is double sorting process: first of all the non-stony material is removed, after which the end product - the granular mixture is carefully sorted into different dimensions. In this way the different materials required by the customer - such as concrete rubble, mixed rubble and brick rubble - are sorted out on the basis of dimensions. Screen are an essential tool for this.

At present, it is possible to divide the sorting lines/plants of construction waste based on mobility to:
- mobile,
- semi-mobile,
- stationary.
Material detection

The latest hardware and software allows previously impossible processes to be performed. The sorting system provides the following possibilities:

1. **True colors and brightness.** Detection of the material color and transparency using different exposures in the visible light range. Double-sided camera detection also available.

2. **Grain size and shape.** Detection of grain size and shape (length/width ratio). This detection can also be used parallel to actual sorting tasks for statistical or quality assurance purposes.

3. **Material composition.** Infrared technology to detect and differentiate materials with the same visual appearance, but with different chemical.

4. **Atomic density.** X-ray scanning to detect and differentiate materials with the same visual appearance, but with elements of different atomic densities.

5. **Metal detection.** Highly sensitive inductive detection and discharge of NE and FE metals.

6. **Multi sensor system.** For certain tasks, the above-mentioned sensors or radiation sources can be combined with each other, e.g. visual and NIR detection, or visually with metal detection.
Magnetic separation
C&DW tends to contain large amounts of metal, mainly reinforcing iron or steel which can be separated out magnetically. In the case of reinforced concrete this of course has to done after crushing. As a result of crushing by the machines described above, the iron is released so that it can be removed. The iron has to be separated from the stone fraction early on, as otherwise it is liable to tear or otherwise damage the many conveyor belts used to transport the stony material after crushing. The crusher or pre-crusher C&DW is generally led on a conveyor belt underneath a fixed magnet or rotating magnetic belt. The magnetic belt (belt magnet) has the advantage of carrying the iron to the side when the latter is removed from the C&DW.
Previously, an electromagnet was used for extracting ferrous material, but nowadays permanent magnets are also used.
Separation

Magnetic separation
In addition to iron, C&DW usually contains various amounts of non-ferrous metals such as aluminium, copper, brass, lead, and zinc. Such metals or alloys are non-magnetic, and so have to be separated out of the C&DW in a different way. Previously, non-ferrous metals were sorted out by hand, but now this is done mechanically by the eddy current technique. Many C&DW crushing plants are now equipped with an eddy current separator, so that aluminium and other non-ferrous metals no longer have to be sorted out by hand.
Separation

Wet separation
Another method of separating out the unwanted material is for the demolition material to be led through a water bath; the lighter material generally floats, while the stony materials sink. One advantage of this is that the stony materials are washed at the same time. A disadvantage is that slurry is left and has to be carried away, which can involve relatively high costs.
A modern refinement of wet separation is the Aquamator, in which a long conveyor belt carries the broken stone granules through a current of water flowing opposite to the direction of the belt. This system is fast and efficient, and although it generates slurry this can be more easily controlled.
Pre-sorting

Construction waste contains many more kinds of non-stony materials than demolition waste. This means that if construction waste has to be sorted in the installation, then pre-sorting is necessary. Demolition waste is frequently also separated into its different components before going to the stationary or mobile crusher. When the shovel dumps the demolition waste into the feed hopper, chute or conveyor belt, it is usually sifted immediately in order to remove the screening sand.

Underneath the hopper, chute or conveyor belts there are all sorts of grates and screens, from coarse to fine. These grates and screens are in nearly all cases, for instance underneath jaw crusher, gyrator crusher or cone crusher and impactor.
Hand sorting of construction waste is frequently carried out before mechanical separation and in certain case after it. It is frequently done on a high mounted conveyor belt, also known as a “picking belt“. The sorters work „by eye and hand“, usually throwing the different materials into containers underneath them.
Sucking and blowing

These methods are used to separate out lighter materials such as paper, cardboard, chipboard, plastic, insulating materials and wood, from Construction and demolition waste. Sorting by means of powerful air current is also known as „wind sifting“. It can be carried out above the conveyor belt, or through the conveyor belt by blowing upwards or sideways; the material removed is then carried away. In some cases both operations may be combined and used at several points in the process. Hazemag and later also Kleeman Reiner have developed efficient systems for this. A conveyor belt carries the broken fraction. At the end of the belt, where the material is about to fall, it enters a powerful, horizontal air current from underneath the belt. The light material is blown „through the air current“ onto a large rotating drum which carries it away, while the stony material falls onto a conveyor belt lower down.
Wet sorting

Wet sorting various processing operations described above have been completed, the material is sorted mechanically according to granule size and quality. This is done by a system of screens, sometimes in two, three or four layers. After being graded in this way the granules are sorted in separate silos, compartments, containers and big bags until being taken away.
Conveyor system

A conveyor system is the one part of sorting system equipment that transport materials from one place to another. Industrial conveyors are designed to withstand large workloads, extreme weather conditions, as well as moving in different directions and at odd angles.

If it were not for conveyors, materials would have to be fed manually which involves hiring labor and creates its own set of human resource challenges. Human labor is a lot less efficient and not very cost-effective in the long run. In order to overcome these and other challenges, commercial conveyors are used in a variety of industries like food, pharmaceuticals, manufacturing, transportation and civil engineering waste treatment.
Types of Conveyors

Conveyors come in various sizes and shapes. These variables change depending on the type of industry where they are used. Some of the common types include:

1. **Chain Belt Conveyors** - Also known as chain edge conveyors, these are designed to carry high volumes of products. You will find these being used on the work floor, in most cases transporting waste materials. Chain belt conveyors are used as sorting line feeds, mixed lines and feed side eject balers.

2. **Steel Belt Conveyors** - Steel belt conveyors use two types of belt designs – piano hinge and steel apron. These conveyors can carry a serious amount of weight, generally anywhere from 20 to 50 tons every hour. Thanks to this tonnage, they are used in heavy feeder applications such as compactors and heavy-duty mixed waste lines.

Types of Conveyors

3. Slider Bed Conveyors - Slider conveyors are used in applications where a chain belt is too weak and a steel belt is too heavy. These have capacities that start from 1 ton and go up to 15 tons and come with a speed varying mechanism allowing for slow to fast operations.

4. MRF Sorting Lines - This is a conveyor type that is not standardized and features a combination of slider bed, chain belt, and steel belts. These conveyors are designed as per the individual requirements of the client.