

Advanced Training Program on Alternative Fuels & Raw Materials

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Pre-processing:
Converting Wastes
into Secondary
Resources

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Importance of Pre-processing

- Pre-processing of wastes into AFRs is an important consideration in achieving successful co-processing of AFRs.
- Wastes are solids, liquids or sludges. They can also be in gaseous form but the cases are very few.
- Wastes, by their very definition, do not have any quality consideration. They generally have very large variation in the physical and chemical characteristics.
- Wastes due to heterogenous nature will be having different size, calorific value, ash content, moisture content, chloride content etc. on lot-to-lot basis.
- If this waste is fed into the cement kiln on as received basis it causes severe process disturbances as well as impacts the quality of clinker.
- Hence, prior to feed the waste materials in the kiln, it needs to be processed to achieve uniform physical and chemical characteristics.
- This processing of waste materials having varying quality considerations into AFRs having uniform quality consideration is called as pre-processing.



Stages Involved in Pre-processing

- Pre-processing involves receipt, storage, testing, handling & processing of wastes physically.
- The wastes include both hazardous and non-hazardous ones. Although pre-processing does not involve any thermal treatment or chemical reactions, there are possibilities of release of effluents & emissions, these need to be managed as per the local regulations.
- Permission for implementing the pre-processing facility needs to be obtained and the prescribed norms need to be complied to.



Unit Operations in Pre-processing

1. Size Reduction or Shredding

- Size reduction of different materials is achieved by using shredders.
- There are three types of actions that facilitate shredding namely Shearing, Tearing and Fracturing.
- Shearing involves the cutting of material with scissor like tooling, tearing involves pulling the material with great force & fracturing *involves* breaking of the brittle materials using impact.
- Some examples of materials that are commonly shredded are: [tires](#), [metal cans](#) & sheets, [car wrecks](#), [wood](#), [plastics](#), leathers, papers, [clothes](#), industrial hazardous and non-hazardous wastes, Municipal Solid Waste, Refuse Derived Fuel, etc.



Different Types of Shredders

An industrial shredder can be equipped with different types of designs:



Single Shaft Design



Double Shaft Design



Three Shaft Design



Four Shaft Design



Unit Operations in Pre-processing

2. Drying

- Industrial dryers help in removing moisture present in different kinds of materials on a large scale. Industrial dryers come in many different models depending upon the type and quantity of material to be processed. The selection of the appropriate type of dryer depends upon the factors such as the nature of the material to be dried, final product quality requirements, Volume of material to be dried, available space for installation, etc.
- The dryers are utilized to dry all the three types of waste materials viz. liquids, solids & sludges. The material to be dried include aqueous waste streams, organic liquids contaminated with moisture, plastics, combustible waste materials, industrial hazardous and non-hazardous waste streams contaminated with moisture, Municipal Solid Waste, etc.
- The various sources thermal energy utilized for drying requirement is obtained from waste heat available in the plant or is generated using different fuel sources. These fuel sources include fossil fuels such as coal, oil or gas, biomass & other alternative fuels, Solar energy, etc.
- The common types of industrial dryers utilized for the drying various kinds of liquid, solid and sludges are [fluidized bed](#) dryers, [rotary dryers](#), [rolling bed dryers](#), spray dryers, conduction dryers, convection dryers, e



Different Types of Dryers



Fluidized Bed Dryer



Rotary Dryer



Rolling Bed Dryer



Spray Dryer



Unit Operations in Pre-processing

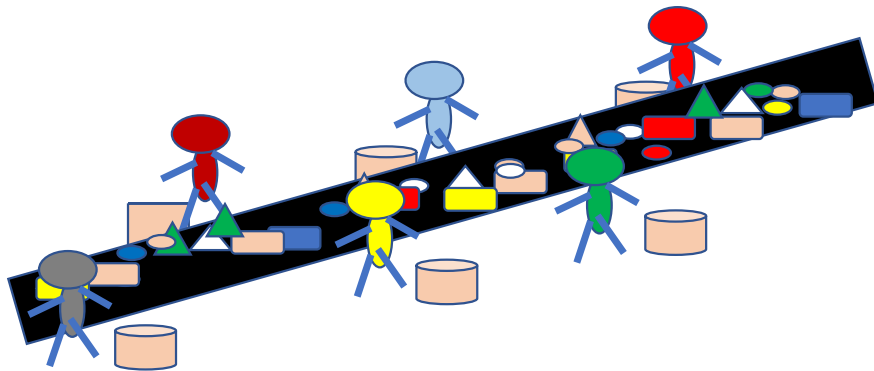
- 4. **Bailing**
 - Bailing is an operation to densify the loose material to reduce its storage footprint and transportation cost. A bailer converts loose material into blocks of different geometry. Various kinds of manual, semi-automatic and automatic bailing machines called as Bailers are available in the marketplace. The automatic bailing machines may be driven electrically or hydraulically. Bailing machines are used for creating compact bundles of materials such as paper, plastics, cardboards, tyres, metals, agro-waste, processed waste, RDF, dry MSW, etc.



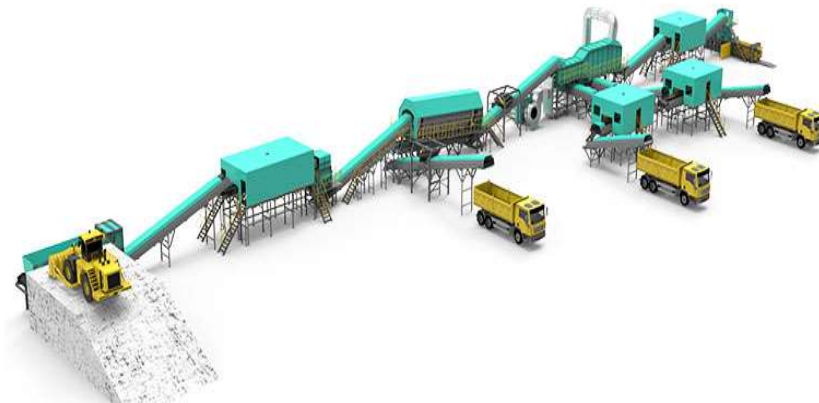
Unit Operations in Pre-processing

5. Segregation

- Segregation is a very important operation in segregating constituents present in MSW, RDF, Mix Plastic waste, Mix paper waste, e-waste, C&D waste & other kinds of wastes. A new approach which is gaining popularity is to engage robots in the segregation process where robots can be programmed to segregate waste materials based on the shape, weight, colour, appearance, text, logo, photo, etc defining the products.



Manual



Automatic



Unit Operations in Pre-processing

6. Blending

- Segregation is a very important operation in segregating constituents present in MSW, RDF, Mix Plastic waste, Mix paper waste, e-waste, C&D waste & other kinds of wastes. A new approach which is gaining popularity is to engage robots in the segregation process where robots can be programmed to segregate waste materials based on the shape, weight, colour, appearance, text, logo, photo, etc defining the products.
- Blending refers to the mixing of ingredients to achieve a desired property to the mix. As elaborated in the introduction of this chapter, waste does not have any quality consideration. Its property varies from source to source, time to time, lot to lot, etc. When wastes must be utilized as resources, they need to have uniform quality. To achieve uniform physical-chemical characteristics in the waste, it needs to be processed by various pre-processing operations defined above. In addition to implementing the above operations, for waste to have uniform characteristics, necessary ingredient needs to be incorporated in the same. This objective is achieved through blending.



Unit Operations in Pre-processing

6. Blending

- Whether wastes are liquids, solids, or sludges, blending operation is very much relevant for converting them into AFRs. Blending operation is carried out to modify calorific value, ash content, moisture content, chlorine content and other parameters of the wastes to the desired uniform level.
- Blending operation is carried out in different modes. For example, in liquid streams, blending is carried out in agitated tanks, for solids it is carried out in the shredding operation and in sludges it is carried out during the impregnation process. To ensure uniformity in the processed waste stream, at least one lot is prepared and kept ready for use and the other lots remain in preparation mode.
- Various waste streams that are processed using blending are aqueous liquid streams, organic liquid streams, RDF, plastic wastes, industrial hazardous wastes, industrial non-hazardous wastes, agro-wastes, etc and also a mix of all of these different kinds of wastes.



Waste Acceptability Criteria

- a. They should not influence the cement quality in terms of setting times or the early strength. (AFRs having phosphate levels higher than the prescribed limits.)
- b. Their use in cement should not lead to leaching of the heavy metals from the concrete. (AFRs having more heavy metals than clinker capacity to handle them. Many countries prescribe the limits of different heavy metals in the AFR.)
- c. They should not impact the emissions or cause damage to the environment. (Materials containing Hg, Hexavalent Chromium, etc.)
- d. They are safe to handle and process in the given facility. (AFRs having lower flash point than the flash point for which the facility is designed.)
- e. They do not impact the cement production process. (AFRs having higher level of Chlorine, Alkalis or Sulphur than the process can handle.)



Salient Features of Pre-processing Facility

1. **Entry gate:**

Entry gate is provided to ensure that the material entering the pre-processing facility is meeting the required statutory, commercial, environmental, safety and administrative protocols. These need to be checked before accepting the waste / AFR inside the plant.

2. **Weigh bridge:**

Weigh bridge is desired to ascertain the weight of the in-coming and out-going material.

3. **Laboratory:**

Laboratory is implemented to evaluate the quality of the incoming wastes, intermediately processed materials and fully processed AFRs. The instruments and equipment required for the assessment of the materials depends upon the nature of the incoming material, intermediately processed material and fully processed AFRs.



Salient Features of Pre-processing Facility

4. **Storage shed**

Storage shed for appropriate storage of incoming material, intermediately processed material and fully processed AFRs.

5. **Pre-processing plant & machinery**

It consists of different plant and machinery designed and implemented to process the defined waste streams into AFR. It also contains the equipment required to handle, move, and transport the waste materials, intermediate materials as well as the processed AFRs.

Design of the entire plant and machinery for pre-processing would depend upon the physico-chemical nature of the waste material.



Salient Features of Pre-processing Facility

A. Solid Wastes

- The plant and machinery required for pre-processing of solid wastes consists of properly sized shredder. For removing ferrous metals magnetic separator and for non-ferrous metals, eddy current separator is used. The inert materials are removed by implementing the pneumatic separation facility and oversize materials are removed by screening through an appropriate screening arrangement. Oversized material is sent for recycling back to shredder.
- The solid waste streams can also be utilised for impregnation purposes depending upon their characteristics. Saw dust, rice husk, other biomasses, spend carbon, paper waste, cloth waste, etc are the examples of the same.

B. Liquid Wastes

- The plant and machinery for pre-processing of liquids consists of an agitated tank with screening arrangement of the coarse and fine particles. Before feeding the new liquid stream in the tank, compatibility test is carried to check whether new volume is compatible to mix in the existing liquid stream present in the agitated tank.



Salient Features of Pre-processing Facility

C. Wastes Sludges

- The plant and machinery for pre-processing of sludges consists of a floor or pit-based impregnation arrangement. The mixing of the sludge with dry material is made using appropriate tool and then is passed through a suitable mixing equipment.
- Sludge wastes can also be mixed with liquid wastes to reduce their viscosity and fed as liquid AFRs by pumping them using suitable pumps.
- Sludge wastes can also be pumped directly into the kiln inlet or riser duct using concrete type pump.



Testing required on AFRs

S. No.	Parameter	Remarks
1	Physical State Solid Liquid Sludge	Size Viscosity Viscosity
2	Proximate Analysis	Moisture, Ash, Volatiles, Fixed Carbon
3	Ultimate Analysis	Carbon, Hydrogen, Nitrogen, Sulphur
	Ash Composition	CaO, SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , K ₂ O, Na ₂ O, MgO, P ₂ O ₅ , etc.
	NCV (Net Calorific Value)	Kcal / kg, MJ / Kg
	Density	Kg / m ³
	Halogens	Chlorine, Bromine, Fluorine
	Flash point	Deg. C
	Heavy Metals	Sb, As, Pb, CO, Cr, Cu, Mn, Ni, V, Cd, Hg, Tl, Zn, Be,



Environmental & Safety Provisions

A. Environmental Provisions:

Volatile Organic Carbon Emissions, floor seepage of hazardous or non-hazardous waste streams and odour are the three important environmental considerations that need to be addressed while designing the facility.

B. VOC emissions:

To deal with the VOC emissions, these may be exhausted from the facility and then they are either thermally destroyed or catalytically destroyed or adsorbed on a suitable adsorbing media such as activated carbon. If the pre-processing facility is installed within the cement plant, then these exhaust gases can be diverted into the kiln.

C. Floor spillages of the waste streams:

They need to be managed by having impervious floor in the facility so as to avoid its seepage in the soil and ground water. The impervious floor can be achieved by installing geopolymer membrane below the concrete flooring. Further, the facility needs to have proper drainage system to divert the seepages into a containment tank for subsequent treatment through a suitable technology.



Environmental & Safety Provisions

D. Odour Control:

Most of the waste materials have undesired odour which causes substantial concern to the employees and the surrounding community. The VOC emission control may reduce the intensity of the odour but to improve the situation further, there are two more technology options. The first one is the use of fragrance spray in the premises and the second is use of adsorbing sheets installed in the direction of wind so that the VOC emissions are adsorbed on to these sheets.

E. Safety Provisions:

Exposure to toxic materials, run away reactions due to incompatible materials, Fire and explosion due to various reasons such as flammability of the materials, low flash point bearing materials, inappropriate design of the machinery and electrical facilities from ATEX considerations, etc. To deal with this situation following considerations need to be considered.



Environmental & Safety Provisions

F. Equipment design:

The equipment needs to be certified to the prevailing ATEX conditions in the facility.

G. Exposure to toxic materials:

Proper exposure protection needs to be ensured using appropriately selected Personal Protective Equipment (PPEs).

H. Runaway reactions due to incompatible materials:

The compatibility study of the different materials needs to be properly studied / understood and the incompatible materials need to be stored away from each other to avoid their contact. The storage of material needs to be properly designed in the pre-processing facility accordingly.



Production of AFR from Waste Streams

- For successful pre-processing, it is important to have the analysis of the physico-chemical characteristics of all the waste streams available in the stores. The cement kiln requires AFR having certain desired characteristics. AFR having such desired characteristics is produced by utilising a mix of these waste streams in defined proportions and utilising different waste treatment technologies that are illustrated above.
- While arriving at the desired proportion mix, the Solid, Sludge and liquid AFRs need to be properly configured and they need to be pre-processed accordingly and blended to arrive at the final AFR mix that meets the acceptable AFR quality as desired by the cement kiln. For this, therefore, the Solid, Sludge and Liquid AFRs need to be suitably pre-processed by utilizing different technologies as defined above.
- Many of the waste management companies pre-process hazardous and non-hazardous wastes into Alternative Fuels and supply to cement industries. Pre-processing of wastes into Alternative Fuels is practiced successfully in many different countries and largescale production of Alternative Fuels is carried out. The Alternative fuels are produced in both liquid and solid states and co-processed by cement plants.



Thanks!



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