POWDER TREATMENTS

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In powder conditioning, the powders prepared by various methods are subjected to a variety of treatments to improve or modify their physical, chemical characteristics.

:Majority of powders under go treatments prior to compaction like

i) Cleaning of powders [solid: impurity,liquid: moisture, gas: air]

ii) Grinding/crushing to obtain fine size .

iii) Particle size classification to obtain the desired particle size ،distribution

،iv) Annealing

، v) Mixing and blending of powders

،vi) Lubricant addition for powder compaction

vii) Powder coating

) Toxicity of powders

CLEANING OF POWDERS

solid, liquid & gaseous, from the ،Refers to the removal of contaminants powder particles.

- Solid contaminants : Come from several sources like nozzles or crucible .linings

They interfere during compaction and sintering preventing proper mechanical bonding.

Contaminants are non-reactive, but they act as sites for crack nucleation

Non-metallic solid impurities can be removed from powders by particle separators & metallic electrostatic separation techniques

Liquid contaminants : Drying to remove moisture

- Gas contaminants : Gaseous impurities like hydrogen and oxygen get storage or handling if proper care is ،into powders during processing .not taken

Finer the powders, contamination will be more because of large powder surface area,

These gaseous impurities can form undesirable oxides during processing at relatively high temperature or gets trapped inside the material as pores, reducing the in situ performance of the P/M part;

PARTICLES SEPARATION

1-Classification

A- Dry Classification

B-Wet Classification

2-Hindered settling

3- Magnetic and electrical separation

Classification is the separation of particulates into a coarse and fine fractions.

Classification should be distinguished from solid-fluid separation

Classification is usually by:

Size particles, density, particle shape, electric, magnetic, and surface properties.

Classification of particulates gravity, drag, centrifugal, and collision.

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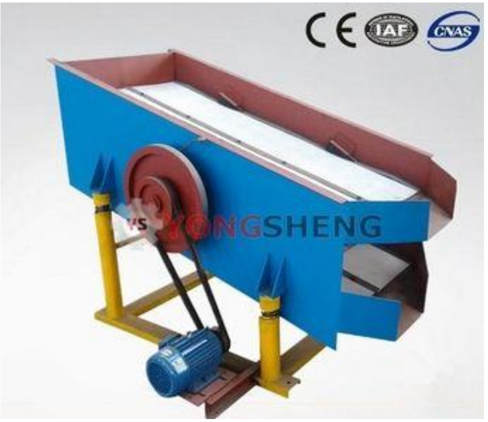
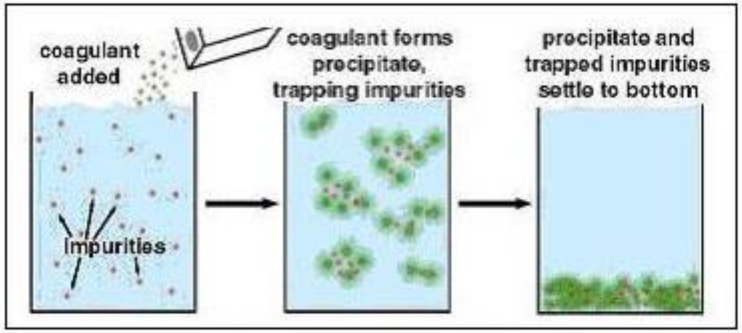
Table 1 gives a listing of various classification **equipment**

Classification	Size range
Wet	
Screens	1 m–44 μm
Sedimentation Classifiers	1 mm–10 μm
Hydrocyclones	500 μm–0.1 μm
Elbow Classifier	100 μm–0.1 μm
Centrifuge	50 μm–0.1 μm
Dry	
Screens	1 m–44 μm
Expansion chamber	100 μm–10 μm
Air Classifier	1000 μm–0.1 μm
Gas Cyclone	500 μm–0.1 μm

Wet classification equipment



Screen Classification

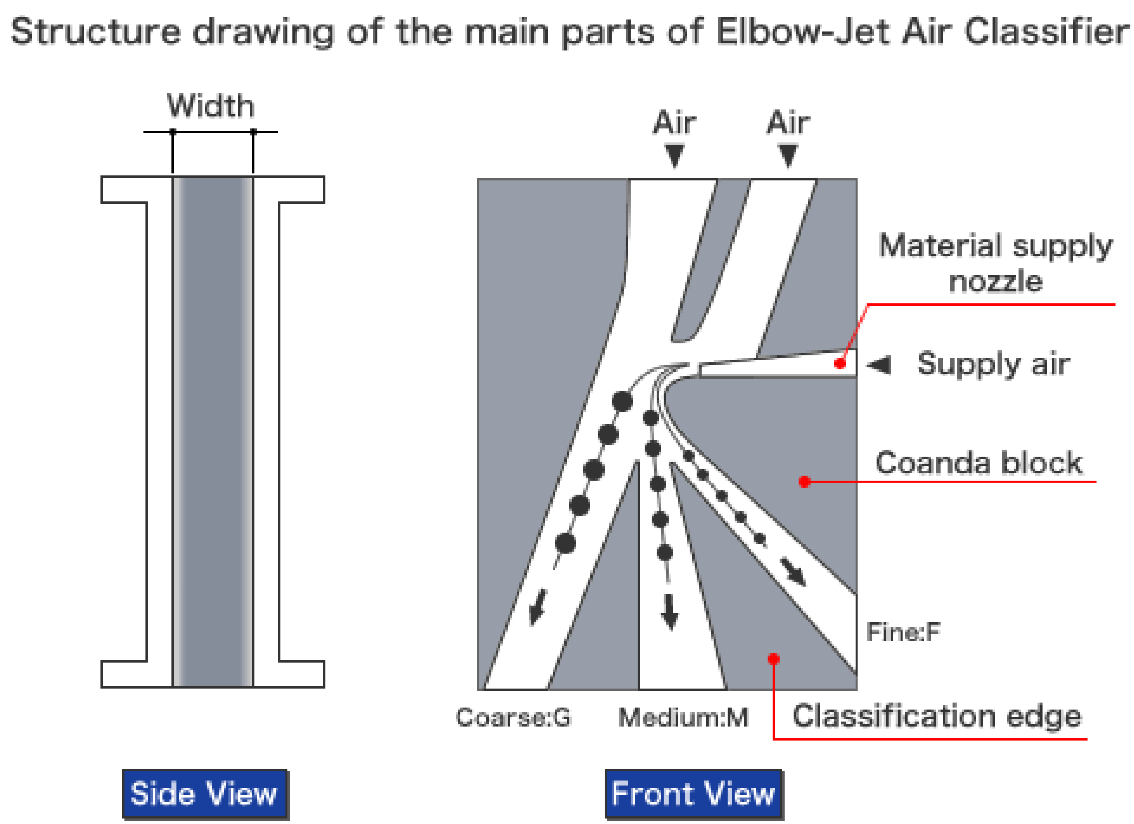


Coagulation/Flocculation/Sedimentation

Rake Classifiers

Lamella Separators

Hydro Cyclones



Elbow_classifier

Dry Classification Equipment

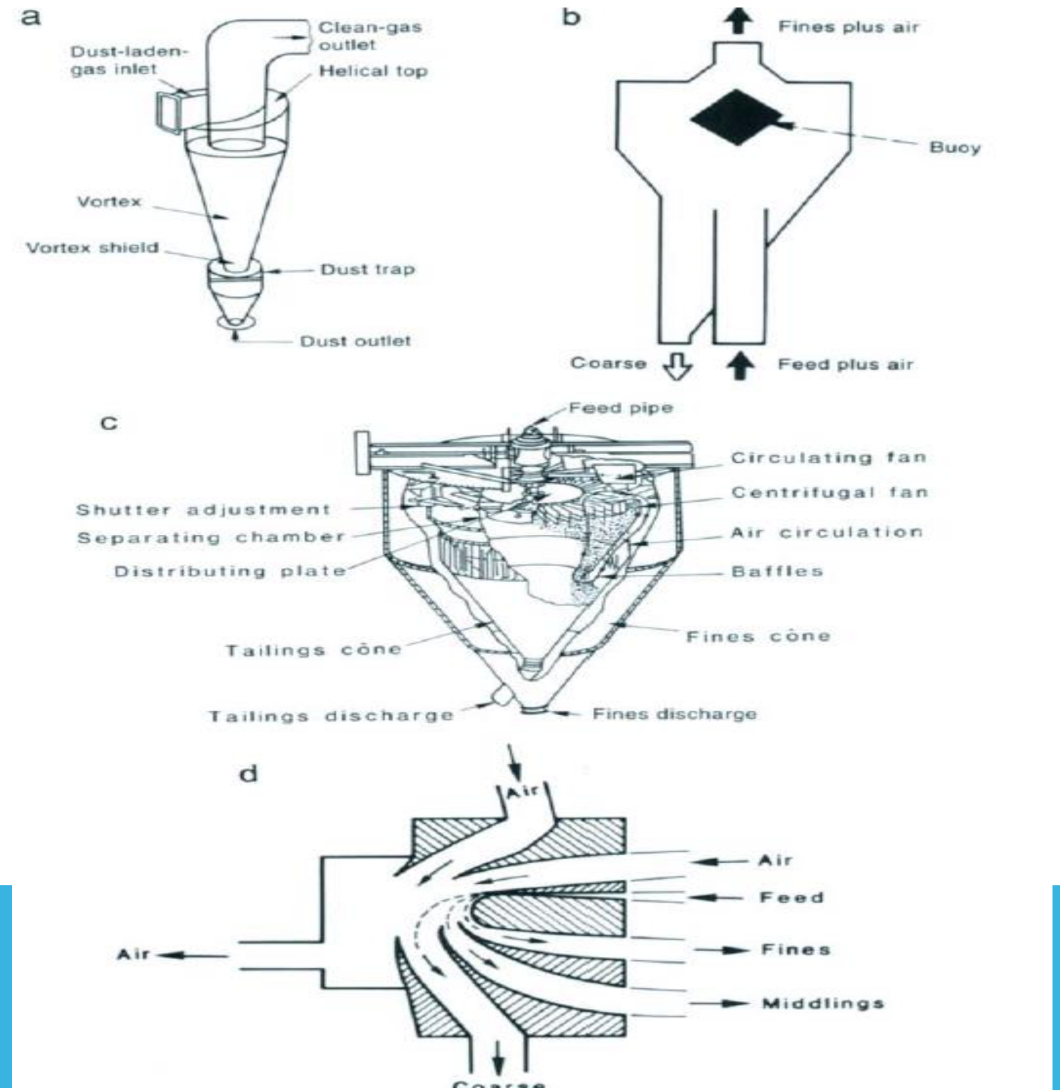


FIGURE Air classification equipment: (a) cyclone, (b) expansion chamber, (c) modern complex air classifier, and (d) classifier based on particle inertia.

Classifier Fundamentals

1-Forces

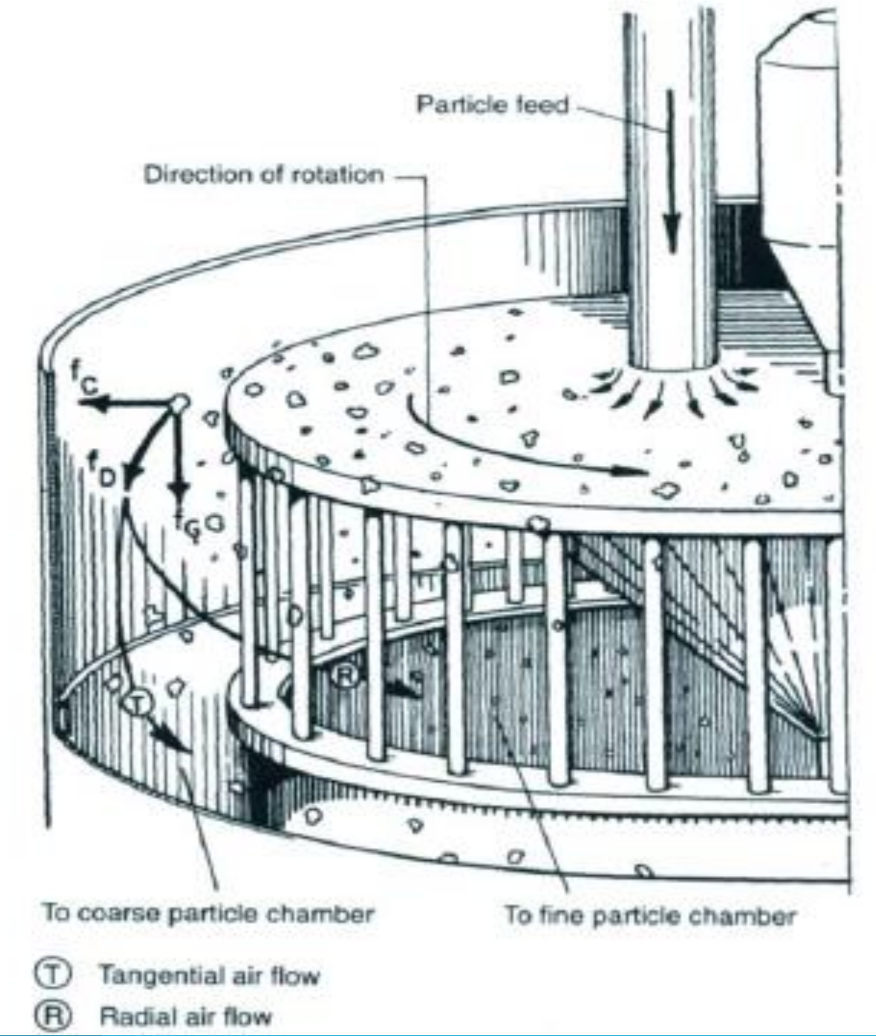


Figure1 Forces acting on a particle in a gas classifier

2-Collision

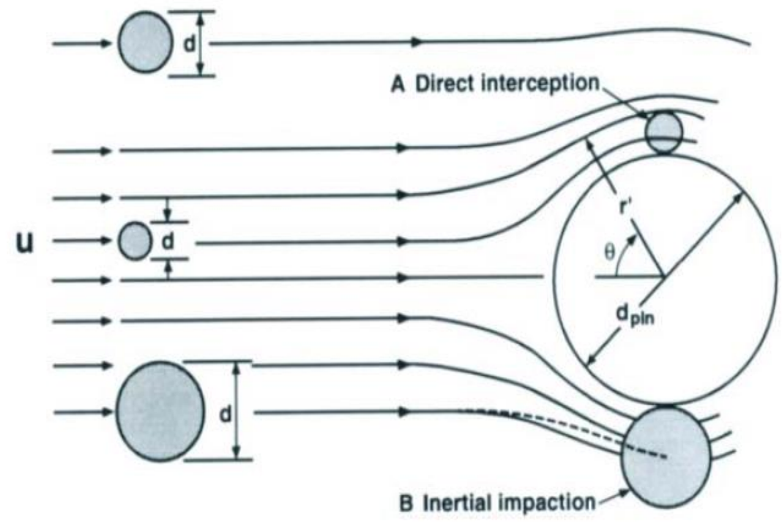


Figure2 streamlines and particle trajectories approaching a pin

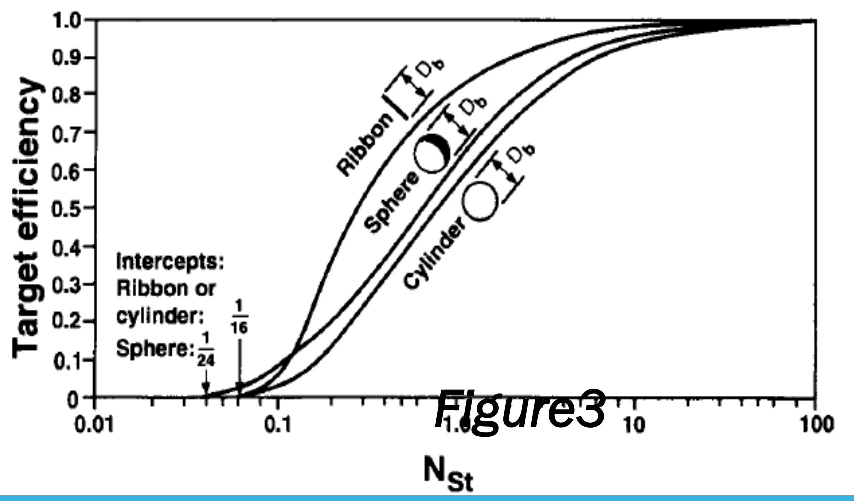
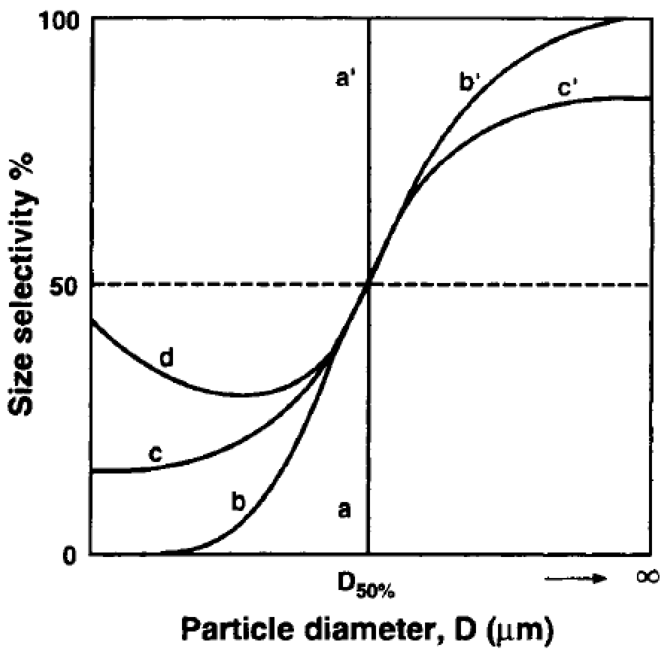


Figure3

4.Size Selectivity



5-Powder properties

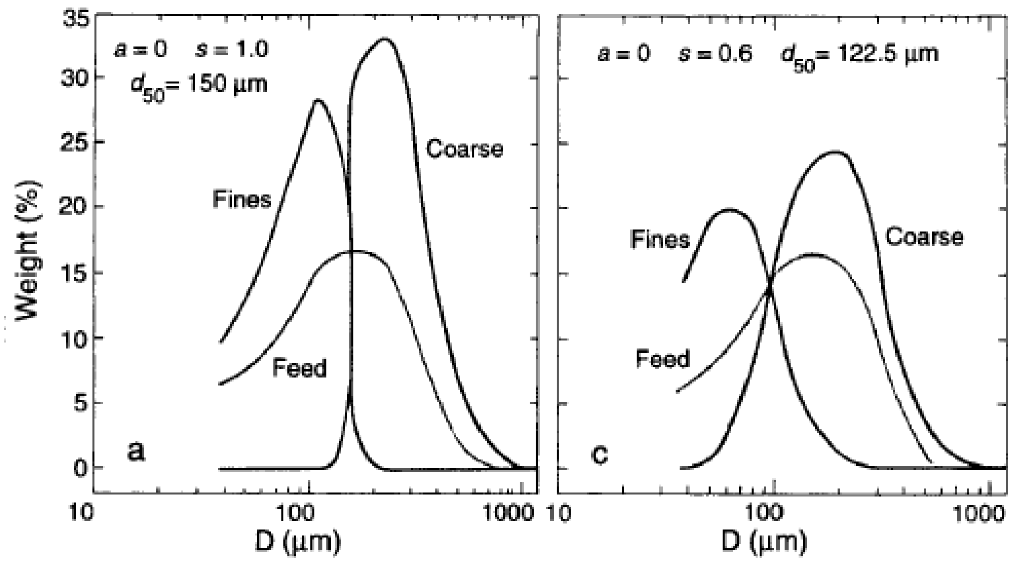


FIGURE Size distributions for various types of classifier performance.

A- Dry Classification Equipment

Dry classification equipment uses a gas stream to convey the solids.

The gas used most often is air, is often used to describe this type of equipment (see Fig. 1).

B-Wet classification

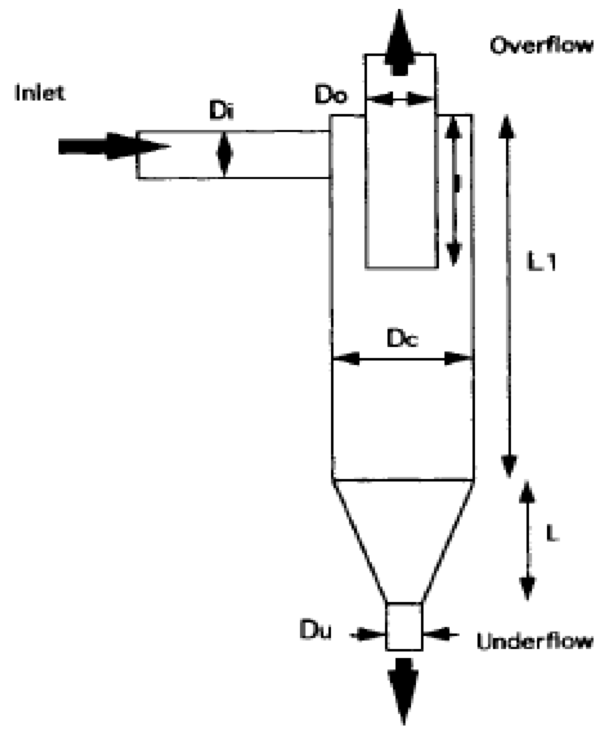
is performed by

filtration, settling, centrifugation, and hydrocyclones .

Hydro cyclone The In hydrocyclone design, the particle laden flow enters radially and rotates within the body of the hydrocyclone.

Forces of gravity, centrifugal and drag, act on the particles to force a separation.

The particles larger than the cut size are sent to the underflow, and the particles smaller than the cut size are sent to the overflow along with most of the liquid.



2-Hindered settling

When the particles are close together, hindered settling occurs.

$$Vm = D^2 g(\rho_p - \rho_m) / 18\eta$$

$$V_t = \frac{2R^2[\rho_s - \rho_f] g h(\phi)}{9\eta}$$

we find

	Unhindered	Hindered, $\phi = 0.10$	Hindered, $\phi = 0.30$
$R = 0.1\ \mu m$	$V_t = 80\ \mu m/hr$	$V_t = 25.7\ \mu m/hr$	$V_t = 8.0\ \mu m/hr$
$R = 1.0\ \mu m$	$V_t = 8$ mm/hr	$V_t = 2.57$ mm/hr	$V_t = 0.8$ mm/hr

3- Magnetic and electrical separation

TABLE 1 Classification of Magnetic Separation

- magnetic separator
  - static-magnetic-field type
    - (low-intensity type)
      - belt type
        - top-feed type
          - OS varnner*
          - Ferrogum separator*
        - under-feed type
          - Crockett wet separator*
      - drum type
        - top-feed type
          - YS drum separator
        - under-feed type
          - Gröndal drum separator
          - Multistage drum separator*
    - (medium-intensity type)
      - belt type
        - top-feed type
          - Eriez rare earth roll separator*
      - drum type
        - top-feed type
          - Eriez rare earth drum separator
          - PERMOS magnetic separator
    - (high intensity type)
      - high intensity type
        - wet high intensity magnetic separator WHIMS
          - Frantz ferrofilter*
          - Jones high-intensity separator*
          - Carpco high-intensity wet separator*
          - Eriez wet high-intensity separator*
          - NY drum separator*
        - high intensity magnetic separator (HIMS)
          - Superconductive suspended magnet
          - Coupled pole separator
          - High-gauss separator
          - DESCOS (superconductive-drum-type magnetic separator)
      - high gradient type, HGMS
        - SALA-HGMS*
        - DEM filter*
        - Superconducting HGMS*
  - a. c.-magnetic-field type
    - traveling-magntic-field type
      - OYB separator*
      - AC spiral separator*
      - OY-table-type separator*
    - vibrating-magneic-field type
      - DS-type separator*
    - electromagnetic-induction type

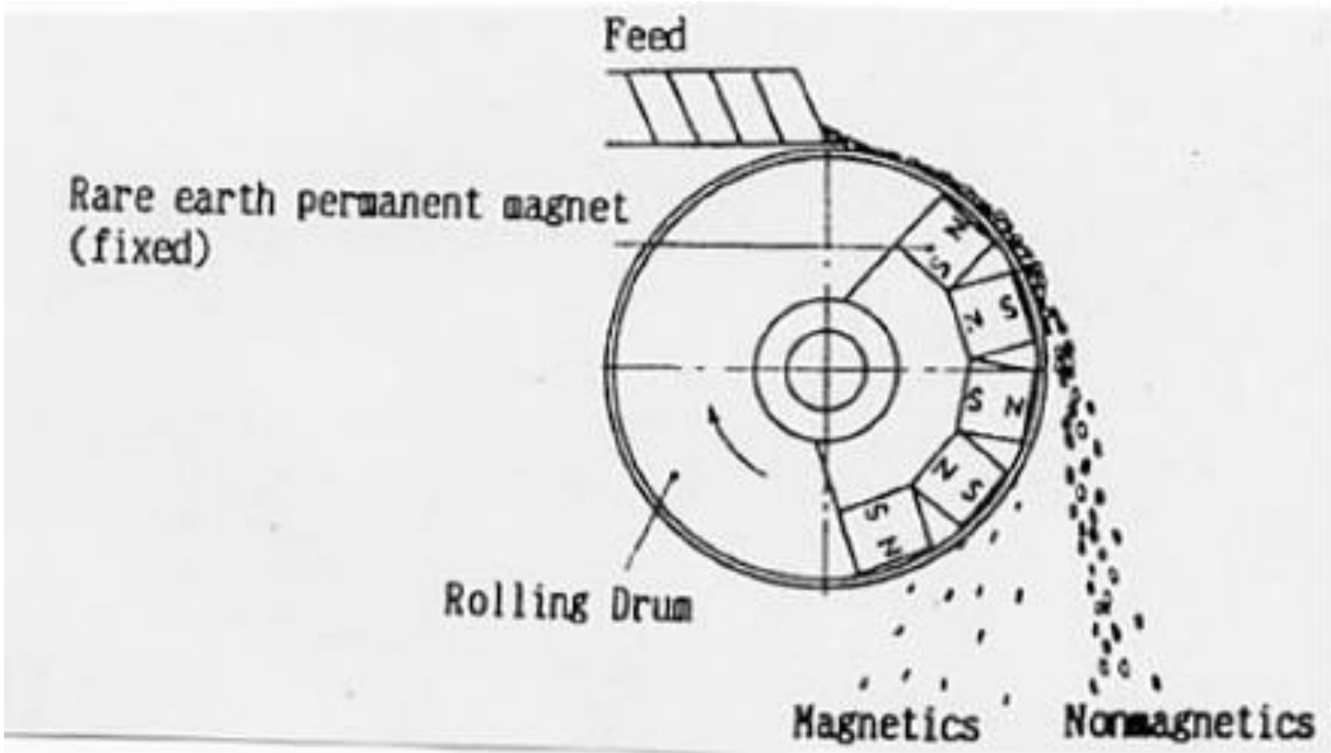


FIGURE Drum magnetic separator of the dry type.

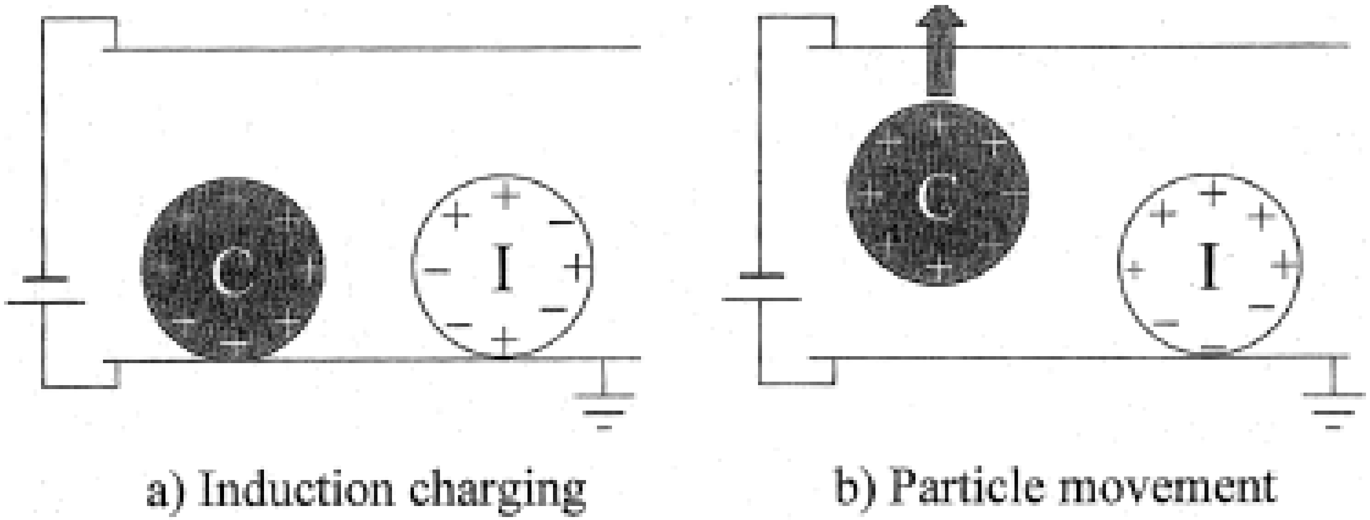


FIGURE Motion of particles under an electrostatic field. C, particle made of conductive material; I, particle made of insulating material.

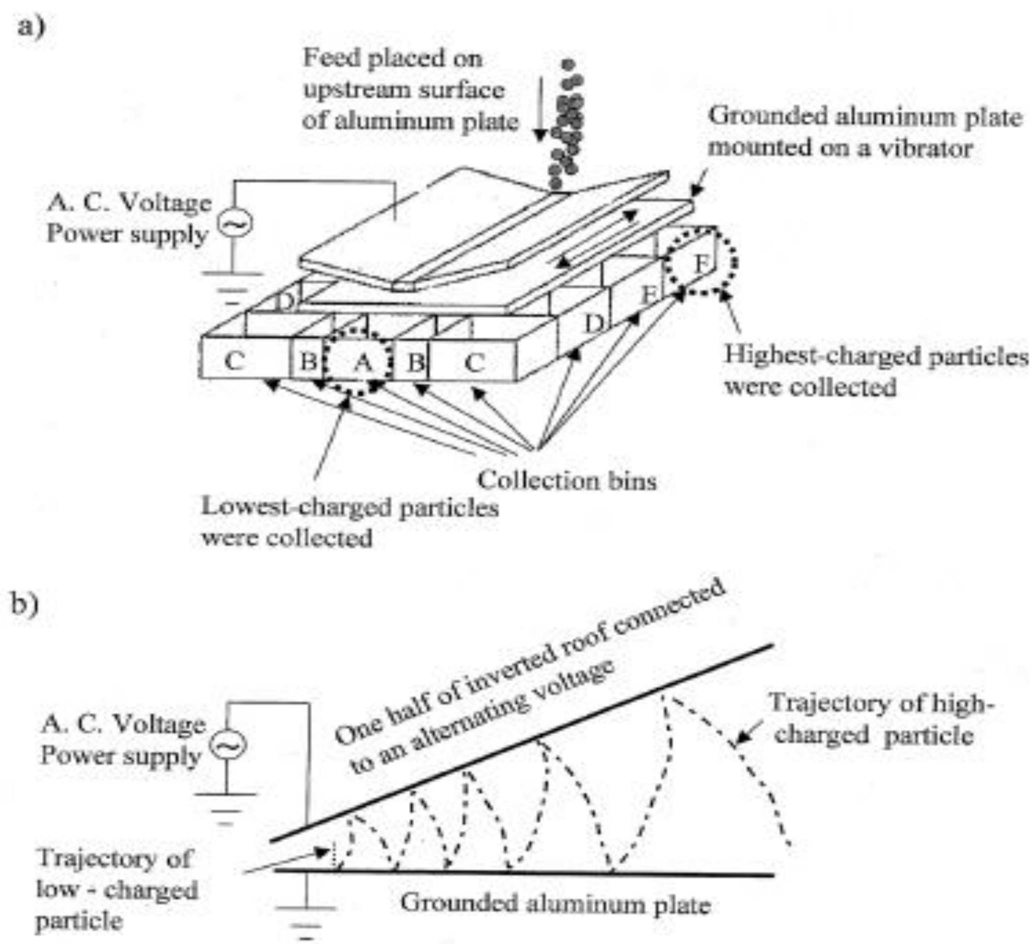


FIGURE Electrostatic beneficiation apparatus: (a) oblique view of apparatus showing inverted roof and collection bin locations; (b) end view showing trajectories of charged particles.

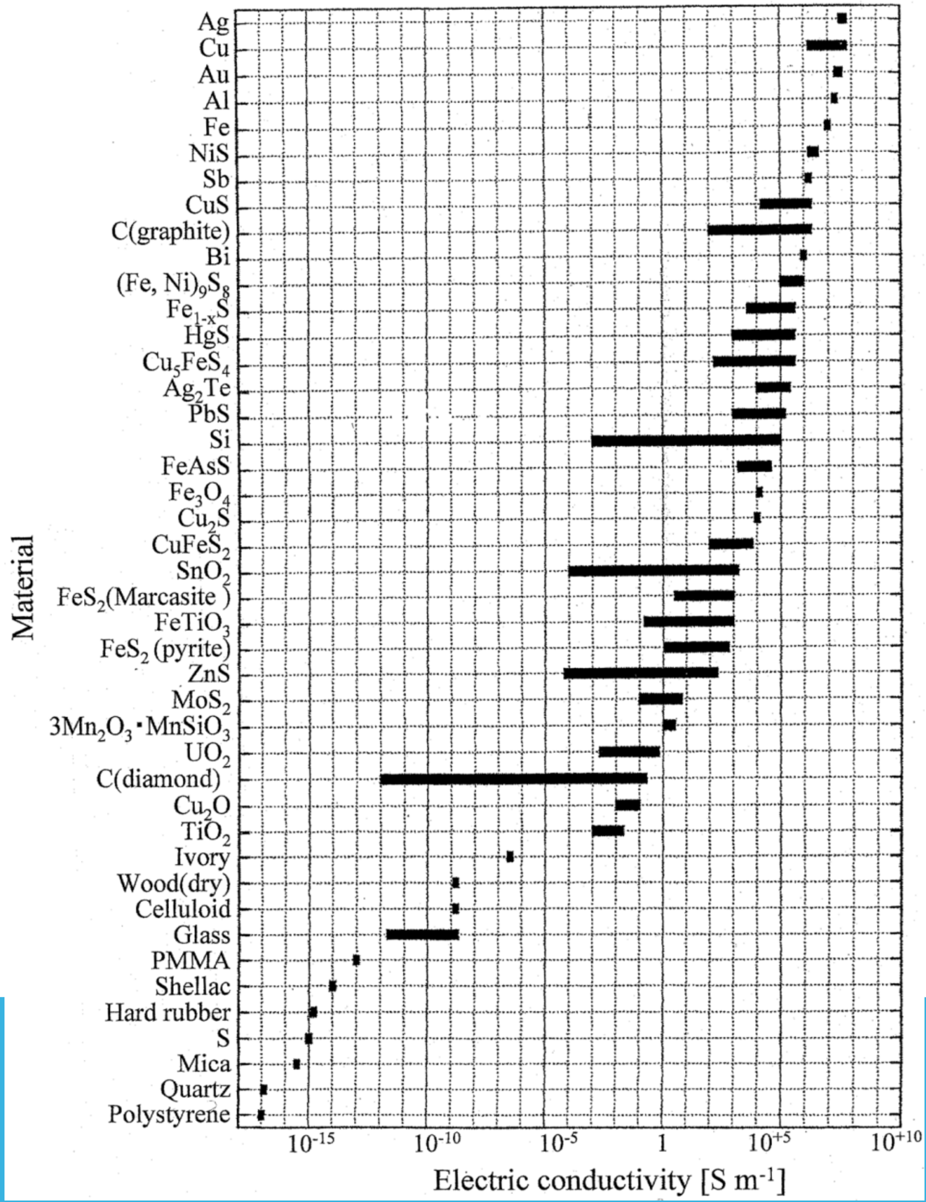


Figure10 Electric conductivity for various materials.

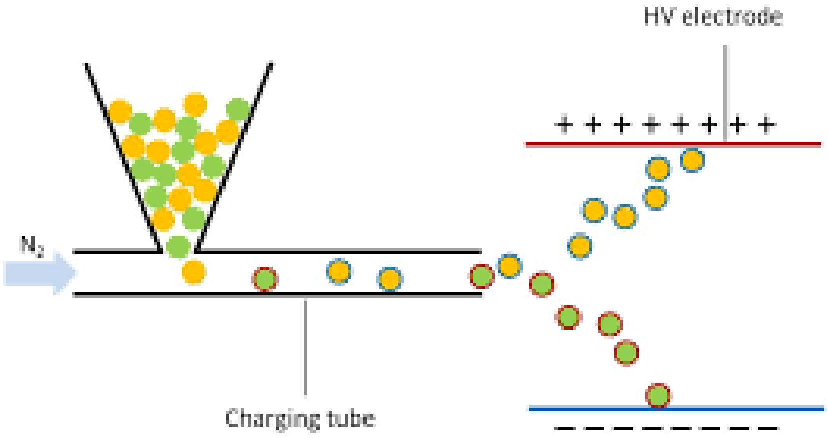


TABLE .2 Work Functions for Various Materials[3,4]

Material	Work function (eV)	Material	Work function (eV)	Material	Work function (eV)
Zn	3.63	BaO	1.1	Polyethylene	5.24±0.24
C	4	CaO	1.60±0.2	Polyethylene	6.04±0.47
Al	4.06–4.26	Y_2O_3	2	Polypropylene	5.43±0.16
Cu	4.25	No_2O_3	2.3	Polypropylene	5.49±0.34
Ti	4.33	ThO_2	2.54	Polystyrene	4.77±0.20
Cr	4.5	Sm_2O_3	2.8	Polyvinyl chloride	4.86±0.73
Ag	4.52–4.74	UO_2	3.15	Polycarbonate	3.85±0.82
Si	4.60–4.91	FeO	3.85	PMMA	4.30±0.29
Fe	4.67–4.81	SiO_2	5	Polytetrafluoroethylene	6.71±0.26
Co	5	Al_2O_3	4.7	Polyimide	4.36±0.06
Ni	5.04–5.35	MgO	4.7	Polyethylene Terephthalate	4.25±0.10
Pt	5.12–5.93	ZrO_2	5.8	Niron66	4.08±0.06
Au	5.31–5.47	TiO_2	6.21	Pylex7740	4.84±0.21

Powder Annealing

Heat treatment is generally carried out before mixing or blending the powders.

Some of the important objectives are,

i) Improving the purity of powder:

Reduction of surface oxides from powders by annealing in hydrogen or other reducing atmosphere.

Dissolved gases like hydrogen and oxygen, other impurities are removed by annealing of powders.

Lowering impurities like carbon results in lower hardness of the powder and hence lower compaction pressures & lower die wear during compaction. For ex:, atomized powders having a combined carbon and oxygen content as high as 1% can be reduced after annealing to about 0.01% carbon and 0.2% oxygen.

Heat treatment is done at protective atmosphere like hydrogen, vacuum.

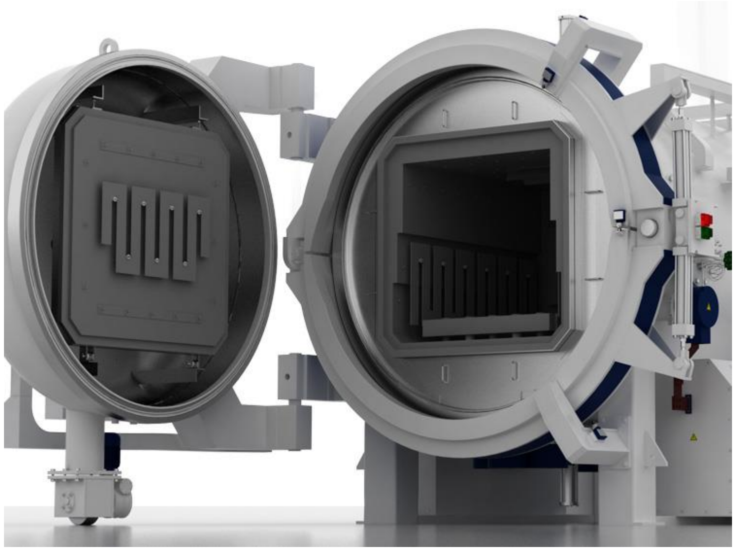
ii) Improving the powder softness:

Aim is to reduce the work hardening effect of powders that has be crushed to obtain fine powders; while many powders are made by milling, crushing or grinding of bulk materials. Powder particles are annealed under reducing atmosphere like hydrogen. The annealing temperature is kept low to avoid fusion of the particles.

iii) Modification of powder characteristics:

The apparent density of the powders can be modified to a higher or lower value by changing the temperature of treatment.

Ultra High Vacuum furnaces



Mixing and blending of powders

The various types of mixing methods are,

• (i) convective mixing: transfer of one group of particles from one location to another,

•(ii) diffusive mixing: movement of particles on to newly formed surface,

(iii) shear mixing: deformation & formation of planes within the powders

Depending on the extent of mixing, mixing can be classified as

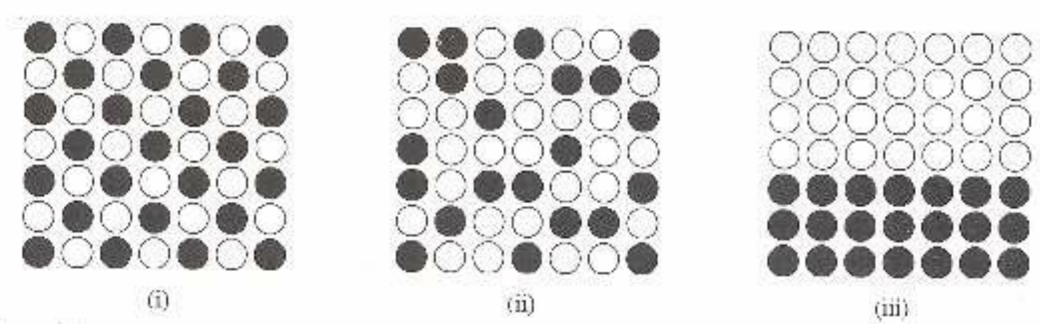
•perfectly mixed or uniform mixing,

•random mixed, &

•totally un-mixed.

The mixing should be stopped when random mixture is achieved.

Over mixing leads to reduced flow characteristics of the mix.



uniform mixing random mixed un-mixed

Table 3 shows a classification of various powder mixers, based on the manner by which the powders are set in motion. This table also lists rough ranges of powder properties appropriate to each type of mixer.

Although mixer performance should be evaluated on the basis of the powder properties being handled, operating conditions, and the application purpose, the general features of each mixer are as described below

cubic rotary mixer

horizontal cylinder

inclined cylinder mixer

Vee-Cone Blenders

'S' Type Mixers

double cone mixer

The rate of mixing is rather low in a rotary vessel, but a good final degree of mixedness can be expected.

The powders to be mixed are **charged** up to 30–50% of the vessel volume.

The **rotational speed** is set at 50–80% of the critical rotational speed, NCR, given as

$$N_{cr} = \frac{0.498}{\sqrt{R_{max}}} \ (s^{-1})$$

Where

R_{max} (m) is the maximum radius of rotation of the mixer.

Lubricant powder

A normal body binder must have several characteristics:

• It must leave a minimal amount of ash after firing • It must easily burn out at low temperature • It cannot be abrasive • It must improve the mechanical strength of dry pieces • It does not cause bodies to stick to mold	• Its dispersion must be easy • It cannot be toxic • It does not affect the glazing stage of manufacturing • It must be as inexpensive as possible.

Types:

Inorganic Binders, Sodium Silicate, Magnesium Aluminum Silicates,Bentonite, Polyacrylates, Paraffins, Wax.

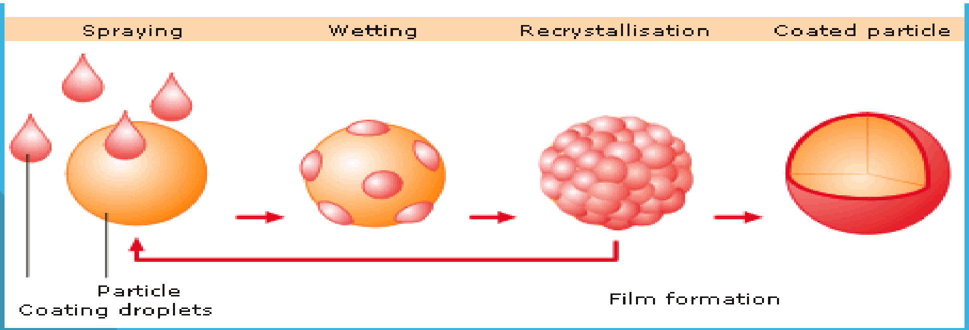
Powder Coating

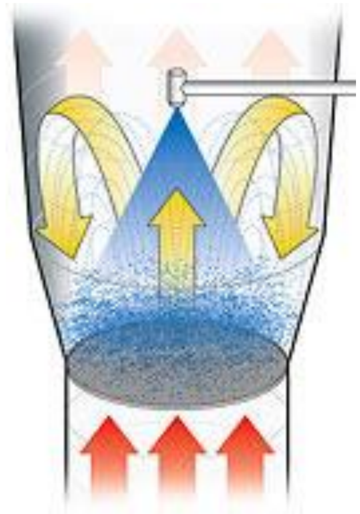
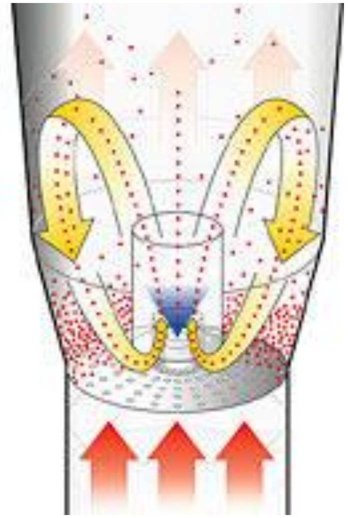
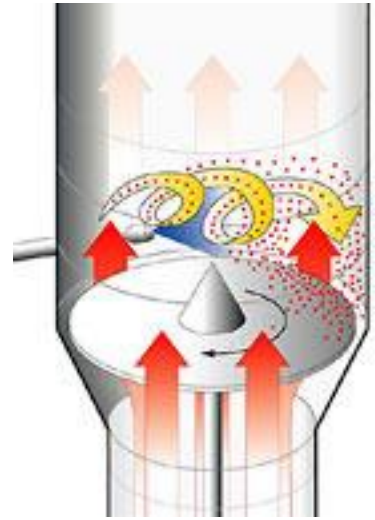
Spray can be used for all fluid systems, be it in batch or continuous operation or if the film is applied from a sprayed solution, suspension or hot melt.

For this processing option the parameters have to be chosen to avoid agglomeration,

For hot melt coating the droplets must be small enough not to form solid bridges.

The quality of the coating extensively depends on the statistical residence time of the particles in the coating zone.



Top-Spray Coating	Bottom-Spray Coating	Tangential Spray Coating
To Produce perfect film ,care must be taken that the droplets 1- Do not become too viscous before touching the substrate, in order to maintain a good spread ability. 2- The particle motion, 3- The travel distance of droplet from nozzle to substrate are uniform	This processing consists of a perforated bottom screen with defined free areas. Most of the process air is channeled through the center via a tube, as such producing a venturi effect, which sucks the product from outside the partition past the spray nozzle.	This processing technique is the production motion is provided by a motor driven rotor disc. The coating material is sprayed concurrently inside the rotating product

Toxicity of powders

• Toxicity leads to undesirable health effects like eye, skin irritation, vomiting, respiratory problems, blood poisoning etc.

• powder like lead, nickel are highly toxic & Al, iron are less toxic

• Precautions: Use of protective gloves, respiratory masks, protective clothing etc.; use of well ventilated storage, workplace; careful handling, disposal of wastes

• flammability & reactivity data is required

• Health effects: Inhalation – disturbs the respiratory track; remedial measures include moving the person to fresh air. Artificial breathing is required if patient not breathing properly.

Skin, eyes – Brushing, washing skin and eyes with water and soap. Clean eyes with fresh water for 15 mts.

•Sb , Ba , V, Be, Se, Co, Zn, Cd oxide .

•borax (or gerstle borate), copper, chromium (chrome), manganese, nickel, potassium dichromate.