SNS COLLEGE OF PHARMACY AND HEALTH SCIENCES
Sathy Road, SNS Kalvi Nagar, Vazhiyampalayam, Coimbatore, Tamil Nadu 641035

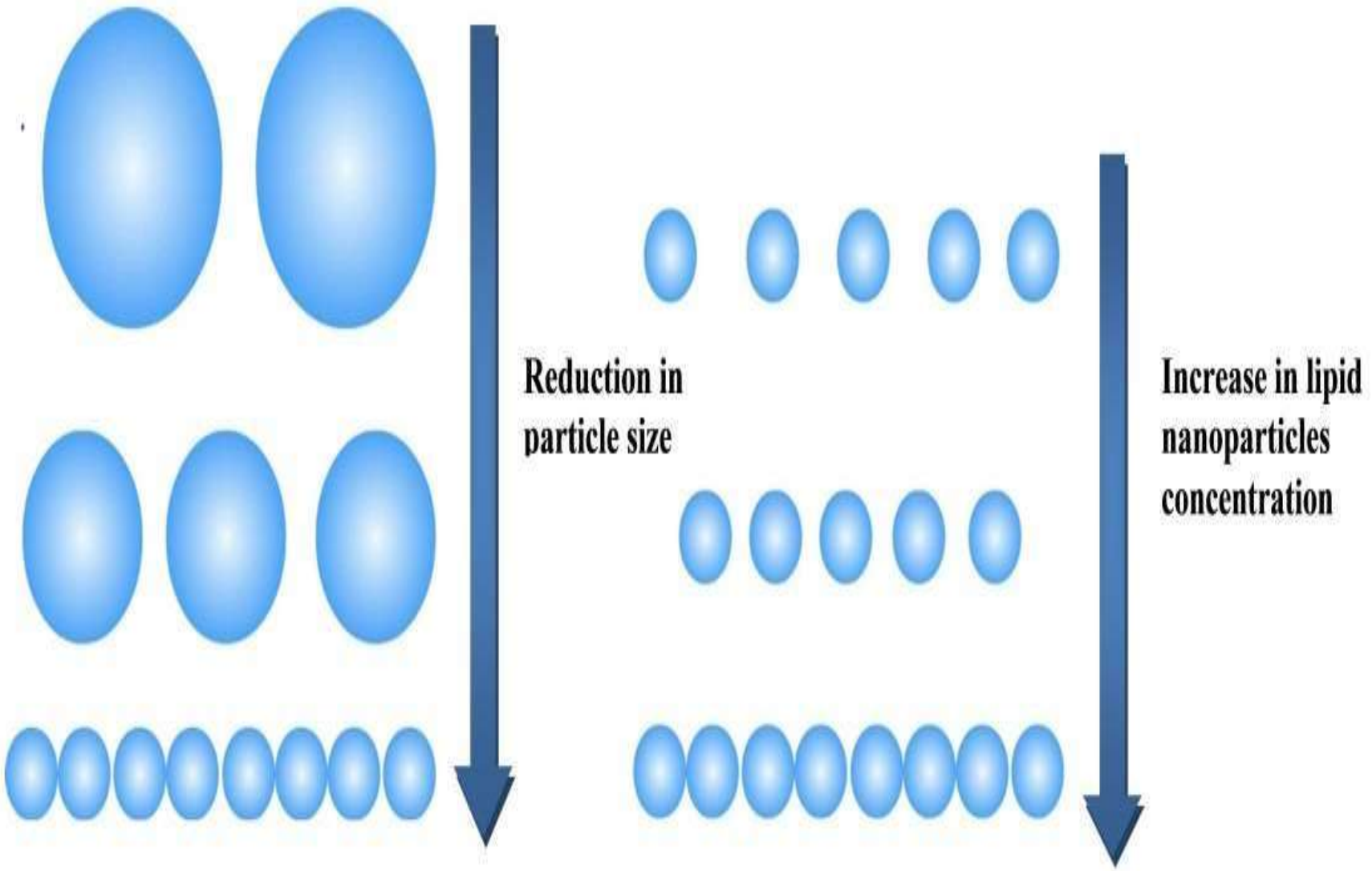
SIZE REDUCTION

What is the meaning of size reduction ?

- Size refers to physical Dimension of an object.
- Reduction refers to decrement or the process of decreasing the size.

Simple definition of SIZE REDUCTION

- Size reduction is the operationcarried out for reducing the size of bigger particles into smaller one of desired size and shapewith the help of external forces.
- COMMINUTION is another term used for size reduction.


Reduction in
particle size
Increase in lipid
nanoparticles
concentration

OBJECTIVES OF SIZE REDUCTION

- In the materials processing industry, size reduction or comminution is usually carried out in order to:
  - Increase the surface area because, in most reactions involving solid particles, the rate of reactions is directly proportional to the area of contact with a second phase.
  - Break a material into very small particles in order to separate the valuable amongst the two constituents.
  - Achieve intimate mixing.
  - To dispose solid wastes easily .
  - To improve the handling characteristics.
  - To mix solid particle more intimately.

Advantages and disadvantages of size reduction

Advantages of size reduction

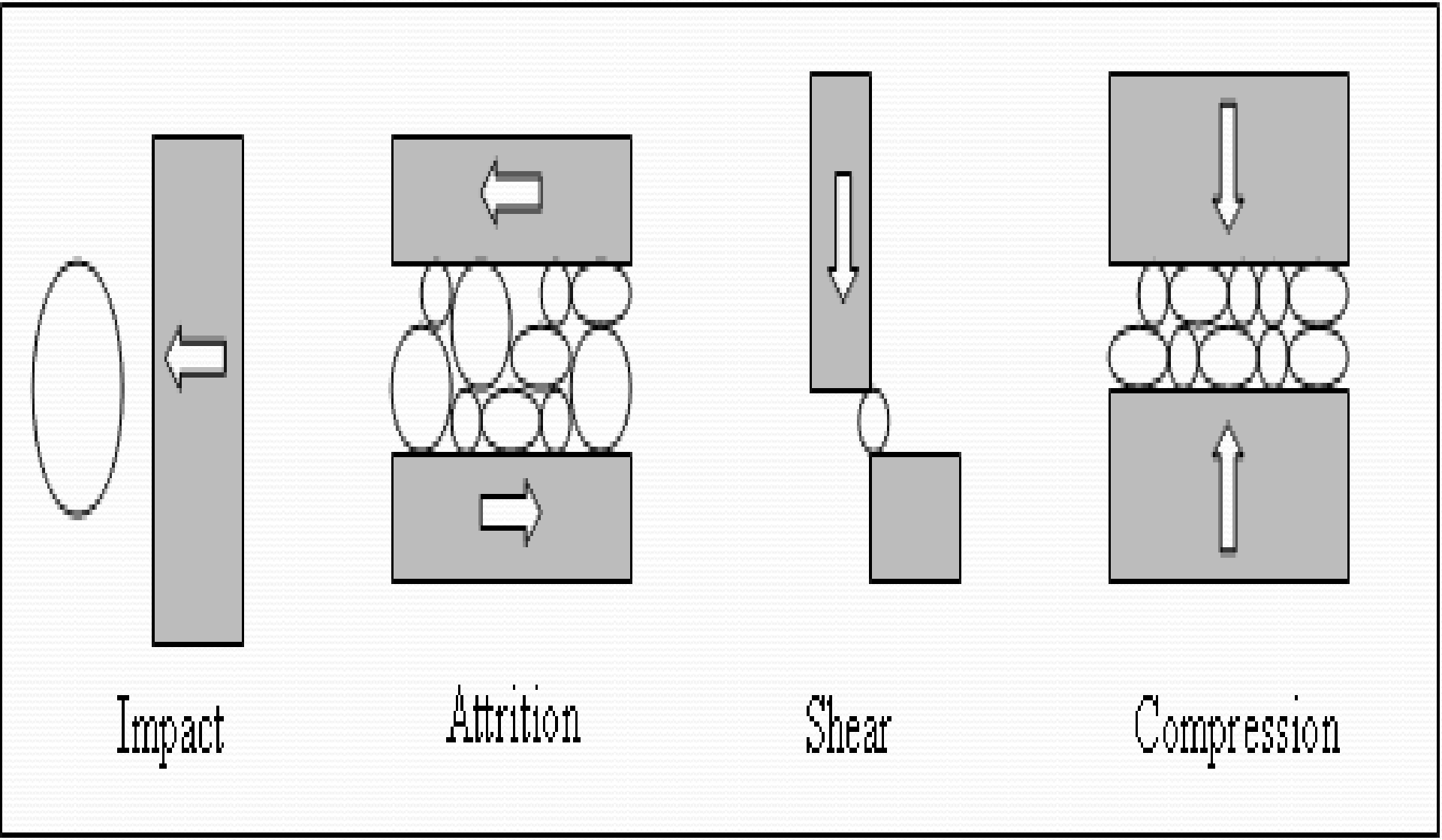
- Content uniformity
- Uniform flow
- Effective drying
- Increases surface area orviscosity
- Uniform mixing and drying
- Improve rate of absorption . Smaller the particles greater is absorption.
- Improve dissolution rate.

Disadvantages of size reduction

- Drug degradation
- Contamination

Mechanism of size reduction

- **Impact** —particle concussion by a singlerigid force (hammer).
- **Compression**—particle disintegration by two rigid forces (nutcracker).
- **Shear** —produced when the particle is compressed between the edges of two hard surfaces moving tangentially.
- **Attrition** —arising from particles scraping against one another or against a rigid surface (a file).


Impact
Attrition
Shear
Compression

Type of impact When impact force are apply?

- Gravity impact

1. In gravity impact ,the free falling material is momentarily stopped by the stationary object.
2. Example – coal dropped onto a hard steel surface

- Dynamic impact

1. Most often used when it is necessary to separate two material which have relatively different friability
2. The more friable material is broken first
3. Less friable material remains without broken
4. Example – material dropping in front of a moving hammer

- A cubical particle are needed or material too hard

When compression forces needed?

- If material is hard
- If material is abrasive
- If the material is not stick
- When material will break cubically
- Where the finished product is to be relatively coarse in size

Factors affecting size reduction

- **Hardness:**

- It is a surface property of the material.
- It is frequently confused with a property named strength.
- Thus, it is possible for a material to be very hard, but if it is brittle also then size reduction may present no special problems.
- An arbitrary scale of hardness has been devised known as Moh's Scale;

- Moh's Scale = 1 is for graphite
- Moh's Scale < 3 is for soft material
- Moh's Scale > 7 is for hard material
- Moh's Scale = 10 is for diamond

The harder the material the more difficult it is to reduce in size

Factors affecting size reduction

- **Material structure:**
- Some substances are homogeneous in character.
- Mineral substances may have lines of weakness along which
- the materials splits to form flake-like particles.
- Vegetable drugs have a cellular structure often leading to long fibrous particles.

Factors affecting size reduction

- **Abrasiveness:**
- Abrasiveness is a property of hard materials (particularly those of mineral origin).
- It may limit the type of machinery that can be used.
- During the grinding of some very abrasive substances the final powder may be contaminated with more than 0.1 percent of metal worn from the grinding mill

Factors affecting size reduction

- **Softening temperature:**
- During size reduction process sometimes heat is generated which may cause some substances to soften, and the temperature at which this occurs can be important.
- Waxy substances, such as stearic acid, or drugs containing oils or fats are examples that may be affected.
- Some methods can be used to overcome this like cooling the mill, either by a water jacket or by passing a stream of air through the equipment.

Factors affecting size reduction

- **Moisture content:**
  It is found that materials do not flow well if they contain between about 5 and 50 per cent of moisture. Under these conditions the material tends to cake together in the form of balls. In general, grinding can be carried out satisfactorily outside these limits.
- **Crushing strength:**
  The power required for crushing is almost directly proportional to the crushing strength of the material.

Friability:
The friability of the material is its tendency to fracture during normal handling. In general, a crystalline material will break along well-defined planes and the power required for crushing will increase as the particle size is reduced.

Stickiness:
A sticky material will tend to clog the grinding equipment and it should therefore be ground in a plant that can be cleaned easily.

Soapiness:
In general, this is a measure of the coefficient of friction of the surface of the material. If the coefficient of friction is low, the crushing may be more difficult.

Explosive:
Such materials must be ground wet or in the presence of an inert atmosphere.

Materials yielding dusts that are harmful to the health:
Such material must be ground under conditions where the dust is not allowed to escape.

SIZE REDUCTION THEORIES

- The energy requirement for particle size reduction is a function of input and output of particle size, hardness, strength and other propertiesof solids.

Various theories for energy requirement are:-

- **Rittinger's theory**
- **Kick's theory**
- **Bond's theory.**

- The energy required to reduce the size of particles is inversely proportional to the size raised to the some power.

$$\frac{dE}{dD} = -c/D^{n} \qquad \ldots. \quad (1).$$

Where,

E=amount of energy required to produce a change

D=size of unit mass

C, n=constants.

Integrating equation (1),

$$E = C \ln(d_i/d_n) \quad \ldots \quad (2)$$

(d_i/d_n) = reduction ratio.

If n=1.0 equation **(2)** becomes Kick's theory.
If n=1.5 equation **(2)** becomes Bond's theory.
If n=2.0 equation **(2)** becomes Rittinger's theory.

Rittinger's theory

According to this theory energy E required for size reduction of unit mass is directly proportional to the new surface area produced.

$$E = K_R\ (S_n - S_i) \qquad \ldots. \quad (3)$$

Where

S_i = initial surfacearea

S_n = new specific surfacearea

K_R = Rittinger's constant.

E= amount of energy

Applications:-

Applicable to brittle materials undergoing fine milling.

This theory ignore deformation before fracture.

Bond's theory

This theory states that energy used in crack propagation is proportional to the new crack length produced.

It also states that deforming set of particles is proportional to change in dimensions.

$$E = 2K_B \left(\frac{1}{\sqrt{Dn}} - \frac{1}{\sqrt{Di}} \right) \quad \ldots \quad (4)$$

Where

K_B = Bond's work index.

Di = initial diameter

Dn = new diameter.

1. Bond's work index is the work required to reduce unit weight from a theoretical infinite size to 80% passing 100µm.
2. This theory is useful for rough mill sizing.
3. The work index is useful forcomparing efficiency of milling operations

Kick's Theory

- This theory states that the energy used in deforming a set of particles of equivalent shape is proportional to ratio of change in size.

$$E = K_k \ln \frac{d_i}{d_n} \qquad \ldots\ldots \quad (5)$$

Where

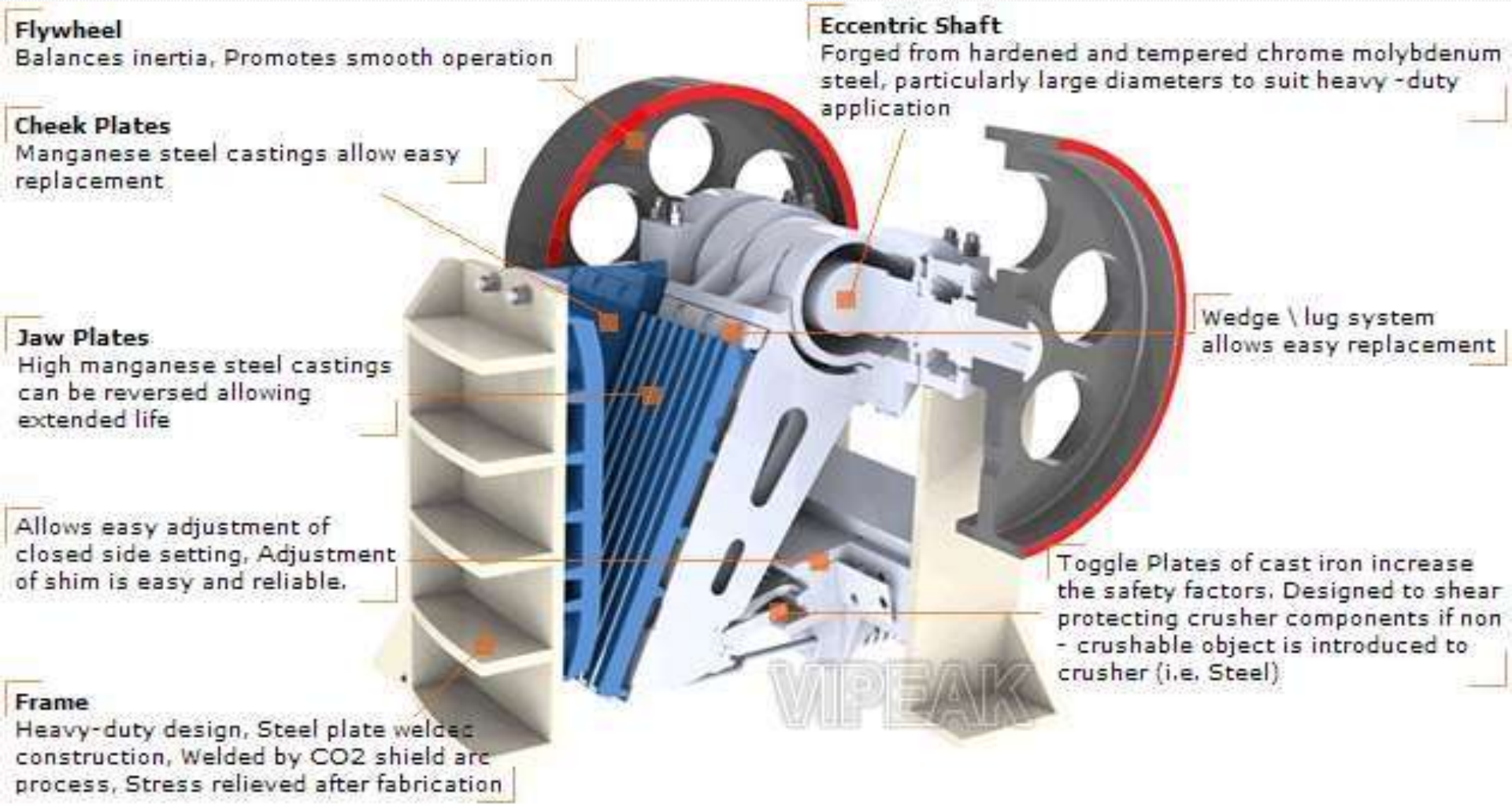
K_k = Kick's constant

D_i = diameter of particle in the initial stage

D_n = diameter of the new particles.

For compression of large particles kick's theory is useful.

Size Reduction EQUIPMENTS
jaw crusher



Roll crushers

Hammer mill

Ball Mill

Fluidized bed jet Mill