Introduction

*One of the **main responsibilities** of **mineral processing engineers** is to create/construct/ analyse **the processes** (or, at least, to **understand** the existing **processes**).*

- *<u>Some processes involved in mineral processing</u>*

  *Crushing, Grinding, Screening, Concentration, Drying, Filtering, Dewatering, mixing. Separation, **and Other process***

- ***<u>A Mineral Processing Engineer:</u>***
  - ***works with large quantities***
  - ***large equipment***
  - ***continuous mode***
  - ***feed streams and product streams are continuously fed and withdrawn from the process***
  - ***steady state operations (all parameters such as T, P, liquid livel, flow rates, compositions, etc. are all constant with time***
  - ***works closely with mechanical, electrical, civil, chemical, and metallurgical engineers in order to design and operate the physical equipment in a plant.***

<u>What are the typical activities a Mineral Processing engineer works with?</u>

1. DEVELOPMENT: to commercialize (scale up) a mineral processing (Benefication) process

Lab size process → pilot plant → plant

*2. **DESIGN: A team of engineers design the commercial plant, based on experience and data obtained from the Lab size process and the pilot plant. The Mineral Processing Engineer specifies:***

- ❑ ***Process flow rates and conditions***
- ❑ ***Equipment types and sizes***
- ❑ ***Materials of constructions***
- ❑ ***Process configuration***
- ❑ ***Control systems***
- ❑ ***Safety systems***
- ❑ ***Other***

*3.**CONSTRUCTION : Assembling of all components into a complete plant.***

*4.**PRODUCTION : running the plant or operations and maintenanace.***

Things that are important and relevant:

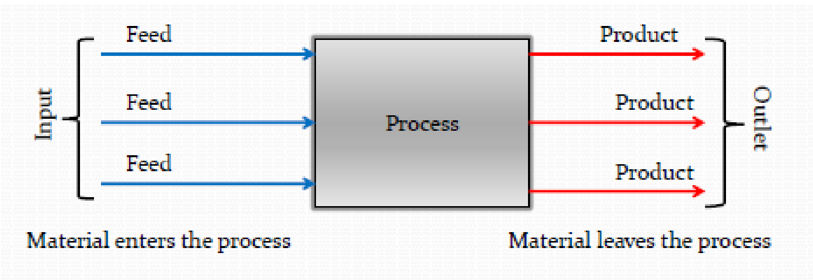
- ***efficiency***
- ***safety***
- ***design modifications***
- ***reduce costs***
- ***improve product quality***
- ***reduce pollution***

***5. TECHNICAL SALES** (marketing)*

***6. RESEARCH** and DEVELOPMENT*

What is a process?

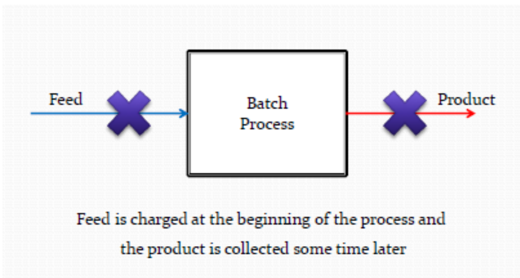
***A Process** is an operation or series of operations in which certain objectives are achieved.*



Process Classification

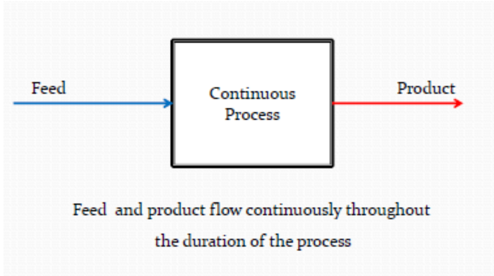
Three type of process. Based on how the process was built to operat.

1. ***Batch process***
2. *Feed is charge to the process and product is removed when the process is completed*
3. *No mass is fed or removed from the process during the operation*
4. *Used for small scale production*
5. *Operate in unsteady state*
6. *The process is fed and products result only at specific time.*



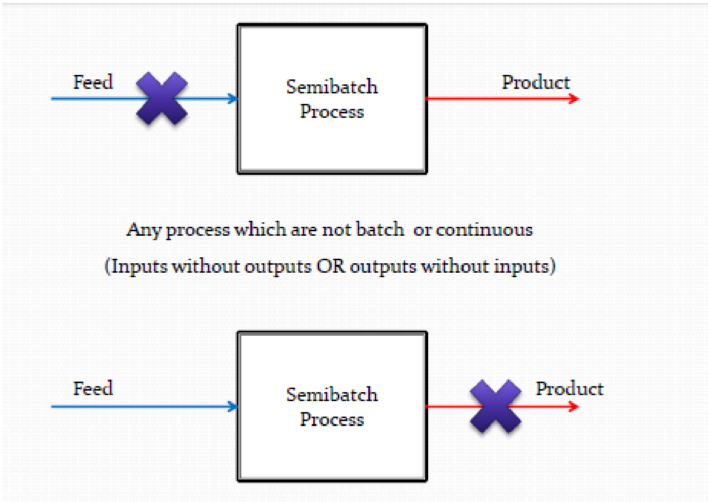
7. ***Continuous process***

- *Input and output is continuously fed and remove from the process*
- *Operate in steady state*
- *Used for large scale production*



8. ***Semibatch process***

- *Neither batch nor continuous*
- *During the process a part of reactant can be fed or a part of product can be removed.*



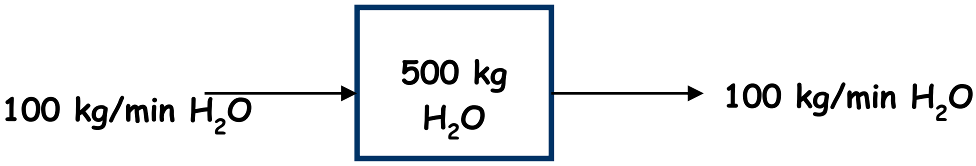
Operation of Continuous Process

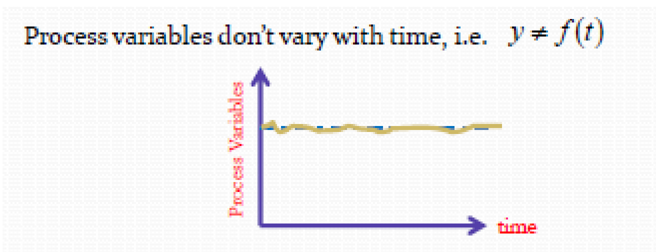
1. **Steady state**

- All the variables (i.e. temperatures, pressure, volume, flow rate, etc) do not change with time
- Minor fluctuation can be acceptable

At steady-state accumulation = 0

Rate of addition = Rate of removal



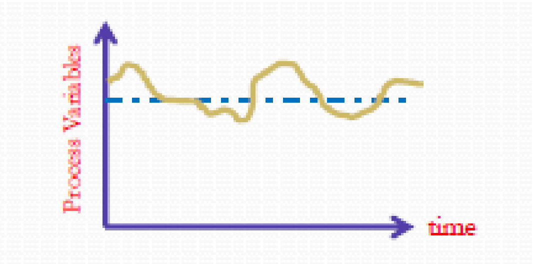


2- Unsteady state or transient

- Process variable change with time, in particular mass flow rate.
- {Input} ≠ {Output}

*At **unsteady-state**, the process variables change with time. (One class of unsteady-state processes are oscillatory, where they process variables change with time in a regular way. All other unsteady processes may be called Transient meaning that the process variables continuously evolve over time*

Unsteady-State (Transient): Process variables vary with time, i.e. *y=f(t)*



Open and Closed Systems

System

The system mean any arbitrary portion of or a whole process that consider for analysis. You can define a system such as a reactor, a section of a pipe, or an entire refinery by stating in words what the system is.

Or, you can define the limits of the system by drawing the ***system boundary***, namely a line that encloses the portion of the process that you want to analyze.

The boundary could coincide with the outside of a piece of equipment or some section inside the equipment.

- ***A System** is a portion or whole of a process (or a plant) to be analyzed*

There are two important classes of systems

Closed system.

The material neither enters nor leaves the vessel, that is, no material crosses-the system boundary. Figure below represents a closed system and shows a two-dimensional view of a three-dimensional vessel holding 1000 kg of H2O.. Changes can take place inside the system, but for a closed system, no mass exchange occurs with the surroundings.

- ***Closed system is*** *a system that does not have material crossing the system boundary.*

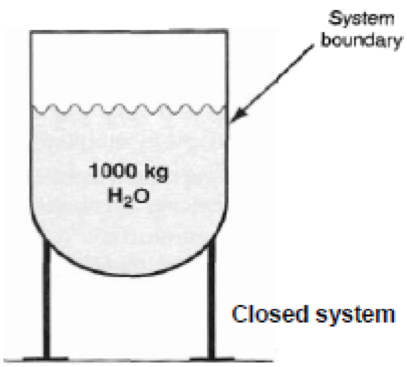


Figure   Closed system.

Open system.

An **open system** is one where material does move across the boundaries.   Suppose that you add water to the tank shown in Figure 6.1 at the
rate of 100 kg/min and withdraw water at the rate of 100 kg/min, as indicated
in Figure 6.2. Figure 6.2 is an example of an open system (also called a flow
system) because material crosses the system boundary.

- ***Open system*** *is a system in which material crosses the system boundary.*

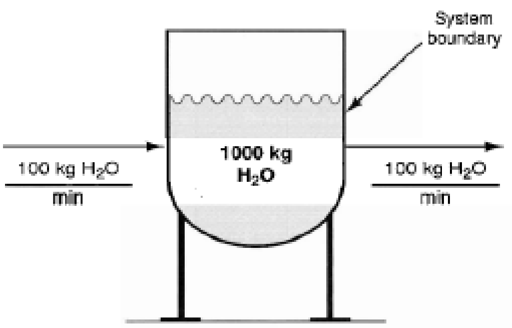


Figure   An open steady-state system.

Material Balance

Material balance are based on:

Law of Conservation of Mass

- The law states that mass can neither be created nor destroyed
- Material balance equations are the manifestation of the law

TOTAL MASS INPUT = TOTAL MASS OUTPUT

or total mass at start = total final mass

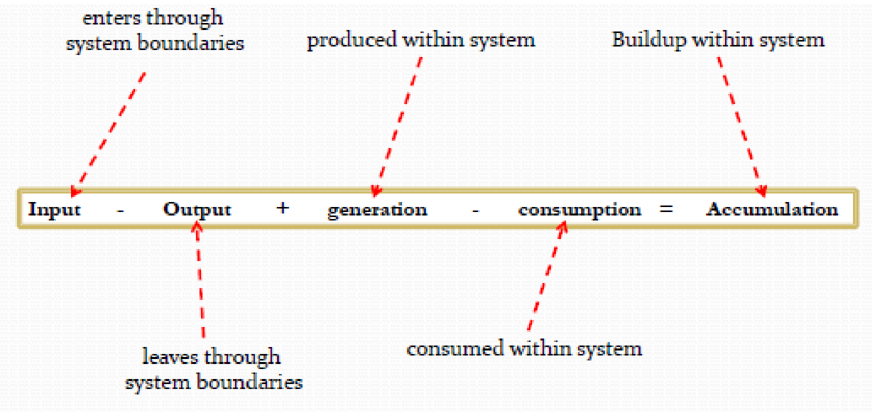
- The design of a new process or analysis of existing one is <u>not complete</u> until it is established that the inputs and outputs of the process satisfy the material balance equation.

General Material Balance Equation

- A balance on a material in a process system may be written as:

Input + generation - output - consumption = accumulation

- The equation may be written for any material that enters or leaves any process system
- It can be applied to the total mass or total moles of this material or to any atomic species involved in the process
- Notes: **generation** and **consumption** terms refer only to generation of products and consumption of reactants as a result of chemical reaction. If there is no chemical reaction then these terms are zero.



Industrial process

Every industrial process is designed to produce a desired product from a variety of starting raw materials using energy through a succession of treatment steps integrated in a rational fashion. The treatments steps are either physical or chemical in nature.

A Typical Industrial Process

The layout of a chemical process indicates areas where:

- raw materials are pre-treated
- conversion takes place
- separation of products from by-products is carried out
- refining/purification of products takes place
- entry and exit points of services such as cooling water and steam

Units that make up industrial process

An industrial or chemical process consists of a combination of chemical reactions such as synthesis, calcination, ion exchange, electrolysis, oxidation, hydration and operations based on physical phenomena such as evaporation, crystallization, distillation and extraction
An industrial or chemical process process is therefore any single processing unit or a combination of processing units used for the conversion of raw materials through any combination of chemical and physical treatment changes into finished products.

Unit processes

Unit processes are the chemical transformations or conversions that are performed in a process.
In Table 1.1, examples of some unit processes are given.

Table 1.1 Examples of unit processes

Oxidation	Calcinations	Ion Exchange	Hydrolysis
Condensation	Hydrogenation	Decomposition	Neutralization

Unit Operations

There are many types of chemical processes that make up the global chemical industry. However, each may be broken down into a series of steps called **unit operations.** These are the physical treatment steps, which are required to:

- put the raw materials in a form in which they can be reacted chemically
- put the product in a form which is suitable for the market

In Table1.2, some common unit operations are given.

Table 1.2 Examples of unit operations

Agitation	Dispersion	Pumping	Classification
Settling	Distillation	Filtration	Flotation
Size reduction	Evaporation	Mixing	Crushing

It is the arrangement or sequencing of various unit operations coupled with unit processes and together with material inputs, which give each process its individual character. The individual operations have common techniques and are based on the same scientific principles. For example, in many processes, solids and fluids must be moved; heat or other forms of energy may be transferred from one substance to another; drying, size reduction, distillation and evaporation are performed.

By studying systematically these **unit operations**, which cut across industry and process lines, the treatment of all processes is unified and simplified.

Flow Diagrams

Some industrial or chemical processes are quite simple; others such as oil refineries and petrochemical plants can be very complex. The process description of some processes could take a lot of text and time to read and still not yield 100% comprehension. Errors resulting from misunderstanding processes can be extremely costly.

To simplify process description, flow diagrams also known as flow sheets are used**. A flow diagram is a road map of the process, which gives a great deal of information in a small space.** Chemical engineers use it to show the sequence of equipment and unit operations in the overall process to simplify the visualization of the manufacturing procedures and to indicate the quantities of material and energy transferred.

A flow diagram is not a scale drawing but it:

- pictorially identifies the chemical process steps in their proper/logical sequence
- includes sufficient details in order that a proper mechanical interpretation may be made

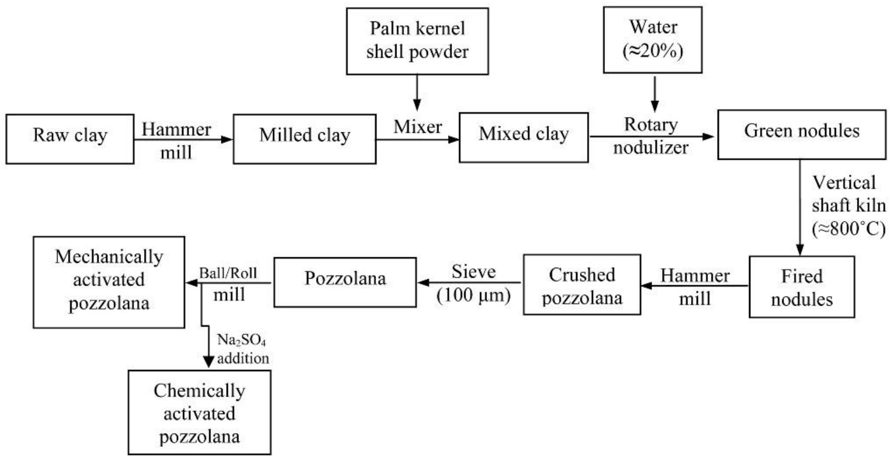
Two types of flow diagrams are in common use, namely, the block diagrams and the process flow diagrams.

Block Diagrams

This is a schematic diagram, which shows:

- what is to be done rather than how it is to be done. Details of unit operations/processes are not given
- flow by means of lines and arrows
- unit operations and processes by figures such as rectangles and circles
- raw materials, intermediate and final products

Fig. 1.1 is an example of a block diagram.



Process flow diagram / flow sheet

Industrial or chemical plants are built from process flow drawings or flow sheets drawn by chemical engineers to communicate concepts and designs. Communication is impaired if the reader is not given clear and unmistakable picture of the design. Time is also wasted as reader questions or puzzles out the flow diagram. The reader may make serious mistakes based on erroneous interpretation of the flow diagram.

Communication is improved if accepted symbols are used. The advantages of correct use of symbols include:

- the function being performed is emphasized by eliminating distractions caused by detail
- possibility of error that is likely to occur when detail is repeated many times is virtually done away with
- equipment symbols should neither dominate the drawing nor be too small for clear understanding.

Flow sheet symbols are pictorial quick-to-draw, easy-to-understand symbols that transcend language barriers.

Some have already been accepted as national standards while others are symbols commonly used in chemical process industries, which have been proven to be effective. Engineers are constantly devising their own symbols where standards do not exist. Therefore, symbols and presentation may vary from one designer or company to another.

Figure below is a cement process flow diagram illustrating the use of equipment symbols