**Basic Principles and Calculations in Chemical Engineering**

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**Lecture – 2**
**Basic Features of Chemical Process**

Welcome to massive open online course on basic principles and calculations in chemical engineering. So in this lecture we will discuss something about basic features of chemical process. We have discussed in our earlier lecture that, what is the history and also definition of the chemical engineering?

And also some contribution of chemical engineers in different disciplines and their role in our society as a chemical engineer? So, that chemical engineering process of course we should know, what are the different type of forces are there in industry, and also in different aspects of producer essential chemicals. So in that case, we will discuss here.

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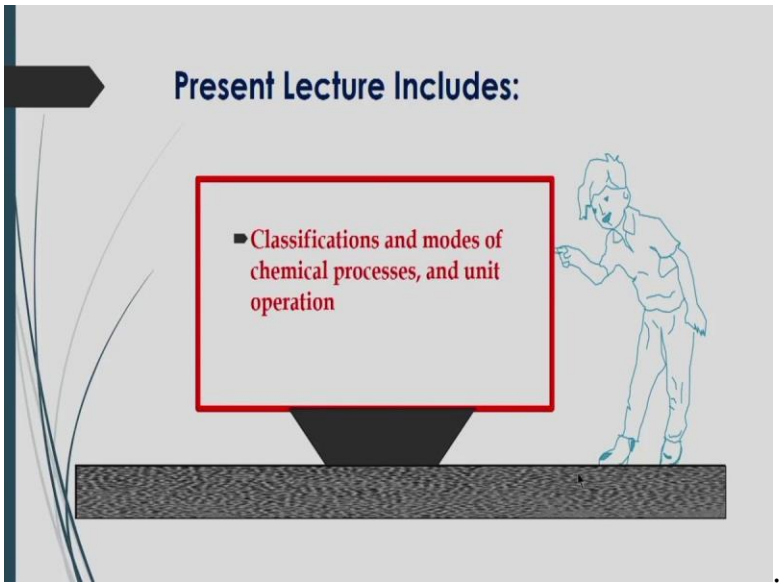


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How we can classify that chemical processes? And also what are the different modes? And different features of that are chemical processes? What is the definition of processes?

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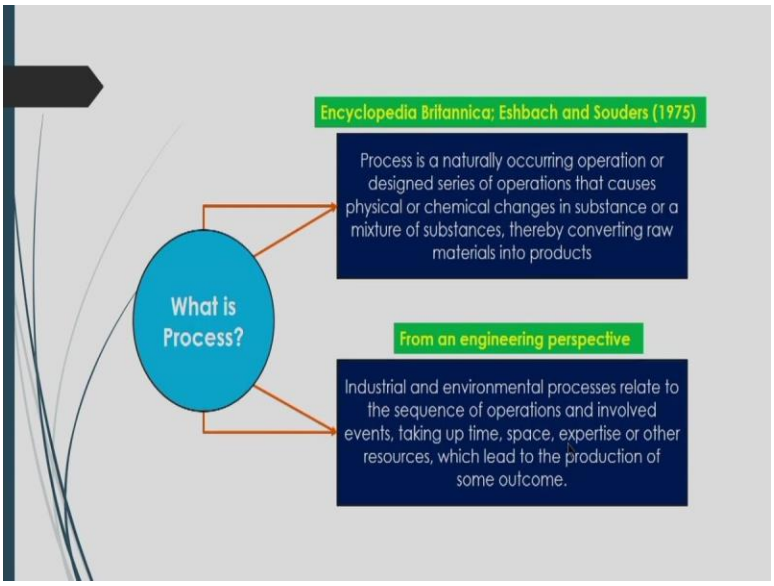


First you have to know different definitions of the processes are there. As per Encyclopedia Britannica, that process is defined as naturally occurring operation, or designed series of operations that causes a physical, or chemical changes in substances for a mixture of substances. There by converting raw materials into products and also this process.

What is different to by other aspects of from engineering perspective like? That is defined as Industrial and environmental processes. That is related to the sequences of operations, and involved events taking up time space expertise or others resources. Which lead to the production of some outcome, which are requiring in our social life? So, this is the definition of this process.

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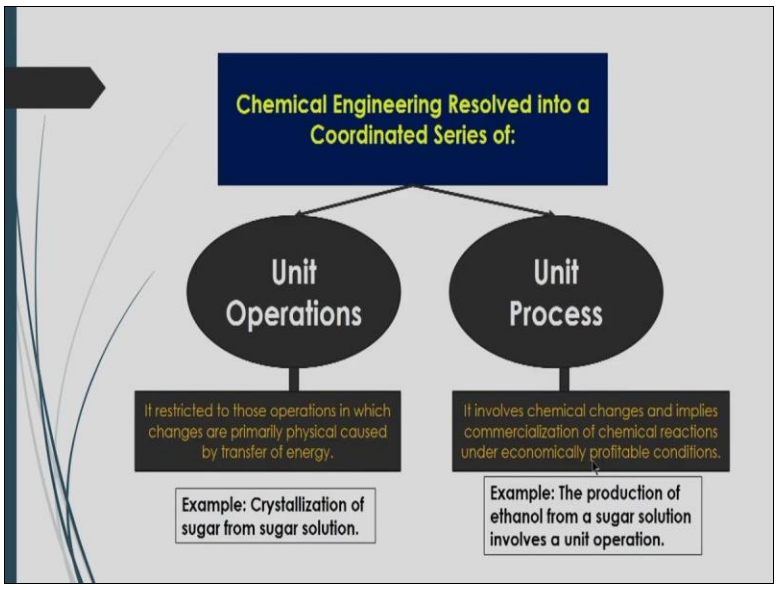

Now if we talking about that chemical engineering process, this chemical engineering, resolve into a coordinated series, of like sometimes it can be divided into two parts like unit operations and unit process. What is that unit operations? It is actually restricted to those operations in, which changes are primarily physical, that caused by the transfer of energy.

As an example you can say that here crystallization of sugar from sugar solution; in that case this operation actually only regarding; as the changes of physical phenomena, where caused by the energy supplied for this operation. Whereas unit process, it involves the chemical changes and implies the commercialization, of chemical reactions under certain conditions.

And also it will be under, that economically profitable conditions like, this is basically that involvement of the chemical changes. As an example you can say that, the production of ethanol from a sugar solution; which involves a unit operation there. So, this is that division of this chemical engineering process into two parts like unit operations, and unit process.

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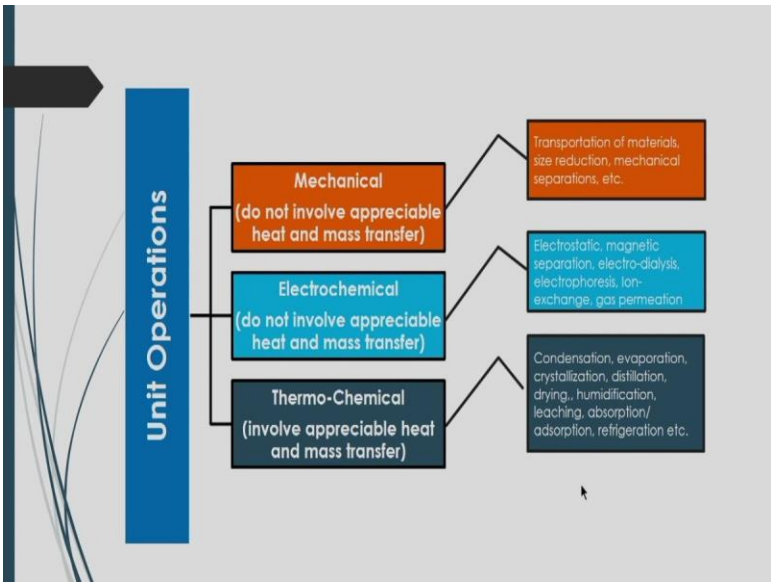


Now, if we look into the matter of unit operations this unit operations, can be divided into different kinds, like this may be mechanical, this may be electro chemical, and this may be thermo chemical mechanical. That case it will not require any appreciable amount of heat and mass transfer. In that case like transportation of the materials from one position to another position or another one location to another location. This is also one kind of the process where,

you can say there will be no chemical reactions only mechanical parts of device to be used to transfer this materials from one location to the another location.

Another operation like, reactions and there were no other compound forms those operations, like size reduction bigger particles to be converted to the smaller particles. This is generally of an important process in mineral Industries, where you will see that to beneficiation of the mineral particle sometimes size matters. So, in that case some small are some particles to be converted into smaller particles.

So, that there will be beneficiation will be easier even sometimes that, in chemical processes where catalyst particles are being used. In that case final Catalyst particles give you the more interfacial area or surface area for its activity, even sometimes exestuation of gases particles in solid particles. There the cursor solid particles to be converted or reduced to smaller size of that particles.

So, in that case this size reduction is one of the important processes for the Chemical Engineering operations. So, these are the important this mechanical separation. Also you have to sometimes as an engineer; it is required to separate those finer particles from the cursor particles. That is called segregation operation.

So, there it is sometimes to separate that separate of the particles. Even sometimes the from the slurry system you have to separate the solid particles from the slurry to clean the water. So, this is one type of mechanical separation, like membrane separation, when filter and patient separation. So, these are the basic operations of that, chemical engineering processes.

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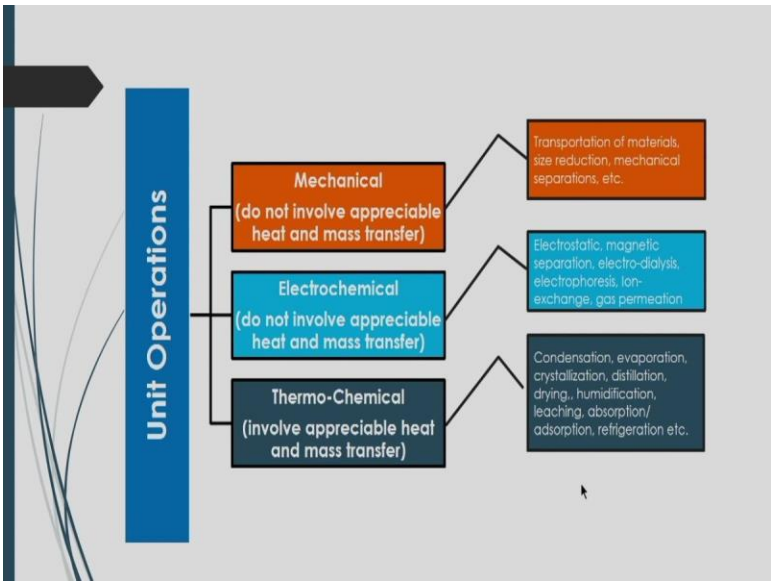


So, this is called mechanical operations, whereas another type of operation is called electrochemical operations. In this case also do not involve appreciable heat and mass transfer like electro static, magnetic separation, even electro dialysis, electrophoresis, Ion exchange, gas permeation. So these are the operations are called this electrochemical operation.

And third one is called Thermo chemical operation. In this case you will see some amount of heat and mass is required in that case involved, that appreciable heat and mass transfer there. So like condensation process evaporation process, here crystallization process, even distillation process, even drying, humidification, leaching, even absorption, refrigeration etc. All those operations are regarded as this thermo chemical operation.

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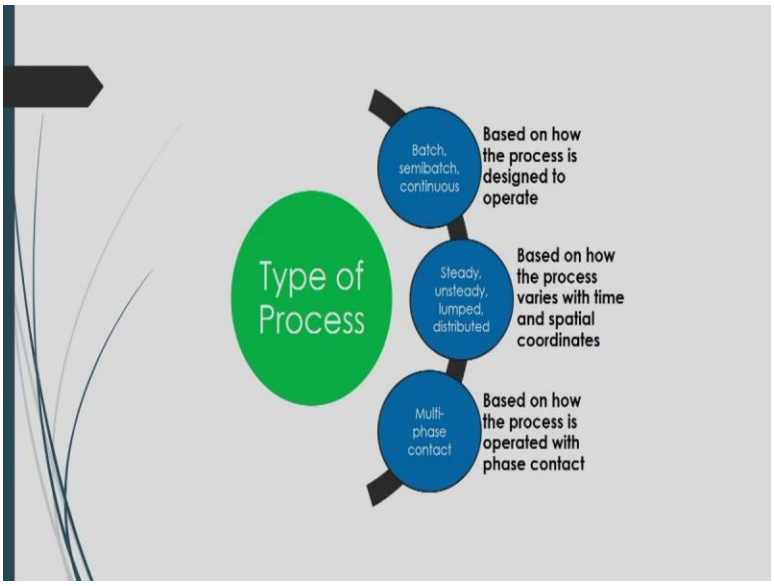


Now, if we talking to that type of processes. We can have different type of processes like, as per mode of that operation. We can divide into different types like this sometimes it can be regarded as based on how the processes is designed to operate, even sometime it is classified as based on how the process of varies with time and also special coordinates. And also it can be classified based on how the processes are operated with phased contact.

So, as per based on, how the process is designed to operate? It can be called as batch process, semi batch process even continuous process. Now based on how the process varies with time and special coordinates. It can be classified as steady; unsteady when alarmed even distributed the processes. Now if we have another type of process, like where the phases will be come in contact with each other. So, there also you will see that there will be some transfer of mass from one phase to the phase.

So that type of process is called multiphase contact process. Like gas liquid operation, gas-liquid reaction, even solid gas operations. In chemical engineering process of digestion operation is one of the important processes, where you will see that, multi faces are come in contact with each other. So that, there will be a mass transfer from each phase to another phase and also heat transfer operations also take place between the phases, where heat is transferred from to the another phase through the inter phase.

So, we can say that, this is one type of process which can be classified based on the contact of the phases. So, it is called as multiphase contact process.

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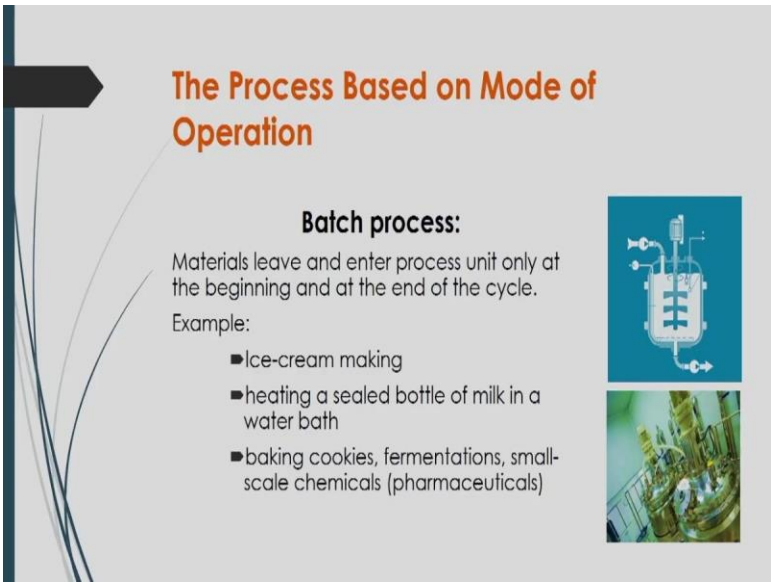


Now, what is that the processes that based on mode of operation like batch processes? What is that batch processes here. In that case materials leave an enter the process unit only at the beginning and at the end of the cycle. Here as shown in the figure in the slide. That at a certain amount of batch this operation is taking place like ice making, even heating is sealed bottle of milk in a water bath, even fermentation process, even a small scale chemicals production like; pharmaceuticals.

So, those process are batch process, where in a certain amount of chemicals are to be processed in a particular unit under certain condition. In that case there will be no continuously supplied amount to processes, those operations in the batch system. So batch process is generally we can say that, the substances to be entered into the process unit only at the beginning and at the end of the cycle of operations.

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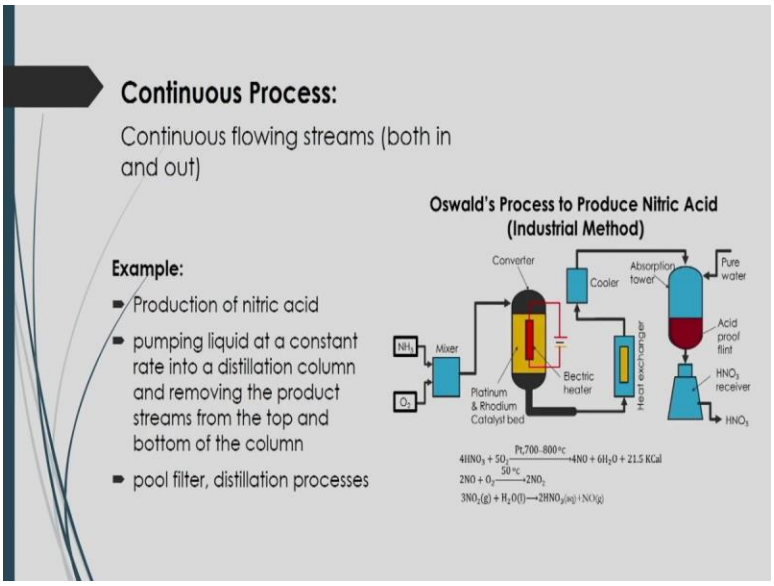


Whereas continuous process. It involves to the continuous flowing of streams, both inlet and outlet the position and like; you can say that, production of nitric acid, pumping liquid at a constant rate into distillation column and removing the product distance from the top and bottom of the column. Even sometimes you will see that pull filtration process in distillation process those are continuous process.

In that case continuously this inlet and outlet will be there and in certain process unit. The streams in the inlet and at the outlet will be flowing at a certain rate like here examples is given, like nitric acid production by Oswald's process, where Ammonia and oxygen are being sent at a particular rate through the mixture to the reactors, where at certain temperature like 700 to 800 degree centigrade and around the tiny bar.

So, continuous here Ammonia and oxygen is supplied where as the outlet, you can say that nitric acid will be produced at a certain rate. So, this is called continuous operation, where you can say in both the inlet and outlet streams, these chemicals will be flowing at a certain rate.

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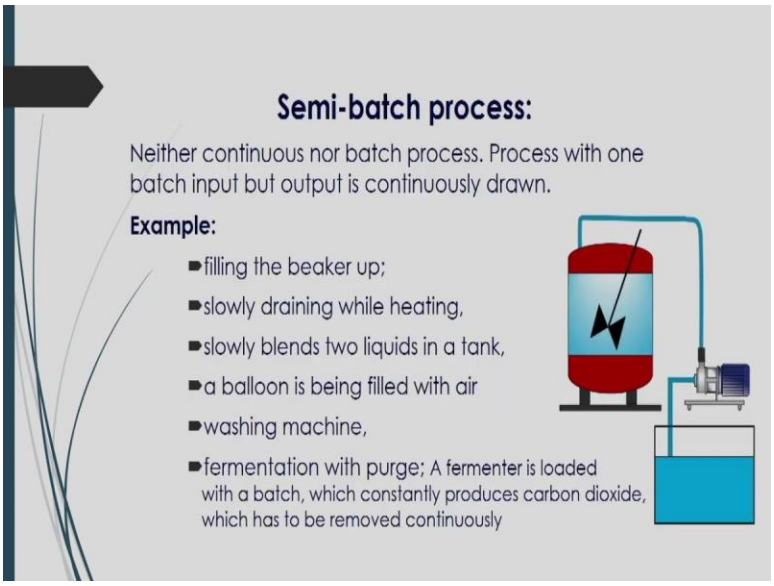


Now, what is that semi batch processes. This is also important one, that some processes are being taken place, it may be neither is continuous batch process, where you will see that process with one batch input but output is continuously drawn there. Some amount will be continuously taken out from the output or outlet in a reactor. And this process is regarded as semi batch process in this case, you will see that like one example; feeling the beaker of you will see that are continuously beaker is filled with water, at a certain rate.

Whereas from the outlet in. There is no liquid is taken out and also slowly draining, while heating also suppose in a greaser, whatever your using for your bath. You will see that in a certain batch of liquid, there in the greaser it will be heated. Then for use that hot water will be used with certain rates from there. So this semi batch process.

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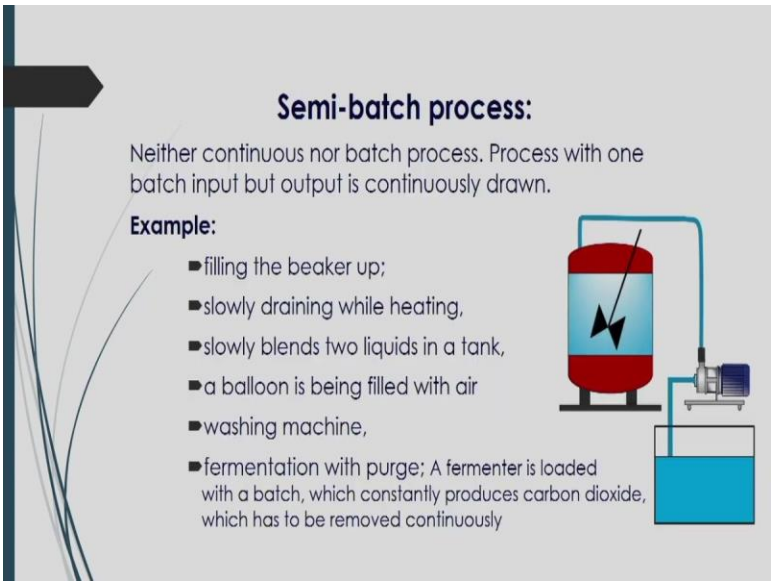


Even you will see slowly blends to liquids in a tank also you will see that, two liquids will be supplied in a tank in a batch wise and you will there be blend or mixing of this two liquids and then mixture of this liquid should be taken out continuously from the tank. Also one example you can see that a balloon, whenever it will be filled with air. It will be semi voice process. In this case in late will be there at a certain rate.

Whereas there will be no outlet of that. So gas is filled at a certain rate whenever a balloon is filled with air, where will not come out from balloon. So, that why it is regarded as the semi-batch process. Like also washing machine, you will see that there, this is a semi batch process. Even Fermentations process a loaded with batch**.** Which constantly produces carbon dioxide? Which has to be removed continuously?

So, these are the examples of semi batch process. Now the processes are which actually classified batch is on.

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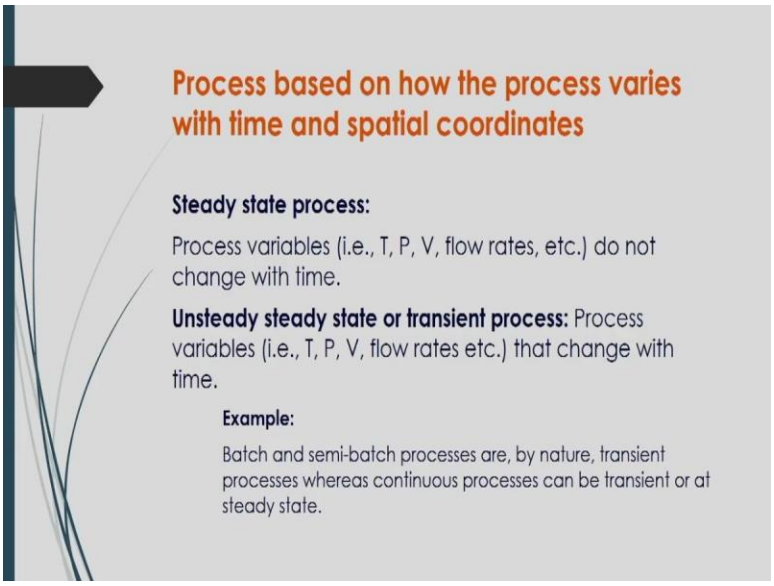


The variation of the processing with time and the same your concentration with respect to special coordinates there. So, process viable, whenever it will be changed with time and with special coordinates. So, based on which we can classify the processes into the steady state process, even transient process also. So, steady state process means here process variables like temperature, pressure, even volume, even fluoride etc.

That does not change with time. So, it is referred to as steady state process. Whereas unsteady steady state or transient process, that gate process variables (like temperature, pressure, and volume or flow etc.) That change with the time. Example batch and semi batch processes are by natural transient process, whereas continuous process can be transient or at steady state process there.

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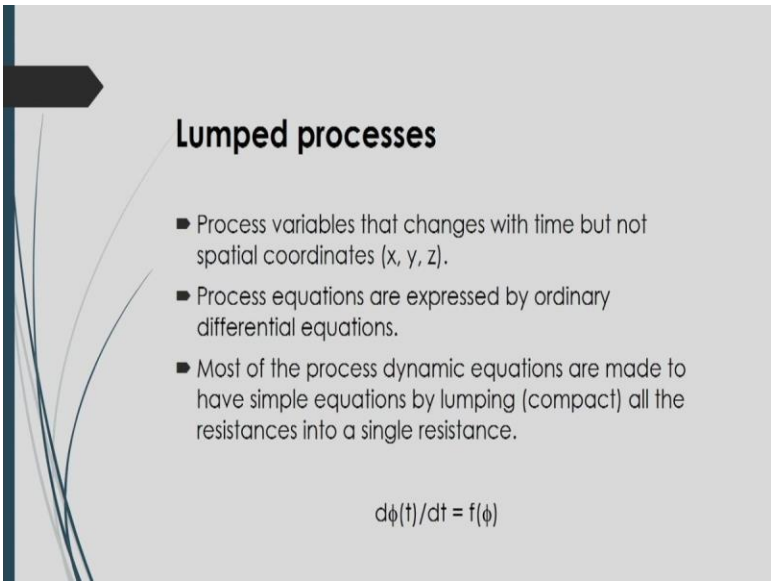


Another important classification of this process is called lamed process, where the process variables changes with time but not special coordinates (like xyz or special coordinates.) In that case process equations are expressed by ordinary differential equations. And most of the process dynamic equations are made to have simple equations by lumping compact. All the instances into a single resistance like here.

If we consider that some process variables pi, it changing with respect to time and then, we can say that this change of this a process

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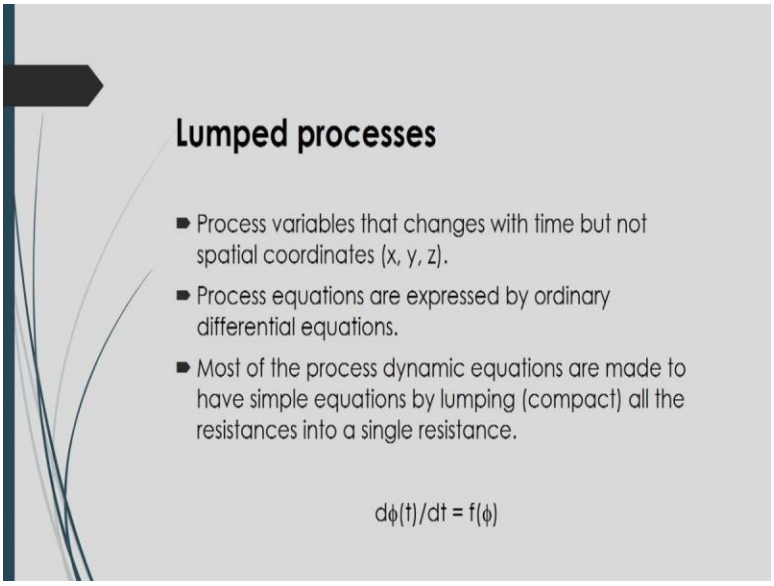


Variables will be a function of those variables, like this year. So here, if suppose this

consignation change with time that will be a function of some concentration. So in this case, we can say that these process dynamic equations are made to have simple equations by lumping or compact, all the resistances into a single resistance there. Examples-

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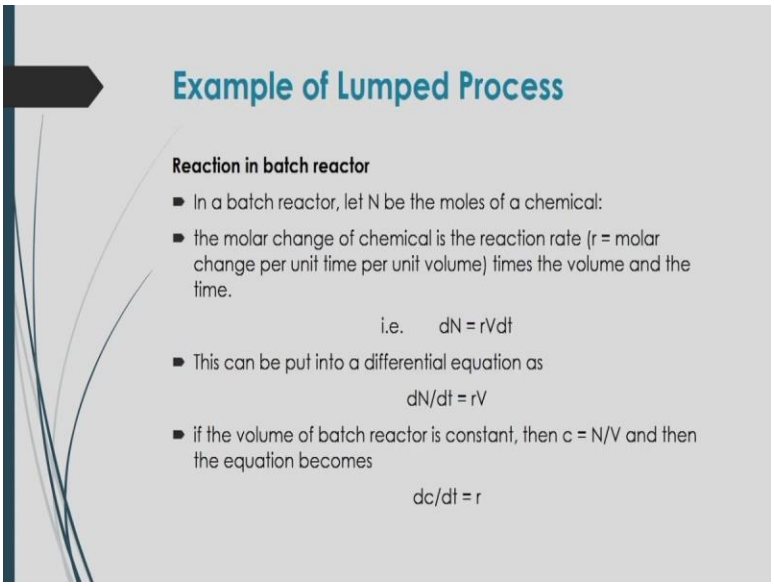


We can say that the reaction in batch reaction here in batch reactor. Here like batch reactor supposes there will be an N mole of the Chemicals are taking part in a reaction. So, that case molar change of chemical is the reaction rate, which is represented by r, this is called molar change per unit time Park unit volume and this molar change of chemical.

That is called that reaction rate the time in the volume and the time will be regarded as this and DN that will is equal to r into V into DT. So, these molar changes of chemical reaction rate, which can be regarded as like this. And this can be put into differential equation as like this DN/DT that is visible to hear RV. So, we can say that if the volume batch reactor is constant. Then we can represent it as c will be equal to N/V and then the equation will become like dc /DT that will equal to r.

So, here in this slide, its shown that in a batch reactor there is a reaction is going on, and if you are considering that N the number of moles of a chemical. And the molar change of that chemical by that reaction will be regarded as DN that will r into V into dt ,where r is called molar change for unit volume per unit time. And this can be put into differential equation like

this. Here dn/dt equal to RV and if the volume of this batch reactor if you keep constant. Then we can define this concentration of this reactant as N/v and then the equation can be represented as dc / DT will be equal to r. So, this is one example of lump process.

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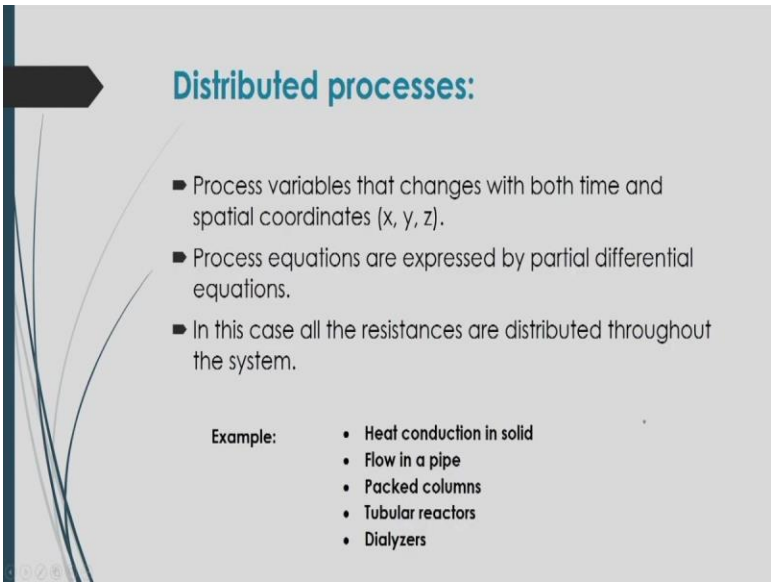


Another process it is called distributed processes, where process variables changes with the both time and special coordinates. So, here you will that the variables will be changing with respect to time as well that is position there. There processes equations are generally expressed by partial differentiate equations. Because here the variables which changing of two variables like here time as well as coordinates there.

So in this case all the resistances are distributed throughout the system there, like heat conditions in solid flow in pipe, like flowing palate column tubular reactor, even dialyzer also. So all those processes are regarded as distributed process, where in that case will be see heat condensation in solid. That is heat temperature will be changing with respect to time as well as the solids or that special coordinates s, y, z position of the solid.

Even flow in pipes that you can say that its velocity of the fluid. It may change with respect to y-axis, z-axis even this velocity may change with respect to time also there velocity, whenever changing with respect to time. It will be called as acceleration and deceleration and also if, the velocity changing with respect to actual position. Then we will be called as that is velocity

gradient in a particular direction.

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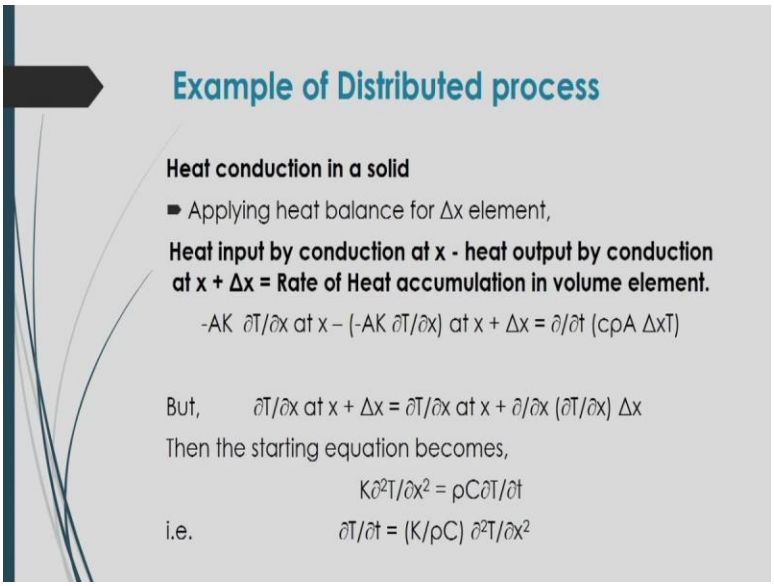


An example you can say that heat conduction in a solid. Let us have this derivation of this equation of that heat conduction in a solid. So that we can have this variation of this temperature with respect to time as well as special coordinates like x, y or z.

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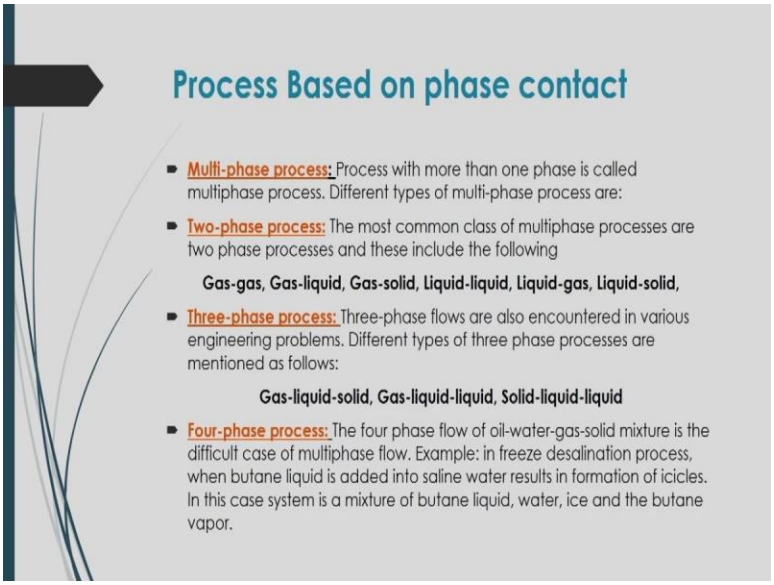


Now, what are the processes that can be obtained based on the phase contact. Basically this is a multiphase process, where more than one phase is involved for the process. That is why it is called multiphase process and different types of multiphase process are like two phase process, three phases process even four phase process also there. Now, what is that two phase process is

the most common class of multiphase processes are two phased process and this include the following, like gas, gas liquid operation like.

If, you want to absorbed the carbon dioxide gas in a liquid like Sodium Hydroxide. Then it will be called as gas liquid process, where carbon dioxide gas from the gaseous mixture to be transported to the liquid phases or transferred to the liquid phases. So, it is called mass transfer between gas and liquid or you can say that physical separation of the carbon dioxide gas to the liquid phases.

Even in chemical and physical chemical also it is there because here you will see that gas will be absorbed by chemical reaction in a liquid also. So, that will be also that gas liquid operation even gas solid sometimes absorption of gas into solid. So that it is also gas solid operation. Even you will see that gasification of the coal in that case cash and solid particles should be there. So this is called to phase process. Even liquid liquid also like extraction process.

Suppose component that is mixed in a certain liquid will be extracted from that liquid to another unmixable liquid. So this is liquid liquid operations, even liquid gas. Sometimes for absorption and desorption purpose you will see that, some liquid will be spread into a continuous gas in space. So, that you can get the more contact area between gas and liquid and they are more absorption and desorption or efficiency of the chemical process will be there.

And also liquid-solid operations also these are called two phase process.

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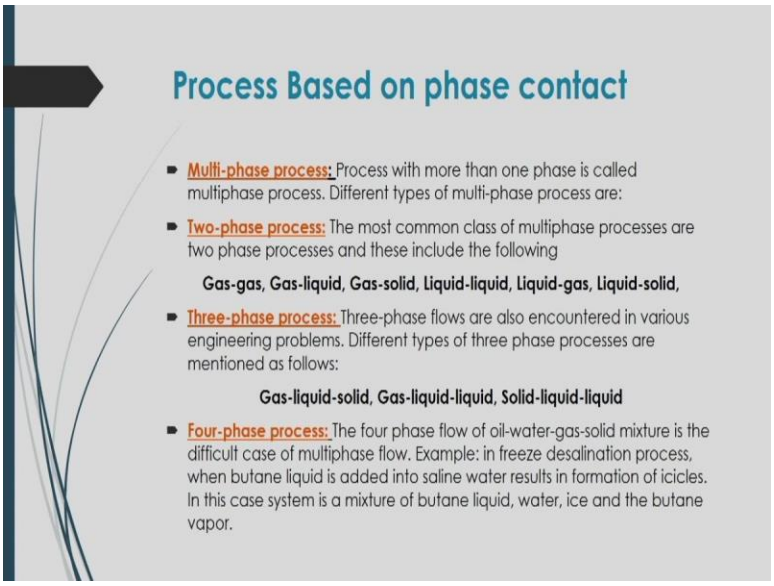


Three phase process like various engineering problems these are actually involve physically and chemically engineering processes. Where you will see that, from the synthesis gas there are different types of hydrocarbons are produced in a slurry bubble column reactor. Where gas liquid and solid phases are involved in the reactor there; like carbon monoxide and hydrogen gases will be come in contact with the catalyst particle and from that contact that Castile liquid at a certain temperature and pressure in presence of catalyst particles.

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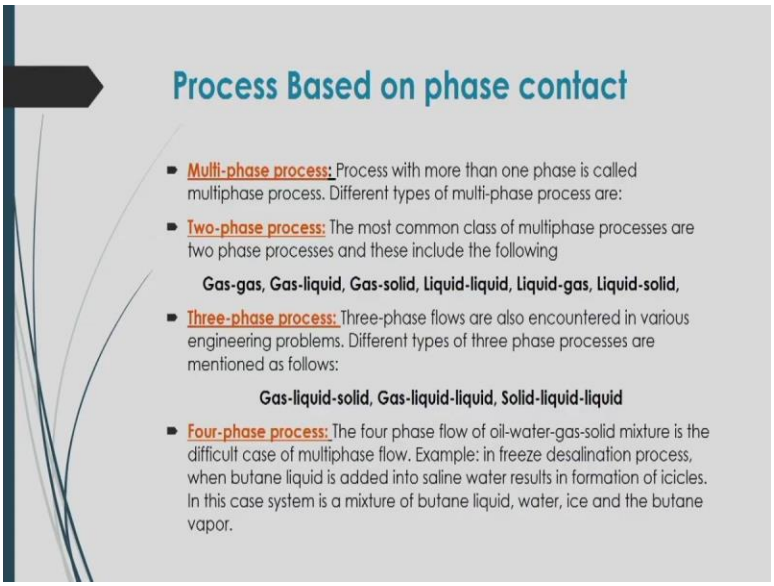


You will see that it will be converted into different types of Hydrocarbons there and this is called gas- liquid- solid. And this gas liquid solid operation sometimes it is called that is fischer-tropsch synthesis. So, that is called hydrocarbon production from the synthesis gas and also gas- liquid-

liquid operation. Sometimes we will see some chemical engineering operations, where extraction is being done by gas addition, where more turbulence will be created, even more interfacial area will be produced. And also there will be that enhancement mass transfer in the liquid to another liquid.

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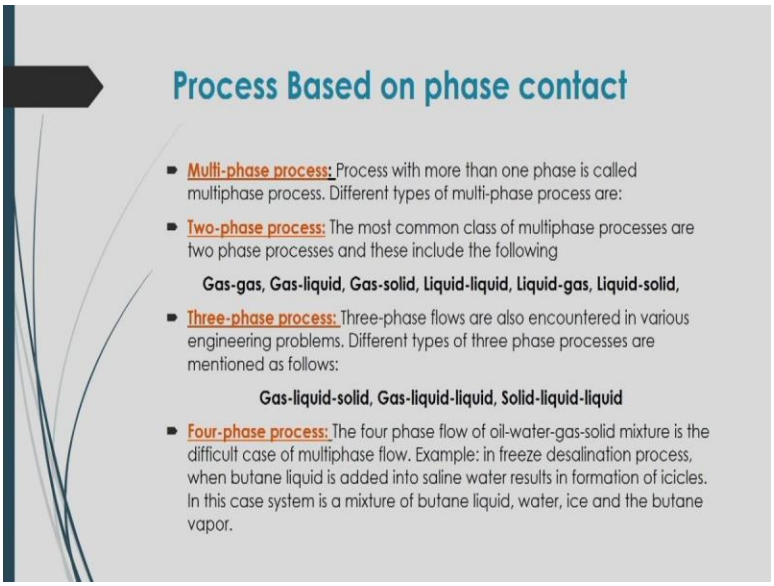


Now, also you will see that the solid- liquid- liquid operations also there; like leaching operations. That some solid particles should be used to extract that contaminated component from another liquid. So, this is also three phase operations there and as a four phase process you can say the four phase flow of oil- water- gas- solid mixture there is difficult multiphase flow .example we can say that in a freeze desalination process.

When butane liquid is added in to saline water that will results in the formation of Ice skates. In this case system is a mixture of butane liquid, water, ice and the butane vapor.

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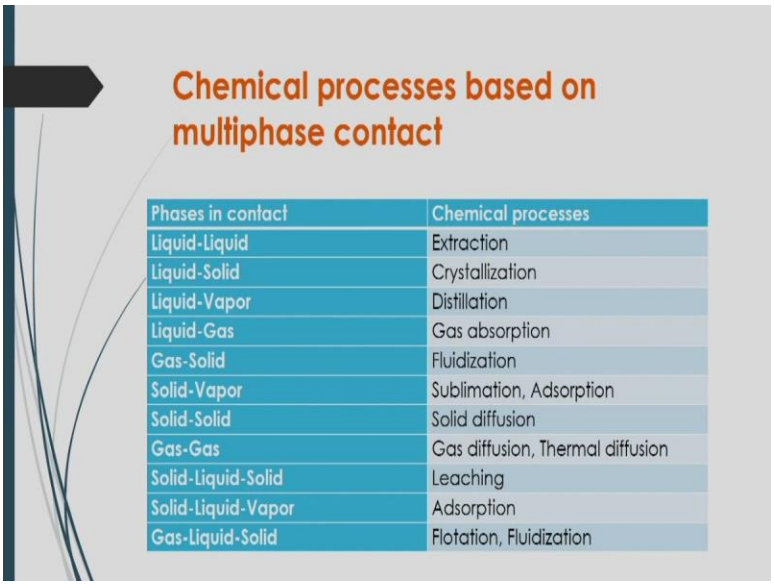


Now, we can divide or we can referred that chemical processes based on multiple contact like; that liquid- liquid here extraction process, liquid-solid like crystallization, liquid-vapor distillation process, liquid –gas that absorption, gas- solid like fluidization, solid -vapor it is called sublimation or adsorption process, even solid-solid is called solid diffusion, even gas-gas system gas diffusion thermal diffusion, solid-liquid-solid like leaching there,

Even that a solid- liquid-vapor it is called adsorption, gas-liquid-solid it is called flotation, fluidization. So, these are the various chemical processes based on the multiple contacts.

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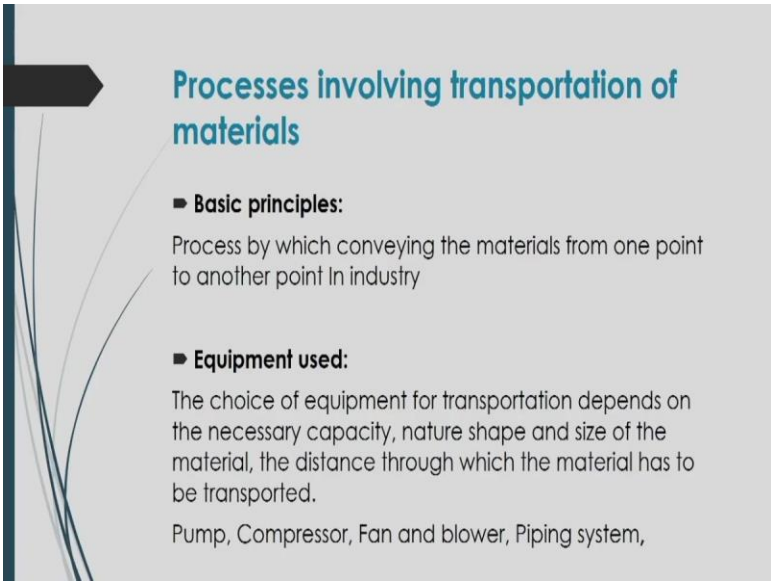


Now processes which are involving transportation of the materials. Sometimes the process can

be classified based on the transportation of the material, like some materials will be convent from one point to another point in industry in that case some equipment are being used like choice equipment for the transportation. That depends on the necessary capacity shape also the size of the material of the distance through which the material has to be transported like pump compressor human hand blower piping systems are used for transport in the material from one a point to another in industry.

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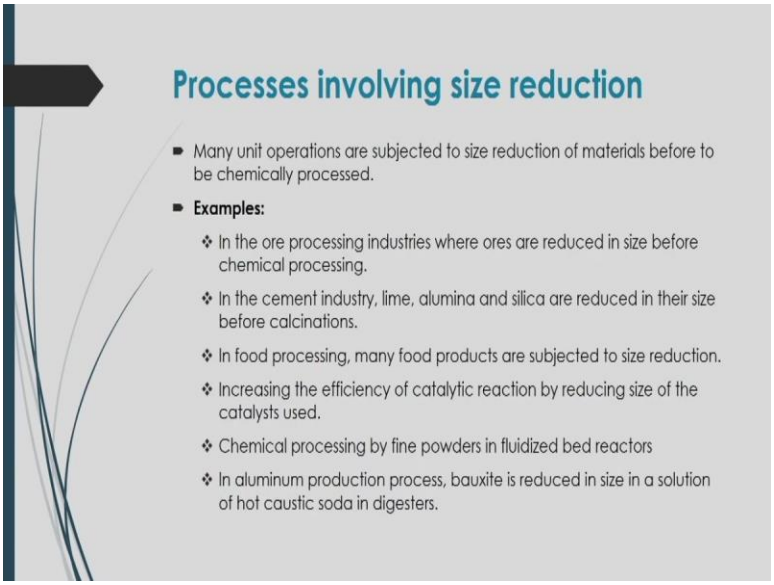


The process involving size reduction like many unit operations in you will see subjected to size reduction of materials before to be chemical processed. Example in the core processing industries, where ores reduce in size before chemical processing and in the cement industry, you will see that lime, Alumina and silica reduced in their size before calcinations. In food processing Mini food products are subjected to size reduction.

In disintegration of catalytic reduction reaction by reducing size of the catalyst used. Chemical processing by fine powder in fluidized in bed reactor. These are the process involved in size reduction even in aluminum production process you will that Bauxite is reduced in size in a solution of hot caustic soda in our digesters. So, these are the various examples of process involved with size reduction.

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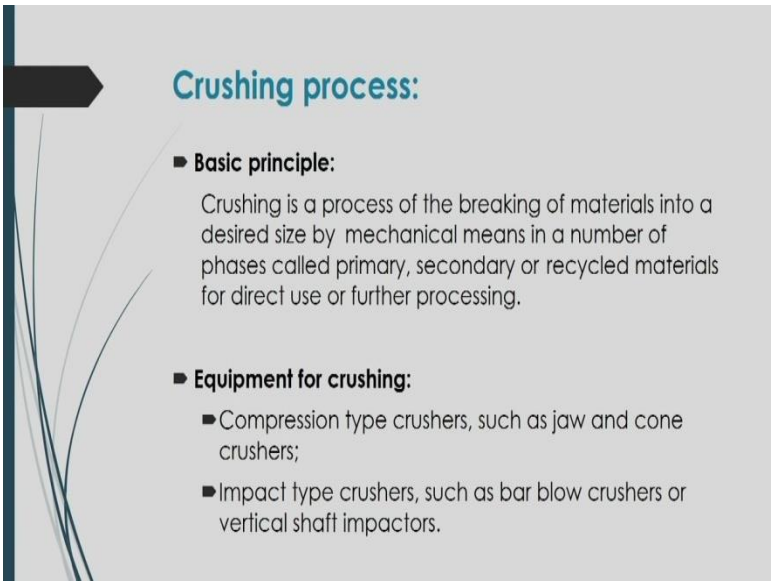


Crushing process also one important transportation process like based on size reduction there. Basic principles, in this case process of breaking up material into a desired size by mechanical means a number of phases are called primary, secondary or recycled materials for direct use further processing. This case some equipment for the crushing can be referred as crusher that called jaw crusher, cone crusher etc.

And also impact type of crusher, are also available commercially such as bar blow crusher or vertical shaft impactors, are important equipment for this crushing process.

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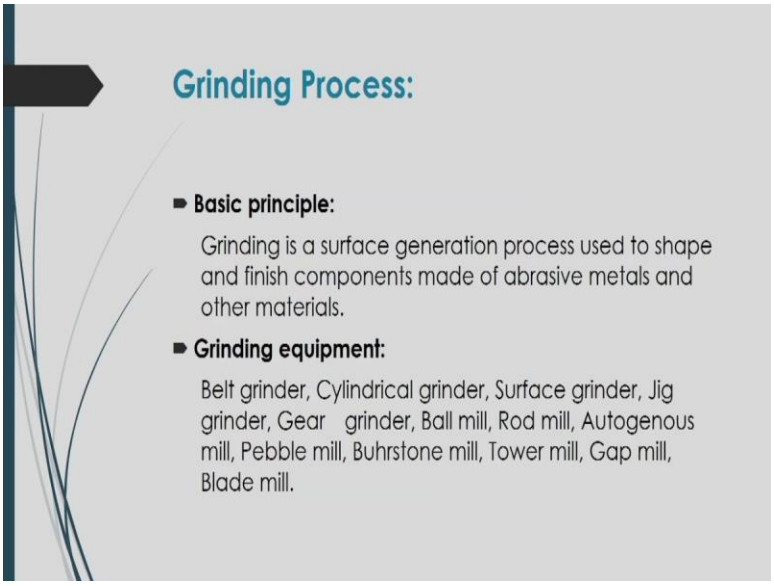


Grinding also another process for the size reduction there so, it is surface generation process,

where you see that, it is be used to shape and finish the components, which are made of abrasive metals and other materials there. Like Grinding equipment like: belt grinder, cylindrical grinder, surface grinder, Buhr stone mill, Tower mill, gap mill, even blade mill, even gear mill also see that, the ball Mill, Rod mill, these are the some basic equipment by, which you can do this grinding process.

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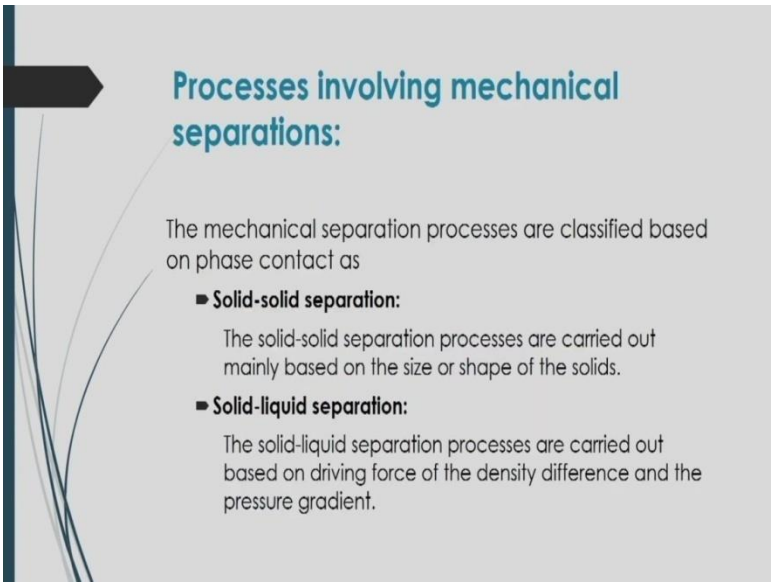


And those are every important in Mining industry basically for beneficiation and also separation of the minerals from the ores, even in fluidize operation, whenever catalyst particles are being used for the chemical reactions in fluidize there. The size of that catalyst particles matters, in that case the catalyst particles are converted into very fine catalyst particles by grinding process. Now another important process, it is called types mechanical separation.

In this case solid-solid separation process is carried out mainly based on the size or shape of the solid. And solid-liquid separation, in that case it is carried out based on the driving force of the density difference on the pressure gradient. As shown in the slide that, there are two types of the mechanical separation process based on the phase contact. And that case, like solid-solid separation the process, this based on size or shape of the solid and solid-liquid separation in that case driving force of density difference and pressure gradient are consideration for the separation process.

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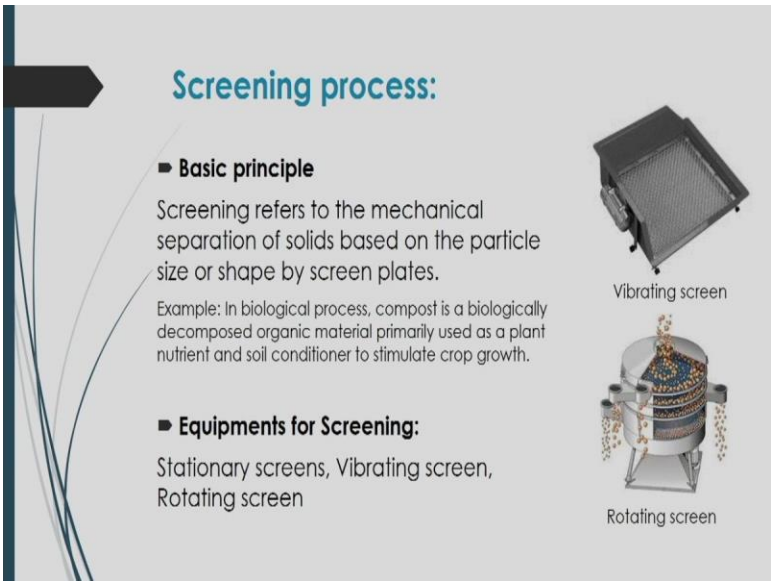


Another important screening process also one of the mechanical separation processes, in that case screening refers to the mechanical separation of solid based on particle size of a shape by screen plates. Example in biological process, you can see that compost is a biological decomposed organic material is primarily used as a plant nutrient and soil conditioner to stimulate the crop growth. In this case stationary screens, vibrating screen, rotating screens are be used for this mechanical separation.

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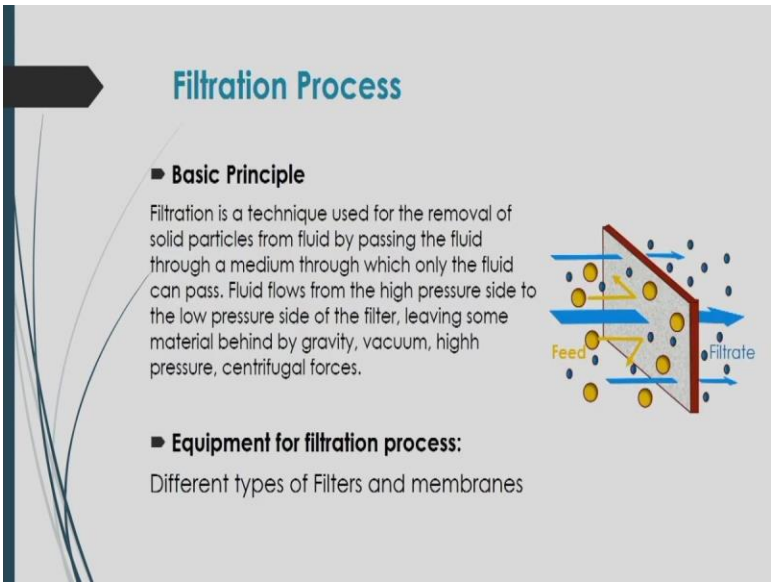


Filtration process is also one of the important mechanical separation processes, where you will see that solid -liquid involved there even gas-solid is also involved there. In this case the removal of solid particles from the fluid by passing the fluid through a certain medium which only the

fluid can pass. And in this case fluid flows from high pressure side to low pressure side on the filter. As shown slide that; here you will see that, this is one medium per's through which that feed particles transferred from one side to the side, based on the presser difference there.

So, in this case fluid is flowing from the high pressure side here this side, this is the low pressure side. So whenever this fluid is flowing from the high pressure side to the low pressure side, you will see that leaving some material behind the gravity, vacuum, high pressure, centrifugal forces. Those are being used or sometime you will see membranes are also being used to separate these unwanted material in the feed stream.

Whereas in the other side should it will be regarded as filtrate, which are purified fluid just by removing unwanted material to the other side. So this is the basic principle of filtration process. Now this case you will see different types of filters and also membranes are being used for the separations of contaminants, even some solid particles in the solution by this filtration process.

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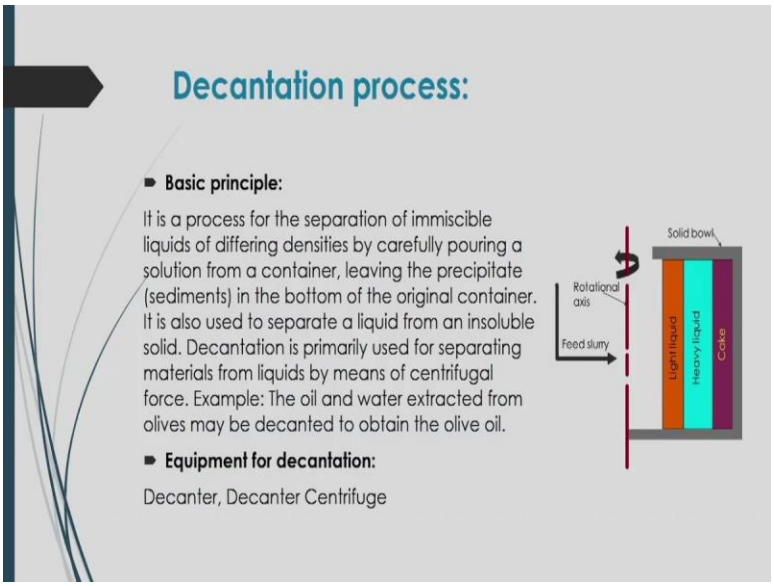


Other important process, it is called decantation process. Here in this case the separation of miscible liquids of different densities by carefully pouring a solution from a container is being done, which leaves the precipitate in the bottom of the original container. It is also used to separate a liquid from an insoluble solid. Now, decantation is one of the important equipment which is primarily used for separating materials from the liquid by means of this centrifugal

force. Example like: oil and water that is extracted from olive oil may be decanted to obtain the olive oil. In this case decanter, decanter centrifuge are common equipment for this decantation process.

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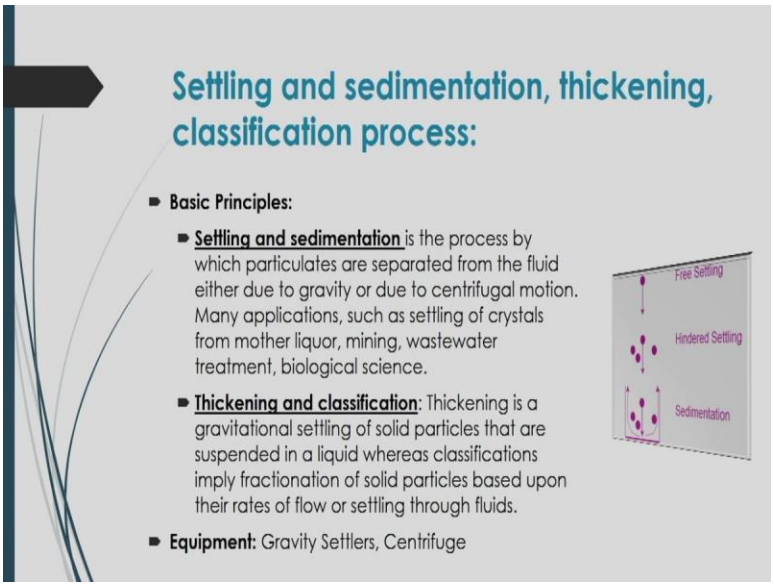


Another important process for separating the solid particles in the mixture. It is called settling and sedimentation, whereas this process involve for the separation of the particulates from the fluid due to gravity or due to centrifugal motion. Many applications like: settling of crystals from mother liquor, mining, wastewater treatment, biological science. These are some examples of this operation of setting and sedimentation.

Thickening and classification also gravitational settling of solid particles that are suspended in a liquid where as classifications simply the fractions of solid particles based upon their rates of flow or settling through fluids. In this case gravity settlers and centrifuge are being used for this settling and sedimentation even thickening and classification process.

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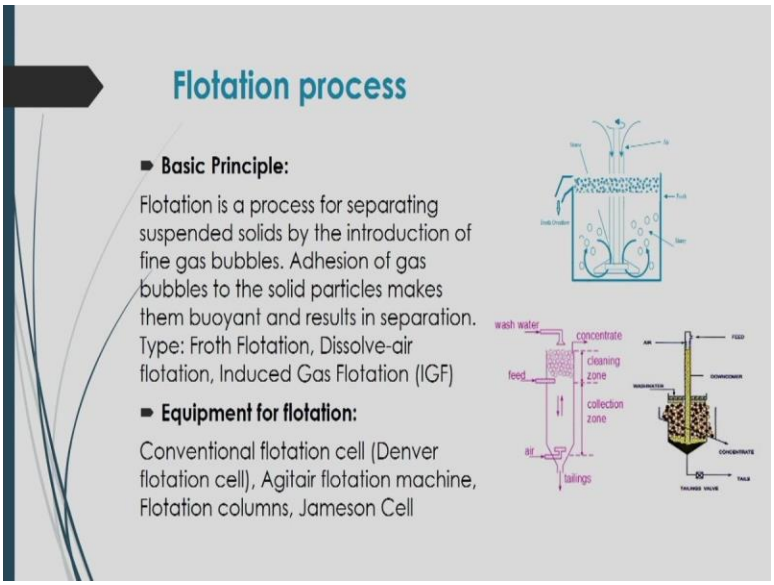


Flotation process is one of the important chemical processes process where you can separate on the fine particles from the ores. Or you can benefice in the ores to separate the valuable materials by this flotation process. Even this flotation process are being used in d-inking process there, where the paper industry there to remove the ink from that waste papers. There using the flotation process.

Even then some other chemical processes where you will see that waste water treatment there also this flotation process are being are used as a merited, where fine particular particles are being separate by this variations processes just by using different further. So, this is one of important process in chemical engineer. In this case you see that gas is actually introduced from the bottom part of flotation column.

So that, adhesion of gas bubbles to the solid particles make them buoyant and result in separation. Like froth flotation, Dissolve-air flotation, some type of flotation column or flotation machine where this flotation process is being done. Conventional flotation cell like (this called Denver cell), Agitair flotation machine, flotation column cell, jomsome cell are commercial available flotation equipment, where this flotation process are being done. Another important chemical engineering process it's called Agitation and mixing process.

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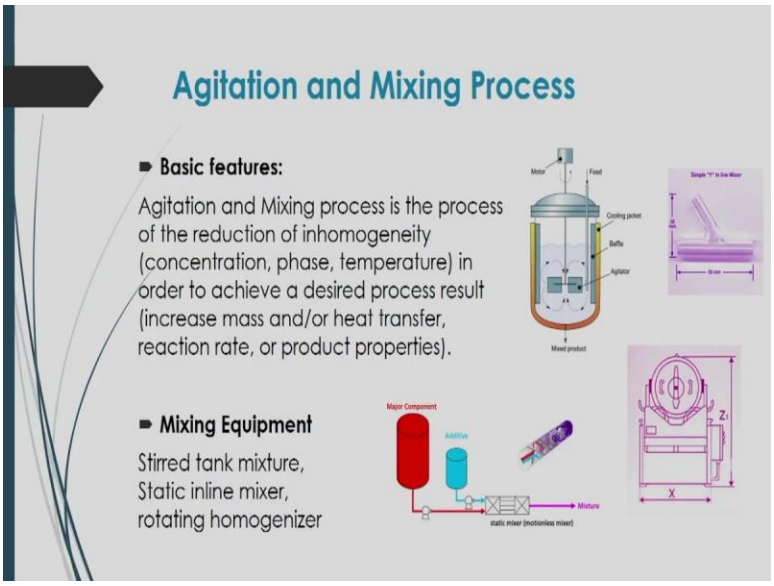


In this case the reduction of in homogeneity (of the concentration, phase, temperature) in the fluid mixture in order to achieve a desire process result like: increase in mass and /or increase the heat transfer, reaction rate, or produce properties, like this. So in this case, what is that the agitation and mixing basically done because of well mixing of the fluid elements or you can say that, even phase different phases are particular reacted there.

Just uniformly, how the martial can be mixed inside the reactor. So that is why this agitation mixing process has been done. It is require for enhancement of mass transfer and enhancement for heat transfer. Even enhancement of the reaction rate there, in the chemical engineering process like: stirred tank mixture, static inline mixer, rotating homogenizer, these are the basic equipment for these agitation mixing process.

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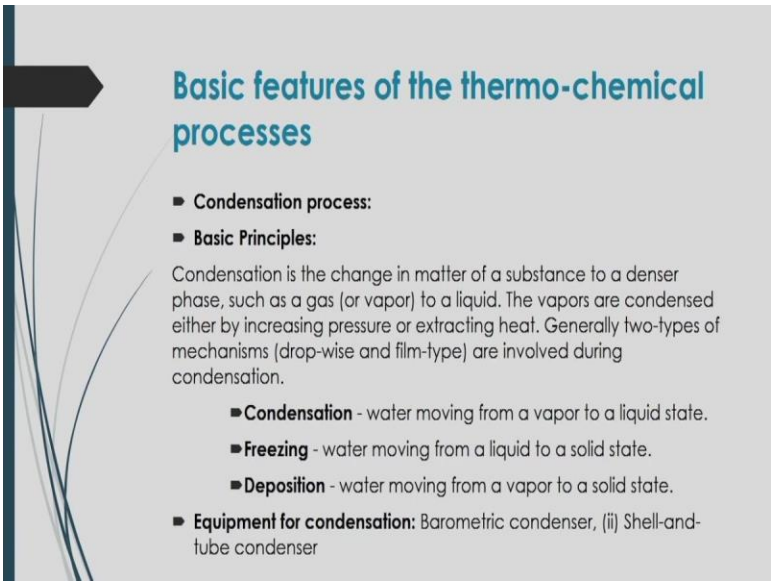


Now, what are basic features of the thermo- chemical processes? Here like condensation is the process is change in matter of a substance to a denser phase, such as a gas to a liquid. The vapors condensed by increasing in pressure or extracting heat .Generally two-types of mechanism (drop-wise or film-type). This condensation is being happened so during this condensation basically the changes in matter of a substance are happened.

In that case in case of condensation what are moving from a vapor to liquid state in freezing? What are moving from a liquid to solid state and deposition? What are moving from vapor to a solid state? So these are basic mechanism of these condensation processes or you can see that thermo-chemical processes. So equipment and condensation it is called barometric condenser, shell-and-tube condenser are commerce level able which are being used for condensation for this condensation process.

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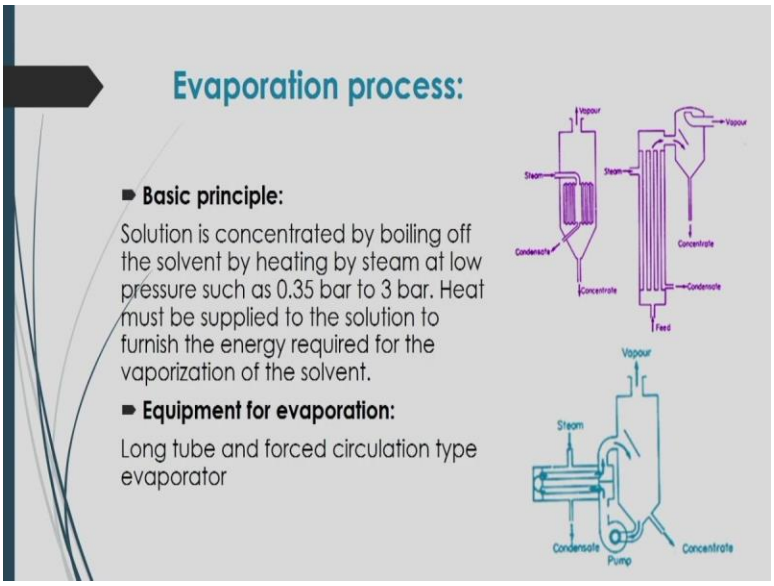


Evaporation processes this all so one type of thermo-chemical process. This case solution is concentrated by boiling off the solvent by heating by steam at low pressure such as 0.35 bars to 3 bars. In this case heat must apply to the solution to finish the energy required for the vaporization of the solvent and equipment for the evaporation are generally long tube and forced circulation type evaporator.

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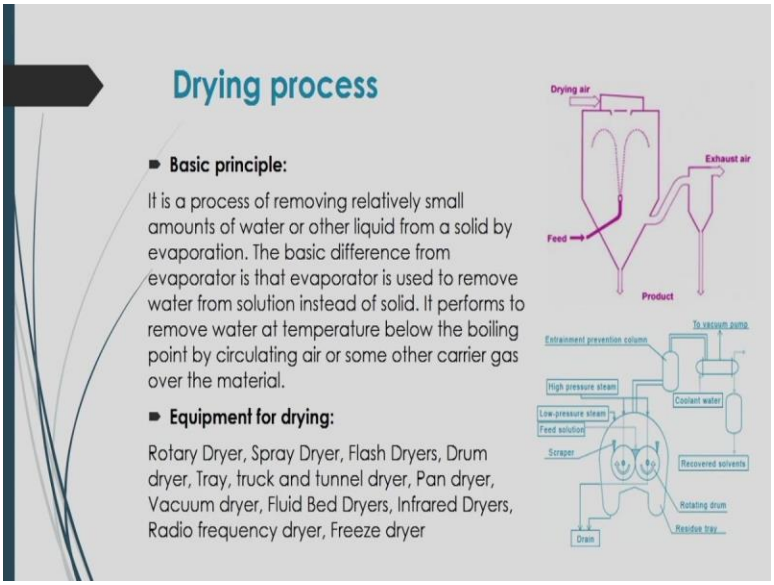


Drying process is also another important aspect of the chemical engineering process there. Before going for any reaction or any other physical separation or mechanical operation some drying is important. Even some products which are coming after reaction that it needs to dry for its coeternity state further beneficiation operation. So, in this case it is a process of removing

relatively small amount of water or other liquid from a solid by evaporation. The basic difference from evaporator is that evaporator is used remove water from solution instead of solid.

It performs to remove water at temperature below the boiling point by circulating air or some other carrier gas over the material. And equipment of the drying like: rotary dryer, spray dryer, flash dryer, drum dryer, tray, truck and tunnel dryer, even some other intensive fluid unit like: it's called freeze dryer, radio frequency dryer are being used for this draying process.

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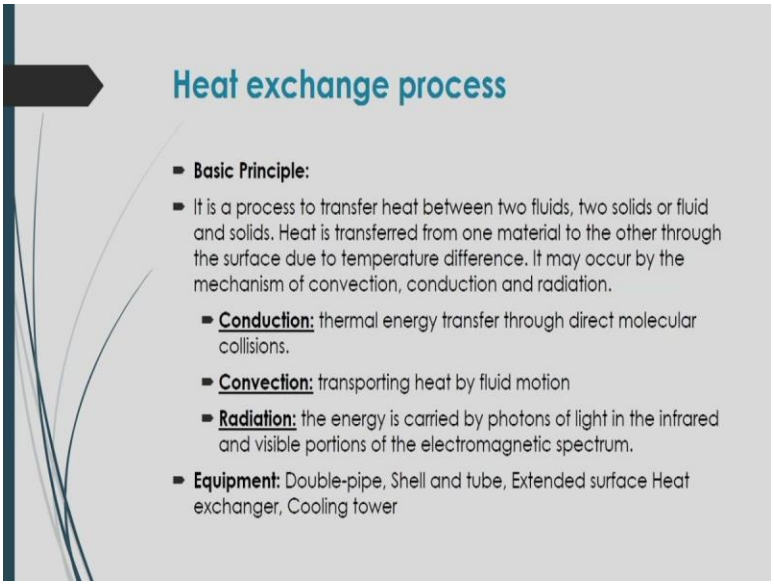


And heat is process also another chemical engineering process. That is heat transfer of operation basically regarded in this. It is process to the transfer heat between two fluids, two solid or fluid and solid. Heat is transferred from one martial to the other through the surface of the material due to temperature gradient or temperature difference. It may occur by mechanism convention, conduction and radiation.

What is that conduction? Conduction is basically thermally energy transfer from one position to another position by direct molecular collisions. And convection transfer heat by fluid motion. And radiation the energy carried by photons of light in the infra red and visible portion of the electromagnetic electric spectrum. So, this called radiation. For heat exchange process generally double pi, shell and tube, even extended surface, heat exchange serving used, even cooling tower also industrial used for cooling the martial to transfer heat from martial to the other liquid.

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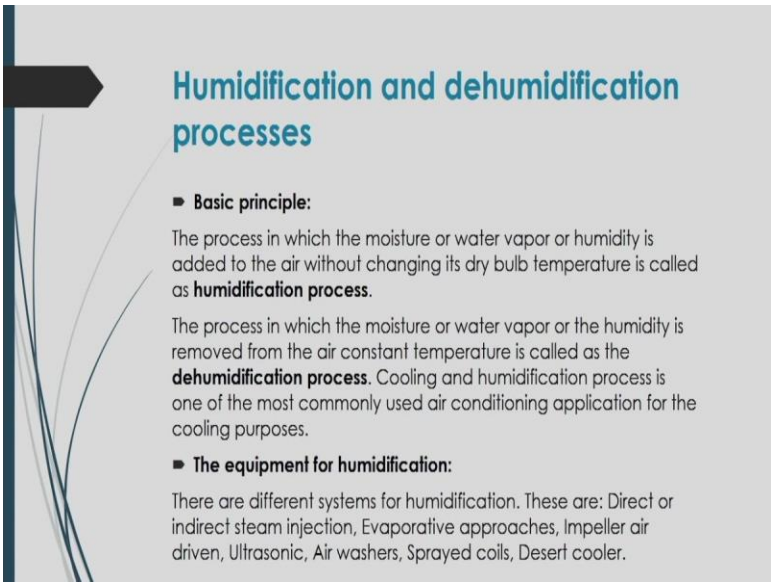


Humidification and dehumidification processes, in this case the process being done where the moisture or water vapor or humidity is added to the air without changing its dry bulb temperature. It is called humidification process. The process in which the moisture or water vapor or the humidity is removed from the air constant temperature. It is called dehumidification process.

Cooling and humidification process is one of the most commonly used air conditioning application for the cooling purposes. In this case the different for humidification are there these are direct and indirect steam injection, evaporative approaches, evaporative ultrasonic, air wisher sprayed coils, desert cooler are being used for this air-condition purpose by humidification and dehumidification process.

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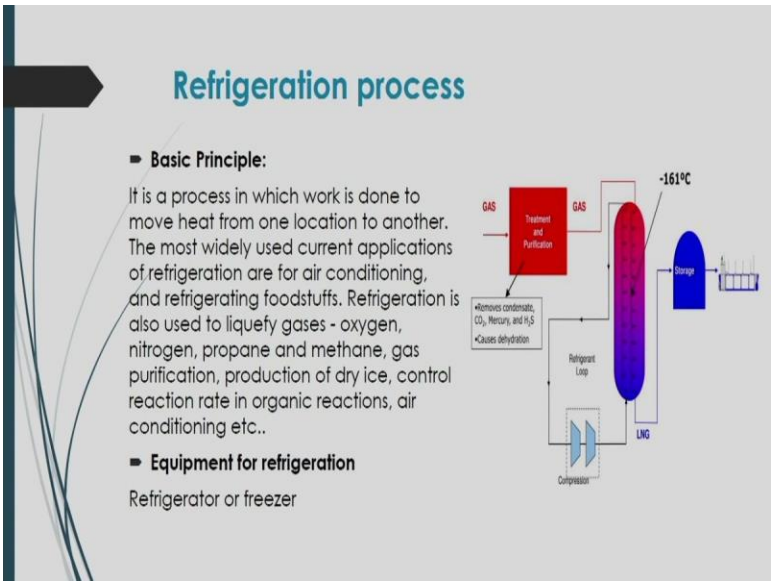


Refrigeration is another important process in chemical engineering operation like. It is process in which work is done to move heat from one location to another. In this case refrigerator or freezer is important. In this case, it is widely used for current application of refrigeration are for air conditioning, refrigerating foodstuffs. Even refrigeration is also used to liquefy different gases like: oxygen, nitrogen, propane and methane, gas purification purposes,

Even it is being used for production of dry ice, control reaction rate in organic and inorganic reactions, air conditioning etc. So, these are applications for the refrigeration process.

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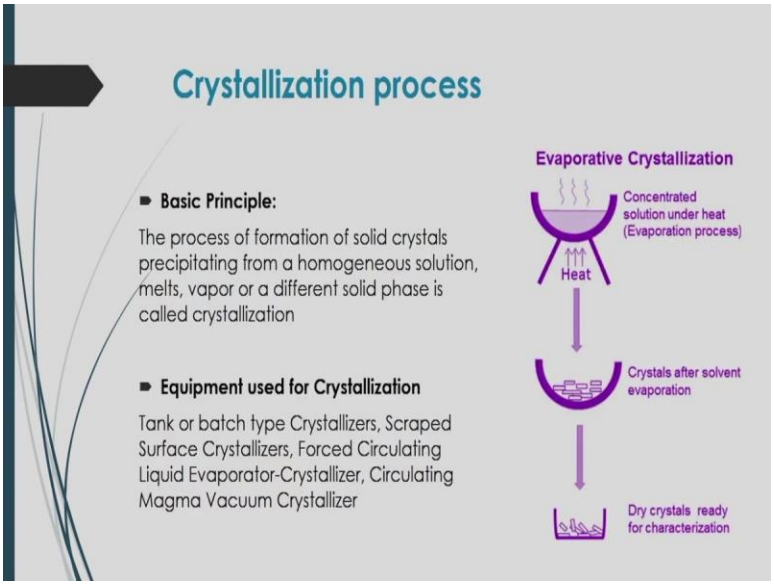

Crystallization is also one important unit operations for chemical engineering process. In that case the process is being that happens just by formation of solid crystal precipitating from a homogeneous solution, melts, vapor or a different solid phase, which is called crystallization. That case tank or batch crystallizers, scraped surface crystallizers, forced Circulating liquid evaporator – crystallizers are being used.

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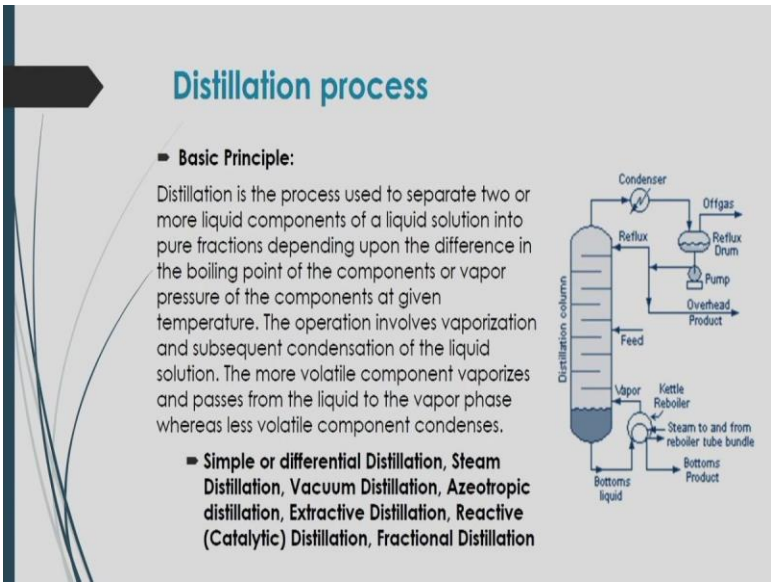


Distillation process is heart of the chemical engineering process there. This also thermo-chemical process you can say that, this process generally used to separate two or more liquid components of a liquid solution into pure fractions that depends upon the difference in the boiling point of the components or vapor pressure of the components at given temperature. The operation involves in this case vaporization and subsequent condensation of liquid solution.

The more volatile component vaporizes and passes from the liquid to the vapor phase where as less volatile component will be condensing. So, based on this vaporization and condensation and distillation is being done and you will see top of the column here? As shown in the slide that from the top the column this vapor coming out after vaporization you sees that to be condenses to a product.

And then it will be separate into different component and from the bottom also the heavy product will be coming. And then it will be regarded as bottom product and it will be process tagging for

separate different hydrocarbon there. So, this is actually distillation process more details on distillation process off course you will read in chemical engineering unit operations, where all those process are describe in details.

And there are separate courses that you have to do as a chemical engineering there. This actually lecture just given that very brief of those processes, that introduction that different chemical engineering process based on that type or classification unit process and unit operation like this.

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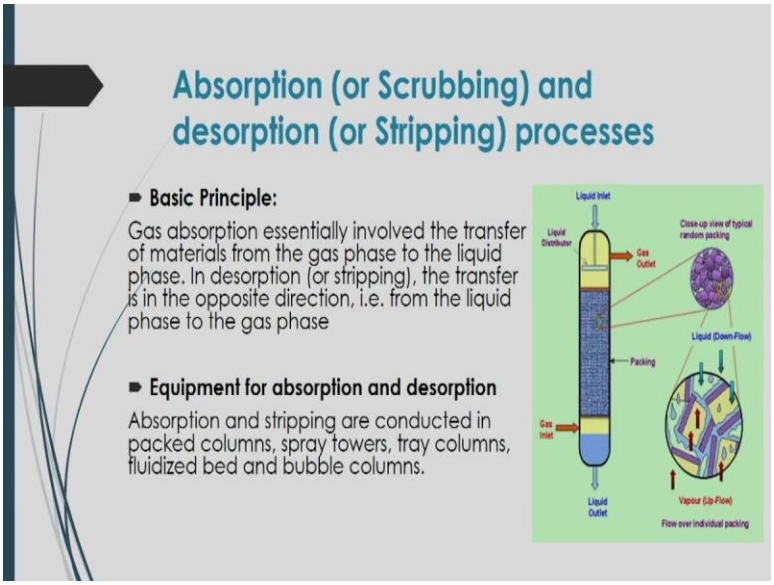


Absorption and desorption process the gas absorption is one of the important separation process in chemical engineering, where gas absorption essentially involved the transfer of materials from the gas peace to the liquid phase. And oppositely you can see that, desorption of course there. It is also sometimes called stripping.

In this case the transfer is the opposite direction, i.e. From the liquid phase to the gaseous space, like different types of absorber and stripper in striper as packed columns, spray towers, tray columns, fluidized bed and bubble columns are being used for the absorption and desorption purpose.

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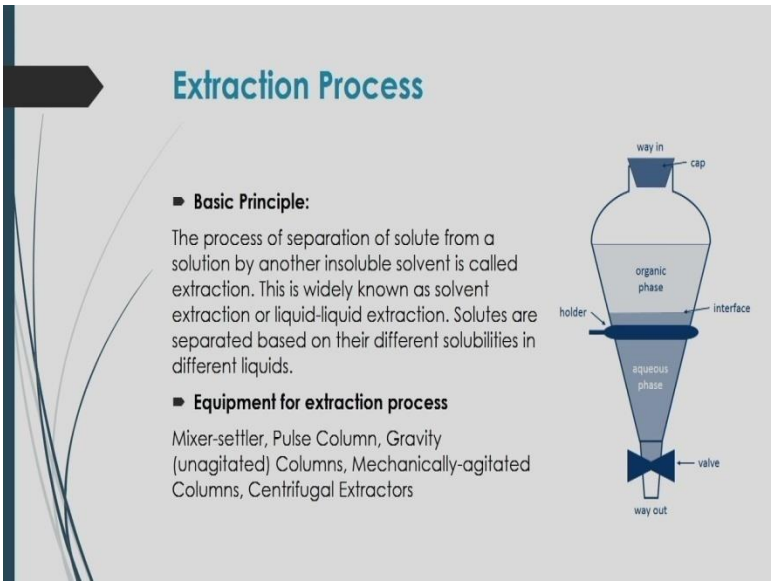


Extraction process in this case the process of separation of solute is being taken place from a solution by another in soluble solvent and this is widely known as solvent extraction. Or liquid-liquid extraction, salutes are separated based on their different solubilities in different liquids. Mixer-settler, Pulse column, Gravity columns, Mechanically-agitated column, Centrifugal extractors these are the some common equipment, that are being used for this extraction process.

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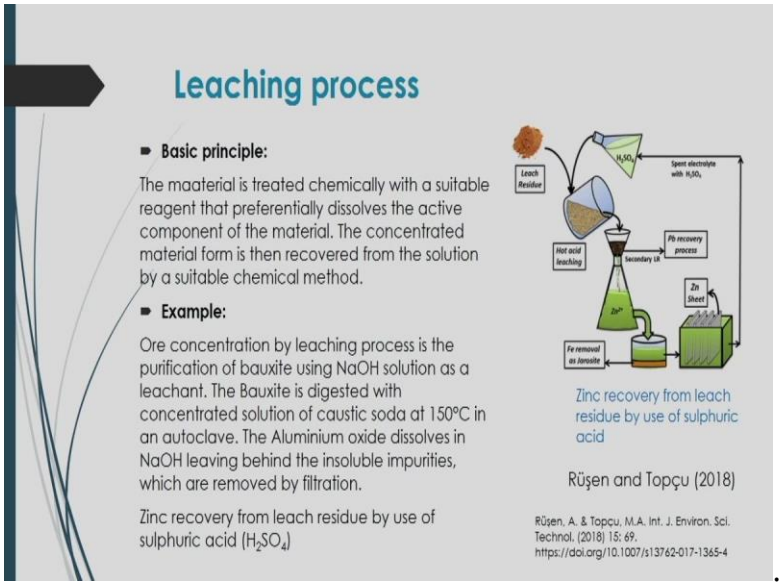


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Leaching process like in this case the martial is treated chemically with a suitable reagent that preferentially dissolves the active component of the material. The concentrated material from is then recovered from the solution by a suitable chemical method. In this case on example say that,

ore concentration by leaching process is the purification of Bauxite using sodium hydroxide solution as a lea chant.

The Bauxite is digested with concentrated solution of caustic soda at 150 degree Celsius in an autoclave. The Aluminum oxide dissolves in sodium hydroxide leaving behind the insoluble impurities, which are removed by filtration. This case Zinc recovery from leach residue by use of sulphuric acid there. So this leaching operation. Here schematic of leaching of Zinc recovery from leach residue by use sulphuric acid as shown in this slide.

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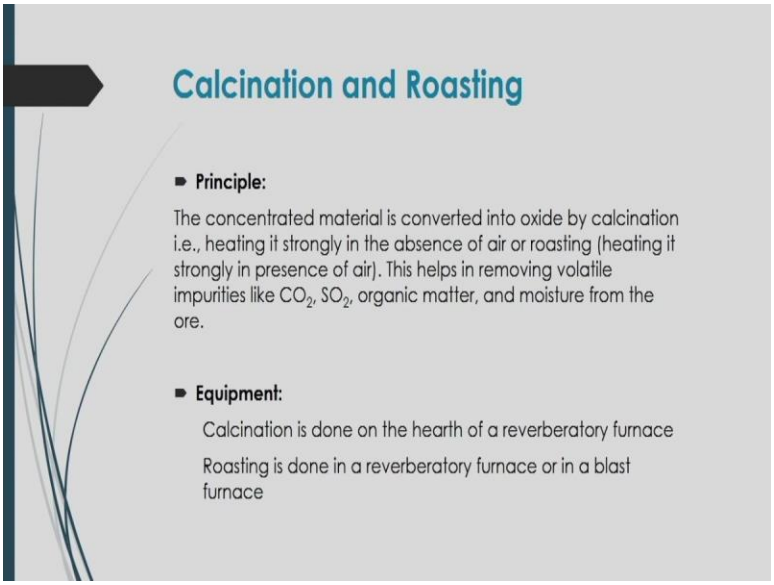


Similarly calcinations and roasting process are also very important chemical engineering process there. In that case the concentrated material is converted into oxide by calcinations i.e. heating it strongly in the absence of air or roasting there (heating it strongly in presence of air there). And this helps in removing volatile impurities like carbon dioxide, sulfur dioxide, organic matter, and moisture from the ore. Like calcinations is done on the hearth of a reverberatory furnace there. Roasting is done in a reverberatory furnace or in a blast furnace.

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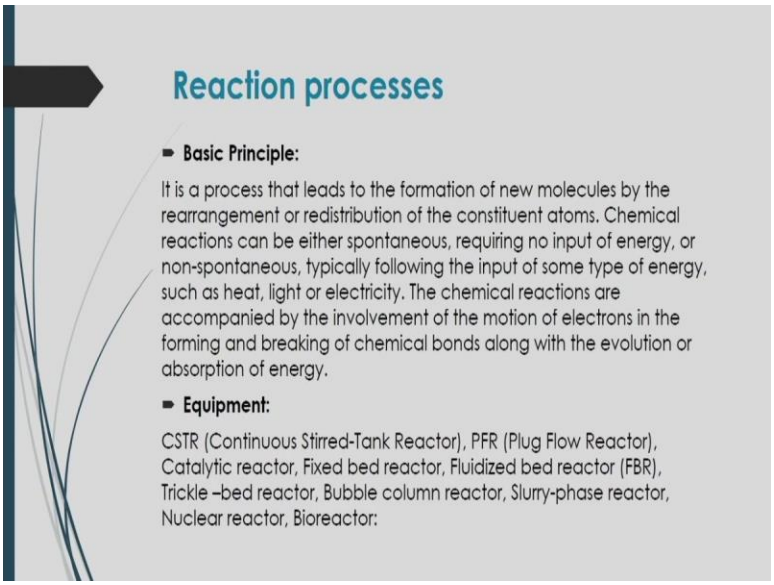


Similarly, reaction process it is process that leads to the formation of new molecules by rearrangement or redistribution of the constituent atoms. That chemical reaction can be either spontaneous, requiring no input of energy, or non-spontaneous, typically following the input of some type of energy such as heat, light or electricity. So in this case after reactions you will see different types of products output will be coming at a certain condition pressure and temperature.

That you have to maintain and also that depends on that output, depends on other different variables like: flow rate, even martial we shall be used, even catalyst contestation, even uniform meter, mixing characteristics, fluidized bed inside the reactor. And in this case are CSTR, plug flow reactor, fixed bed reactor, fluidized bed reactor commonly used for that reaction purpose.

But now days the process intensification you will see there are several other different type of reactor is now coming for the intensify the chemical process of this reaction you will see that like: micro mixer, micro reactor. These are reactor which is being use for this reaction process.

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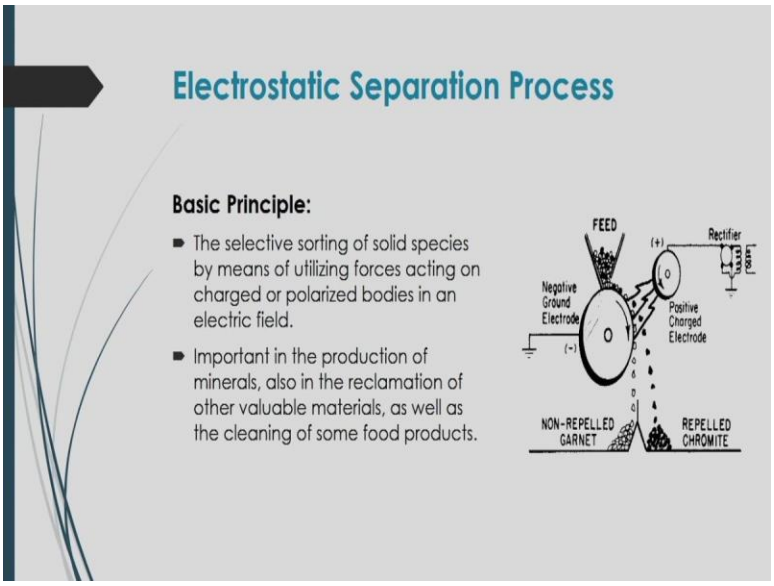


Electrostatic separation process also regarded as chemical engineering process where selective sorting of solid species by means of utilizing forces acting on charged or you can say that polarized bodies in an electric field. So this case it is important in the production of minerals also the reclamation of other valuable materials, as well as the cleaning of some food products there.

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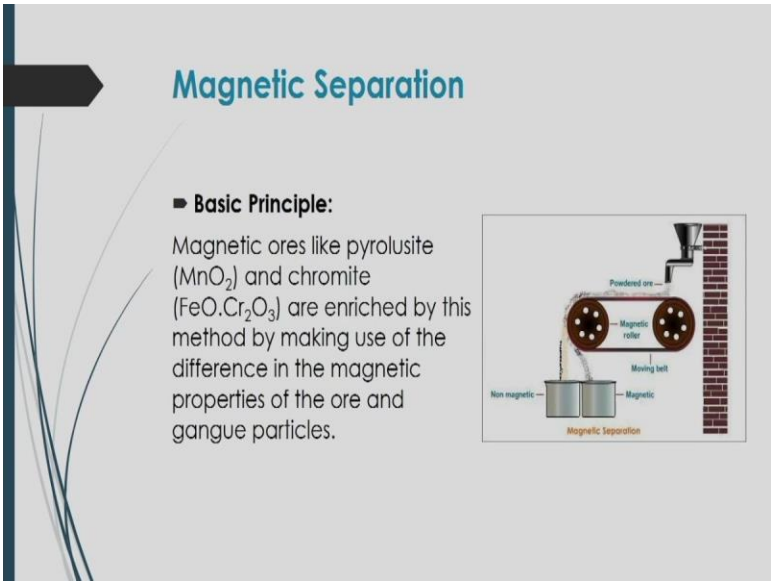


Magnetic separation is also one mechanical operation there. Magnetic ores like pyrolusite like manganese oxide and cromite are enriched by this method by this method making use of the difference in the magnetic properties of the ore and gangue particles.

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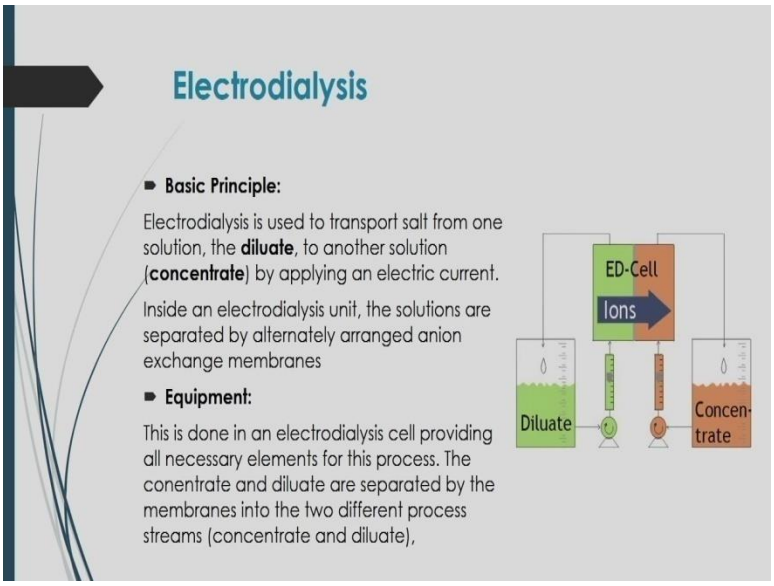


Electro dialysis also important chemical engineering process, where transportation of salt from one solution is required in that case, it is called dilate , To another solution by applying an electric current and this is done electro dialysis cell that providing all necessary elements of the process.

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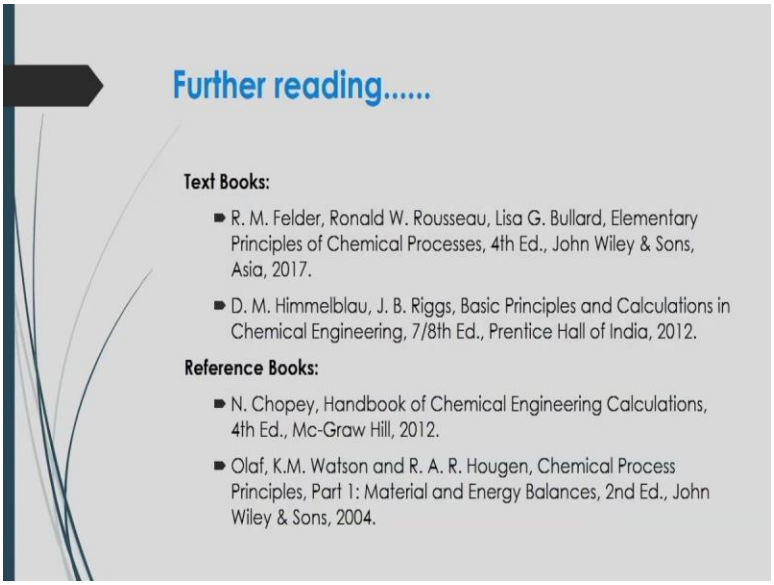


So this lecture we have described different chemical engineering process in very brief. And also the process is classified into different types like: some are mechanical, some are thermo chemical, some are purely thermal, some are purely mechanical, and some are phase contact based. So I think you have gained some knowledge on that different chemical engineering process.

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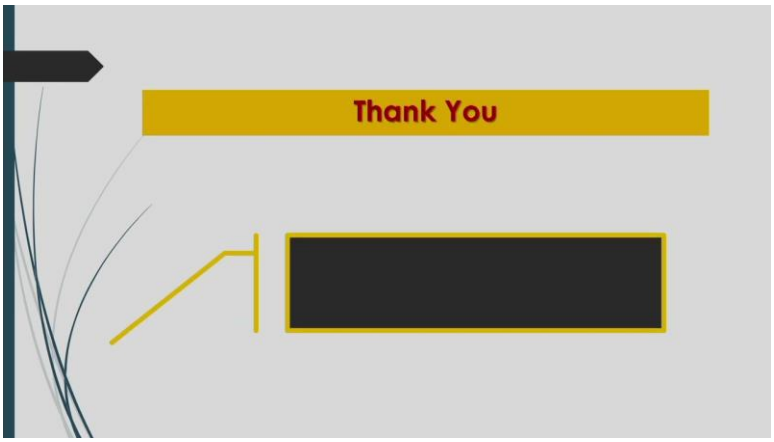


Now next lecture onward, we will that described that how this chemical engineering process are involved with different calculations? Even, how rate of that input and output even what are the units are to be used? How is the martial and energy balance to be done for the process calculation there? So thank you for giving that tenseness for lecture and next lecture will discuss something about that unit systems and dimension.

Thank you.