Inorganic Chemical Technology
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Lecture - 02
Introduction of Unit Operations

Welcome to the MOOCS course Inorganic Chemical Technology, the title of today's class is Introduction of Unit Operations. Before going into the details of today's lecture what we do we have a kind of Recapitulation of what we have seen in the previous lecture.

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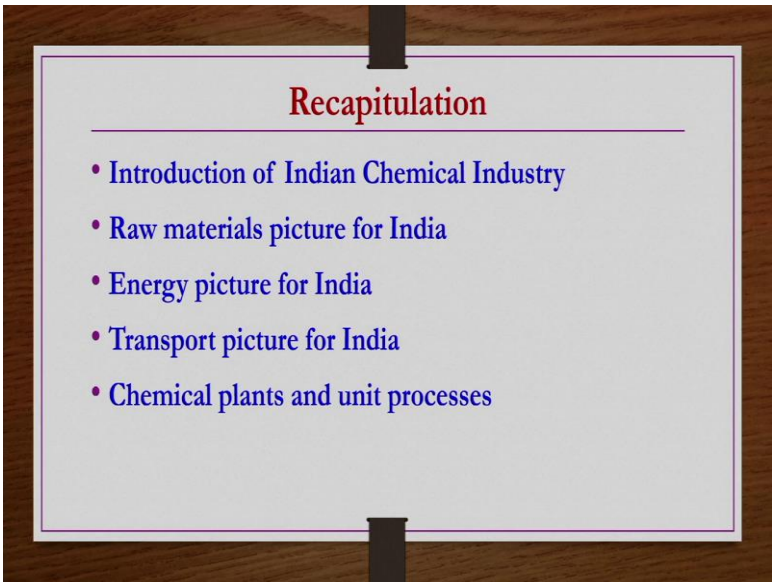

In the previous lecture what we have seen we have seen a few statistics of Indian chemical industry and then with respect to the different types of chemical plants, the availability of raw materials energy and then transport facilities are very much essential in general. So, then what we have seen we have seen raw material picture for India, energy picture for India and then transportation picture for India that those things we have seen.

In addition what we have seen we have also seen how a Chemical plant may be grouped as a kind of combination of different types of unit operations and unit processes. And at the end of the class what we have seen we have seen different types of unit processes which are very common in many of the chemical plants that is what we have seen right.

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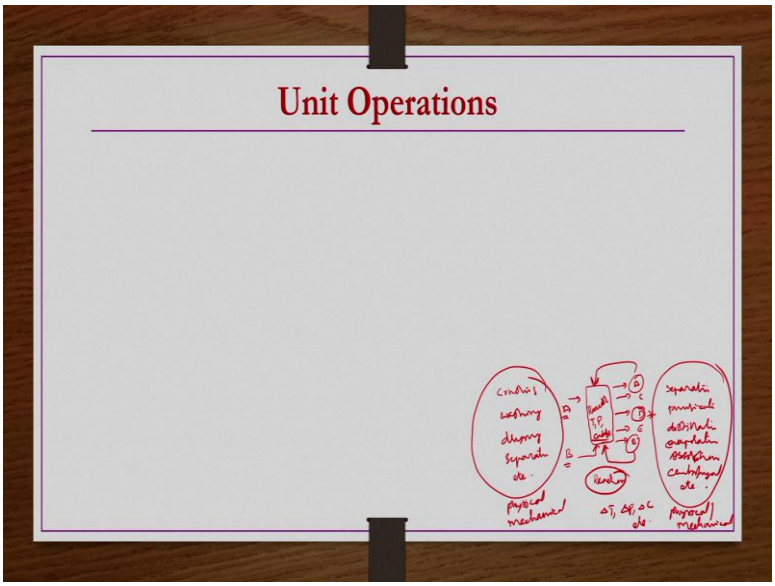

Now, in today's lecture what we see we see unit operations. So, before going into the details of unit operations we once again see how a chemical plant may be sub class classified as a different group of different types of unit operations and unit processes right. So, let us say what we can have we can have a reactor in a chemical plant, in general because most of the chemical plants there are reactions occurring.

In fact, almost all there may be some plants chemical plants there may not be any reaction there may be only separation purification and drying kind of thing they are very small minor plants, but in general common plant we may be having reactor right. It is an equipment what type of reactor it is let us not worry about it.

In this reactor section there may be a reaction taking place, let us say reaction taking place between 2 components A and B and then from this reaction after the reaction occurring at a given temperature pressure and then catalyst if at all required or non catalytic whatever right.

Reaction has occurred and then you may be having products like C D E something like that. And out of which only C is the main product by products C and E and then there may be unreacted A and there may be unreacted B as well right. So, this is what in general in any common reaction that we can generalize it ok.

So now, a reaction further may be reversible irreversible those details we are not going in that can be any kind of reaction let us say generalized one this one. So, now this reactant A and this reactant B may not be available in a very pure form in general, they may be available in a very crude form from the natural resources that we have right.

So, then there may be a requirement that these raw materials has to be purified to get required A level, what is level of reactant that should be suitable for a reaction to undergo. Something like you know combustion coal combustion as I explained previously.

Coal may be available in big lumps, but such big lumps we cannot be processed in fluidized bed combustion reactors. So, that the combustion can be done and then you know energy can be produced and all that. So, that is what we have seen, but now that before getting that is final sizes of the coal we have to undergo several processes right.

So, some of these process that we have seen like you know crushing, that is size reduction kind of thing and then a washing of the mud and other kind of ingredients etcetera, then drying, then separation. Let us say in the raw material you may not be having only a there may be other things also there same may be same or similar kind of operations may be required to get a purified B which is suitable to undergo reaction with a purified A right.

So, you know there may be n number of kind of things right. So, after the reaction let us say the product purification also we may need to do, because we understand that not only the main product D other than that one C and D in byproducts are there and there are some kind of un reactants A and B are there right.

So, then what we have to do you have to purify separation by separation or other kind of purification technologies something like you know distillation, evaporation depends on the reaction type and then product that we have then absorption. These kind of several types of you know centrifugation like that n number of operations need to be carried out, that is what we have seen in the previous lecture.

So, now all these things whatever are there prior to the reaction all these steps or all these steps represent some kind of physical or mechanical changes only. There are no chemical changes at all in this process. Similarly here also after the reaction product purification or

separation of reactants A and B and then getting back and then this A and B probably you may be getting back to the reactor, so that to enhance the reactivity or increase yield etcetera, alright.

So, these things again may need some kind of these operations shown in the right hand side here in the box. So, here again all these things are physical changes only, physical or mechanical changes only occurring there are no reactions regular there are no reactions at all in either of these circled things. There may be driving force like delta T delta P delta C etcetera that is a different issue, but there is no reaction at all here.

So, except this reaction step whatever the rest of the things are occurring in the plant all of them which are physical or mechanical changes only, we call them unit operations right. So now, sometimes you know in the reactor not only the unit process, which is some kind of reaction not only some kind of reaction, but also some kind of physical changes may also occur.

So then that means this unit operations whatever we are going to discuss they may occur individually or simultaneously in parallel along with the reactions or unit processes right. Their main purpose is that you know cleaning, purifying etcetera, so that to make the reactant suitable for the required reaction to undergo. Then also it is what is the other thing of this unit operations you know the separation purification of products etcetera those kind of things.

So, where all these changes whatever physical or mechanical changes are occurring all of them have been done by one or other kind of unit operations. So, now what I mean to mention here that I was mentioning different types of activities or changes physical or mechanical changes that may take place in different types of unit operations that is what I am trying to mention here, the same thing we are going to see here again, ok.

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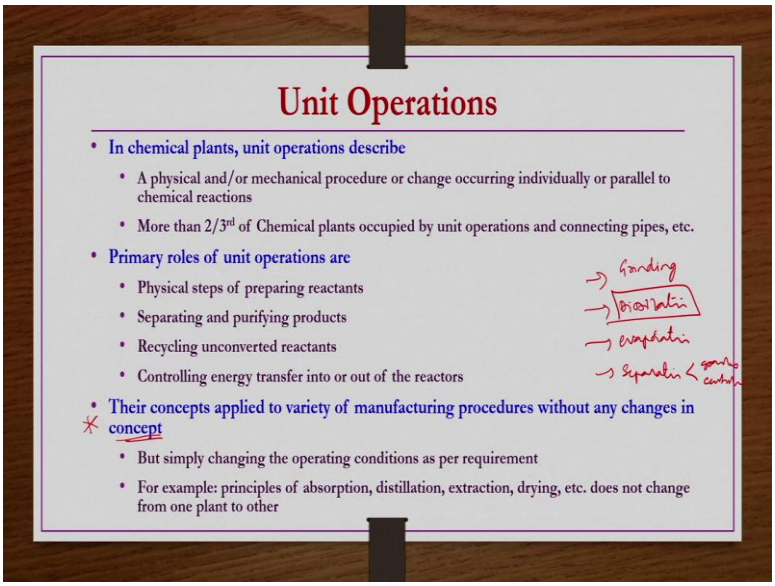

So, in chemical plants unit operations describe a physical and a mechanical procedure or change occurring individually or parallel to chemical reactions or unit processes and then more than 2 by 3rd of chemical plants occupied by unit operations and connecting pipes etcetera.

So, just now I have explained there is only one reactor, but there are n number of different types of unit operations involved and they are being connected in different manners depending on the chemical plant and all that ok. So, from that itself what we can understand that we can understand that majority of the chemical plant is occupied by this unit operations and then connecting pipes etcetera.

So, what are the primary roles of unit operations? That we have already seen if we list them they are physical steps of preparing reactants, reactants may not be in pure form that we get from the natural resources. So, then we have to prepare them suitable to reaction to occur ok. So, separating and purifying our products, then recycling of unconverted reactants and controlling energy transfer into or out of the reactor as per the requirement of the reaction ok.

So, these are the primary roles and then there may be a few other things also, but this is how we can put them in a kind of grouped manner. What are the primary roles? So, these are the primary roles of unit operations, then another good thing about this unit

operations are that their concepts applied to variety of manufacturing procedures without any change in the concept.

Let us say you have concept of grinding, you have a concept of distillation, you have a concept of evaporation let us say different types of concepts are available are separation etcetera separation by gravity or you know or by centrifugation etcetera this kind of different possibilities are there. So, you are going to see some of them in today's lecture as a basic information, but in detail you see in different courses.

I will be mentioning against each unit operations in which course are you going to study in detail about those things anyway. So, let us say their concepts they are same only thing that as per the operating conditions and then physical properties of the solids, liquids that are involved in the process, only changes occurring because of the changes in the physical properties of material involved or operating conditions etcetera only, otherwise concepts are exactly same.

So, concepts are not changing from one plant to the other plant if you go as long as the unit operation is remaining the same. So that means, principles of distillation are going to be same whether are you considering it in a petroleum industry or polymer industry or whatever, only thing that depending on what component you are fractionating in different diffractionations by distillation that makes difference and then size of the reactor may be different and then operating conditions may be different.

But the principles are going to be same that is the good thing about these unit operations right. We can apply them without any changes in the concept, but simply changing the operating conditions as per requirement. For example, principles of absorption, distillation, extraction, drying etcetera does not change from one plant to the other.

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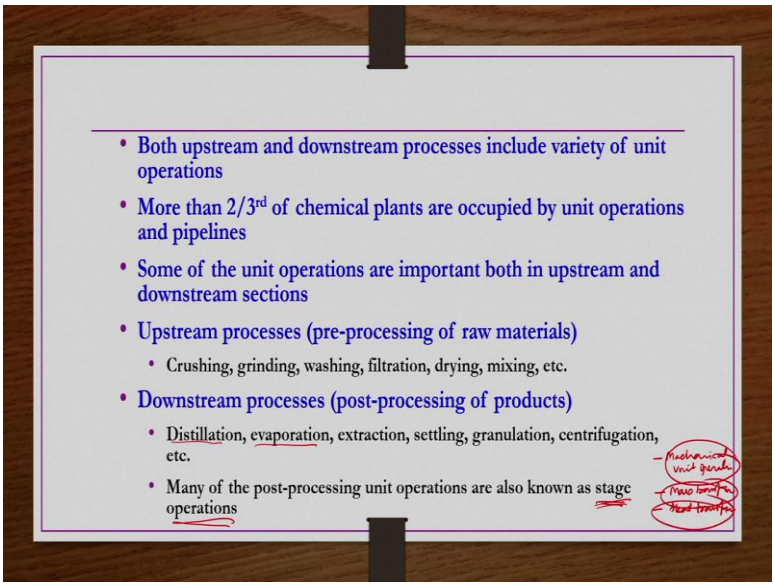

So, some more details about unit operations if you see both upstream and downstream processes include a variety of unit operations. Just now we have seen prior to the unit processes whatever the unit operations are occurring we call them upstream processes. Upstream processes they are having n different types of unit operations and then after the reaction whatever the purification separation etcetera, recycling etcetera are there.

So, we call them downstream unit operations right. So, they may be having n different types of operations in under each category, there may be some cases where given a particular unit operation may be useful both in upstream and downstream. Let us say drying, drying of raw materials may be required in the upstream process and then drying of the products may also required in the downstream process as well.

So, right and then more than 2 by 3rd of the chemical plants are occupied by unit operations and pipelines, some of the unit operations are important both in upstream and downstream sections as I mentioned for example, drying right. For example, separation size separation or separation by centrifugation or separation by gravity field etcetera are found to be important in both upstream and then downstream sections of many of the chemical plants.

Upstream processes which are nothing but pre processing of raw materials some examples crushing, grinding, washing, filtration, drying, mixing etcetera; downstream

processes that is post processing of products like distillation, evaporation, extraction, settling, granulation, centrifugation etcetera.

And then some of these downstream processes like distillation, evaporation etcetera they are also known as stage operations. What does it mean by stage operation? Stage operation in the sense there may be different stages or you may need to calculate how many different stages are required alright.

So, for a given process how many plates are needed for a given operation etcetera, those calculations you in general do in your mass transfer course right so, where you will be discussing about studying about distillation, evaporation etcetera. So, because of them because of such reason they are also known as the stage operations.

But not all unit operations are stage operations, only few of them are stage operation like you know distillation, evaporation, absorption etcetera. Now what is the point of understanding or you know trying to study this unit operations unit processes is important to understand, why?

Because now when we go into the details of a production of given inorganic chemical in the due course from second week onwards what we may be having we may be seeing several types of sections like absorption of some gases may be taken taking place right, drying of some products may be taking place, fractionation of some components purification of some components may be taking place.

So, there we may be using different types of unit operations and labeling them in the flow sheet accordingly. So, it is essential to understand them right, understanding all these unit operations is not possible in one single course anyway alright. So, why? Because these unit operations are so many that we cannot cover in one single course.

Let us say you have a mechanical unit operation course where, you see most of the solid-solid operations and solid-fluid operations, where separation or purification etcetera may be done by different types of unit operations though there you can see. Whereas, several types of stage operation like distillation etcetera that you can understand in you know mass transfer courses.

And there may also be some kind of purification or something like that in by using the heat exchanger. So, such kind of things you may be studying in detail in heat transfer course etcetera like that. So, there are several courses dedicated to study in detail about each of them.

So however, since this course chemical technology is in general offered in the 4th semester of UG curriculum and by that time you may not have gone through majority of these courses. It is essential to know a few details about such unit operations right. So, in the previous lecture unit processes we have anyway discussed, now we are going to see a few common unit operations of the chemical plants, which are very common right.

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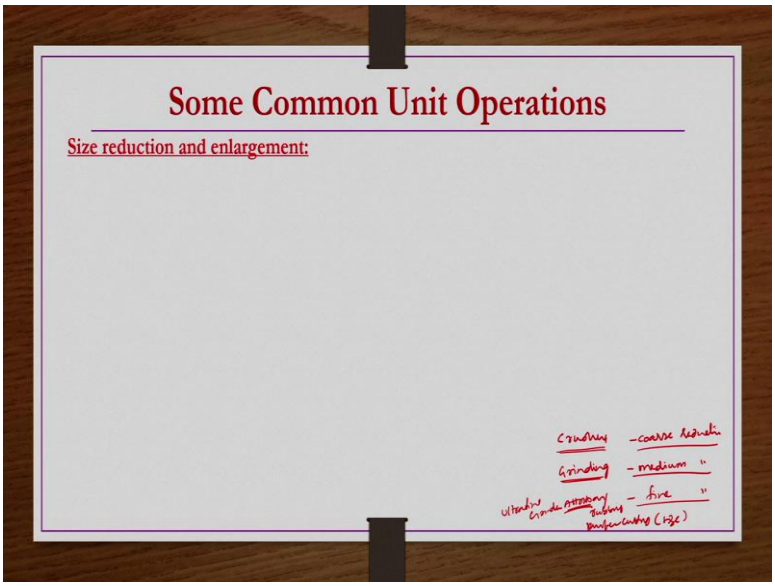

What we are going to see under this particular heading of some common unit operations, we are going to list a few common unit operations and then schematically see how they look like. They are not true engineering design pictures, but you know they are just a simple schematic representation.

So, that to have a feel about that and then in addition to that we are going to see some of their applications ok. So, these operations are often grouped in different categories like you know solid-solid operations, solid-fluid operations and then solid fluid separations etcetera like these categories are there.

So, accordingly we are going to see them one by one. Size reduction and size enlargement again, now this size reduction size enlargement is a very common terminology in mechanical unit operation. In fact, this half of the syllabus of mechanical unit operation course is dealing with different types of size reduction and size enlargement equipment right.

So, this size reduction equipments in general you know divided as coarse reduction, medium or intermediate reduction and then fine reduction alright. Coarse reduction like you know you have big equipment where you do the crushing, crushers etcetera like you know you have big lumps of you know resources that you get naturally.

So, they may be sizing in 50 mm or 50 centimeters also possible even bigger also possible such bigger lumps you cannot use in the reactor. So, then they have to be reduced to the smaller size like few mms or sometimes even few microns also. So, coarse reduction is the one where few centimeters like 50 centimeters 100 centimeters big size particles or lumps are there, you reduce them into 1 centimeter or few mm something like that right.

That is what known as the coarse reduction that is done by the crushing, then medium reduction where you do the grinding. So, that few mm are 1 or 1 centimeter or 2 centimeter size particles may be reduced to much smaller like you know fractions of mm or some microns size something like that.

Then fine reduction where you know attrition or rubbing kind of actions taken place. So, that the feed size is in general fraction of mm and then you get some microns or you know nanometer size also possible in general by the size reduction. So, since here based on the size of the feed and then product these things are the common terminology coarse reduction, medium reduction and then fine reduction kind of thing there is another thing is that in a cutting or sizing.

If you want exact size exact size of the material then let us say you want like 1 mm cubicle shape something like that. So, then exactly if you wanted to do then cutting kind of thing reduction equipments are also there right. So now, the coarse reduction you have the crushes and then medium reduction there are equipments like a grinders and then for fine reduction you have equipments like ultra fine grinders etcetera.

And then for cutting, cutting knives etcetera are there. So, these kind of different types of equipments are there. So, all these things we cannot go through here as I mentioned you know this size reduction and enlargement comprises half of the mechanical unit operation courses, where you are going to see or where you might have already seen probably their working principles etcetera equipments used applications, advantage, disadvantages etcetera all those things.

You might have gone through or you may be seeing when you do this mechanical unit operations course. So, like that under each category there are several details. So, I will be giving some of the details which are required to understand at this level or you know to understand this particular course ok.

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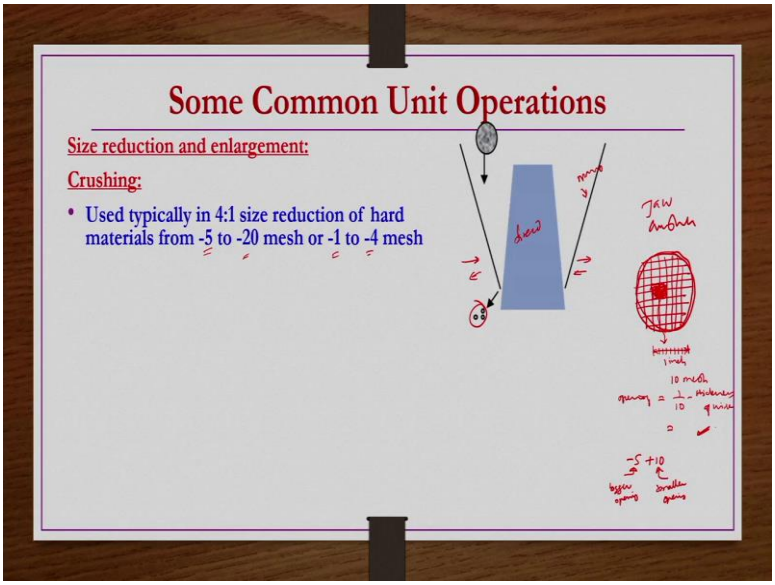

Crushing let us say it is a jaw crusher type it is one of the equipment representation of one of the coarse reduction equipment we call it jaw crusher; where there are 2 jaws are there one is fixed another one is moving right. So, let us say here it is fixed it can be other way also not necessary only this one has to be fixed and then this one has to be moved it is other way also and then this is moving and then this moves in this direction in one particular direction like this right.

So, then what happens the bigger lumps which are 50 centimeters or in sometimes even bigger lumps you know they are dropped here in between and then while these are moving. So, then this material will be trapped in between and then because of the

compression that material experiencing between these 2 jaws that will be reduced and then smaller particles will be produced right.

So, usually use typically in 4 is to 1 size reduction of hard materials from minus 5 to minus 20 mesh or minus 1 to minus 4 mesh ok this size reduction 4 is to 1 that represent the ratio between feed size to the product size right. So, that is what and then what this minus 5 minus 1 minus 4 etcetera and then what is this mesh there are standard terminology in this one also.

Let us say we have a mesh something like this know mesh in the sense that in general saving mesh is whether that you see at your home in general in your kitchen. So, something you visualize. So, then that is certain kind of sieves let us say if you have like this. In industrially we may have different types of sieves as well that you are going to see in your mechanical unit operation course, but now this is how you have taken.

Now, let us say you take one particular section let us say I am taking this particular section here right. So, the linear dimension of that section is I am drawing the linear dimension of that particular section is 1 inch I have taken such a way and then I am counting how many openings are there in that 1 linear inch dimension of the sieves. So, if there are 10 are there 10 such kind of openings are there it is known as a 10 mesh or mesh number 10 ok.

The number that are written here is nothing but how many openings are there per linear inch space of the you know in the screens or mesh ok, so that is what it is. How to get this one? So, let us say now let us say for 10 inch if you wanted to know opening, opening of this now there are 10 openings in 1 linear inch distance there are 10 openings are there right.

So, how to know how much is each opening size, so that is 1 by 10 inch minus thickness of the wire that has been used to construct this particular mesh. So, that you get opening size opening right, this is all you are going to seen your mechanical unit operation course anyway. Now then what is mean by minus 5 and then plus 10 are something like that ok.

So, now, what you understand here what you understand if the number is smaller the size of the bigger the size of the opening would be bigger obviously, right because it is a

reciprocal of this number minus this thickness of the wire. If the number is bigger then that means it is a smaller opening.

So, minus 5 plus 10 that means it has passed through bigger opening of 5 mesh screen and then plus 10; that means, the material that has passed through this one and but that is retained on the 10 mesh it is not able to pass through the 10 mesh size. So, that you can have several screens one after other and then at the top you are having the biggest opening screen and then gradually you arrange the different screens or different mesh numbers.

So, that the gradually the screen opening decreasing and then bottom most may be having the finest opening one right. So, that you know you under each fraction under each compartment you get the particles of different sizes, that is the size separation is required right.

So, as per your reaction whichever size material is required that fraction you can take and then remaining one accordingly you process. Whether further is size reduction may be there and then sometimes you know by this crushing there may be over sizes are there, very fines are there which are not suitable.

So, then you can take them to the size enlargement section and then make a bigger size particles etcetera required otherwise you can discard them right. So, this is what we means these meshes etcetera. So, all these things are also you are going to learn in your mechanical unit operations course. Since these numbers appearing here so, then I explained here for your knowledge, right.

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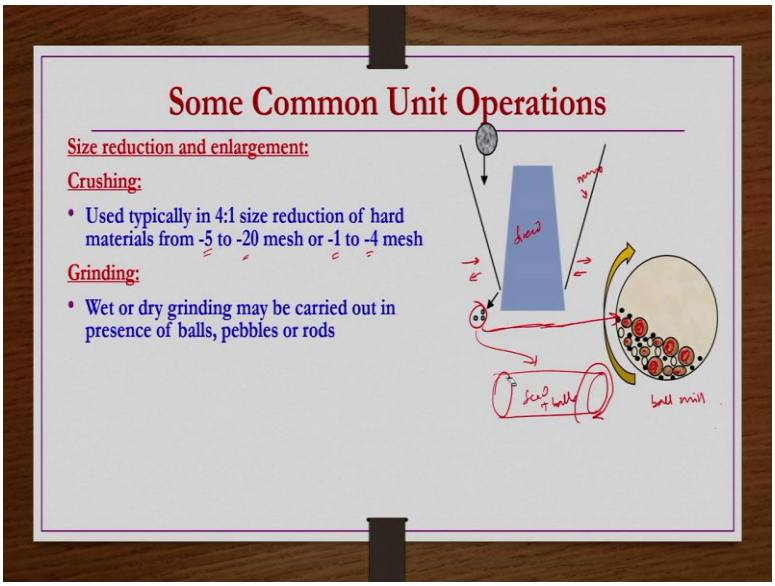

The grinding is next level size reduction equipment as I mentioned crushing is a one kind of operation which is used for the coarse reduction, grinding is a kind of one operation where intermediate or medium size reduction has to be done. So, here wet or dry grinding may be carried out in presence of balls, pebbles or rods.

So, something like that these schematic represent, but represent of the operation only. You know there they are known as the mills different types of mills, now this is known as the ball mill this also you are going to see in mechanical unit operation course. So, here heavier balls of different sizes let us say these are the balls, they are different size these you know these filled ones right filled with this color.

Now they are bigger balls metal balls or you know wooden balls and a different size of heavier balls heavier compared to the nature of the particles, you know material that you wanted to crush. Let us say these particles whatever you are getting from this jaw crusher may not be suitable for reaction even now after undergoing this coarse reduction, you need further finer particles. So, then this product you can you may take into certain kind of mills ball mills hammer mills etcetera different types of mills are there.

So, you put them in ball these balls are nothing like a kind of a cylindrical container. The feed material which you wanted to you know further reduce that one along with the balls you put them and then you rotate them, these balls are rotating like this when they are rotating this material moves up and then fall down.

So, when all the material moves up and fall down you know the heavier balls may be falling into the material which you wanted to reduce the size further. So, they fall on those particles, those particle will further reduce in size in their sizes ok. So, this is typical this is what happens there are again the principles and then rotation speed etcetera all those things not part of the course.

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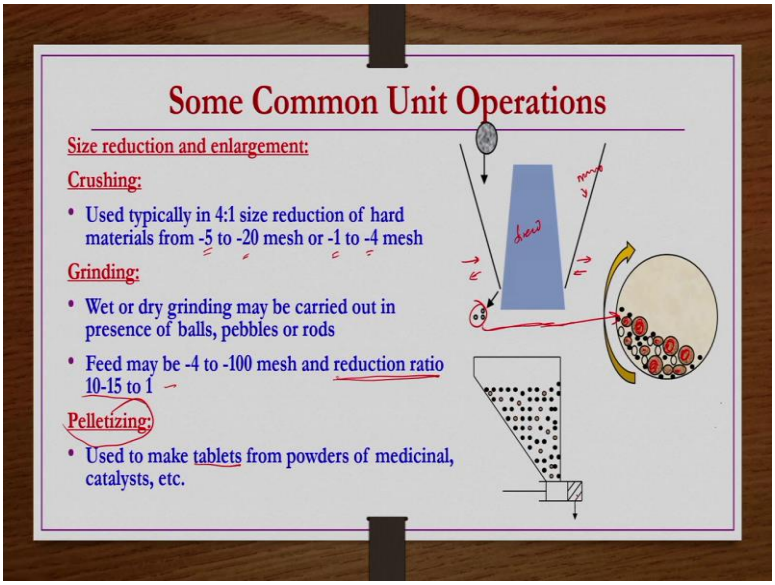

Now, here feed may be minus 4 to minus 100 mesh size and then reduction ratio may be 10 to 15 to 1 ok. Reduction ratio is nothing but the it is feed size divided by the product size, product size is obviously the smaller one compared to the feed size ok. Pelletizing is a size enlargement equipment size enlargement process alright.

So, there are different types of operations there for the size enlargement we are seeing one of them here. So, usually they are used to make tablets from powders of medicinals and catalysts etcetera. So, here you take the material whichever you wanted to pelletize, these may be very fine particles from these mills also they are crushing and grinding and ultra fine grinding. You may be having very very fine particles and then you cannot throw let us say because, if they are having some important value like catalyst etcetera.

So, then what you do and you can pelletized them if they are pharmaceutical value, then also you cannot throw them. So, then what you do you can pelletized them? So, pelletizing or tableting is very common in the pharmaceutical industry, because the

tablets etcetera whatever you take they have been tabletized or pelletized by using these size enlargement equipments ok.

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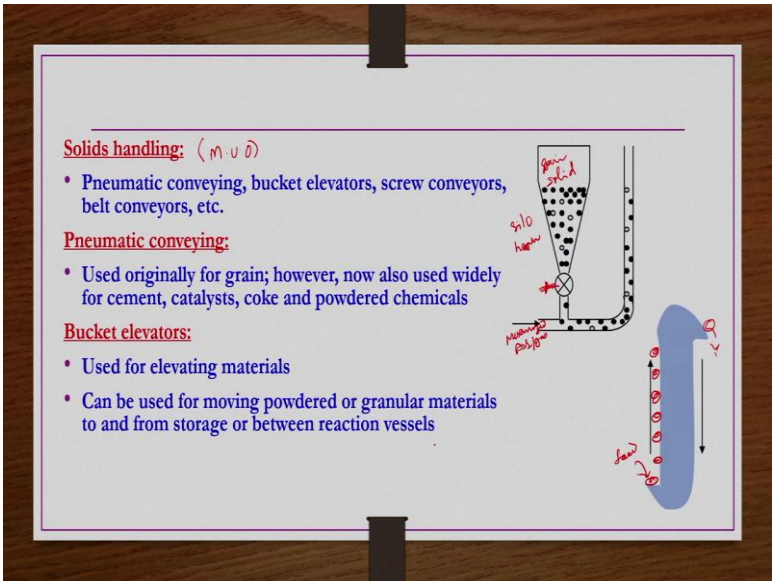

Next is Solids handling, pneumatic conveying, bucket elevators, screw conveyors, belt conveyors etcetera comes under this picture. So, these things also you may find in mechanical unit operation course much details. In the pneumatic conveying what happened there is usually used for the grains; however, now also used widely for cement catalysts coke and powder chemicals etcetera.

What happens in this one let us say you have a solids fine solids etcetera, grains etcetera you are having in a silo, these kind of containers that we use for storing the solids are known as the silos or hoppers etcetera. They are also different designs are there. So, we will see later them you can see them in different courses.

So now, here this material you take them in a silo and then there is a opening here, this opening when you open the material comes to the pipeline and then from that pipeline you need to elevate them or take to the some higher levels or different position. So, what you have to do you have to provide the pressurized air.

Air or some kind of gas which is not reacting with the material, so then these things will be elevated or taken to the next level wherever they wanted to be taken right. These are

also important let us say you have a gas solid reaction and then solids you need to feed continuously. So, then there you may have such kind of situations.

Bucket elevators, so they are used for elevating materials in general. So, what we have. So, now, this section is actually rotating right. So, there are some kind of bells are there. So now, these locations buckets are connected actually, different types of buckets, different size buckets are in general you know connected.

So, now when they are rotating the material here feed material that comes. So, when the bucket is located this section. So, that you know comes here that feed material, I am calling feed because it is not feed or you know product is not always with respect to the reaction in this course especially when it is about unit operations.

So, bigger size are you know material that you wanted to take from one level to the other level, so that you take here. So, this bucket moves here and then like that all the buckets comes here and then when they comes here they can be transported to the different levels right. So, these bucket elevators are very common in majority of the cement industries etcetera and then coke processing unit's etcetera.

Can be used for moving powdered or granular materials to and from storage or between reaction vessels, in general.

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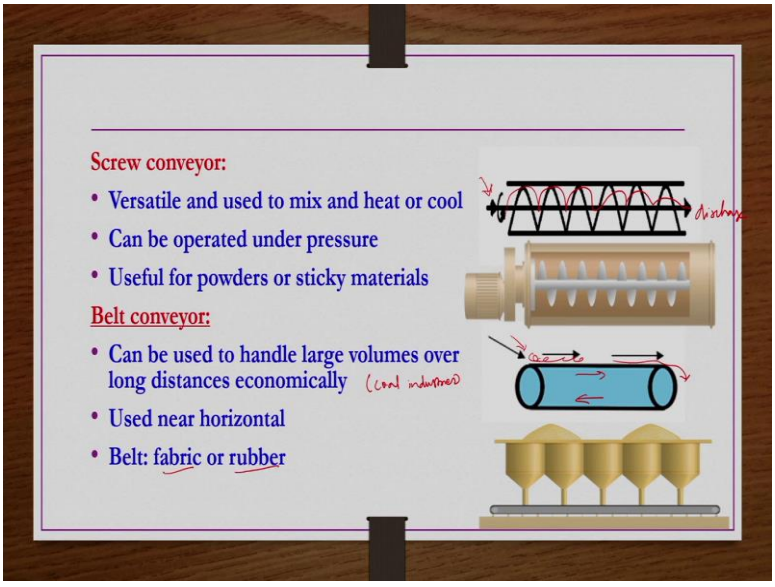

Next is another type of conveyor, so screw conveyors screw conveyors are very versatile and used to mix and heat or cool in general. So, here what we have we have a section under which inside that one there is a screw actually right. This screw rotates in a different direction right one particular direction.

In this screw what we have we have a screw that rotates in one particular direction. So now, the material that you wanted to transport from one level to the other level that you can take it here right and then when this screw moves this material is taken to this level and then from here to this level like this. It continuously moves as the screw moves forward and then material will be discharge to the other side.

The similar way we can do the so called you know drying or cooling or heating or cooling of the material can also be done. Now in such case the material and then screws would be at different temperatures. So, some kind of screw conveyors look like this as well as shown here. So, can be operated under pressure also useful for powders and sticky materials, let us say silos are hoppers that have shown in the previous slide.

You know if you have such kind of silos and then you wanted to store powder very sticky material or very fine material and then use the pneumatic transport for the conveying that is not possible, because the sticky or very fine material does not comfortably come through the silos so easily. And then they further conveying may not be possible by pneumatic conveying right.

So, under such conditions if you have this screw conveyors it will be very easy to move such kind of a very fine or sticky materials. Belt conveyor can be used to handle large volumes over long distances economically, this belt conveyors are very common in coal industries, rather coal industries coal mining.

Especially if you are doing underground mining of coal then you know deep into the earth several meters sometimes kilometers also you may be digging in and then there you may be finding the coal. And then this digging is not done in a horizontally completely or completely vertical they are digging at a certain angles etcetera. So, then material that has been found that has to be transported through usually they are often transported through this belt conveyors ok.

But they are also applications in other industries also most right, wherever the solid handling is required in any chemical plant, so such this screw conveyors belt conveyors etcetera are very common. Now, whatever the material that feed that you wanted to transport. So, that you take here and then this belt rotates in this direction. So, then when the material comes here right and then as the belt moves that material is transported to the other side of the belt ok.

So, this is another way of belt conveyor where you have the material stored in big silos or hoppers right. And then that material if you wanted to convey to the reacting vessel or some other unit operation. So, then what you have at the bottom you have the belts something like that and then these belts are moving to those directions.

So, whenever you want material you open this solid storage equipment like silos or hoppers and then that material flows on to the belt and then movement that material comes, because this belt is moving. So, the material will also be moved to the next level. And then usually these are used near horizontal conditions most of the belts are fabric or rubber kind of materials.

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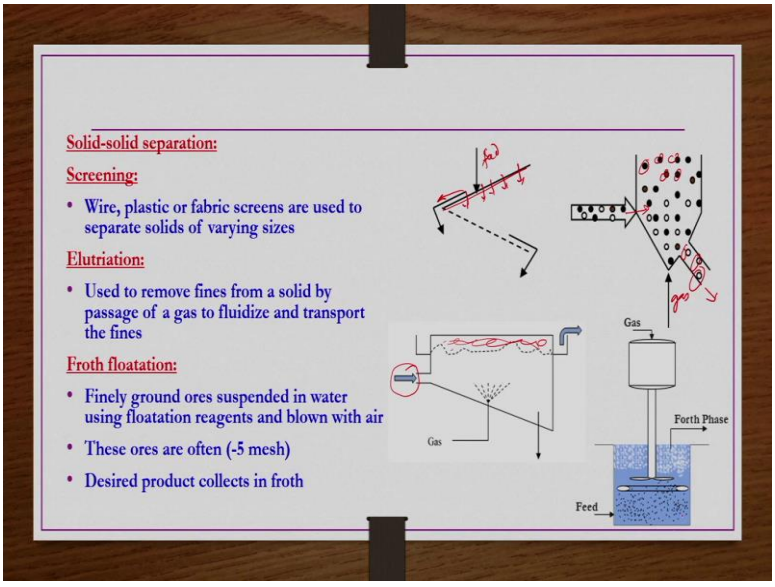

Next solid-solid operations such kind of unit operations also we studied in detail in mechanical unit operations course; however, few details we see here Screening. Screening as I mentioned you know they are wire plastic or fabric screens often they are used to separate solids of varying sizes.

So, let us say one particular screen of a bigger size is arranged in this direction right, so then material that you wanted to separate into varying size, so that you pour it here feed material. Now whatever the material that is passed through the opening of this mesh right, so that means, the material that is having size smaller than the opening of this mesh that will pass through and then will be falling on to the may be collected as one kind of fraction.

And then which is not able to pass through or the material which is having size bigger than the opening of this mesh that will be taken or you know move downwards like this and then the next screen would be having opening, which is smaller than the previous screen which is above of this one, right.

Like that n number of screens are available or arranged and then different sizes based on the different sizes you can have different fractions, you can arrange them as a kind of stacks in vertical manner and different possibilities are there. Now elutriation it is used to remove fines from a solid by passage of a gas to fluidized and transport the fines.

So, what happens for simple representation what you have you have a mixture of solids, which are including intermediate and then very fine particles, let us say you take them into a container like this right and then pass them like this and then from the bottom of this one you allow a gas to flow upward. So, whichever particle lighters the darker ones are the lighter particles they will be fluidized and then taken as a separated as a different leg from the top.

Whereas the whichever are the particles are you know bigger on or which may not be fluidized because of this incoming gas velocity, they will be collected as a different fraction from here like this ok. Next is Froth floatation in this operation finely grounded ores are suspended in water using floatation reagents and blown with air so, that whatever the fine lighter material ores etcetera are there.

They are suspended at the top along with the froth; whereas, the heavier mud dirt etcetera are there, which are heavier they will be settling at the bottom of the floatation cell and then discarded as tailings ok. So, these ores are often having size minus 5 mesh desired product collects in froth like this.

Let us say you have the finely ground whatever the mixture ores and then mud etcetera there that all you bring here into the rotation cell and then you add some amount of floatation reagents, then you aerate it using a gas. So, that more these bubbles and then more amount of froth forms and then this froth what will do that will carry the particles the fine ores whatever are they will be attached to this froth and then they will be lifted and then they will form as a top layer at the top along with the froth.

So, then this fines along with the froth are collected from the top as product; whereas, the mud, dirt etcetera which are heavier, which are not being attached to the froths they will be settle at the bottom as a tailing or the material to discard. Different representations are there for this froth rotations etcetera also.

So, one other representation is given here. So, what we have we have a container you are sending the feed material continuously and then you are adding you know flotation reagents and then you are aerating using a rotating provision provided here. Now, the froth is forming right. So, in this one and to that froth the fine purified or washed ores would be attached, whereas the mud etcetera would be remaining at the bottom as tailings.

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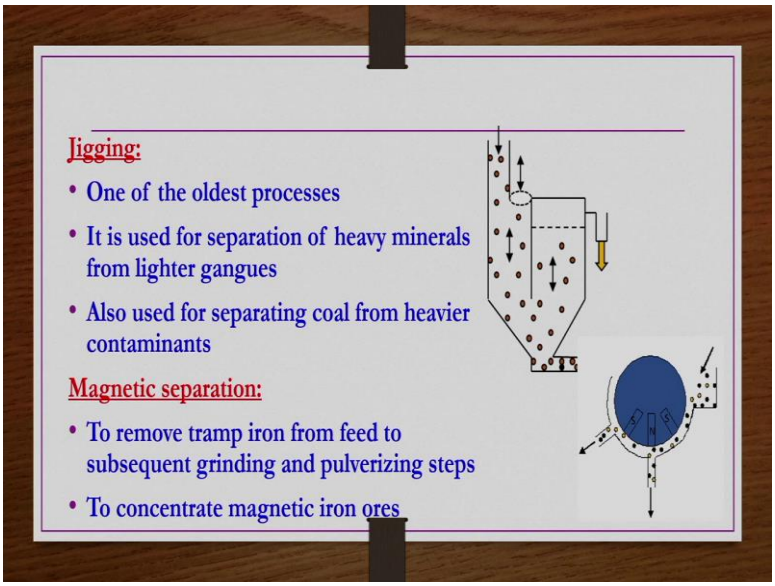

Jigging is one of the oldest processes it is used for separation of heavy minerals from lighter gangues, also used for separating coal from heavier contaminants in general. But

nowadays this is not used very much in majority of the chemical plants, because of the advanced methods have come into the chemical plants.

Then magnetic separations to remove tramp iron from feed to subsequent grinding and pulverizing steps. So, this is one example to concentrate magnetic iron ores is the another one. What happens let us say whatever the material after the crushing or the coarse reduction let us say big lumps you have passed through a jaw crusher, so that you did coarse reduction right after that you have a material of few mm size right.

Now, that material may be having not only the desired material, but there may also be some metals or something like that may be there right. The same material again you take to the grinders to grind to get the intermediate reduction followed by the fine reduction. What will happen? So, if there are metal particles etcetera are there you know they may be damaging the grinding equipment; they may be damaging the ultra fine grinding equipment.

So, sometimes it is necessary to remove such kind of metals from the mixture of raw materials mud etcetera. So, you need to do such kind of separation sometimes. Sometimes what happens that metal particles themselves which are having certain kind of magnetic properties they themselves may be important material.

So, before taking them further or washing them and all that what you can do you can allow them to pass through this magnetic separation unit. So, that you know metallic component they may be attached to this magnetic portion and then non metallic material whatever are there they can be separated out. So, either way it is important to do sometimes this magnetic separation.

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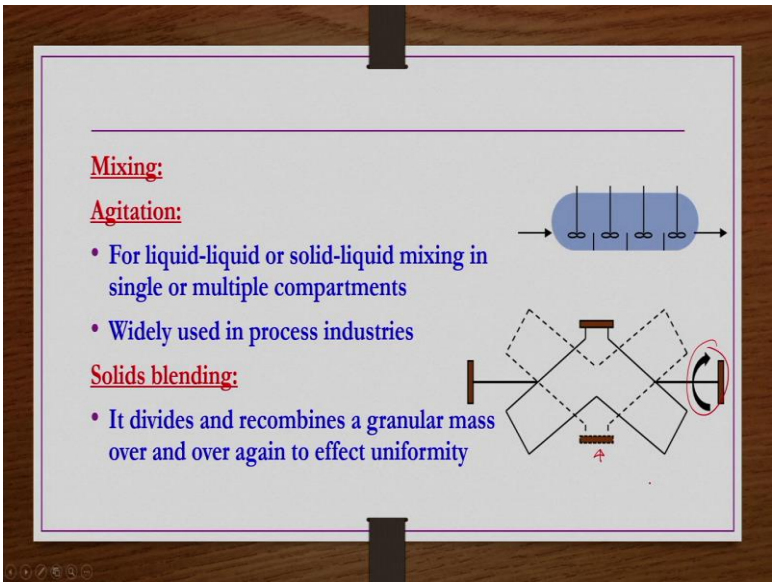

Then mixing agitation is one of the type of mixing which is used for the liquid-liquid or solid-liquid mixing in single or multiple compartments. For example, here you have a agitation equipment where different multiple compartments are there, where these materials are coming and being agitated or mixed and then uniform or properly mixed material is taken out from this end ok.

This may be single unit or there may be multiple compartments, it is widely used in process industries. Then solids blending it divides and recombines a granular mass over and over again to effect uniformity, sometimes you know you need to have a kind of a uniformity of the material before taking the material to the next level right.

So, here what you have you have a solids blending. So, where you can pour this material here through one end right and then this blending equipment is such that you can rotate in particular direction. So, when you are rotating these things the material will mixed up and then once you feel that you know enough uniformity has brought in. So, you can open from the other side and then collect the material.

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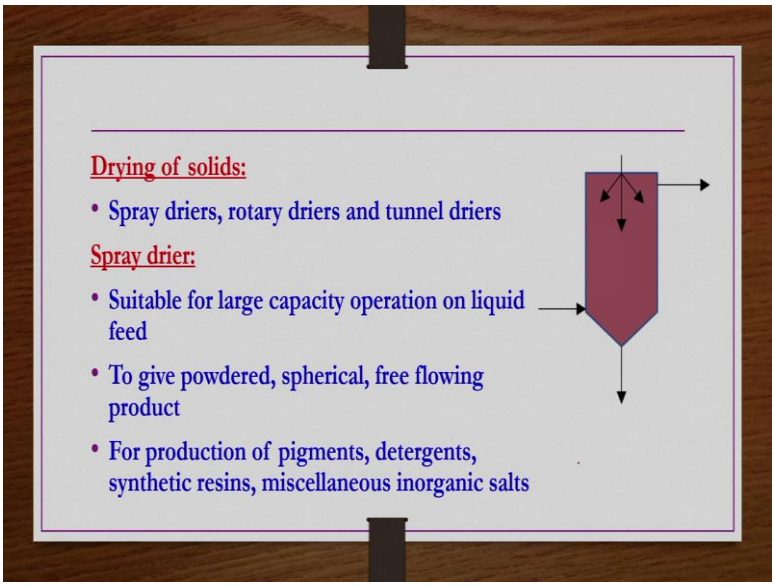

Next Drying of solids different spray driers are there spray driers, rotary driers and tunnel driers etcetera. Spray driers suitable for large capacity operation on liquid feed to give powdered spherical free flowing product. Let us say you have a material coming down here and then that you wanted to dry it or you make it a free flowing spherical in nature in general, then what you can do you can allow them to pass from the top and then from bottom in opposite direction you allow on the gases of at different temperatures.

And then pass through that, so that you know these heating etcetera may take place if required. So, that the drying may take place right or if you wanted only spherical free flowing kind of products. So, then that can also be taken place the depend temperature difference etcetera all are depends on the applications right.

And then whatever the powdered material spherical free flowing product is say that you can collect from the bottom. For production of pigments detergents synthetic resins miscellaneous inorganic salts such kind of spray driers are often used.

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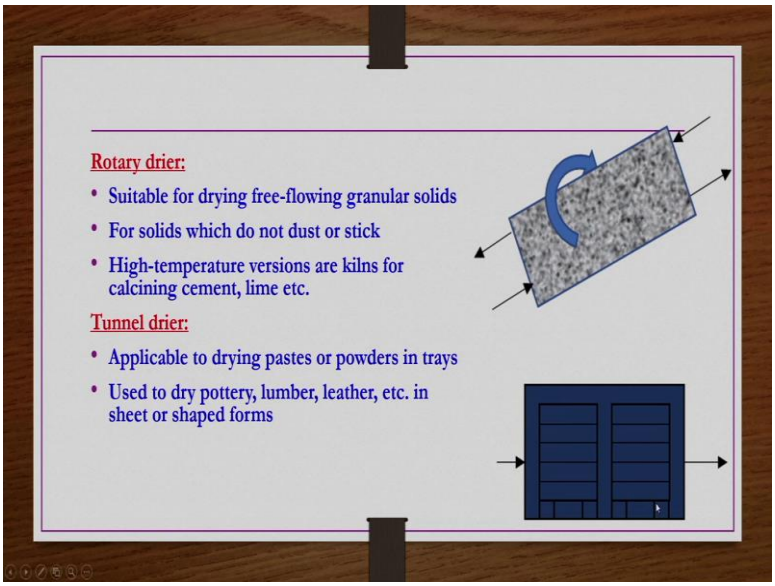

Then rotary drier they are suitable for drying free flowing granular solids, for solids which do not dust or stick and then high temperature versions or kilns for calcining, cement, lime etcetera they are very common in organic chemical industries. So, pictorial representation is given here. Then tunnel driers applicable to drying pastes or powders in trays used to dry pottery, lumber, leather etcetera in sheet or shaped forms.

So, some pictorial representation is given here. So, details you may be studying in your mechanical unit operation course.

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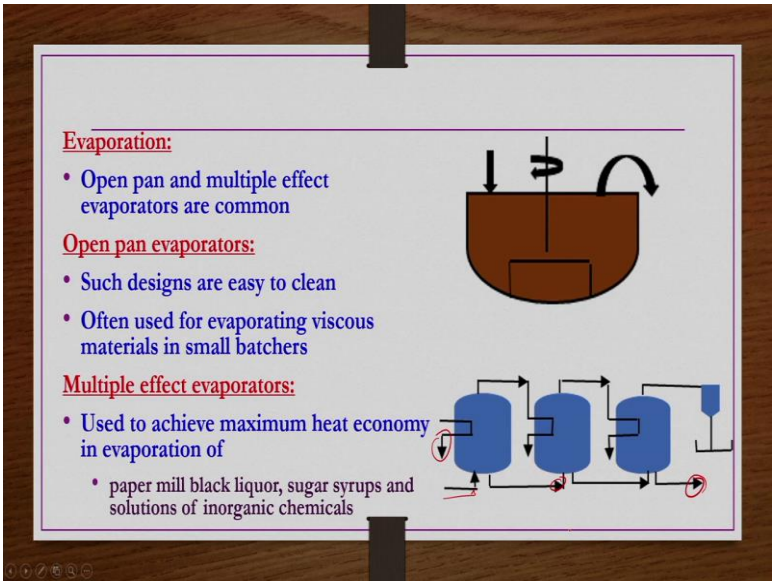

Then evaporation, evaporation is a very common process for majority of chemical production units where you know some of the volatile component may be evaporated alright. So, for such reasons we may need to go evaporation which is more economical compared to the other kind of process. Sometimes what happens you know the same operation can be done by different unit operations, but it is better to choose a kind of one which is you know economically better one.

So, open pan and multiple effect evaporators are very common in chemical plants, open pan evaporators such designs are very easy to clean often used for evaporating viscous materials in small batchers. And then it is a simple kind of equipment that you can see a container where you have a liquid viscous liquid etcetera whichever you wanted to do the evaporation of the material. So, then feed you can take it and it is rotating and it is at different temperatures delta t is provided here. So, that evaporation can take place.

Whatever the viscous material after evaporation has been done that can be collected as a product. The same can be done economically much better way if you use multiple effective operators, used to achieve maximum heat economy in evaporation of a paper mill a black liquor, sugar syrups and solutions of inorganic chemicals.

Paper mill and then sugar syrups etcetera, sugar industry etcetera is the one where a lot of evaporation process need to be done, paper mills you will be surprised to see that paper production when we study. So, from the pulp we prepare a pulp and then from that pulp we will making a paper right different size and then thickness etcetera.

In that process what you will be realized to see that that pulp is more than 90 percent is water. So, evaporation of the such amount of water etcetera is not going to be easy and then if you are not doing efficiently using the chemical engineering principle. So, then it is not going to be economic right. So, one of such kind of provision to have a heat economy in evaporation is by making multiple effective operators like this.

Let us say that material whatever you wanted to evaporate. So, that is taken here through this feed and then heat is supplied here right. Some amount of evaporation is taken place and then that material is taken to the next level here, whatever the heat that is taken away from this one.

So, that will be fed as a kind of feed inlet heating provision to the next level, like that it is done in different stages. So, then that is known as the multiple effective evaporations. At the finally, you may have a desired you know material which is having less amount or no amount of moisture or water etcetera.

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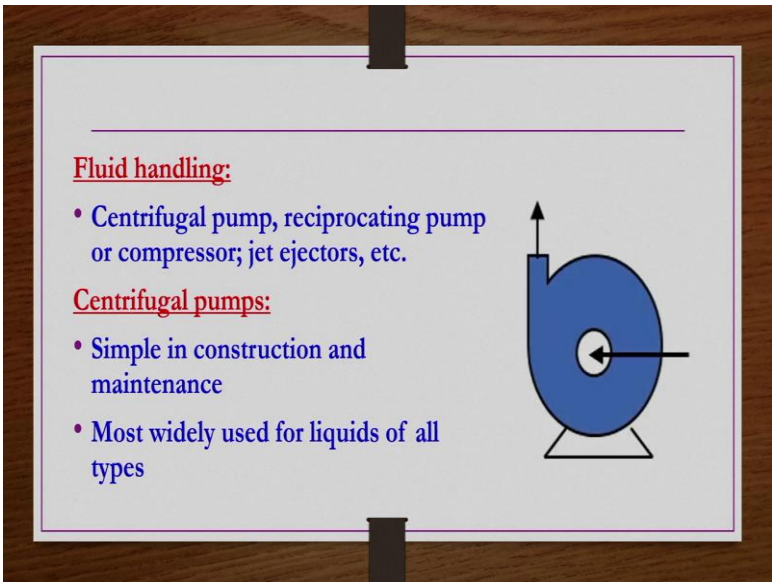

Next is Fluid handling, different types of fluid handling equipments or pumps are available some of them are centrifugal pump, reciprocating pump or compressors, jet ejectors etcetera. Centrifugal pumps simple in construction and maintenance mostly used for liquids of all types, where centrifugation principles are used to transport the fluid from one level to the other level.

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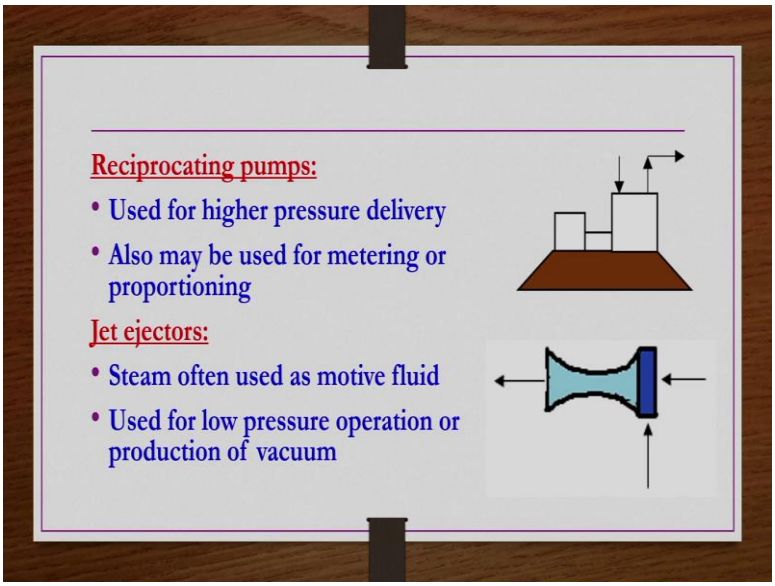

Reciprocating pumps used for higher pressure delivery also may be used for metering or proportioning, a pictorial representation is shown here. Jet ejectors steam often used as motive fluid used for low pressure operation or production of vacuum, pictorially shown here in jet ejectors ok. This is about a few of a common unit operations in the next class we are going to see a few more unit operations which are very common in chemical plants ok.

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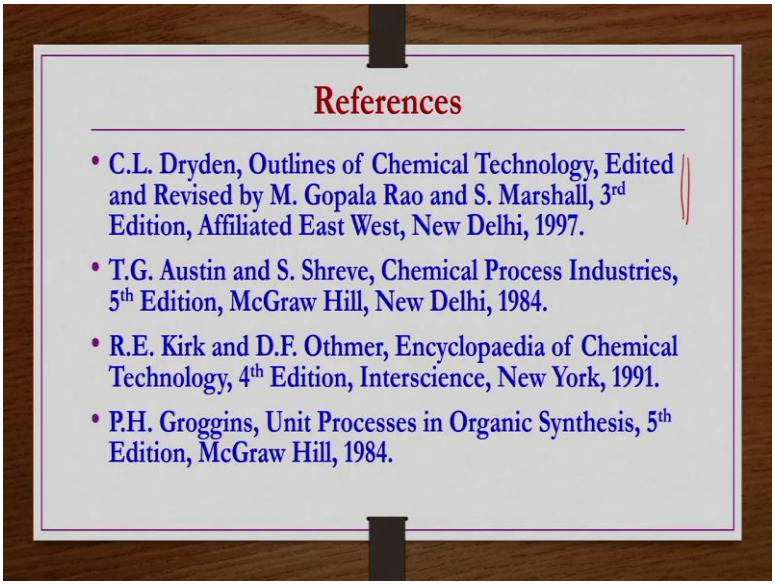

The references for this particular lecture are provided here; however, most of them you can find in this particular book outlines of Chemical Technology by Dryden.

Thank you.