Introduction to Mineral Processing
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Lecture - 50
Gravity Concentration (Contd.)

Hello, welcome to this week tenth of this lecture series. So, we are discussing about the gravity concentration techniques. So, what do we start with, I will show you another very important gravity concentrators, which are known as jigging or say jigging concentrators.

Now, jigging is a very old concept even our say such a few 100 years back, even people used to use this technique. But now the mineral processing engineers have tried to perfect it in a much better way. So, this is what I was I am going to talk in this lecture now what is jigging.

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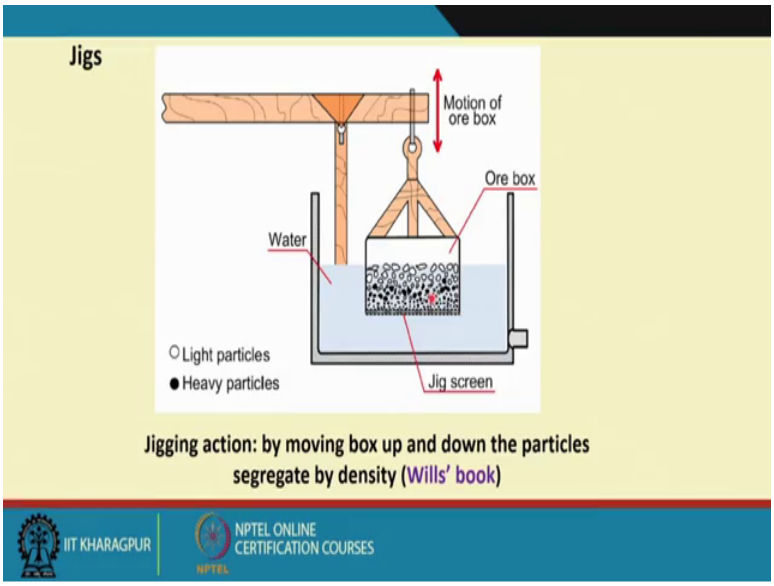

If we look at this picture this I have taken again from bay wills book, that if I have a your ore box like this and this is a say just imagine that at the bottom, you have got some screen or the screen apertures are finer than the apertures than the particle size of the finest one. So that means, whatever the finest particle you have the if the aperture size is smaller than that.

So, essentially if you have a mixture of different particles, differing in size and density; So, all the particles can be rested on these your say jig screen and you will be having a bed formation like this. Now, these white particles say suppose they are representing light particles and dark colored particles they are representing the heavy particles.

Now, let us say that this is my ore box and by some kind of this mechanism, we dip them or we move into a water body say continuously. So, what do we do? We are trying to dipping it and then raising it dipping it and raising it.

So, what will happen? After sometime we will find that there is some reorientation of the particles, based on their densities as well as the size and this is nothing, but is known as jigging, and this is what I was talking about that even few 100 years back even actually people, they used to use this for separating many particles like it may be your say small stone chips from your rice grains or maybe for concentrating your say the cassiterite minerals which is available in many places across the globe, sometimes they used to use it for even for gold extraction processer or maybe say gold concentrating processes.

Now, question is that, that is if I just dip into that. So, what will happen? So, that this fluid that is the water, it will try to displace the particles so; that means, the volume of this ore box will be increased where the different particles will be also moved upwards.

Now when we do that what we exactly we were trying to do? Now, this black colored heavy particles maybe was trying to go down, but they were not having adequate void spaces available that is the free path was not available for this particle to move down; but when you are increasing the volume by a fluid medium.

So, these particles are getting the void space, but again you have got a resistance offered by the fluid. So, when you are moving it and dipping it so, what you are trying to do? That is when you are moving up; that means, the particles will be the water also will try to go down because you are trying to take up the box.

So, the water will be drained and because of that the particles which are faster settling, they will be also having a downward motion which is getting accelerated because of the downward motion of the water. Now, when you are dipping it so, the water will try to go up. Now because, when the water will try to go up; So, the particle bed also will be expanded. So, when the particle bed is expanded so; that means, you are increasing the void space between the particles. We will discuss more about this to clear all your doubts in due course of time.

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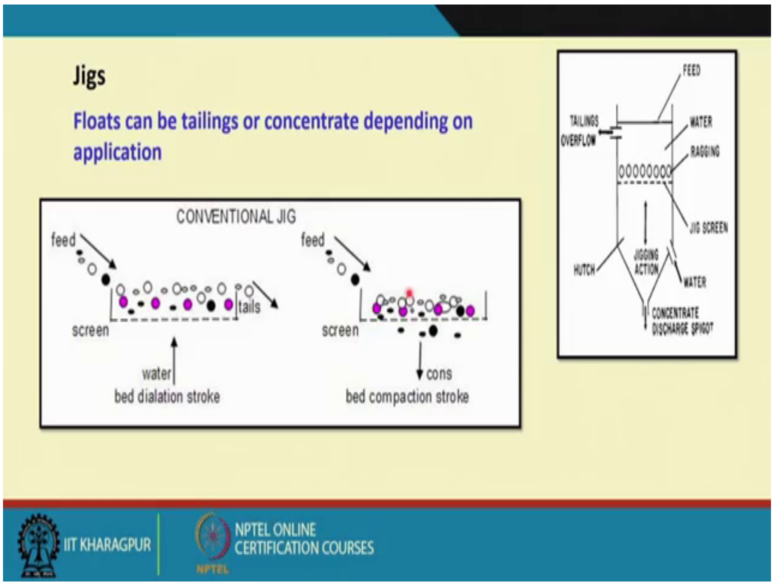

Now, this principle is known as the jigging principle and now for these mineral particles even that I wanted to show you like this some kind of your schematics that is again. So, what is happening if I have a screen? So that means, that is what I was trying to explain you that the screen apertures should be such that that all the particles can rest on them.

So, this is the feed stream, say suppose this is coming now I want to make it continuous one. The earlier one what I have shown you that is a batch type process. Now, say suppose you imagine there is a continuous process I want to adopt this, your technique.

So, what you do? You are having a feed that is again your dark colored particles are heavier and these lighter colored particles are basically the whiter you know. So, that the lighter colored particles are basically the lights that is your light particles. So, what will happen when you have a mixture like this, and then you have you can have some kind of particles like this, whose densities may be in between so, but the feed material is poured into this bed jig bed.

So, they will initially form a bed of particles. Now, if you have a your water it is going up and down. So, essentially after certain time you will find that the lighter color lighter particles they are coming through this your overflow because when the water will go up.

So, this volume space of this will be expanded and because of that there will be some water also will be say going down towards this your, if you have some kind of arrangement that water will pass through only one outlet. So, the water will try to move in this direction from here to here, it will have a horizontal velocity gradient and that will transport whatever the lighter color lighter particles are there in the top layer, and that is how you can separate the lighter materials.

Why we are saying tailings? Because most of the cases in while dealing with minerals, the mineral part the my wanted materials are relatively heavier density than my unwanted materials. So, normally in the jigging we say that this is the overflow materials they are tailings and whatever is left with that is called we call it concentrate. Now how do you take out the concentrate? There are also different mechanisms that I will show you in subsequent slides.

So, first let me explain you that how it works ok. So, you see that even you can have some kind of arrangement that your jig screen plate may not be that fine. So, it may have some perforations which are even bigger than your the particles. So, what will happen in this case? So, when you are bringing down the water velocity because when you are having your eyes are rising your velocity of the water.

So, all the particles will be suspended and may be the tailing particles will be going out through this, but in this case when it is going down that is when the water is going down, because the perforations are much bigger. So, even the concentrate particles they can pass through that, because they will be at the bottom most layer and they can pass through that. So, that is how we can take the your say concentrate also. So, that is called the bed compaction stroke.

So, if I have that type of arrangement, that is what should be the dimension of my screen apertures we can fix that. So, during the upward movement of fluid, that is in this case we call it the your upward direction that we call it pulsion. So, during the pulsion your tailings are taken out and when it is going down. So, that is called the suction.

So, during the suction stroke, that is when the fluid is going down your relatively tensor particles will be taken out through the under flow. This is these are the two techniques we can use that is here the aperture sizes. So, it is called the jigging over the bed because here the aperture sizes are such that, that all the particles that is even your finest of your particles they are coarser than the aperture size that is your say screen aperture size. So, here the it is called the jigging over the screen at this is called a jigging under the screen. Now, there may be another situation where, I can have some kind of your ragging material.

That means, you artificially want to increase the density of your bed so that I can have your minimal effect of the differences between the particle sizes that is the separation I want to promote based on only the density we want to promote it. So, there we can use some kind of your bigger particles, which are having higher densities and when the water having a movement like this upward movement so, this particle also will be we call it fluidization.

So, this particle also will be lifted up, but there they will be lifted much lesser distance in the upward direction, they are my particles because they are heavier higher density particles and they are much bigger sizes. So, in that case, we can have a overflow that is the tailings because the bed expansion, but when it is contracting. So, what will happen; because the particle sizes are relatively bigger here. So, you have got a bed, but you have got your voidage inside the ragging materials because these ragging materials are heavier and coarser.

So, they will travel faster than any particle of this mixture. So, this particle will now rest on the jigging jig screen. So, this particle sizes should be bigger than the jig screen apertures and, but because they are bigger. So, they will be having some void spaces in between the particles that is your ragging materials.

So, my coarser particles my denser particle size, if it is finer than my your jig screen apertures, but they are finer than my ragging materials. So, what will happen? The relatively denser particles they will pass through that ragging bed and then they will pass through the or say actually that jig screen.

So, that is how you can have a removal between the tailings and concentrates, but here you see that here also you are having additional water so, that I can have sufficient upward velocity of the water. So, were injecting water through this. So, that to control the what is what should be the your say your expansion rate, that is how much of fluid fluidization velocity, we call it there is a upward velocity of the water should be.

So, that we decide based on because if it is if the water velocity is too high. So, even the lighter particles they may overflow like this which is uncontrollable, but I want the overflow particles to pass through this launder, we have a tailing overflow a discharge gate. So, it should be collected through that. So, we have to adjust we have to control my upward water velocity in such that, only the lighter particles they go out through my tailing discharge gate.

So, how do I control it? That is by controlling this water flow rate because it is in the upward direction and this also helps that if by any chance any small tailing particle, they pass through this aperture they will be also sent back here because the small lighter particles, they may pass through this, but this because of this upward velocity of water, they may not get contaminated with the concentrate whatever we are collecting through the concentrate discharge gate.

So, when the heavier particles are settling down. So, we have got a concentrate discharge spigot and the concentrate is being collected through that. So, this is in simpler terms how a jig works, but it is little bit complex to control all the parameters to perfect the separation.

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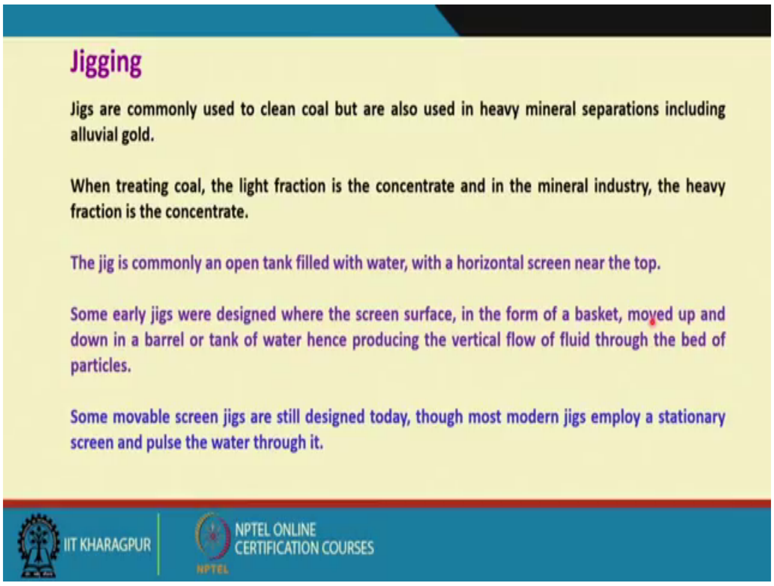

So, now with this introduction let me tell you that jigs are these days are commonly used to for coal processing. But they are also used extensively in heavy mineral separations including alluvial gold, even in iron ore processing and even cassiterite processing, even in chromite processing in certain cases so, but apart from mineral processing these days these principles are also being applied in recycling industry like hospital lowest recycling industry, like electronic waste recycling industry. So, there is a very important unit operation and considerable changes in the designs in the design features, have been made by the different manufacturers.

So, we would not go by the different manufacturers your design will only concentrate will only focus on the a general design purpose the general design features. So, there is a fundamental difference between the jig in the design features for the jigs, when they are designed for processing coals and when they are designed for processing minerals. What is the fundamental difference?

The fundamental difference is that when treating coal because in a coal my wanted material that is carbon ditch part or it is a carbonaceous material, they are the lightest bit they are the lighter particle than my gang material; gang materials are called shale that is your unwanted material. So, when you are doing jigging. So, it is the clean coal that is my concentrated your coal fractions they are being collected through the tailing launder what we say in case of mineral operation; that means, they are the float fraction and my unwanted materials are the reject fraction.

But in case of minerals as I said that normally, our wanted materials are higher densities than my gang mineral. So, my gang minerals are collected as the float and your heavier minerals are collected through the, your sink. Another difference is that that is in case of coal washing typically for Indian coal, it is the relative volume percent for the rejects is much higher that is what is coming through the sink that is much higher in relation to your minerals because say suppose we are processing gold ores.

So, gold ores that is your relatively higher density particles, they are volume fractions is much less in relation to the our say tailing materials or the unwanted materials. So, what is the fundamental differences between the designs? That is you have to collect a relatively larger volume of material as your sink material, while processing in coal in comparison to while processing minerals.

So, the mechanism through which you are collecting the your sink fraction, that is your it has to be different while designing for coal jigs and mineral jigs. As so, I have written that when treating coal the light fraction is the concentrate and in the mineral industry the heavy fraction is the concentrate. The jig is commonly an open tank filled with water with a horizontal screen near the top that is what we have already explained. Some early jigs were designed where the screen surface in the form of a basket that is what I have shown you at the very first slide.

Moved up and down in a barrel or tank of water, hence producing the vertical flow of fluid through the bed of particles this is what I have already explained to you. Some movable screen jigs are still designed today though most modern jigs employ a stationary jig and pulse the water through it. That means, in case in the first slide what I have shown that screen is basically you are moving.

But the other sketches that is what I have shown here, what is the difference here that this jig screen I am moving up and down, but in the modern day jigs we are not moving the screen, we are moving the particles which are sitting on top of the jig. So, this jig screen is fixed. So, we are not moving this.

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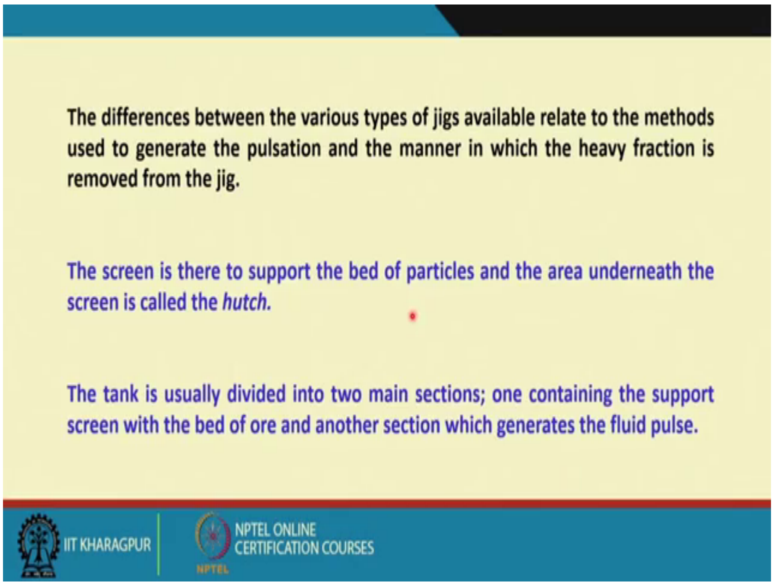

So, this is the difference between your earlier designed jigs and the presented jigs. The differences between the various types of jigs available relate to the methods used to generate the pulsation. Pulsation means the upward velocity and the manner in which the heavy fraction is removed from the jig; that is in case of coal the manner in which the clean coal fraction that is your float material is removed from the jig. So, what are the various design your say differences that is how you generate that upward velocity of water?

That is how you are doing suction and your say pulsation and suction and the manner in which the products are basically taken out. Because here what is happening there is a while doing it for a few times, you will find that there is a stratified bed. Stratified bed means the particles will reorient themselves as so, based on their say density and size.

So, if you know how to control the size; that means, if you are feeding a discrete size range or particles, then the your orientation or the say segregation of the particles will be in such a manner that only the denser particles will form the bottommost bed and the lighter fraction will sit on the top.

So, now, how do I decide that how what is the depth of my your a heavy your higher density particles that is how far in that bed? Suppose the bed height if I assume that it is a static one. So, if the bed height is one meter. So, up to 0.2 meter is my heavier higher density particles or 0.5 meter is my say higher density particles because from what height I should take out my heavier and lighter particles.

So, that is the critical question and then how do I do it without having much of your say mixing up remixing of the higher and higher density and lighter particles. The screen is there to support the bed of particles why you need this screen? Because when you are having suction, then all particles will go down.

So, you need to have a support for the particle. So, that the particles they rest on the surface of the screen bed and the area underneath the screen is called the hutch so; that means, whatever is the area given. So, this is called the basically the hutch.

So, this portion is called the hutch, the tank is usually divided into two main sections. Many times these water sending water from the side, it may create some channeling related issues because how do I disperse this water and how do I control this your upward velocity of water that becomes a very big problem to the designers.

So, the tank is usually divided into two main sections, one containing the support screen and the bed of ore and another section which generates the fluid pulse.

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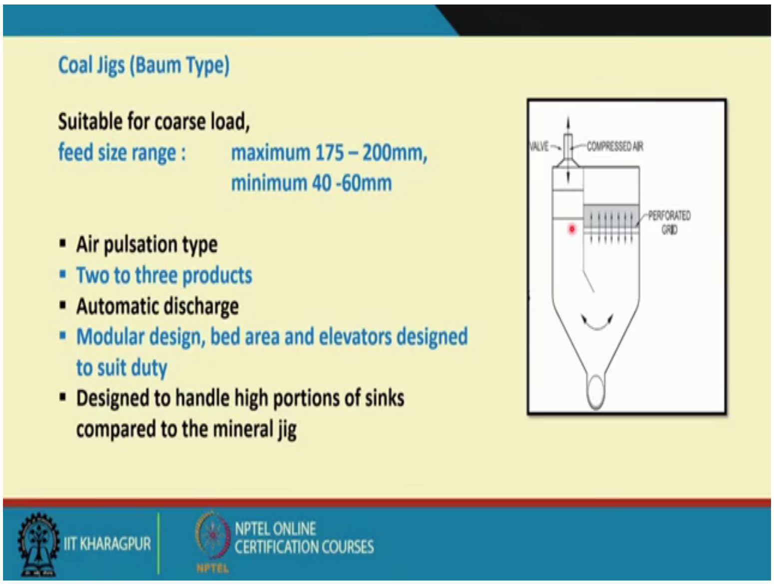

I will show you that is like this that is you have got a entire tank and part of that you have got a compartment here, and then this is the perforated grid that is your screen say suppose the particles are sitting on top of this and this is the hatch that is filled up with water and then here, you have got a compressed air that is you have got some kind of a system that through which, that is you have got a your plunger type of action and then you are just pressing this column of fluid here that is your water. So, big when you are sending when you are trying to compress it that fluid.

So, the fluids because of you have got the available volume here. So, it will try to go up like this. So, that is how. So, when you are pressing the plunger here. So, then that fluid will be compressed and then it will try to expand through these, which will create the upward movement of the water and because of that my bed will also bed of particles also will move up.

And when you withdraw this so; that means, I am pressing it like this and then I am releasing it. So, if I have that type of system with a piston type of system. So, what will happen? When you are withdrawing it, then this fluid will try to go back to fill up the remaining your say back in space that is you want to make a your say fill up the water this back void space will be filled up with water and because of that, there will be a downward movement of your water.

And that is if you I do it repeatedly so; that means, you are having a your pulsation and suction stroke like this. So, this is how you can create the pulsation and your say suction in this, and this is what I am writing here that the tank is usually divided into two main sections; one containing the support screen with the bed of ore and another section which generates the fluid pulse. So, that left head section of that sketch is basically creating the fluid pulse, that is your pulsation and suction stroke you are creating with the fluid.

Because you are pressing compressing it and then because of that the fluid is going up and when you are withdrawing it, the fluid will try to go back. So, you will have a pulsation and suction. So, this is one kind of mechanism.

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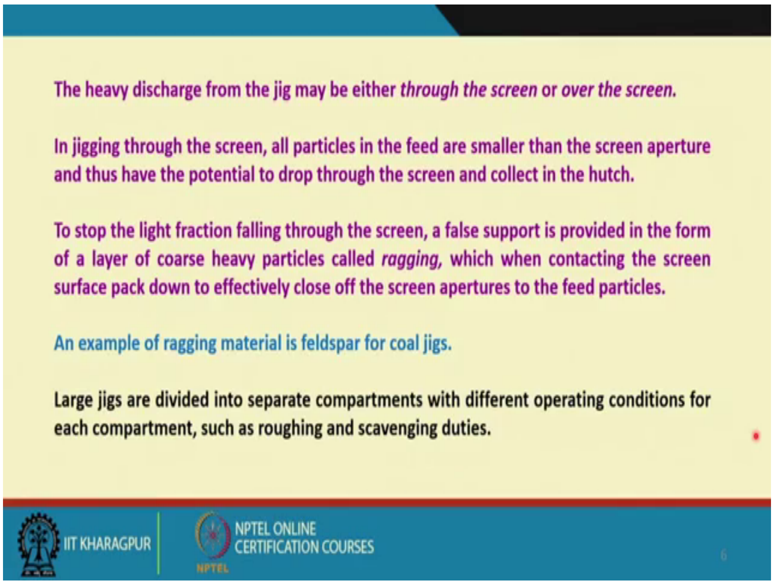

Now, the heavy distress from the jig may be either through the screen or over the screen that is what I have already explained you in the second slide. In jigging through the screen all particles in the feed are smaller than the screen aperture, and thus I have the potential to drop through the screen and collect in the hutch.

That means, in this case it is gene through the screen all the particles are finer than the, your screen aperture. Now, if that is the case then what will happen? All the particles during the suction stroke will go to the hutch. Now, to stop the light fraction, but why do we need a jig then your say screened in? Because you do not need a screened in you just feed all the materials to the, your hutch directly.

But you want to prevent that light fraction falling through the screen. So, what is that you do that is what I have also explained in the second slide, that image that is you to stop the light fraction falling through the screen, a pulse support is provided in the form of a layer of coarse heavy particles called dragging, that is what I have explained it through this that is you have a your jig screen whose aperture is much bigger than the particles what you are feeding.

But these particles are bigger particles and heavier particles, but they can their sizes are more than the aperture sizes. So, they can sit on the your. So, this jig screen is basically kept there to provide support to my ragging materials and so, what happens if fall support is provided in the form of a layer of coarse heavy particles called ragging, which when contacting the screen surface back down to effectively close of the screen apertures to the feed particles.

That means when they when they rest on that particle your screen surface. So, when you are feeding the particles, the particles does not have access to pass through the your screen apertures. So, an example of a ragging material is feldspar for coal jigs. Large jigs are divided into separate compartments with the different operating conditions, for each compartment such as roughing and scavenging duties.

Like what happens in one stage my separation may not be perfect. So, what is being done? You take a your say you take a large compartment, you take a large your volume of tank and then you make compartments. Now, what do you do that is in the first compartment, you adjust your water your upward water velocity or the pulsation and pulsation and suctions your mechanism in such a way that only the heaviest particle that is the heaviest and coarse particles they are taken out from that portion. So, your material is not yet cleaned.

So, now when you are taking out the heaviest fraction from that you if you are not sure that whether still some lighter material is coming through that, then you may send that your sink material to another tank and then they are again you can have some adjustment of the pulsation and suction and you can clean it as long as you are not sure that all the heavier particles in your feed materials, they are cleaned reasonably well from the they are free reasonably free from the lighter particles.

So, the first stage we call it roughing stage, then second one we call it scavenging and next your say consecutive stages which say cleaning stages. It may be reverse also that is you may try to you are say send in the float fraction, your majority of the particles only the heavier and coarser particles you want to say have in your fast say your compartment as your concentrate. But what is being over flown that is your what is being floated. So, that may be taken out, that may be taken to the or may be transferred to the next compartment.

Because you may still have some relatively smaller sizes heavier particles. So, you keep on doing it until you are very sure that you are not losing much of the heavier fractions with your lighter fractions. So, this is what actually is the choice of the designers, that is how do I design my jig and many a times it is again dictated by the nature of your particles what you are going to process. Nature of the particle means they are size distribution, their density distribution and the level of accuracy you want.

So, this is these are the general features of a jig how it works we will explain, I will try to explain you it much it get a depth that how do they really work what are the basic mechanism and I will try to show you some of the dimensions of the industrial scale jigs and I would try to show you some of the your jig compartments also in my next lecture till then.

Thank you very much.