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NPTEL ONLINE CERTIFICATION COURSE

Unit Operations of Particulate Matter

Lec – 17
Flotation (Part -02)

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Welcome to the second lecture of fourth week of the course unit operations of particle it matter and in this week we have started flotation we have started discussion on flotation process in lecture 1 and that we are continuing in lecture 2 also, now as far as flotation is concerned in this particular lecture we will discuss different steps involved in the flotation process then we will discuss different equipment used in the industry for a flotation purpose and through one example we will discuss how the recovery is done or it how the calculation for recovery of a compound is carried out in a flotation process, so let us start the lecture 2 with the steps of flotation.

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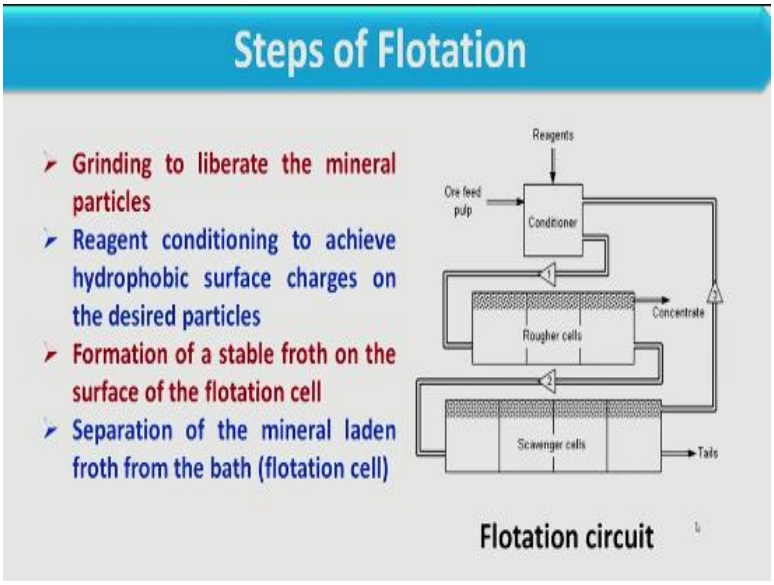

Now as far as steps of flotation are concerned the very first step is the grinding to liberate the mineral particle so if you remember the last lecture we have discussed that you take the rod directly from the minds and these rock first crushed or grind into small particle and then these particle which consists different types of ore that will be used for flotation process so first step of this is to grind or to crush the rock into small particles to liberate the mineral.

Secondly reagent conditioning to achieve hydrophobic surface charges on the desired particle so one I am having this mixture of a small particle we enter into the conditioner where different reagent like collector furthers and modifies all these are added so that whatever component we want to be floated off that it surface characteristic can be changed, then formation of a stable forth on the surface of the flotation cell.

Here in the flotation cell after conditioning material enters and then water and air enters into this it forms a slurry and after flotation process we have a stable froth on the surface of the flotation cell, and finally separation of mineral laden froth from the bath so that we have to separate the forth and then after this after breaking this froth we can collect the mineral we can collect the ore involved in this froth.

We can recover the mineral or ore associated with this forth, so here in this diagram if you see we have shown the flotation circuit here reagents and ore are added into the conditioner where different flotation agents are added to prepare the desired surface of the material and then it enters into the rougher, rougher is nothing but the flotation cell where flotation will be carried out floatation of desired material will be carried out and that will be collected as a concentrate.

But dealing of this that this material which sinks that enters into the scavenger and then finally we have that tail as well as concentrate, so this is the circuit of flotation process.

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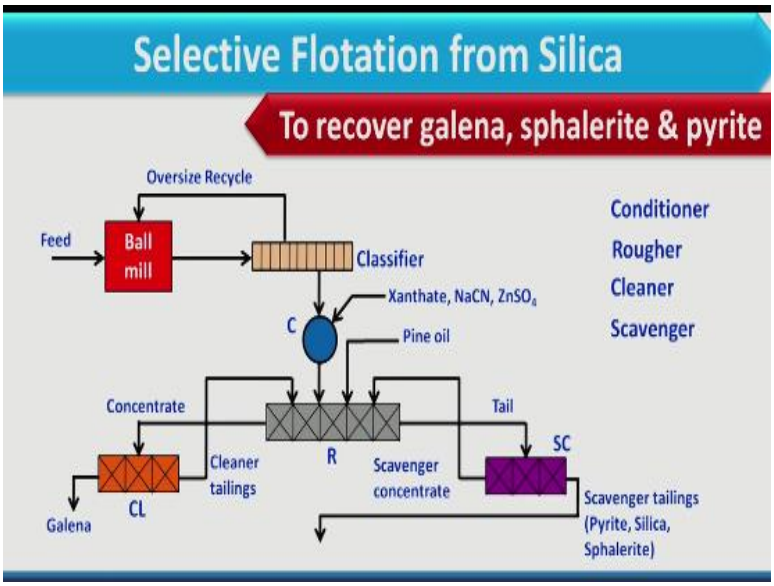

Now in this slide here we will discuss selective flotation from silica and why we are use the selective flotation because it is the mixture of galena, sphalerite, pyrite and silica so we have to recover galena, sphalerite and pyrite from silica one by one. So let us start the flotation process for this as we have discussed that the first step is to grind the rock, so here feed enters into ball mill and after crushing this feed the small the product or the outlet is stream of ball mill enter into the classifier.

Where smaller particle which can be classified which can be separated from the larger particle so larger particle then a certain size will be recycle back to the ball mill and the product of classifier or the outlet stream of classifier or we can say the fine particle which we have collected through classifier enters into the conditioner, so you see here we have the conditioner where Xanthate, sodium cyanide and zinc sulphate enter.

Now what is the purpose of xanthate is it will work as a collector it means it prepares the surface high grow for big now before that sodium cyanide and zinc sulphate has to modify the surface of component for example sodium cyanide is used to depress pyrite that we have discussed and zinc

sulphate is used to depress sphalerite so when we ar6e adding these two modifiers sphalerite and pyrite will be depressed and galena will would be at floating condition.

So after this conditioner the material enter into the rougher where pine oil will be added and pine oil will be used as a frothier, to give stable froth so as we know that we have already depressed pyrite and sphalerite so only galena will be floated off so the concentrate of rougher which consist of maximum amount of galena, it will enter into the cleaner this Cl is nothing but the cleaner.

Because along with the galena some particles of sphalerite and pyrite may come into this so again here we have the floatation process where galena should be floated off and we have collected this concentrate of cleaner as pure galena here recovery is very promising, so telling off cleaner will be recycle back to the rougher because it contains some amount of sphalerite as well as pyrite.

In the similar line the tale of rougher which consist maximum amount of sphalerite and pyrite and it may contain some amount of galena so it will enter into the scavenger where galena will be floated off and in terms of concentrate of scavenger galena enter into or recycle back to the rougher, the tailing of scavenger it consists of pyrite, silica and sphalerite, so you see first step only galena will be floated off or only galena will be separated.

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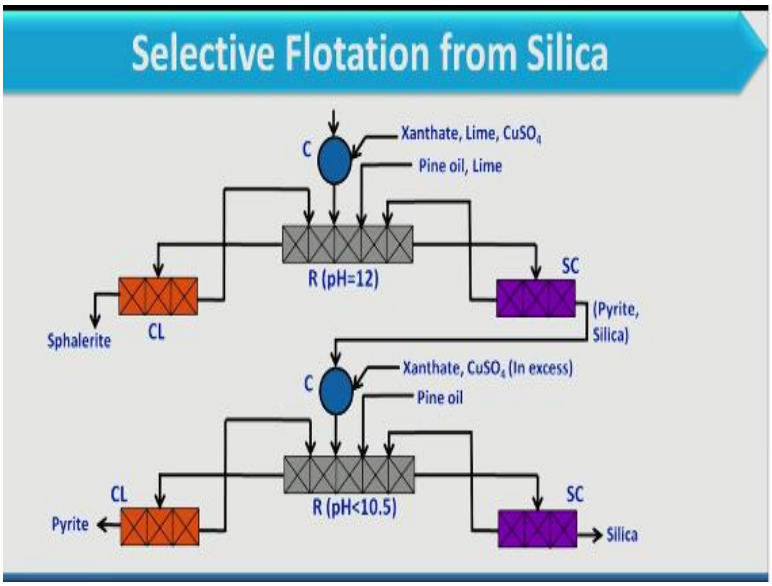

So after this it will again enter into the conditioner now here this stream consists of sphalerite, pyrite and silica. And here we are adding xanthate, lime, copper sulphate now why we are using copper sulphate because copper sulphate is used to activate this sphalerite. And then the mixture enters into the rougher where we are adding pine oil and time, pine oil as a frothier, lime is used to maintain the ph of the media.

Because if you remember the critical ph of sphalerite that is 10.4 and we are maintaining higher ph of the media so only sphalerite will be floated off, concentrate of this rougher consists of maximum amount of sphalerite is we it will enter into the cleaner because it consist some amount of silica as well as pyrite. The concentrate of this cleaner consists of sphalerite in pure form and tale of cleaner which consist of pyrite as well as silica it will recycle back to the rougher and similarly rougher tale enters into the scavenger to collect the tale and where whatever amount of sphalerite is available that is recycle back to the rougher as a concentrate tail of scavenger consists of pyrite and silica.

It will further enter into the conditioner and in this conditioner xanthate and $CuSO_4$ in excess will be used so if we use copper sulphate in excess it will activate pyrite and then following same

procedure of rougher, cleaner and scavenger we can get pyrite as a concentrate of cleaner and silica as a tale of scavenger, so this is the selective flotation process to recover galena is sphalerite and pyrite from silica.

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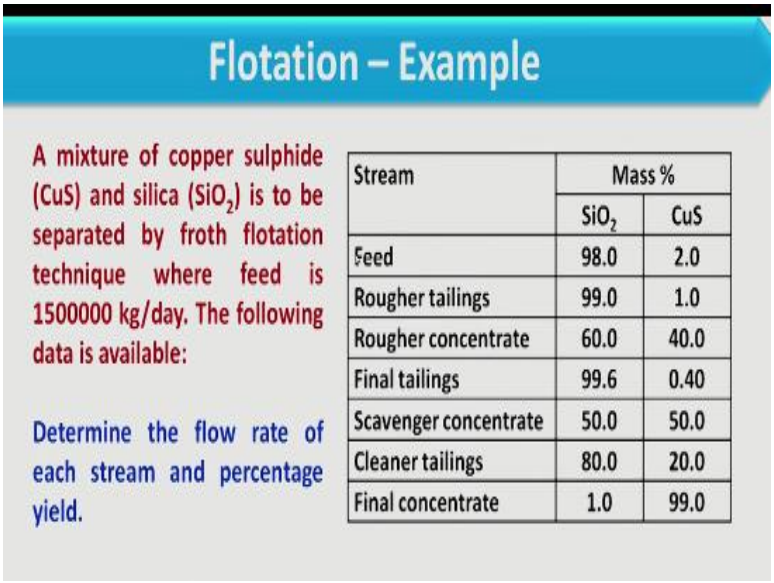

Here I am having one example that how the calculation in flotation process will be carried out to illustrate that a mixture of copper sulphite and silica is to be separated by froth flotation technique where feed is 1.5×10^6 kg/day and the following data is available data is available over here you see here we have feed that is the initial feed which is entering into the rougher so here we have rougher tailing and concentrate.

Final tailing is scavenger and cleaner, so you see here all three units are involves so when we are considering the feed it consists of 98% silica and 2% copper sulphate and similarly composition of other extremes are known, now if you see when we want to recover the copper sulphate the final concentrate which is the concentrate of cleaner it consists of 99% copper sulphate and 1|% silica.

And similarly final tailing which is the tail of scavenger it consist of 99.6% silica and 0.4 % copper sulphate so you can see here recovery is very promising in flotation process, what we have to do in this problem is to determine the flow rate of each extreme and percent yield.

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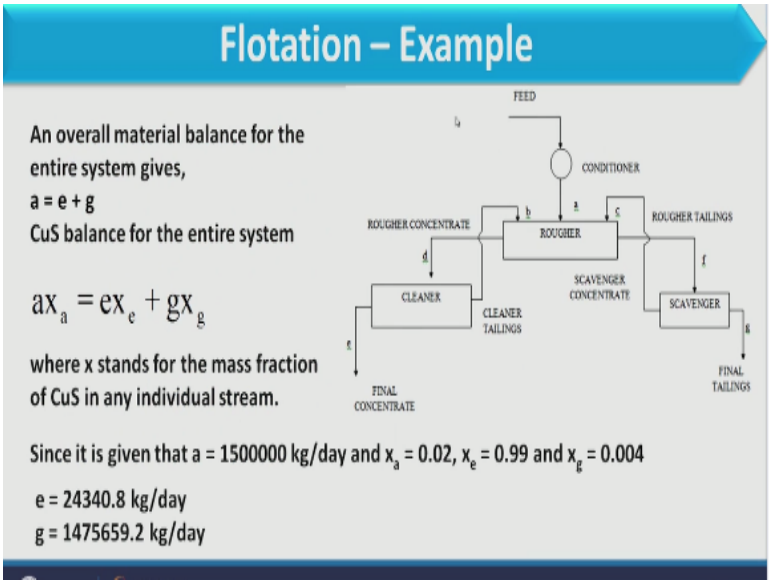

So let us start the solution, here this diagram speaks about the process feed which we are denoting with A enters into the scavenger and then concentrate of scavenger here feed which we are denoting with A enters into the rougher and concentrate of rougher enters into the cleaner from where we are getting final concentrate and tail of rougher enters into the scavenger from where we are getting final tailing as a pure almost pure product.

So different extremes are there which we have named as A, B, C till G so overall material balance on the system is when A = E + G as we have to recover copper sulphate from silica we make the balance of copper sulphate for entire system so whatever is available over here that is $A \times X_A = E \times X_E + G \times X_G$ where X is used for denoting the mass fraction of copper sulphate in individual stream where A is the total feed which is 1.5×10^6kg/day.

X_A is 0.02, X_E = 0.99 and X_G = 0.004 how we can obtain this the for that we have to refer the previous table X_A = 0.02.

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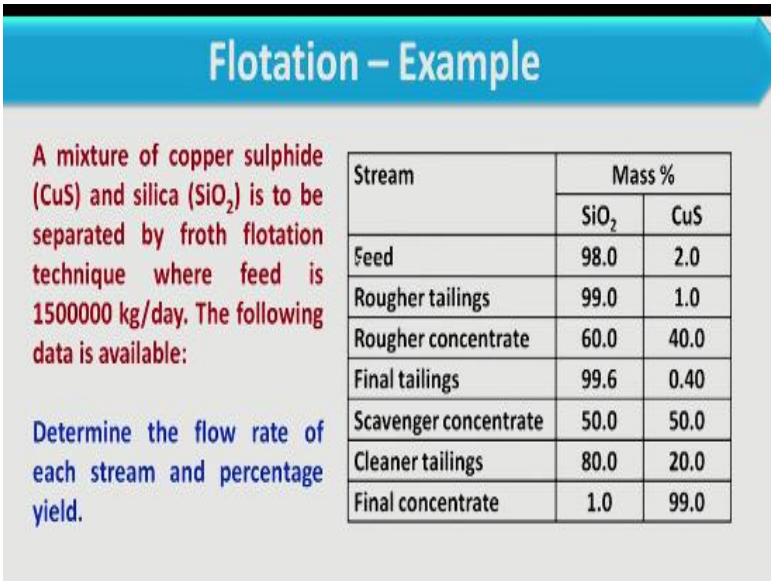

So you see X_A is nothing but copper sulphate in feed so that is s2% so 0.02 we can take from this.

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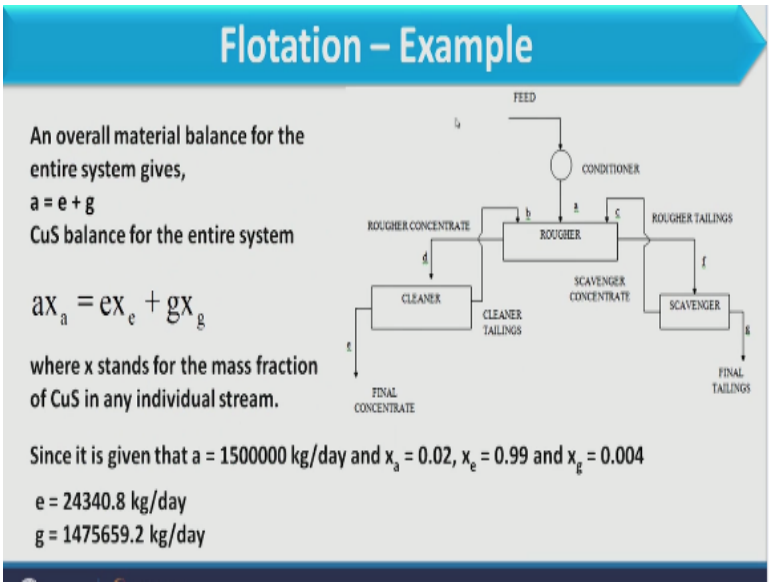

And similarly we can take other fractions after solving these two values while putting the value of fluoride as well as mass fraction we can get E and G as the value shown over here.

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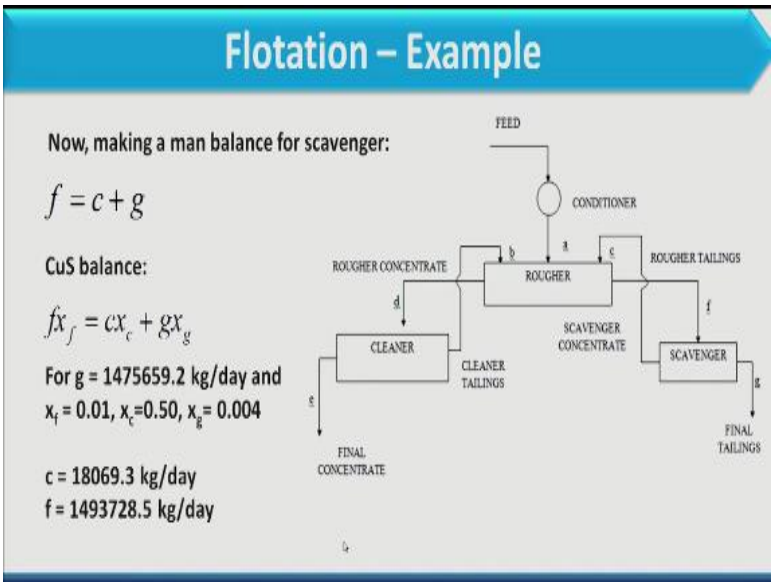

In the similar line we can make the balance over scavenger where F stream is equal to G + C copper sulphate balance in the similar line where G is this much because G we have already calculated from overall balance so that G we put over here and X_F X_E and X_G these value we can obtain from the table which is shown with the problem after solving this two we can calculate a flow rate of stream C as well as stream F. And which we can obtain like this.

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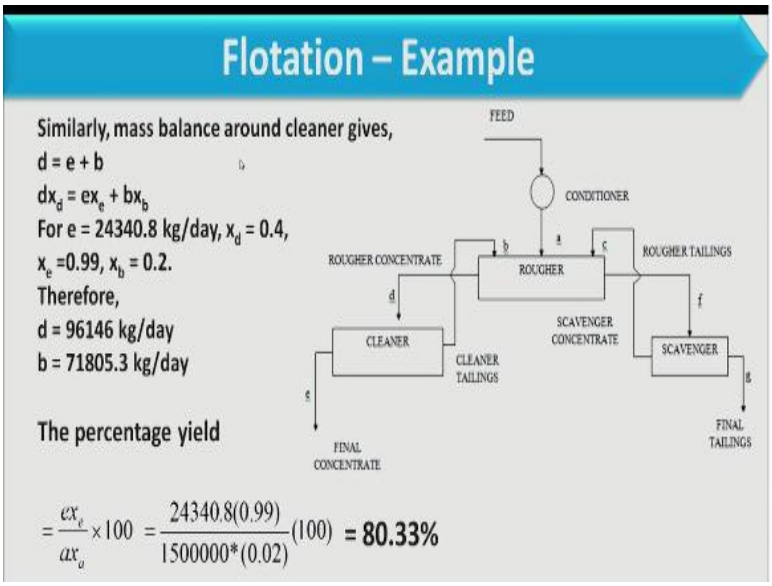

And similarly when we are making the balance over we are making the balance around cleaner so a stream should be D so overall balance should be D = B + E and similarly component balance E we know already X_D X_E and X_B we can see from the table which is given with the problem and here we can get the value of D and B as these values, now next we have to calculate is the percentage yield of copper sulphate.

So that is nothing but $E_{X\ e}$/ ax_a so you see E we have calculated like this total recovery is 99% total feed is 1.5 x 10^6 and x is given as 0.02 so we can see that 80.33 % yield we can obtain from this flotation process for this particular example, now here we will discuss different equipment which are used in the industry for flotation purpose and mainly these are of two types first is mechanical cell and second is pneumatic cell. So let us discuss the mechanical cell.

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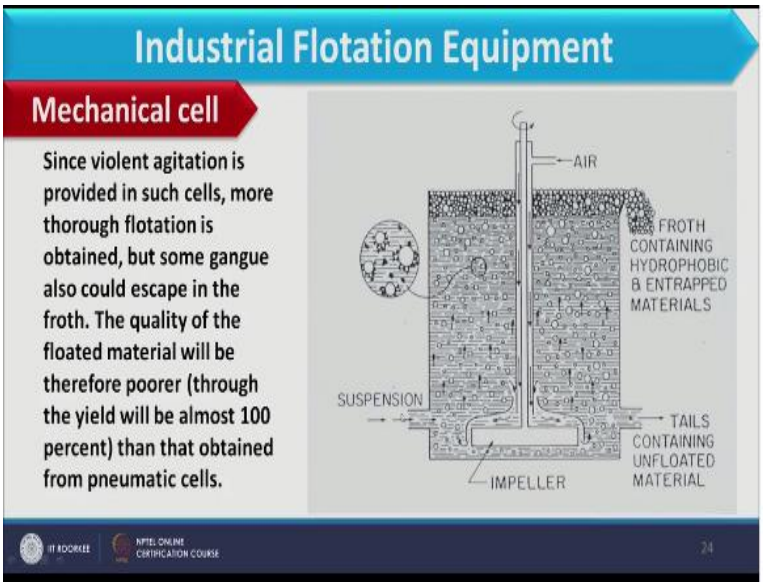

Now what happens in mechanical cell suspension enters into this and this mechanical cell used the impeller and through the periphery of this impeller air enters so you see when slurry enters into this, this slurry contains the water and air we are entering through the agitator and when this is agitated vigorously the air which is entering into this that is broken into a small bubbles and these bubbles float in the cell.

So here we have the water as well as air and suspension carries different compound different agents which make the surface hydrophobic or hydrophilic so you see here when we are considering this particular section its enlarge view shows that some particles are having bubble over it surface so you see here the bubble formation is not very uniform but in some cases more bubbles are involved and in some cases less bubbles are involved.

So when bubbles are significant so that the complete material can be floated of it will floated it will be collected at the so if bubble formation is significant and ensures that the material should be floated off so that would be collected as a concentrate or that would be collected at top of the mechanical cell and that will be collected as froth which consists of material which is hydrophobic and similarly from bottom we can take the tail.

Now if use see this cell here due to this impeller we call it a mechanical cell so since the violent agitation is provided in such cells more thorough flotation is obtained but some gangue also could escape into the froth so you see along with the desired material some undesired material can also enter into the froth because of this agitation. So here the quality of the floated material will be there for poorer.

Though the yield will be almost 100% so that we have already seen that yield in this case is promising we can recover around 99, 98 or more than 99% material in material through this process but because of mechanical or because of thorough wedge because of thorough agitation some undesired material into some undesirable material are entered into the froth and therefore it gives less poor it gives and therefore it gives les pure component less pure material in comparison to pneumatic cell. So here we have another flotation cell.

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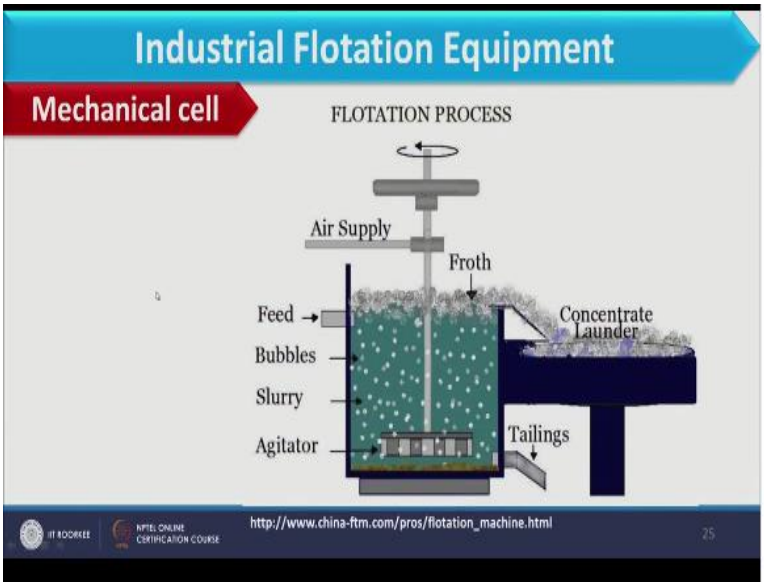

Which is nothing but the mechanical cell only so here concentrate is collected from the top and tailing is collected from the bottom that we have discussed already. Now if you want to study more about this you can go through this link.

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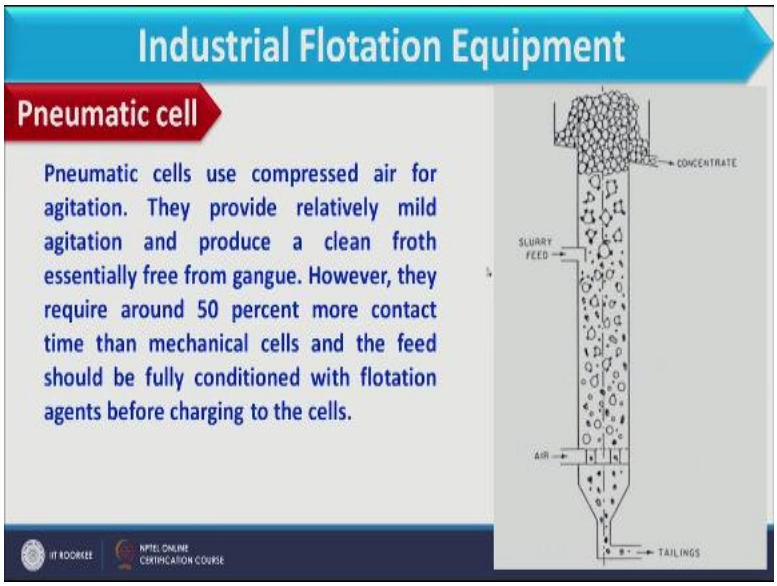

Now as far as pneumatic cell is concerned here we are using the compressed air because here mechanical agitation is not done so agitation is done through compressed air when compressed air enters into the pneumatic cell it provide agitation inside the slurry and through this the air bubbles are broken into small sizes, so pneumatic cells use compressed air for agitation they provide relatively mild agitation and produce a clean froth essentially free come gangue.

If you see this figure here we have the air which enters from the bottom and it is the compressed air so it provide agitation inside the cell so you see here its diameter is very less in comparison to mechanical cell so whatever air enters that is spread throughout the length easily so they require around 50% more contact time then the mechanical cell and the feed should be fully conditioned with flotation agents before charging to the cell.

So here we have after conditioning feed enters into this and contact time over here is more because here agitation is done slowly in comparison to mechanical cell and another advantage of mechanical cell is there because agitation is carried out over there we and inlet the slurry which contains water as well as material which we have to separate and then we can add flotation agents in the mechanical cell itself.

So that is the added advantage of mechanical cell because of agitation flotation agents as well as the flotation process can be carried out simultaneously in mechanical cell, however in pneumatic cell that is not possible and therefore we have to use fully conditioned feed where flotation agents are already included, so here we have discussed the working of pneumatic as well as mechanical cell.

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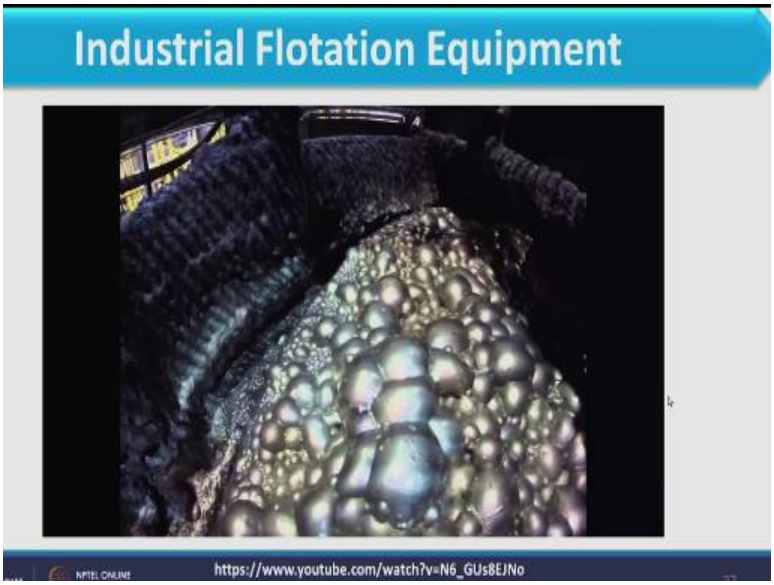

Now in this slide you see here in photographic image is shown where how the bubble look like in actual system that you can observe if you want to study about this more you can go through this link but as far as froth is concerned in actual sense it looks like this.

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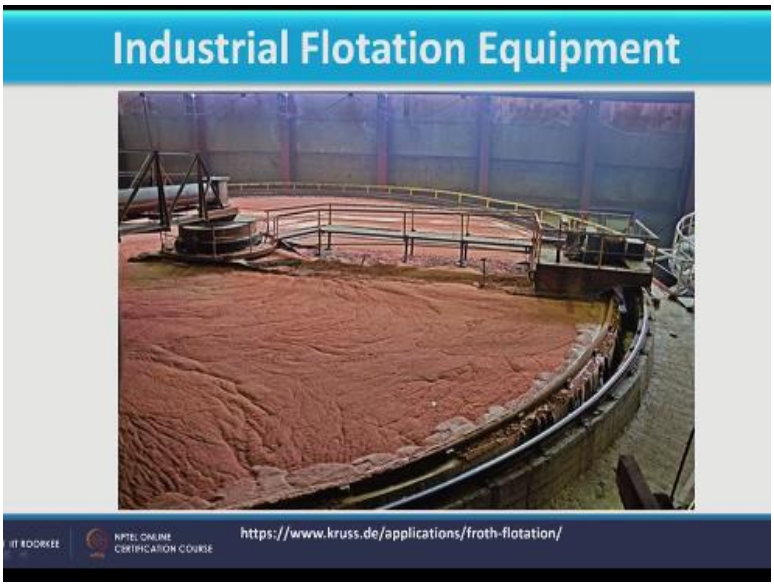

And here also you see at the top froth is there so here flotation unit is very large so that is that will be always a mechanical because pneumatic cell very large we do not use.

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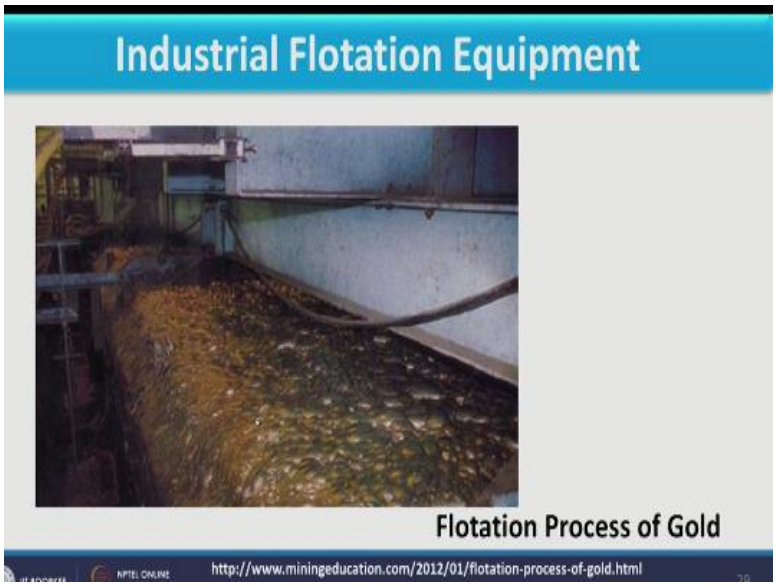

And here we have the flotation process of gold if we have to recover the gold froth of flotation process looks like this, so you can study more about this in this link, so here we have discussed different equipment which are used in industry, now there is one added information which I would like to share like which I would like to share that in single cells single mechanical cell we have different compartments.

And these compartments are very high very large in number like these are some more than 20 or like that these compartments are prepared in a single container so when we are considering very large flotation cell the main unit is 1 cylinder only and where we are making different compartments by metal by placing metal sheet and therefore flotation will be carried out bin each compartments simultaneously.

And their froth will be collected at the top and their forth will be collected at the top and that froth we can take we can take out that froth from one point only so you see inside this we have different compartment so as for as froth is concerned that will be collected at one point only.

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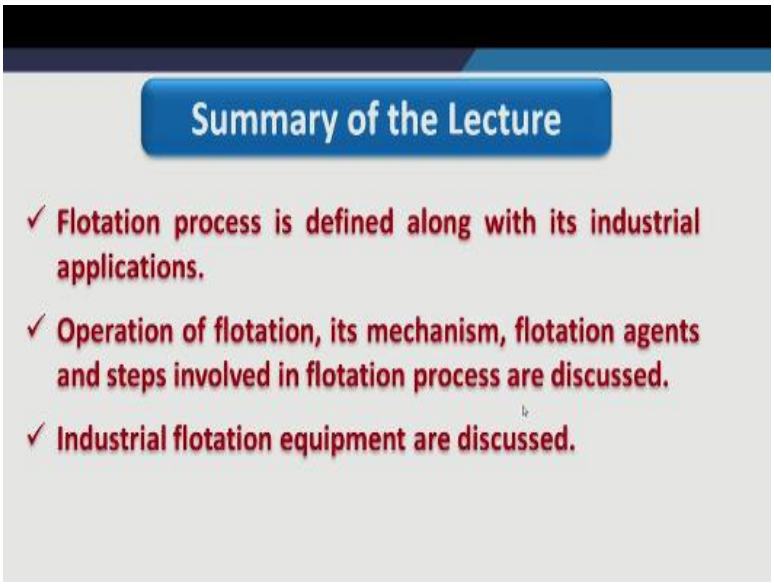

Here we have the summary of this lecture and this summary consists of summary of lecture 1 and lecture 2 of this week here flotation process if defined along with its industrial applications operation of flotation it is a mechanism flotation agents and a steps involve in flotation process are discussed and finally we have discussed industrial flotation equipment which are mainly mechanical cell as well as pneumatic cell.

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And here some of the references are given in terms of book however some web links are also given in respective slide which you can use for further study and that is all for now , thank you.

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