INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL

NPTEL ONLINE CERTIFICATION COURSE

Unit operations of Particulate Matter

Lec- 20
Transportation of solids (Part-03)

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Welcome to the fifth lecture of week four of the course unit operations of particulate matter, in this lecture we will discuss non mechanical conveyors. Now as for as non mechanical conveyors are concerned these are two type first is hydraulic conveyor and second is pneumatic conveyor, and we also called this as hydraulic transport on pneumatic transport, so now these non mechanical conveyors that is hydraulic as well as pneumatic transport these are used for longer distances and why these are used for longer distances for this, we should see some facts.

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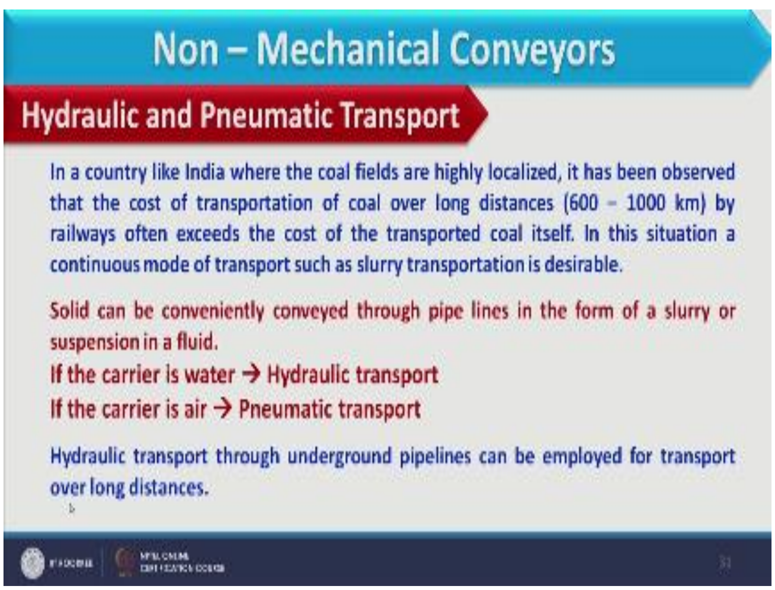

In a country like India where the coal fields are heavily localized what is the meaning of this that when we have to take the coal from one place to another place because coal are found in some specific states only like Jharkhand, Orissa extra. So in this, so these states or these locations are quite specific and from here we have to take the coal to other spaces, we have to take coal to other places, so it has been observed that the cost of transportation of coal over long distances that is around 600 to 1000 kilometer or more than that by railways often exceeds the cost of transported coal itself.

So here we are taking one example of coal and when we are transferring this by railways after some distances it will not be that much economical so in that case we use some other means and these are hydraulic as well as pneumatic transport. In this situation a continuous mode of transport such as slurry transportation is desirable, so what happens in hydraulic as well as pneumatic transport.

The solid is transferred through a media that is in the form of slurry or when it is suspended in the fluid. If the carrier is water, if the fluid is water we call it hydraulic transport and if it is air we call it pneumatic transport. Hydraulic transport through underground pipeline can be employed for transport over long distances, so you see here hydraulic transport can be made underground also so that is one of the reason that it can, that is one of the reason why the hydraulic transport is so popular.

Because it can be transported through any route or underground also so space requirement will not be that much high in this case.

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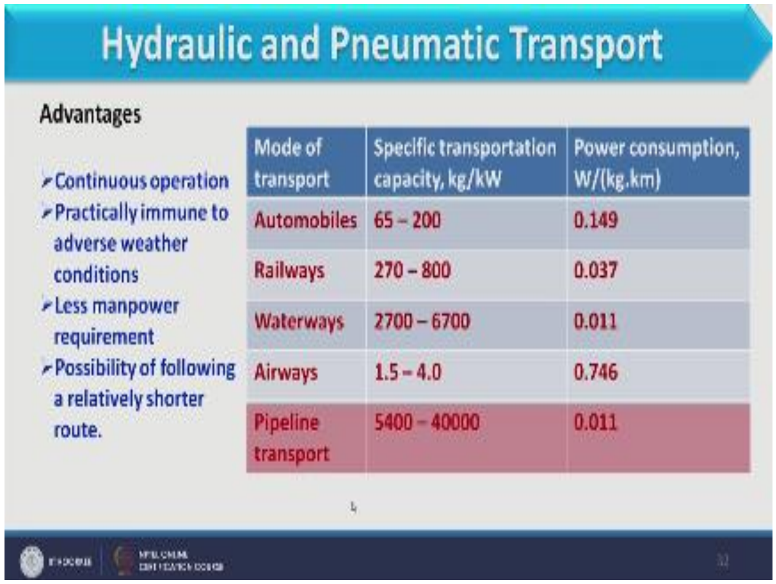

Now let us see few advantages of this, advantages of hydraulic as well as pneumatic transport and these are continuous operation, operation continuous for longer time. Practically immune to adverse weather condition, now what happens when it is transported in the form of slurry it is transported inside the pipes, so either that pipe is available over the earth or inside the earth it is not affected by the weather because slurry is transported inside the pipes.

So that is one major advantage, it has less manpower requirement. Possibility of following a relatively shorter route, because it can be placed underground also so route requirement will be, so route requirement can be reduced or we can go for shortest route in this case. Otherwise when we have to transport through rail or road we have to go with this specific route only. Now here I am having one table which speaks about mode of transport they are different modes of transport.

And specific transportation capacity that is material, weight of the material that is kg/kW that is kg/kW means how much material can be transported per unit consumption of power and power consumption is W/kg/km. When we go for automobile specific transportation capacity moves from 65 to 200 and power consumption 0.149 and similarly you can see other factors whereas when we are considering through airways it is a specific transportation capacities very less and power consumption is significantly high so that is not use for general purpose.

Whereas when we consider for pipeline transportation its capacity varies from 5400 to 40000 kg/kW so that is very huge specific transportation capacity and power consumption is very less even it is almost equal to water waves but carrying capacity in pipeline is significantly higher than the water waves, so in this way pipeline transportation is most economic.

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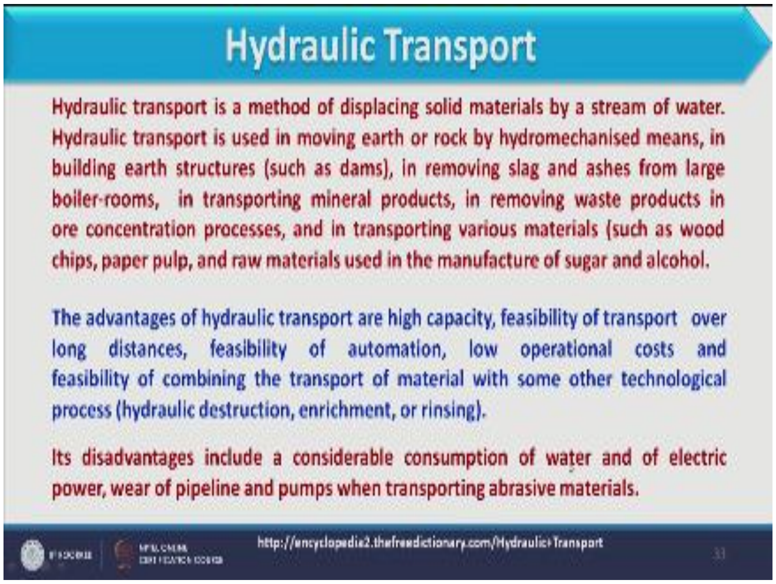

Now let us start with hydraulic transport as we have discussed that in hydraulic transport the mode is water or carrier is water, so when we have to transfer the solid we have to make slurry in the water and then that slurry will be transported through pipe so that is, that happens in hydraulic transportation. Now here we will discuss some of the advantages and disadvantages of hydraulic transportation.

Advantages of hydraulic transport are high capacity, feasibility of transport over long distances, high capacities there feasibility of transport over long distances, feasibility of auto machine, low operational cost and feasibility of combining the transport of material with some other technological process such as hydraulic destruction, enrichment or rising. So here we have different advantages of hydraulic transportation but along with this we have some disadvantages also such as.

Disadvantages include a considerable consumption of water, because it is entirely transferred as a slurry and that is prepared with the water so obviously water consumption is very high in this case, and of electric power consumption is very high because we have to use the pumps, wear of the pipeline and pumps when transporting abrasive materials, so when we have to transport the abrasive material we can have wear and tear in pumps and pipelines extra. So these are some disadvantages for more you can refer this link.

And when we are preparing the slurry or suspension we have to take care about few factors like how much should be the concentration, what should be the volume fraction extra.

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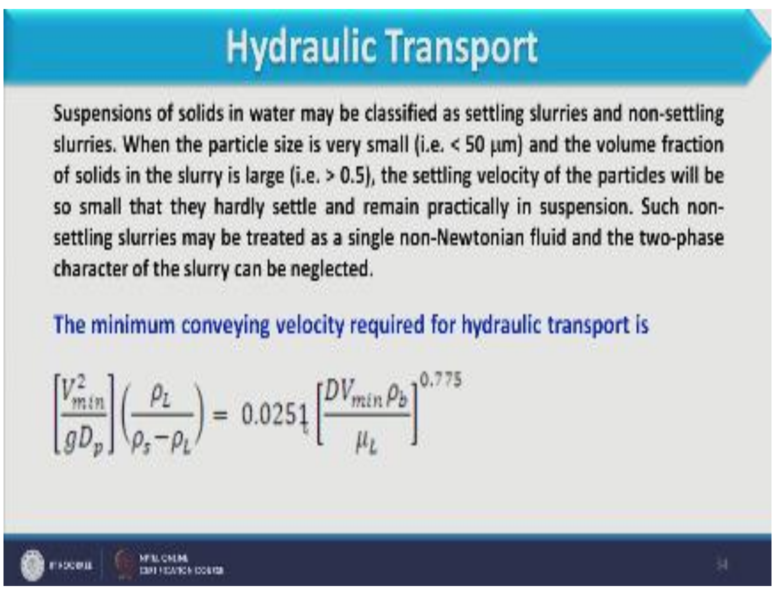

So when the particle sizes very small if it is less than 50 micro meter and volume fraction of the solid in slurry is large that is greater than 0.5 the settling velocity of the particles will be so small that they can hardly settle and remain practically in suspension. So what happens when we have to transport hydraulically the solid which we are, which we have to transport for this we prepare a suspension or slurry but whatever particles are available that should not be settle down.

And when they will not be settle down, when the terminal settling velocity of the particle is lesser than the velocity of slurry, so velocity of the suspension so when it will be greater than when velocities greater for suspension it will never allow particle to settle on the other hand particle will be suspended in the slurry. Now in hydraulic transport what happens when we have to transport the solid we prepare slurry with these solid where solids are mixed with the water and prepare the slurry.

Now what happens in this slurry whatever particles are available that particle should remain suspended and it should not be settle down because in that case there will be forming of solid at the lower section of the pipe and transportation will not happen, so such non-settling slurries may be treated as a single non-Newtonian fluid and the two phase character of the slurry can be neglected.

So when particle size is very small and volume fraction of solid in the slurries greater than 50 we can consider that slurry as single phase where particles are completely suspended in the slurry. Now the minimum conveying velocity required for hydraulic transport is imperially related like this V^2_{min}/gD_p here we have density fraction that is ρ_L/ρ_S-ρ in 2.0 251 into this factor, so here you see u minimum is basically the minimum conveying velocity which lies here also, D_p is the particle size and what is the limitation over this D_p value that we will discuss this is the density of liquid this is for solid and D is diameter of pipe in which transportation occur ρb is the density of bulk and µL is the viscosity of l equate.

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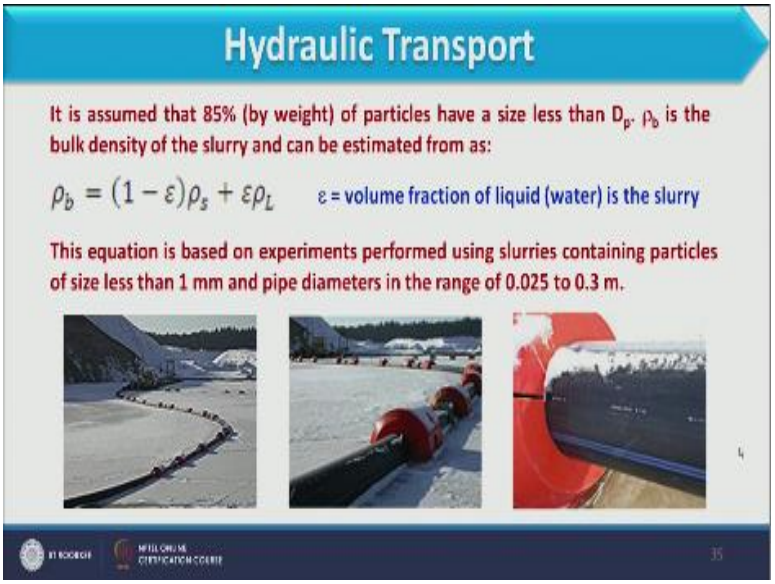

Now in this expression D_p value is the particle diameter and it is assume that 855 of particles have a size less than Dp, so how we decide the dp value like Dp value is decided wherever 85% of the particle is ψ particle is of size less than Dp, so D_p can be calculated as when 85% of the particle lies then 85% of particle will have size lesser than Dp, so when 85% collection is obtained then we can say that then whatever would be the particle size that we can consider as D_p. And through one example with the illustrate in detail how the D_p should be calculated and here ρb is the bulk density of the slurry.

And that is 1 – ϵ ρs + ϵρL, so ϵ is basically the volume fraction of liquid in the slurry, so this equation is based on experiments performed using slurries containing particles of size less than 1mm and pipe diameter should be in the range of 0.025 to 0.3m, so carrying out experiment in this condition we can have that empirical relationship now if you see this image this image shows a pipe line and if you see the environment this is completely cold condition, so here we have transportation of slurry in a hydraulic form.

More closely you can see here we have some slurry which is of black color may be this is coal and here we can observe more closely that in this way the particle prepare the slurry and hydraulically it is transported hydraulically it is transported like this so in adverse weather condition also material can be transported through hydraulic transportation.

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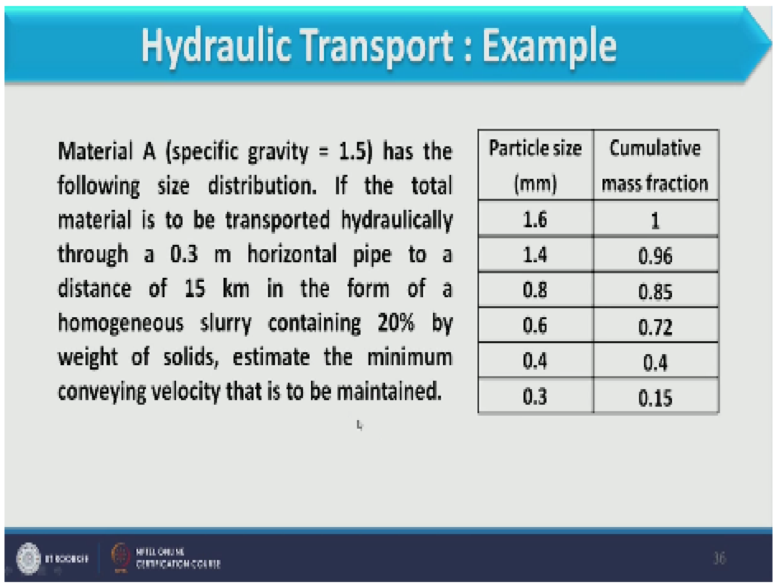

Now here we have one example in this example material a of a specific gravity 1.5 has a following size distribution this is the following size this is the size distribution for the material if the total material is to be transported hydraulically through a 0.3m diameter horizontal pipe to a distance of 15km in the form of homogenous slurry containing 20 person by weight of solid estimate the minimum conveying velocity that is to be maintained, so here you see slurry is preparing the 20% solid mass with 20% solid particle size distribution is given to us.

And other parameter such as pipe diameter etc. Is given to us so let us start the computation of minimum conveying velocity in hydraulic transport.

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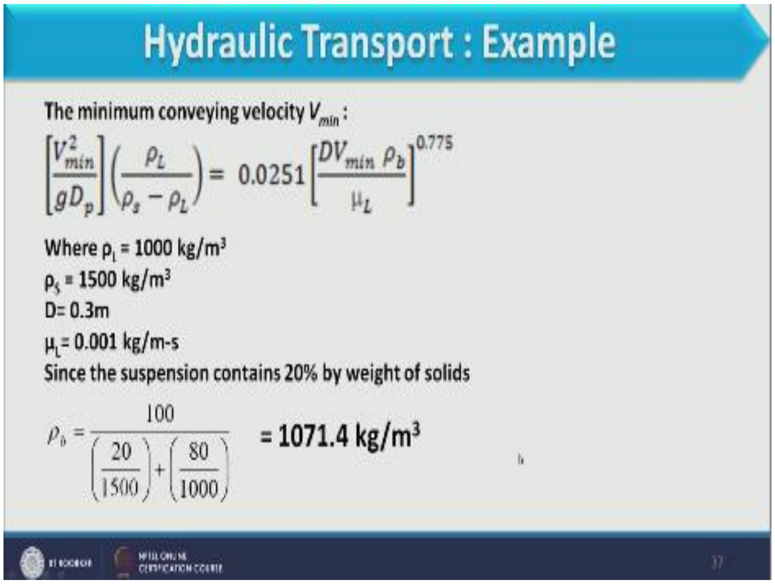

This is the equation that just we have discussed V_{min} will have to calculate over here, so V_{min} lie in both side and where ρL is 1000 because water we have used as a carrier here ρL we have considered as density of water because water is used as a carrier solid density 1500 kg/ m3 diameter of pipe is 0.3m µL is that is viscosity of water, now suspension contains 20% by weight or solid so we can calculate bulk density like 20% if solid, so 80% should be water so 100/20 / 1500 + 80 / 1000 so 1071.4kg/m3 is the bulk density of the slurry.

So ρb we know already now we have calculated value of Dp other parameters we know except V_{min}.

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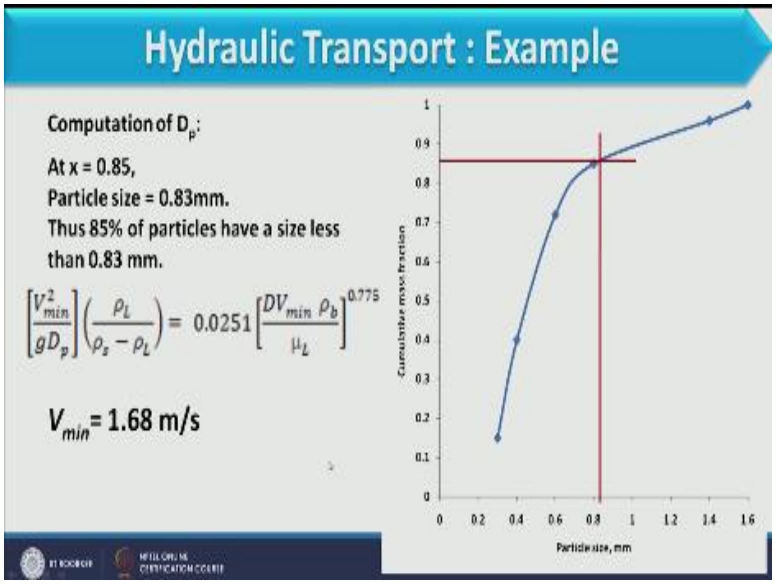

So as far computation of Dp is concerned what we have to do we already know the particle size distribution which is given to us and if you remember we are given particle size as well as cumulative mass fraction, when we plot this in this curve what happens particle size corresponding to 85% mass fraction we have to find. Because as far as definition of D_p is concerned that is corresponding to 85% mass fraction that is corresponding to 85% mass fraction, so when draw the line of line around 85% in this y axis because that is cumulative mass and when we draw the line vertically.

Towards x axis the particle size we can obtain is 0.83mm so here particles size is 0.83 and thus 85% of particle have size less than 0.83 because all these particle will having size less than 0.83 which comes below 85% cumulative mass fraction, so while putting all these value over here we can calculate minimum conveying velocity that is 1.68m/s. So in this way you can calculate the minimum conveying velocity in hydraulic transport, now we will discuss pneumatic transport in pneumatic transport.

You know the carrier is air, now here we will discuss some of the advantages and disadvantages of pneumatic transport.

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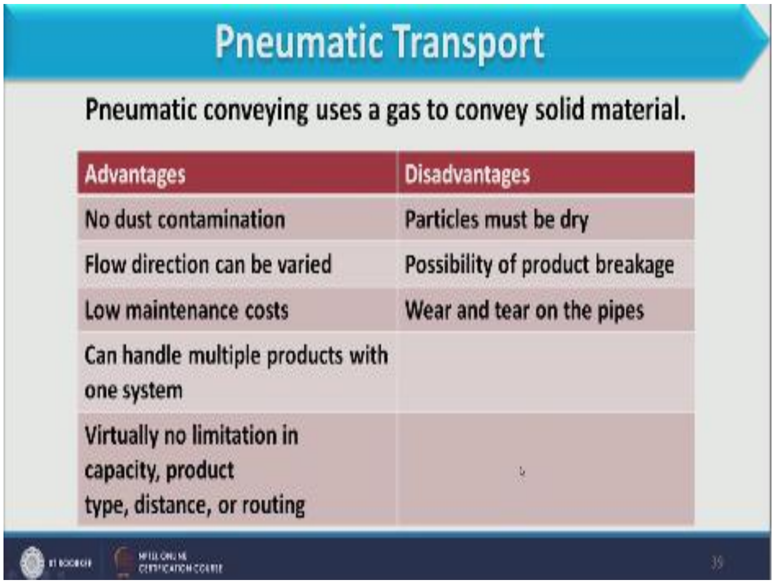

Advantages are no dust contamination flow direction can be varied because we can go for smallest or any route we can go through or we can take any term because that is pneumatically transported low maintenance cost it can handle multiple products with one system because pneumatically it has to transport so it will not a contaminated the inner level of the pipe so we can handle multiple production in the same, we can handle multiple products in the same system or same pipe line.

Virtually no limitation of capacity product type distance or routing these are the advantages along with this some disadvantages are also there like particle must be dry we cannot transport moist solid, so particle should be dry possibility of product breakage because when we particle are transported with the suspension of other particle, so they can strike with each other or they can strike with the wall of the pipe so breaking may occur were and tear on the pipe it happens these are some disadvantages or pneumatic transport.

Now when we consider pneumatic transport as we have discussed in hydraulic transport that slurry that particle should be suspended in the slurry, so in the similar line we consider in pneumatic transport also that particle should be uniformly distributed in the pipe like carrier is air so particle which we are considering that should ne uniformly spread into the convare or into the pipe line, and then this happen with the low density.

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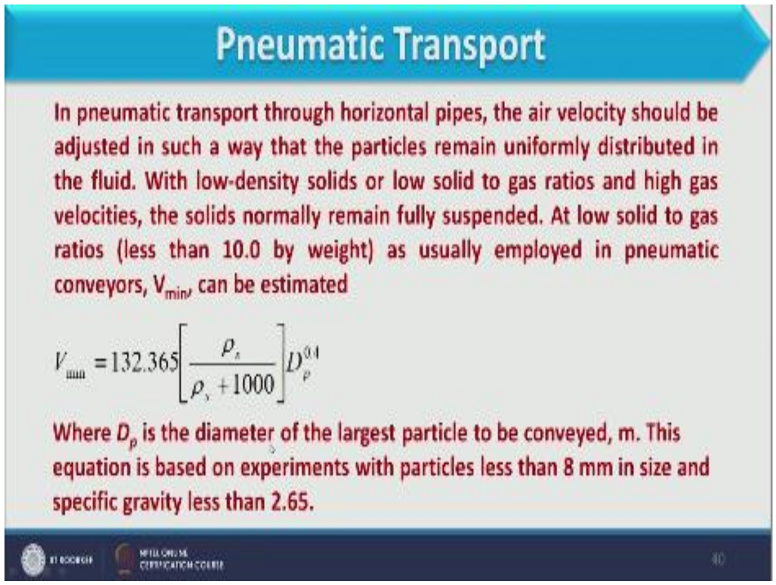

Solids or low solid to gas ratio and high gas velocity the solids normally remain fully suspended at low solid to gas ratio that is less than 10 by weight as usually employed in pneumatic transport minimum conveying velocity can be calculated by this expression where it is equal to 132.365 ρs / 1000 Dp/ 0.4 where Dp is the diameter of largest particle to be convared because when we are able to carry able to convey the largest particle obviously smaller particle will be carried or will be convared easily.

So this equation is based on the experiments with particle less than 8mm in size and specific gravity less than 2.65, so this is about minimum conveying velocity.

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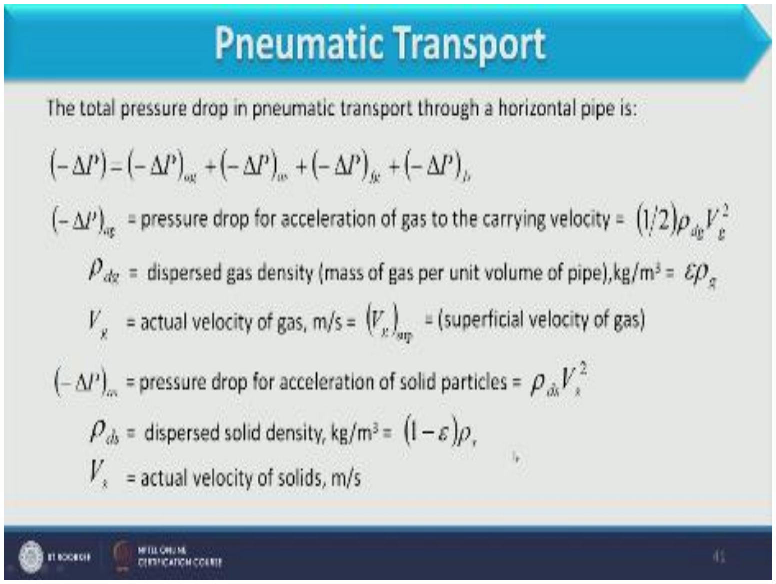

Now here we have total pressure drop in pneumatic transport through horizontal pipe these are different pressure drops and details of these pressure drops are showing in this slide and once we calculate value of total pressure drop we can calculate total power consumption utilized in pneumatic transport, now here we will discuss one example on pneumatic transport.

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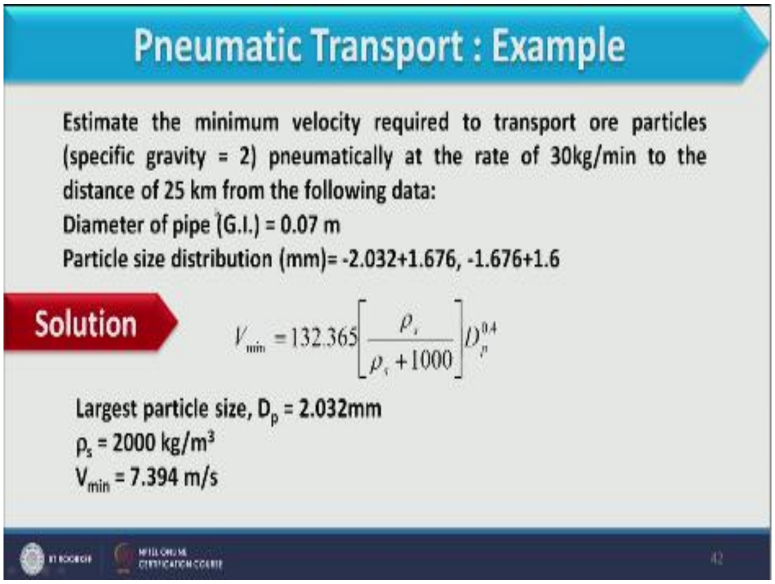

Now in this example what we have to do we have to estimate the minimum velocity required to transport ore particle with a specific gravity to pneumatically so we have to transport the ore particle pneumatically at the rate of 30kg per minute to the distance of 25 km from following data so diameter of pipe is given 0.07m and particle size distribution is given in mm has -2.032 + 1.676 and – 1.676 + 1.6, so in this range particles are available which we have to transport, now how we can calculate minimum conveying velocity.

This is the expression here only problem is with Dp if we find out the value of Dp we can calculate Vmin now if you remember what is Dp,Dp is basically maximum diameter of particle that we have to transport so if you see the particles has distribution maximum should be 2.032 and minimum should be 1.6 so Dp should be the maximum size so here we can consider Dp as 2.032mm so here Dp we have note it down ρs we already know so V_{min} can be calculated very easily, so that is 7.394m or second so in this way we can calculate minimum conveying velocity for pneumatic transport.

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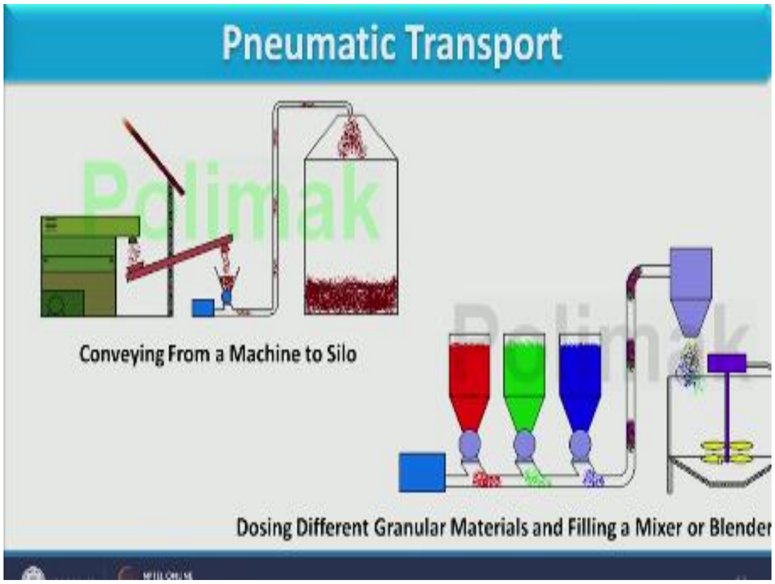

Now in this slide I have shown some of the example where material is filled in silo through pneumatic transport, so you see here material is available which is convey from here to here through you can see this may be your screw convere we can say because feed is coming over here and discharge is a not at the end but before that so that is possible in a screw convere so material is coming over here and here we have the blower through this blow solid can be taken by this air and that is filled in this silo.

Pneumatically another animation we have when we are considering dosing different granular materials and filling a mixture or blender when we have to consider dose of different material and we have to prepare the mixture of this each dose will be collected and then it will be transported pneumatically and while trans porting this mixing occur inside the pipe and therefore when we get the material and discharge and it already a mixture, so in this way we can use pneumatic transport here very interesting example.

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Like if you see this is basically wheat and the we have to pack the wheat that can be pack through pneumatically because from here it takes the wheat and here we put some container where this wheat can be stored, so in this way is storing of wheat or packing of wheat can be done pneumatically, now here we have summary of the lecture now this summary of the lecture.

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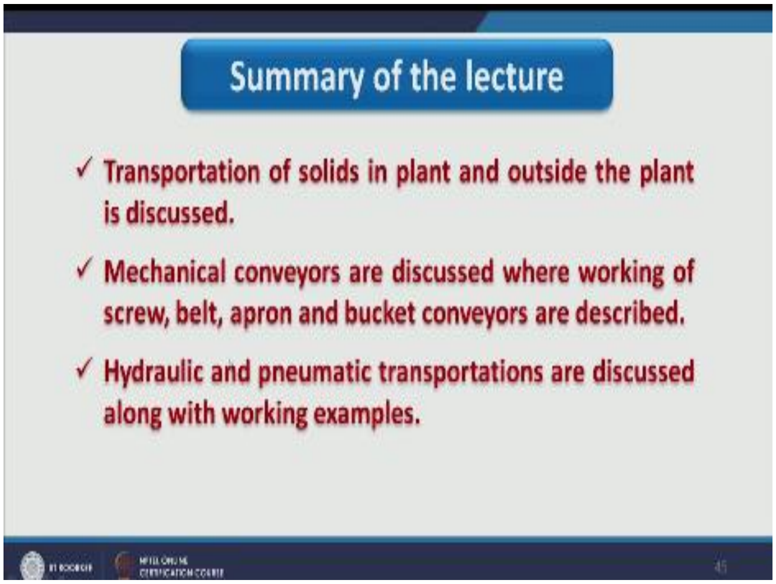

Now this summary of lecture 3, 4 and 5 which we have discussed for transportation of solid, so in this lecture transportation of solids in plant as well as outside the plant is discussed mechanical converse are discussed where working of a screw belt apron and converse our described and finally we have discuss hydraulic and pneumatic transportation along with working example.

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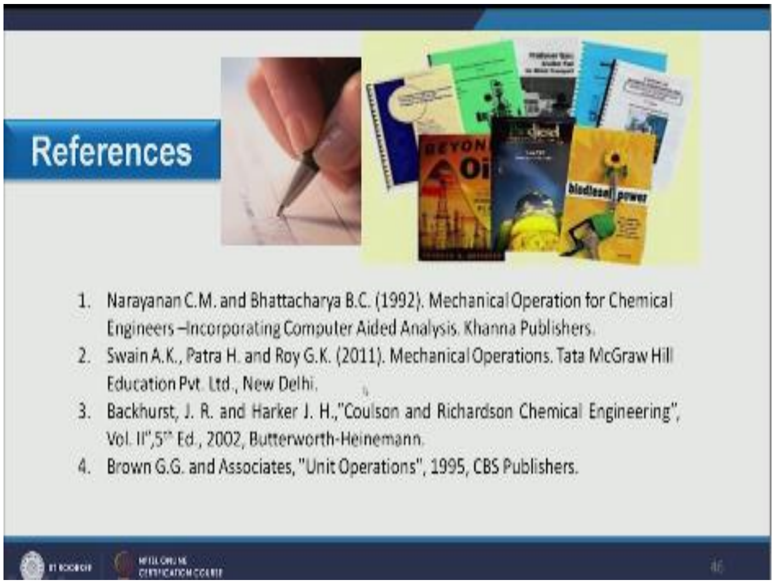

And here you can have the books through which you can go through about transpiration of solid in detail few web lines are also used which are available in this lecture slide so that you can refer and here we are ending this course as it was the last lecture of last week so in this 4 week course we have discussed unit operations such as sedimentation, filtration fluidization, fluidization and transportation of solid I hope you are benefited with this course I wish you success in upcoming online examination thank you for joining new in this course thank you very much.

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