INDIAN INSTITUTE OF TECHNOLOGY

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Unit Operations of Particulate Matter

Lec – 18
Transportation of Solids (Part – 01)

Dr. Shabina Khanam
Department of Chemical Engineering
Indian Institute of Technology Roorkee

Welcome to the third lecture of week four of the course unit operations of particulate matter in this third lecture we will discuss transportation of solid and as for as this topic is concern this topic I will cover in three different lecture, lecture three lecture four and lecture five of this week ion lecture three we will discuss what is transportation of solid why it is important and how it is done what are the measures what are the equipment which are involved in this and then we will discuss mechanical conveyers and few mechanical conveyers I will cover in lecture three and few mechanical conveyers I will cover ion lecture four and in lecture five I will speak about non mechanical conveyers that is pneumatic as well as hydraulic transport.

So let us start lecture three with transportation of solids now as for as transportation of solid is concern where it is used if you have seen even around you when any construction is going on or even if in your housed also we need to transport we need to carry solid from one place and dump in to another place. So that is as for as industries concern the transportation of solid is very difficult in comparison to transportation of fluids.

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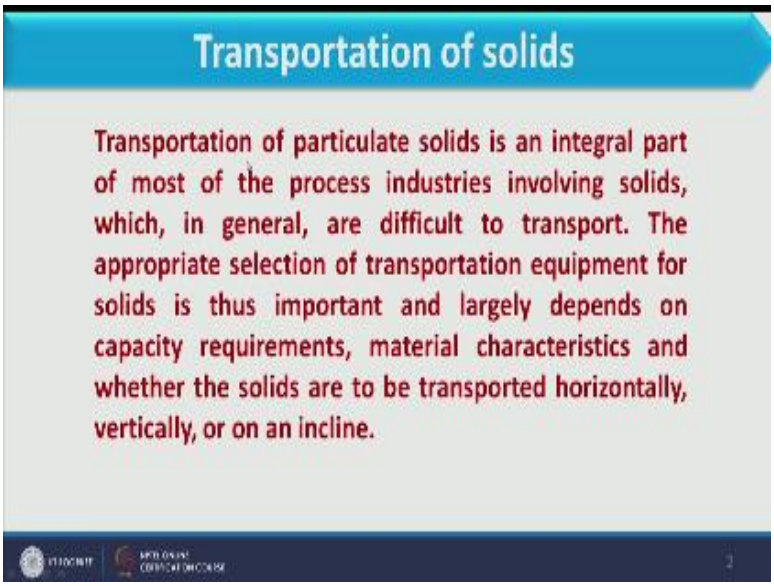

And transportation of particulate solid is an integral part of most of the process industries and it is difficult in comparison to transferring the liquid as well as air so to transport the solid from one place to another place is specific equipment are designed for this purpose as the equipment involved in fluid transport cannot be used over here, so the selection of these equipment depends on the capacity requirement material characteristic and whether the solid are to be transported horizontally vertically or an incline.

And whether the solids are to be transported horizontally vertically or an and incline so you see here we have to transport the solid for different position for different height, so for that purpose specific equipment are to be designed.

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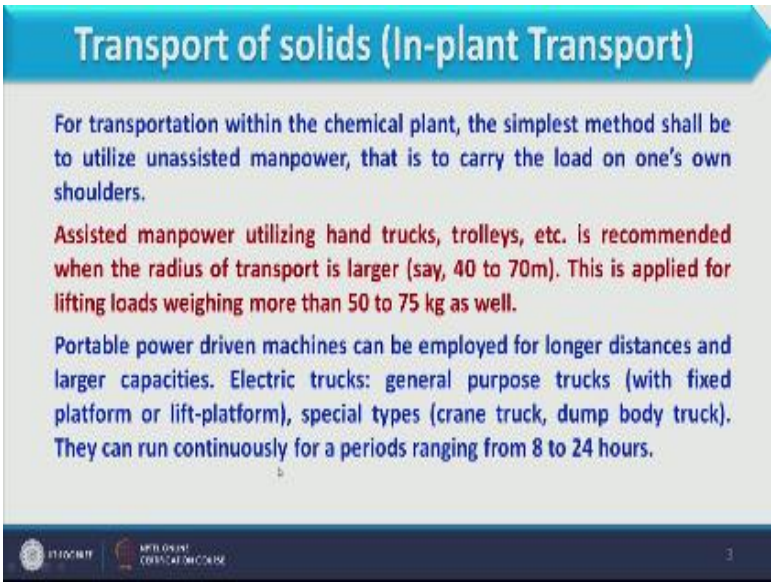

Now we will discuss transport of solids which is implant transport means if in an industry what are the measures what are the ways to transport solid from one place to another place, for transportation within the chemical plant the simplest method should be to utilize unassisted man power that is to carry the load on one's own shoulders, so that is the easiest way to carry the solid from one place to another place even that when any construction work is going on nearby we have see this that unassisted man power it means labor himself carried the solid on its shoulder and then dump it to another place, so that is very common that very commonly we have seen in all places.

But obviously it can be use for very short distance on the other hand assisted manpower utilizing hand truck, trolleys, etc which is recommended for transport the solid then the range of 40 to 70 meter so that is more than unassisted manpower this is applied for lifting loads weighing more than 50 to 75kg as well. So here you see mass which is carried out by assisted man power as well as distance till which this can be use that is specific.

So when we have to use when we have to transport for larger distance than this because up to 70m that is very less as for as big plants are concern even in a smaller plant also 70m distant is

less. So we have to see other options to carry the solid from one place to another place, so for longer distance then this we can use portable power driven machines which has larger capacity in comparison to hand trucks and trolleys.

And these power driven machines are electric truck that is general purpose truck with fix platform and lift plat form and I hope you understand the fix plat form as well as lift platform lift platform dump the material automatically. A special type truck that is crane truck, dump body truck etc they can run continuously for a period ranging from 8 to 24 hours. So in many plants if you see these types of truck are commonly use to take the solid from one place to another place.

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Along with this we can sue power shovels now power shovels is the equipment is the machine that take the material take the solid from one place but it cannot carry it towards another place to carry this we need trucks, so that it can carry the material dump it on truck trolley and truck trolley takes it from one place to another place. So I hope you understand what is power shovels that you can see in this figure in this image details are given in this web link.

So here we have as for as this power shovel is concern we need truck or commercial truck for carrying the material but it is very effectively remove the material from one place. So as for as operations is concern you see this is a specific kind of machine and to run this machine is skilled persons are required so these are expansive and recommended only when large quantities of bulk material are being handled at changing position.

If we need to take them very large material for example if that you have seen for construction purpose when we dig the foundation that is very large area it covers where it can remove the solid from very large area in very less time. But it cannot carry on its own so the commercial trucks are provided with this.

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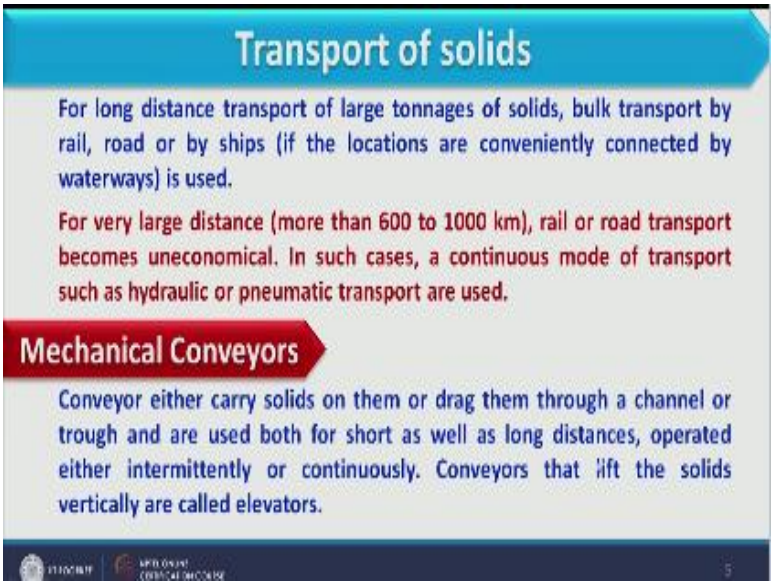

Now all this equipment which we all this assisted power assisted manpower or portable truck or power shovels whatever we have discussed it has the limitation that it cannot move longer distances. So for long distance transport of large tonnage of solid bulk transport by rail, road ort by ship if locations are conveniently connected by water way if two places are connected by are nicely connected by water way then we can use ship, so for longer distance rail road and ships

are used to transport the material for very large distance like when we consider more than 600 or 100 km rail or road transport become uneconomical.

So in this case we have to find other way transport and these ways are hydraulic as well as pneumatic transport, we will discuss about this hydraulic and pneumatic transport in fifth lecture of this week. And now we will discuss the mechanical conveyers which are used extensively as for as industries are concerned so these mechanical conveyer why we call it mechanical conveyer because it use some means like it will be driven by drive or it will be materially pulled by some mechanism so in all this cases mechanical part is involve and therefore it is called as mechanical conveys.

So conveyer another carry solids on them or drag them through a channel or trough and are used both for short as well as long distances, operated either intermittently or continuously. Therefore as for this mechanical conveyer is concern it can be use for larger distances as well as smaller distances and when we have to take the material in between for example when conveyers are made for longer distances and in between we have to take the material that can be done very easily with this mechanical conveyers.

And when we use the conveyer for lifting the material from one place to another place we basically call this as elevators. So as we have discuss that mechanical conveyers are use for shorter distance as well as longer distance it has the capacity caring capacity also which is significantly higher in comparison to the assisted manpower or portable truck and etc, what we have discussed preciously.

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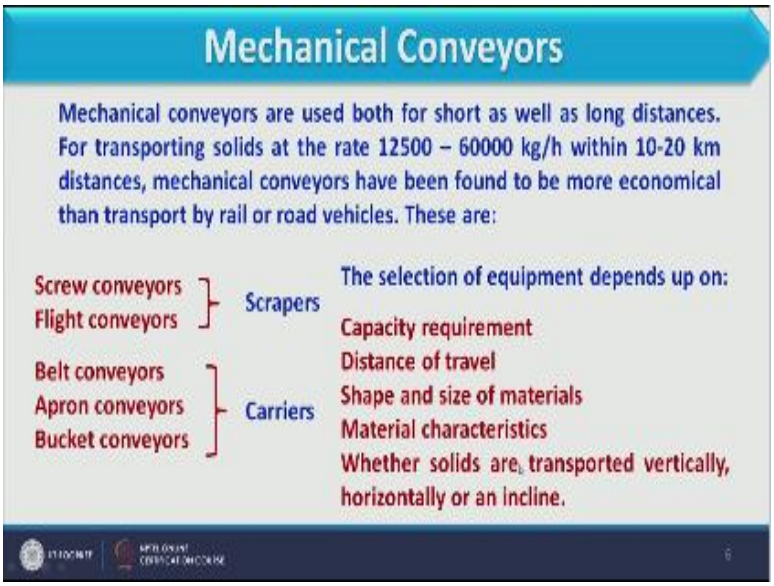

So for transporting solid at the rate of 12500 to 60000kg per hour within 10 to 20 km distance so you can see capacity carrying capacity is very high as well as distance it covers is along 20km which is huge and it is also suitable for very large plants. So up to 20km mechanical conveyers have been found to be more economical then transport by rail or road vehicle. So when we have to go for 10 to 20 km instead of moving that with rail and by road that is very expensive we can use less expensive way and that is the mechanical conveyer.

Now different type of mechanical conveyers are you see here we have different types of mechanical conveyer first is the screw conveyer then we have the flight conveyers and next we have belt conveyers, apron conveyers and bucket conveyers, so these are different types of mechanical conveyers we will discuss some of this subsequently. Now when we speak about screw as well as flight conveyer these are basically called as scrapers because it carry it drag the material from one place to another place and therefore it is called is scraper.

However when we consider belt conveyer apron conveyer or bucker conveyer they carry material on itself and then they move so material will be transported while stain on the conveyer, however in scraper material itself move along with the however in scraper material move not the

conveyer so that is a difference between scraper and other conveyer so therefore we call belt conveyer apron conveyer and bucket conveyer as the carriers because they carry on itself and then they have move.

However a scraper they remain at static position or they revolve on its own position and material move from one place to another place so therefore so that is the basic difference between scraper as well as carriers. Now as for a selection of different conveyers for different purpose is concerned that depends on capacity required how much we have to transport distance of the travel how long we have to transport shape and size of the material like if they are very spherical type or they are very movable type shape is there so we have to move or we have to use the conveyer accordingly material characteristic it means whether the material is sticky whether it is a passive whether it is granule type what is the characteristic on which selection of equipment or co0nveyre it depends.

Whether solids are transported vertically horizontally or an incline yes that is very important factor whether we have to transport on same plane or in an incline or directly towards upper side or vertically so depending upon these different conditions these different factors the selection of conveyer will be done.

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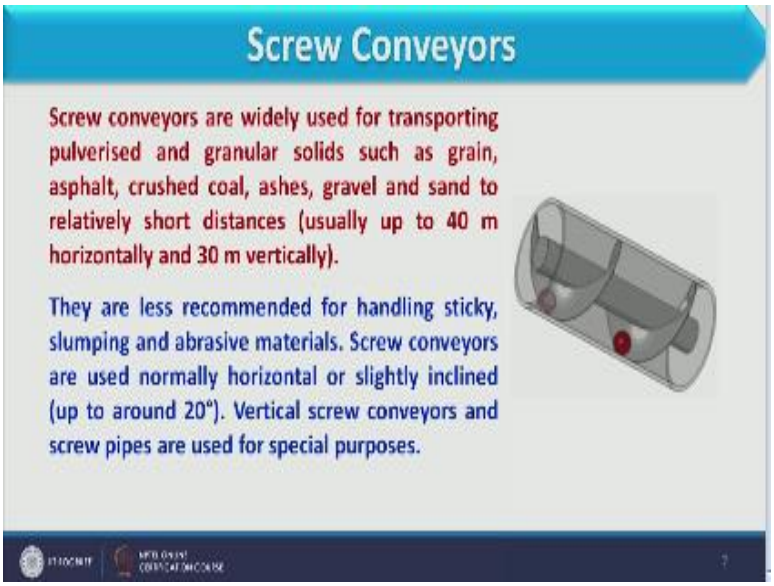

So here we will start discussion on screw conveyer as we have discuss that some of the conveyer we will discuss in detail so let us start with this screw conveyer. Now if you see this animation what this animation shows that material is move from one place to another place through the movement of this screw and therefore it is called as screw conveyer. So screw conveyer are widely used for transporting pulverized and granular solid such as grain, asphalt, crushed coal, ashes, gravel and sand to relatively shorter distance that is up to 40m horizontally or 30 m vertically.

Even they are used in some inclination also so you see as for as screw are concern they basically drag material from one place to another place and that we have already discussed and therefore it is called as scrapers. So as screws drag material from one place to another place that will become easier when we are handling the granular material or sand kind of material therefore this is screw conveyers are not recommended for sticky material along with this abrasive material are also less recommended to be convert through a screw conveyers.

And screw conveyer are normally move horizontally or normally transport the material in horizontal plane however slight inclination is also possible that is up to 20^0 vertical is screw

conveyers and a screw pipes are used for special purpose so usually we have inclination up to 20^0, and we use this for shorter distances in the plant but for transporting granular material they are used extensively.

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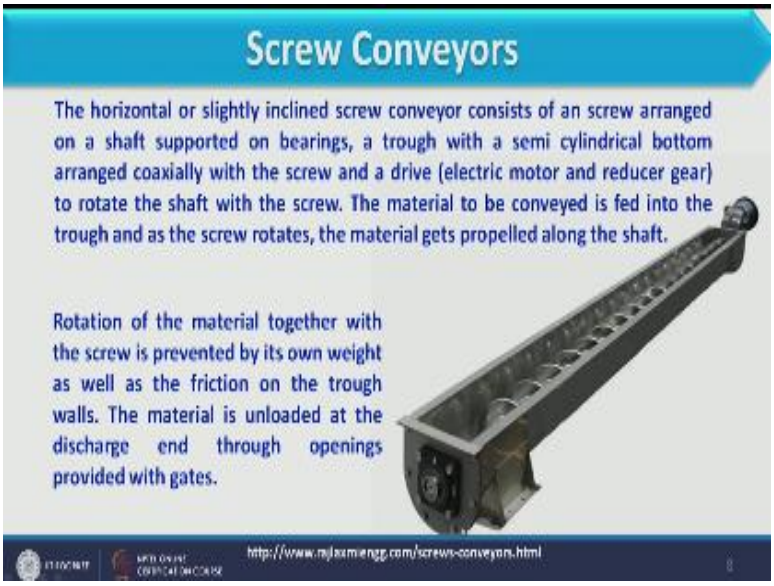

Now in this slide if you see this diagram what is this, this is showing image of a screw conveyer now what happens in a screw conveyer if you see its structure when we consider outer shell of this that is nothing but the semi cylindrical shape. So for a screw conveyer usually we use semi cylindrical bottom or sometimes we also use a square box for transportation for placing this screw.

Now what happens inside this semi cylindrical bottom we have the shaft which is placed at the bottom section of this, now you see here we have the connection of shaft and it is placed inside this over this shaft is screw are mounted, you see these are the screws which are mounted over the shaft, so when we have to carry the material, material will be put over here and that is transported through drag.

So material can be put over here and that can be transported through this screws towards the discharge and will like this where if you see this if you can see this the bottom is the here we have the open space and this trough is made at the bottom of this opening so material can be transported up to a material can be dumped over here easily.

So rotation of the material to gather with the screw is prevented by its own weight as well as the friction on the trough walls. So when the when we put the material we should not put material pout the large amount of material at one time because when the weight of material will be increased it will be difficult for these screws to carry the material therefore less material should be kept over here because material weight is important over here.

And the obstruction through this wall because when some material is line between this screw and wall so that can make where an entire inside this. So material weight of material as well as friction through the wall is the mean obstruction for rotation of these screws. So material is unloaded at discharge and through opening provided with the gates, so here you see where for where we have to drop the material dump the material we can put the gate over here.

Now for example if this is the total length of the screw if I have to drop the material over here so what we can do the bottom sheet of these casings is having gate over here at the bottom side. The bottom surface of this casing should have gate over here and below this gate trough like that should be placed over here and when we drop the material over here that gate should be open and the material can be drop.

So intermittent discharge of material in screw conveyer is easily possible, for detail you can go through this link.

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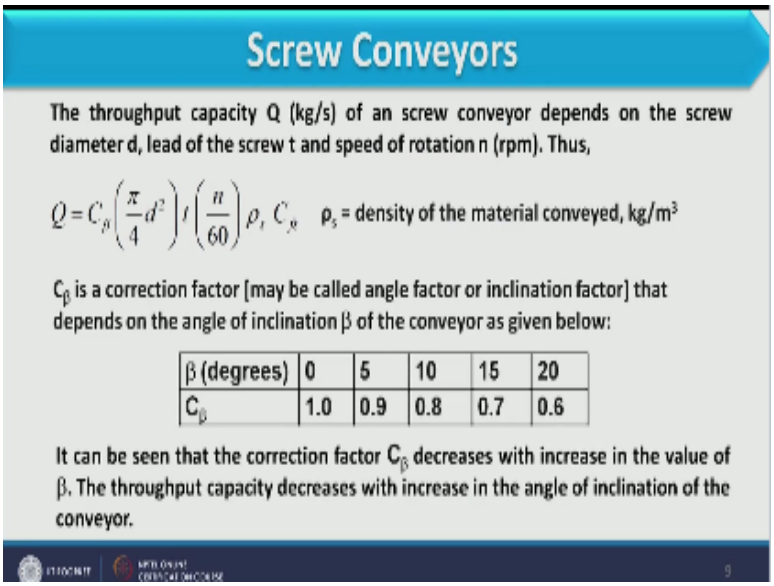

Now as for as capacity of screw conveyer is concerned that we can calculate and it has the empirical relationship the throughput capacity Q that is Kg/second of an screw conveyer depends on a screw diameter that is diameter of this screw is d lead of the screw that is T what is lead of the screw is the pitch between two screws or the distance between two screws as we call as the lead of the screw.

Speed of rotation that is denoted by n and it is given as rpm once we know all these factor w can define through put capacity of the conveyer that is equal to C β π/ 4 d ^{2} t and / 60 ρ s Cfs, now ρs over here is the density of material which we have to convey dt and we have already discussed now what is C β and what is Cfs, C β is a correction factor we can also call it angle factor or inclination factor which depends on angle of inclination which is β of the conveyer.

So when we have to transport the material at a proper inclination we have already discussed so when we have transport a material to proper inclination you can see here up to 20^0 data is shown because if you remember we have discuss the through screw conveyer inclination up to 20 recommended. So here you see angle vary from 0 to 20 and as and value of C β when we are considering it is maximum at 0 inclination means it is maximum when we are moving when w e

are transporting the material horizontally and the value of cβ will keep on decrease till we move up to 20^0, so once the value of Cβ decreases if you see this expression value of q decreases because that is propionate with C β.

So as angle of inclination increases through pout capacities will be decreased therefore it can be conclude that when we transport the material in a screw conveyer in an inclination the through put capacity of this screw conveyer will be decreased. Further the coefficient Cf which is associated with the expression of Q is called as filling coefficient and it is valued depends on type of material conveyed.

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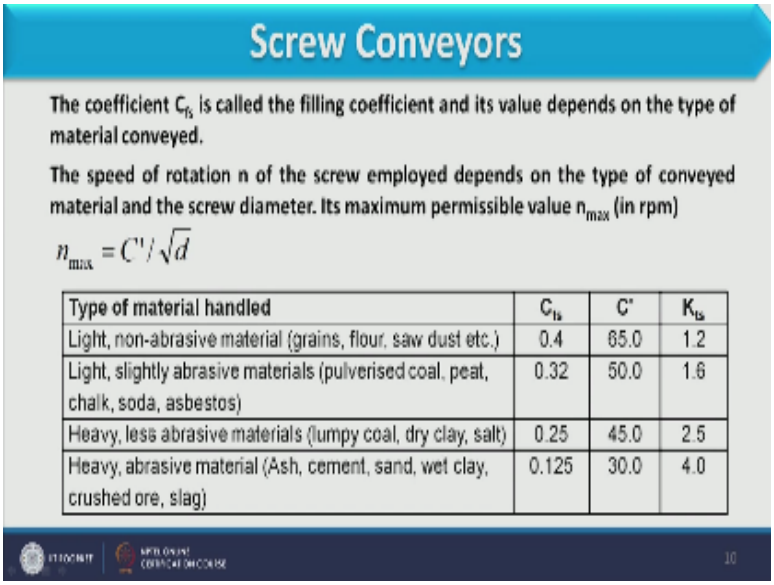

So here we have the table for type of material handle and Cfs factor is given other factors are also given that we will discussed and according to the material value of Cf is given. So for heavy material it is 0.125 value and it can also be concluded that as Cfs reduces capacity reduces so when we have to transport heavier material the throughput capacity of the conveyer should be less.

Further the speed of rotation n of the screw employed depends on type of conveyed material and screw diameter it is maximum permissible value and max in rpm can be calculated by this expressions where c' is the coefficient and the value of c' is give over here, √ d, d is nothing but the diameter of screw so in this way we can calculate capacity which is associated with this screw conveyer as well as the maximum possible rpm we can use in screw conveyer. As well as the maximum rpm that we can sue in screw conveyers.

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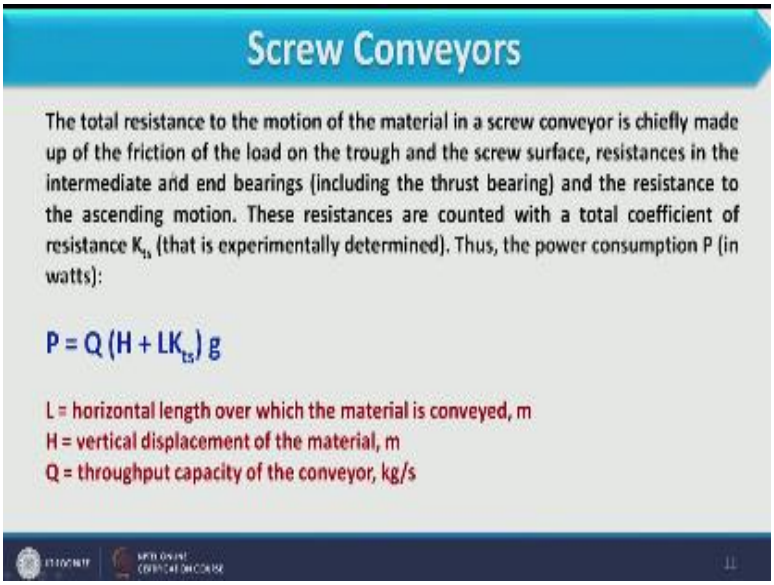

Further if we need to calculate power consumption in a screw conveyer we have to see what are the resistance offered while moving the material from one place to another place in a screw conveyer. So you see here the total resistance through the material in a screw conveyer is chiefly made up of the friction of the load on the trough and screw surface, resistances in inter mediate and bearing that should also been included and the resistance to ascending motion.

So these resistance collectively counted in coefficient and that we called as total coefficient of a resistance and that is nothing but Kts and which can be determine experimentally so the power consumption in screw conveyer can be calculated can be denoted by this expression that p = q, H + L Kts x g, q we know this capacity which we have discussion previous slides L is the total

horizontal distance where we have to convey the material l is the Horizontal distance where we have to convey the material and H is the vertical displacement of material in meter and g you know already.

So considering this equation we can calculate the power consumption in screw conveyer, now as for as value of kts is constant that you can see in the previous slide and that also depends on different materials so here Kts value increases when we go for lighter to heavier material because heavier material will be difficult to transport it will put more resistance to flow and therefore it has more Kts value and therefore power consumption to convey the heavy material would be increased.

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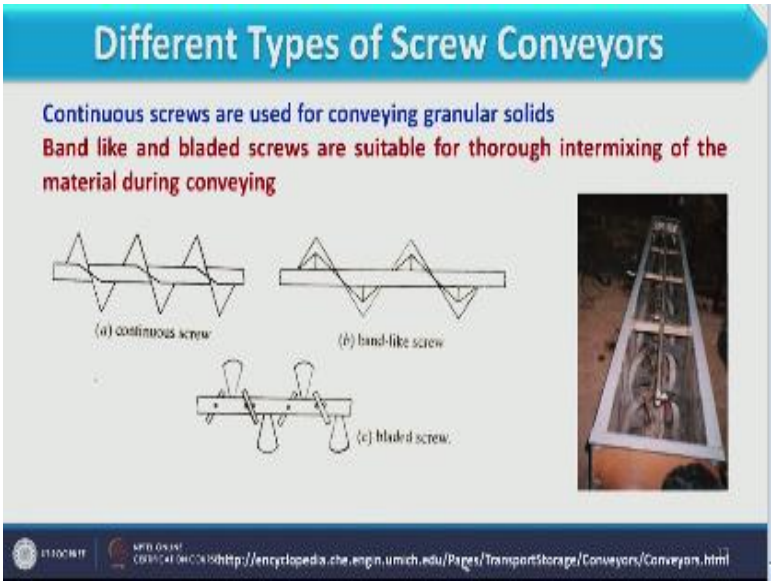

So here we have discussed some empirical correlation to calculate the capacity to calculate maximum rpm and to calculate power consumption in screw conveyers. Now we will discuss different type of a screw conveyer available so as for as screw conveyers are concern we have continuous screw as well as band type which we also called discontinuous screw. Continuous screws are used for conveying granule solids. Whereas band like and blades screws are suitable for thorough intermixing of the material during conveying.

So here some scam tics are shown for continuous as well as band like here you see continuous screw where the screw are of continuous sheet on the hand if you are considering band like a screw it means metal sheet are available on its periphery and this so her in band like screw this metal sheet prepares a ring kind of a structure over the shaft. And it is attached through this bus to the shaft.

So here if you see this image here we have shown the bend like screw or bend like a structure which we also called as discontinuous screw and bladed type of screw is are also available for more you can visit this link.

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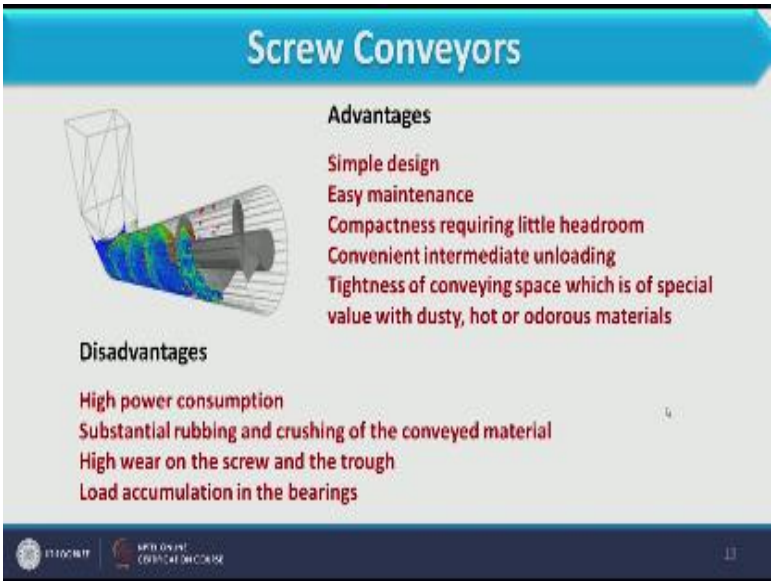

So screw conveyer that material is transported from one place to another place and feed and sometime we will include the hoper through which feed enters in to this and how it discharges the material that we have already discussed. Now the advantages of screw conveyers are simple design easy maintenance compactness requiring little headroom, so space requirement will not be very large convenient inter mediate unloading that we have already discussed that where we have to unload the material only we have to gate at the bottom periphery of the casing.

Tightness of conveying space which is of a special value with dusty hot or odorous material so you can see we have tight encloses sometimes we use semi cylindrical casing but when we deal with dusty or odorous material we can use that we can put that screw in a cylinder complete cylinder that the material should not be lost. Along with this advantages there are some disadvantages also such has it has high power consumption substantial rubbing and crushing of the conveyed material.

Because when material is drag from one place to another place whatever size we have put that size can be reduced by continuous sharing or continuous attrition between the particle so that is the disadvantage whatever size we want as for as conveying is concern we should put some higher particle size then whatever we required. High wear on the screw and the trough load accumulation in the bearing. So these are some disadvantages for screw conveyers.

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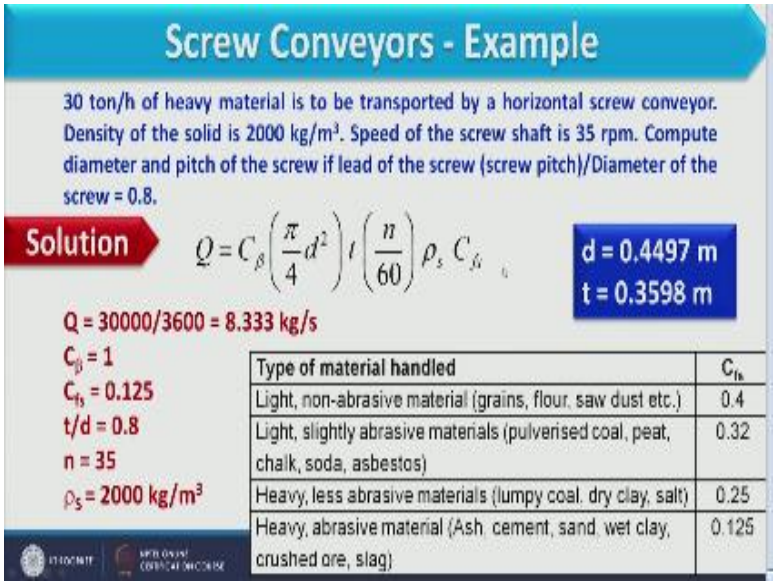

Now here we will discuss one small example where 30 ton per hour of heavy material is to be transported by horizontal screw conveyer density of the solid is 2000kg/m^3 speed of screw shaft is 35 rpm what we have to calculate is the diameter and pitch of this screw if lead of the screw

that is screw pitch divided by diameter of the screw is 0.8 so we have to calculate the diameter of pitch capacity is given to us that is 30 t/ hour.

So q value we can calculate over here c β we have taken as one because we are transforming the material in horizontal plane so angle should be 0 so c β in this case should be 1. Now as we have to transport the heavy material when we refer this table for heavy material we can use cfs value 0.125 so that we have already used over here, t/ d is given as 0.8 rpm is given as 35 and density as 2000kg.m^3 putting all value over here you see t would be replace by t / d so you see t can be replace by 0.8 x d.

So while putting all these value over here we can calculate diameter of the screw which comes as 0.4497m and accordingly the pitch can be found as 0.3598, so you see here we have discuss the screw conveyer which is very important mechanical conveyer we have solve one problems we have discussed its advantage and disadvantage and other mechanical conveyer like belt conveyer bucker conveyer all these we will discuss in next lecture. So that is all for now thank you.

For Further Details Contact

Coordinator, Educational Technology Cell

Indian Institute of Technology Roorkee

Roorkee – 247667

E Mail: etcell.iitrke@gmail.com. etcell@iitr.ernet.in

Website: www.iitr.ac.in/centers/ETC, www.nptel.ac.in

Web operations

Dr. Nibedita Bisoyi

Neetesh Kumar

Jitender Kumar

Vivek Kumar

Camera & Editing

Pankaj Saini

Graphics

Binoy. V.

Production Team

Jithin K.

Mohan Raj. S

Arun S

Sarath K V

An Educational Technology cell

IIT Roorkee Production