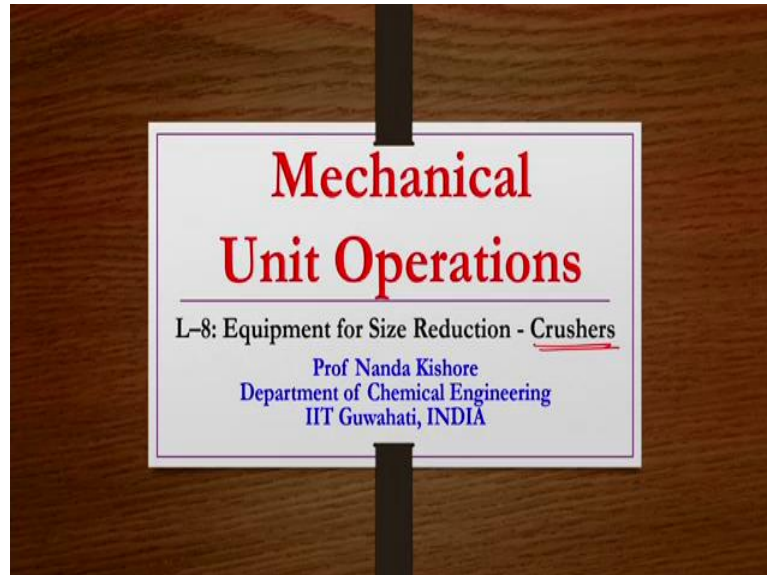


Mechanical Unit Operation
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Lecture 08
Equipment for Size Reduction – Crushers

Welcome to the MOOCs course Mechanical Unit Operations. The title of this particular lecture is Equipment for Size Reduction. There are different types of equipment available for size reduction, so that the bigger size lump particle can be reduced into the smaller size particles. Depending on the applications one can get the coarse reduction, one can have the fine reduction and one can have a kind of intermediate reduction as well.

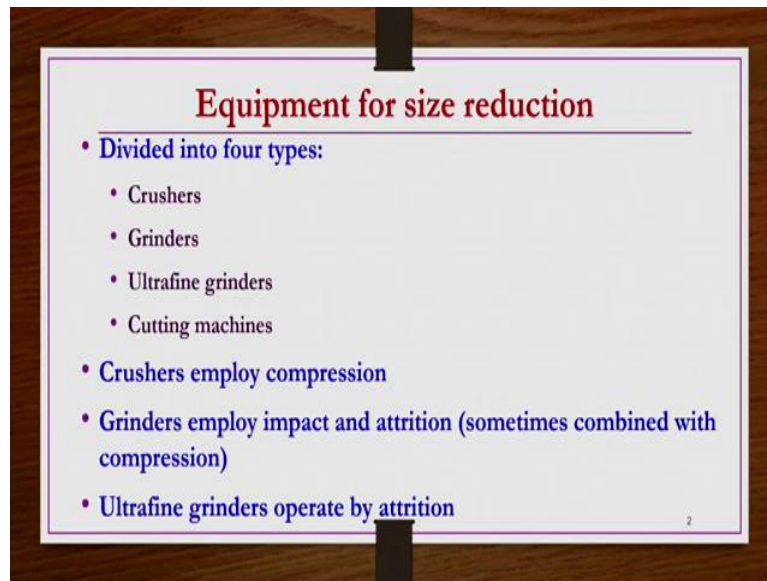
For each type of reduction there is a kind of different type of equipment available, generic type of equipments are available, within the generic type of equipment there are several type of equipments are available. So, in this particular lecture we are going to see the classification of equipment available for size reduction and then out of those classification we will be discussing those details about the crushers.

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Specially, what type of the crushers are available for size reduction, those things we are going to see in this particular lecture.

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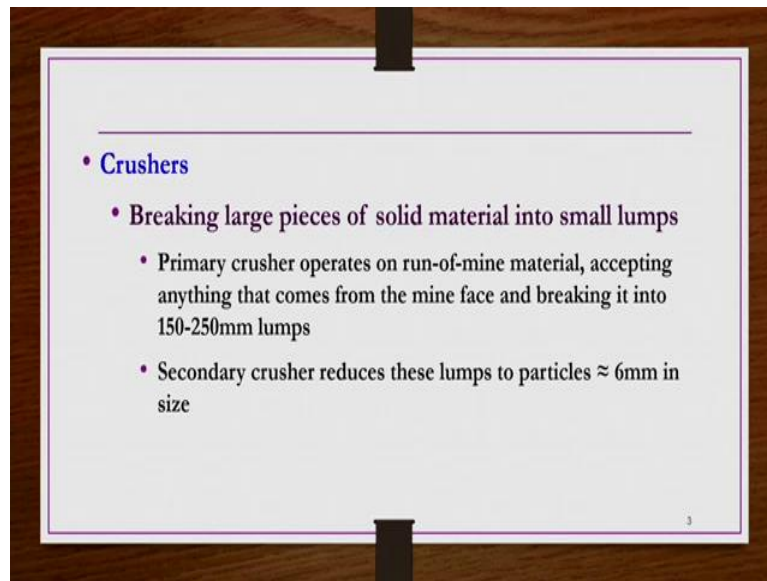
So the equipment for the size reduction can be classified into four different categories. The first one is the crushers, the second one is the grinders, third one is the ultrafine grinders and the last one is the cutting machine. Each of them are having individual kind of restrictions in the feed and the product that one can get and then type of the forces involved in those kind of equipment are also different.

So crushers in general employ the compressive forces, whereas the grinders employ majorly impact and attrition kind of forces. Sometimes it is also combined with compressive forces. We have seen in the previous lecture that what type of forces involved in size reduction. So we have seen that compression impact are hammering, attrition are rubbing and then cutting this kind of four kind of forces we have seen that are available for size reduction.

So, crushers they primarily employ the compressive forces whereas the grinders employ the impact or hammering kind of forces and then attrition. Sometimes the grinders in addition to impact in the attrition kind of forces they also combined with a kind of compressive forces whereas the ultrafine grinders operate by attrition alone.

We see individual details of this equipment crushers. grinders and ultrafine grinders and then cutting machines and then we go into the equipment available under each category of the equipment. These are the categories, they are generic type of names of this equipment are available, they are not kind of a specific kind of thing. Let us say within the crusher, crushers is a one kind of generic equipment, within that generic kind of equipment there are several type of specific equipment are available.

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So, crushers are in general used for breaking large pieces of solid material into small lumps. In general, whatever the raw material that you get directly from mines etc. that you can directly take into the crushers and then break them into the smaller particle, right. In general, from the mines etc. the raw material. the crude raw material that we get they are in very big sizes, 2m average diameter or average size of the lumps or 2m or even more something.

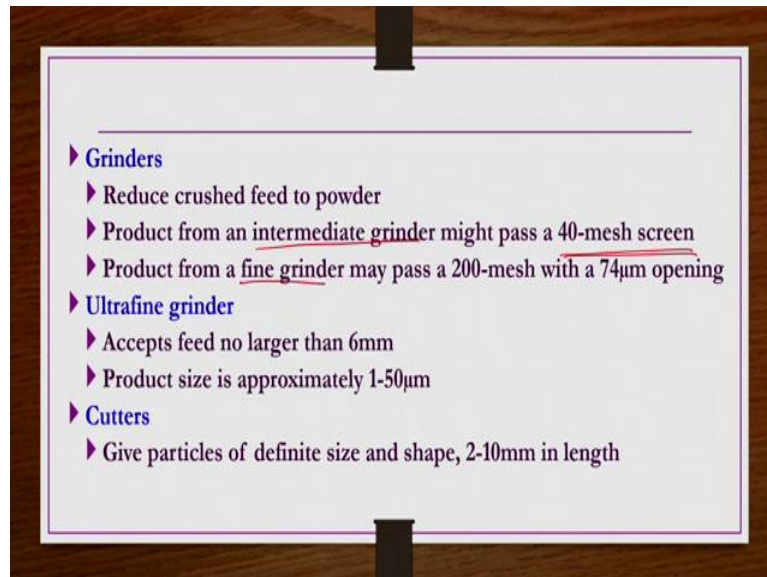
So, in general, 1500mm or 2000mm or above 2000mm, you can see these lumps are having such bigger sizes. So, those big size lumps are in general directly can be taken into the crushers and then they can be reduced to small size like you know 150mm or 100 mm something. This crushers are usually of two types, primary crusher operates on run-of-mine material accepting anything that comes from the mine face and breaking into 150 to 250mm lumps.

So, directly whatever that we get from the mines directly you can take into this primary crushers and then reduce them into 150 to 250mm lumps. There are secondary crushers also which reduce this lumps which are obtained from the primary crushers, those reduced lumps that is approximately 150 to 250mm lumps which are obtained, which are product from the primary crushers.

They will be taken as a kind of feed into the secondary crushers and then secondary crushers will reduce these lumps to further smaller size approximately up to 6mm size. They will not reduce less than 5 to 6mm size, but up to 5 to 6mm size they reduce the lumps 150 to 250mm lumps will be reduce up to 5 to 6mm size in the secondary crushers, okay. These numbers 150

to 250mm are fix mm one cannot say exactly they are approximate kind of numbers. So there can be plus or minus sizes is also possible.

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In the grinders whatever the, reduce crushed feed is there that will be taken into the grinders to get the powder. So after the crushers whatever the reduced crushed feed is there, so whatever the feed that you or whatever the product that we get from the primary and secondary crushers that can be taken as a feed in grinders to get further smaller size particles as powder or something like that. So, in grinders you cannot use the very big particle size directly not use like you know lumps of particles like have a 1500mm or 2000mm size lumps cannot directly use in the grinders.

So, in order to use grinders so the lumps has to be process to the crushers first and then those product from the crushers they should be fed into the grinders to reduce their size to further smaller. In general, product from an intermediate grinder might pass a 40-mesh screen. The product range in the grinders also varies. So, in general, there are two types of grinders available, intermediate grinders and then fine grinders we are going to see those equipment also.

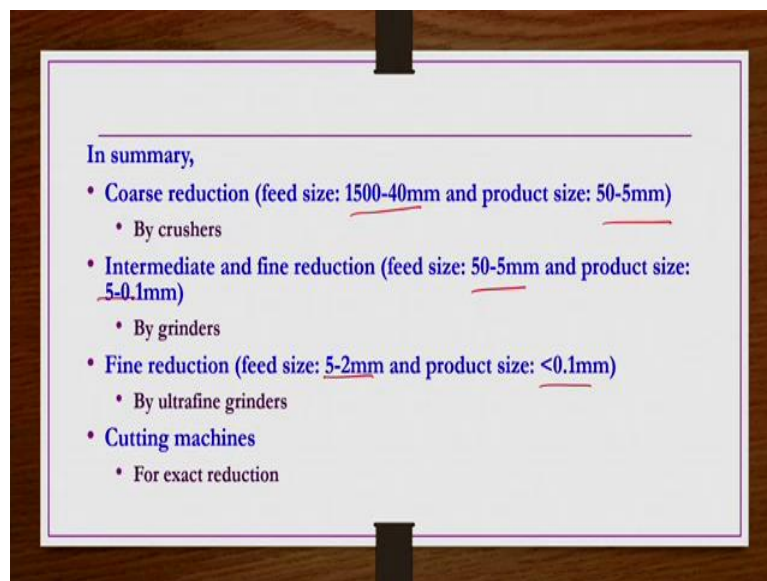
So, whatever the product that you get in general from the intermediate grinders in general they may pass 40-mesh screen. So, 40-mesh screen they may pass, so such small particle you can get further in kind of fine grinder you may even get the product which can pass through 200 mesh that is something like 74 microns etc. So that is product from a fine grinder may pass a

200-mesh with a 74 microns opening. So fine grinder is also possible, intermediate grinding also possible when is grinder.

So grinders can produce both intermediate and finer products or medium and size reduced products. Ultrafine grinders, in general, their feed size is restricted, they will not accept, they feed larger than 6mm in general. So, the feed which is having smaller than 6mm size they can be taken as a kind of feed in ultrafine grinders. Average size of the feed is more than 6mm so that cannot be taken into the ultrafine grinders even if you take that is not going to be helpful.

So, product size is approximately 1 to 50 microns. So whatever the feed that is having less than 6mm size if you apply them for size reduction in ultrafine grinders you may get the products size approximately 1 to 50 microns. So, you can get a product up to one micron also in ultrafine grinders whereas the cutters give the particles of definite size and shape, usually wearing between 2 to 10mm in length, okay. So, if you need exactly same size and shape particle than one has to go for a kind of cutting machine.

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What we understand in summary now here so the first one is the coarse reduction in general like you know that is feed size is like you know 1500 to 40mm in general and then product size is 50 to 5mm. So such range of a you know feed and product if it is there then you can say that particular reduction is a kind of coarse reduction or if you take the largest size lumps like 1500mm something like that and then you do the size reduction by the crushers then you get the product in general 5 to 50mm size.

So that particular type of reduction is known as the coarse reduction because the both the feed and product are in a kind of coarser range. They are in some mm are in cm range. So that particular type coarse reduction we can get, we can accomplish by crushers that is what we have seen. Crusher are in general, both primary and secondary crushers then what you do, you get particles, you know, you product you get approximately not less than 6mm but above 6mm product you get okay.

So that is the reason if you wanted to have a coarse reduction that means coarse reduction in the sense, so whatever is the feed after reduction if you wanted to have the product in a kind of coarse range that is in few mm or few cm it is than it is better to go by crusher and then that particular reduction is known as the coarse reduction. Similarly, intermediate and fine reduction where the feed size in general is 50 to 5mm and then product size may vary 5 to 0.1 mm.

Then that is if you take the feed of size average size between 5 to 50mm and then you do grinding kind of operation for size reduction, then you get the product 5 to 0.1mm size in general or 0.1 to 5mm size in general, so that kind of reduction is known as the intermediate and fine reduction, okay. So, this can be obtained by the grinders, if you are feed and then your product in this range, so then you can say that is a kind of intermediate and fine reduction and then for that purpose it is better to use grinders, it is better to use grinders.

Then fine reduction, if the feed size is less than 5 to 2mm and then products size is less than 0.1mm, then you can call that particular size reduction you know fine reduction that is you take feed of 2 to 5mm size in general and do the size reduction, then product you may get less than 0.1mm. So such kind of size reduction operation is known as fine reduction and for this fine reduction in general, you use ultrafine grinders, you find that this ultrafine grinders are going to be very useful.

Whereas, the cutting machines they are used for exact reduction as I already mentioned, if you are very specific about the size and shape as per the requirement of the consumer one has to go for a kind of cutting machines. Further it should be noted that in this coarse reduction intermediate reduction and fine reduction etc. whatever the feed range and then product ranges are given they are kind of a approximate one, it is not necessary that this range is not very stringent.

So, this feed size may be slightly here and there, and then similarly, the product size may also be slightly be here and there, okay, they are a kind of approximate numbers to give kind of feel whether the product is a kind of a coarser one or the finer one or intermediated one. So, these numbers will serve for that purpose only, but not necessary that these numbers are to be exactly followed in order to define this kind of reductions.

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Classification of size reduction machines in process engineering

Range of reduction	Generic equipment name	Type of equipment
Coarse	Crushers	Jaw crushers
		Gyratory crushers
		Crushing rolls
Intermediate	Grinders	Roller mills
		Hammer mills
		Tumbling mills
		Disc attrition mills
Fine	Ultrafine grinders	Hammer mills with internal classification
		Fluid-energy mills
		Agitation mills

We see some classification of size reduction machines in process engineering. So, what we have seen till now? We have seen generic type of size reduction equipment, they are very generic crushers, what type of crushers, we have not discussed. Grinders, what type of grinders, we have not discussed, ultrafine grinders, what type of ultrafine grinders, we have not discussed because those things are a kind of generic equipment type, generic equipment names.

So, under each category there are several types of equipment are available and then those type of equipment we are going to see in two types, one is like basic coarse reduction, crushers, intermediate reduction, fine and then fine reduction, ultrafine grinders, like that again in the crushers what are the equipment, and then what are the equipment, and then ultrafine grinders what are the equipment are available or which are famously used in industry that we are going to see in the table now here.

So, range of reduction if it is in the coarse range of reduction that is if the feed is between 50 to 1500mm and then product is between approximately 5 to 50mm, then we can say that kind of reduction is coarse reduction. Remember, the product in the sense the reduced size of the

particles. After the size reduction operation whatever the material that we are getting that we are specifying as a product, okay.

It is not a kind of any reaction and then we are getting a product. So, under the coarse reduction we have already seen it is better to use crushers, it is better to use crushers and this is a generic equipment type, crusher is a generic equipment type. Within this crusher we have the several specific type of equipment, so that they are some, some of them are listed here. So, jaw crusher, gyratory crusher and then crushing rolls or roll crusher.

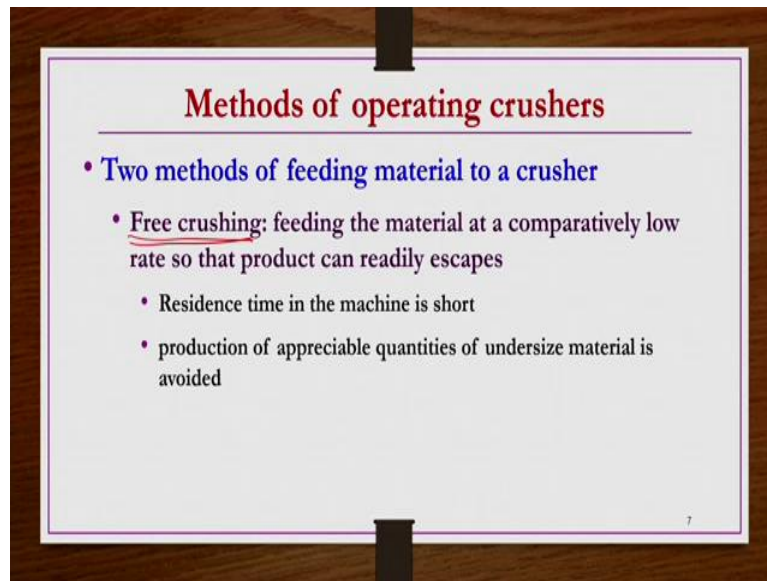
Similarly, intermediate crushers that is if your feed is between 5 to 50mm and then your product is approximately 2 to 5mm, then you can say that particular size reduction operation as a kind of intermediate one and then for that we have seen already that grinders are a kind of better option, grinder are a kind of better option for intermediate reduction that just now we have seen. So, the grinder is again kind of a generic equipment name, within the grinder there are several types of grinders are available.

Some of the important one are which are found to be very reliable in industrial operations are listed out here, so Roller mills, Hammer mills, Tumbling mills, Disc attrition mills are a kind of grinders which are good for intermediate reduction. Then fine, fine reduction that means if you are feed is between 2 to 5 mm and then product after size reduction you get, if it less than 0.1mm then that particular size reduction operation we can call it as a fine reduction.

And then for this purpose ultrafine grinders are very much better option and this ultrafine grinders is a generic equipment name. Within this generic equipment name of ultrafine grinders we have different types of equipment. So, they are Hammer mills with internal classification, Fluid-energy mills, Agitation mills, Collider mills, etc. those kind of things. So, the objective of this particular lecture and then coming lecture is to discuss about this types of equipment, all this type of equipment we are going to see their schematic and in working principle, advantages, disadvantages, capacity, etc.

All those details we are going to see in this particular lecture and then coming lecture. However, this lecture is particularly concentrating only on the crushers. In the next lecture we will be discussing grinders and ultrafine grinders. So, before going into the individual details of this jaw crusher, gyratory crusher and then crushing rolls we will see some other details like methods of operating crushers.

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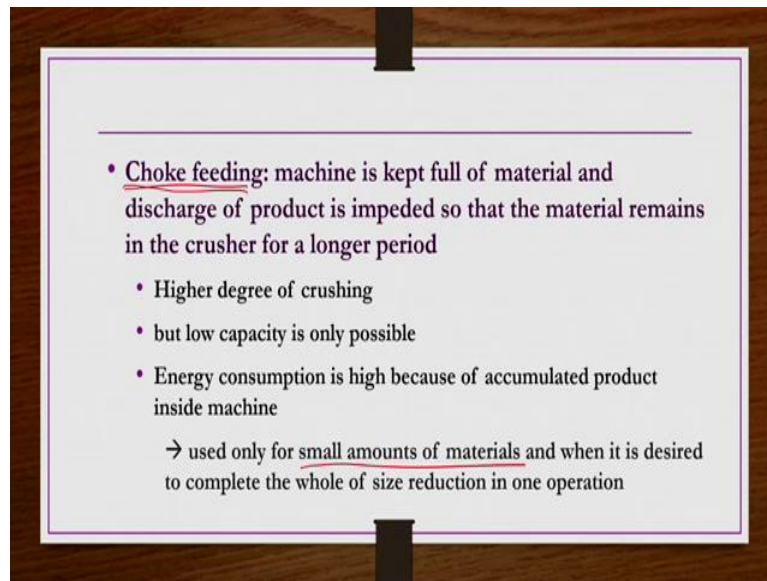


Methods of operating crusher in the sense in terms of feeding, how to feed that equipment, the feed material how are you giving to the equipment and how are you collecting the product based on that one, there are two type of operational method are available for this crushing. Two methods of feeding material to a crusher are possible, one is the free crushing, here feeding the material at a comparatively low rate so that the product can readily escape without any kind of jamming kind of thing.

So, that is what you know called as a free crushing. So, here in general residence time is bit low, is residence time in the machine is sort. And then production of appreciable quantities of undersize material is avoided. Actually if the feed material is staying longer time within the equipment, size reduction equipment for longer time, then you know over reduction may take place.

Because of the over reduction it is possible that you know undersize material may be coming into the product. If you do not wish to have the undersize material in the product it is better to go for the re-crushing where residence time would be less and then you will be getting the product without a much undersize material. As I already mentioned in one of the lectures fine material or undersize material in general it is possible it is possible you cannot avoid but you can reduce, you can reduce by this kind of operational tuning of the parameter kind of thing okay. So, one of the methods free crushing is better one if you wanted to reduce the undersize or fine material in the product.

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The next one is the chocking or choke feeding the second method of operation of crushes is choking feeding where in this kind of method the machine is kept full of material and discharge of product is impeded so that the material remains in the crusher for a longer period right. What you do keep the material very much full and then discharge of particle is slowed, is slow down or delay so that you know the material remains in the equipment for the larger time and then the larger amount of crushing may take place or higher degree of crushing may take place okay.

So, here higher degree of crushing is taking place but what happens the capacity would be low obviously your discharge rate is smaller. So, then your feed rate is coming smaller so than your capacity would be reduced. Capacity in general here in this equipment is measured as a kind of ton per day kind of capacity. Then, since the product is accumulated inside the machine so it is possible that the energy consumption is high and since obviously the degree of crushing is more that means more energy is being supplied to the machines.

So, the energy consumption would be very high because of accumulated product inside the machine okay. So these are the kind of problem with the choke feeding. right. So however you can find it is not kind of problem this can also be seen as a kind of applications. Usually if you are operating with so small amounts material and then it is required to complete the entire size reduction process in one particular equipment, then you can do this choke feeding right.

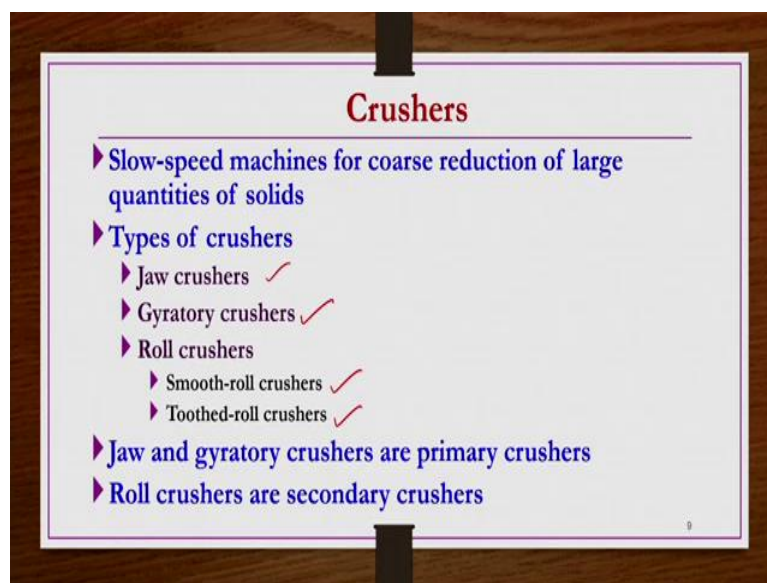
So both of them are having certain kind of advantages and disadvantages, especially you need to handle small amount of material you are not worried about the capacity of the material and then you wanted to or you try to finish the entire size reduction process within one particular

equipment then it is go for the choke feeding. Remember as I already mentioned previously required size reduction may not be possible one single equipment in general, right.

So crushing followed by the grinding is in general required and after the grinding also ultrafine grinding may also be required depending on the application. But it is rarely that within one equipment by or within one particular one single type of equipment you are going to the crushing the entire size reduction is not possible in general even if you do the design product may also not be of specified size as per our requirement.

However, this things are not big issue for a given application than choke feeding can be done then one can try to complete the entire size reduction operation within one single operation equipment. So that is the advantage of the choke feeding or that is the purpose where one can go for kind of choke feeding.

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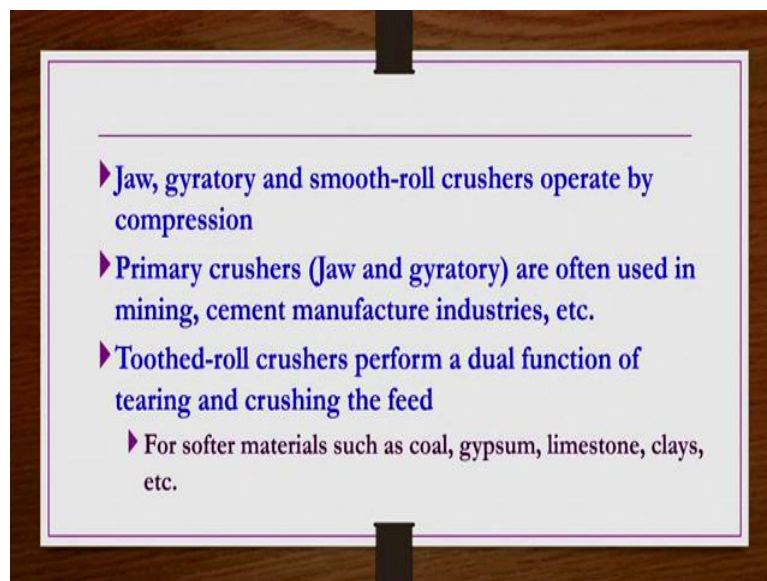
Now what we do we go into the details of individual equipment we start with the crushers, within the crushers what are the type of crushers are available primary, secondary crusher and then jaw crusher, gyratory crushers as I mentioned in the previous slide. So, now we are going into the equipment details, details of individual equipment of the crushers, crusher in general slow speed machines used for coarse reduction of large quantity of solids as I mentioned already from the mines whatever the material that you get directly you take into the reduction machines that is crushers and then you reduce those material to something like you know 50 to 150mm size particle.

From 1500 to 2000 size, you can reduce those particle in lumps into the smaller particle are 50 to 150mm, even 50 to 150mm are also not a kind of a you know smaller once but still they are in the lumps shape. But that is what you know body coarse reduction. These crusher are kind of slow speed machines and suitable for a coarse reduction. There are two types of a crushers, primary and secondary crushers.

So keeping this primary and secondary crusher a side we can see there are jaw crushers, there are gyratory crushers and there are roll crushers or crushing rolls. Within that category we have two types of crushers, smooth roll crushers and tooth roll crushers. Jaw crushers and gyratory crusher are known as the primary crushers, whereas the roll crushers are known as the secondary crushers.

So now we are going to see details of each of this equipment, jaw crushers, gyratory crushers, smooth roll crushers and then tooth roll crushers. Jaw and gyratory crushers are primary crushers, roll crushers are secondary crushers as I already mentioned.

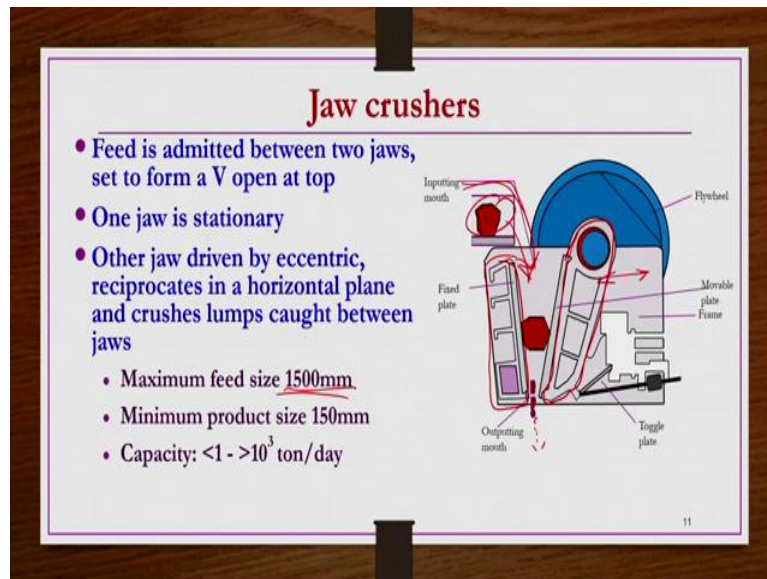
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Jaw and gyratory and smooth roll crusher operate by compression only in general in this three type crushers what we have? We have compressive forces dominating for the size reduction. Whereas the tooth roll we may have a kind of additional forces also. Primary crushers like jaw and gyratory crusher are often used in mining, cement manufacturing industries, etc.

Tooth roll crushers perform a dual function of tearing and crushing the feed, both purpose it is used. Something like for softer materials such as coal, gypsum, limestone, clays, etc. tooth roll crushers are found to be a kind of better option compare to the other kind of crushers.

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So, let us start with the jaw crushers. Jaw crushers in the sense in the jaw crushers there are two jaws one jaw is fixed another jaw one is another jaw is moving like this. So, these jaws are a kind of heavy metal plates they form a kind of V shape. So, whatever the material comes from the top so one of them is moving. So like this when it is moving so the particle trapped the lumps of the materials that is trapped between this two jaws they will break down and then come out as a product from the bottom. So that is the basic principle of the jaw crushers.

So the feed is admitted between two jaws set to form a V open at top like this. So we have a kind of a fixed plate like this or fixed jaw like this here, this is a kind of fixed one and this is a kind of a moveable jaw here we have. So, the feed material are coming from this top section from here you know storage they come from here and then fall here, when they fall here this one of this jaw is moving here and there it can move left to right direction and then up and down direction also depending on the type of jaw crushers.

Let us say when it is moving left to right whatever the material is there trapped between this jaws that will be broken and then the size reduced material will be taken from the bottom as a kind of product okay. So, here what we have one jaw is stationary the other one other jaw is driven by this eccentric reciprocation in a horizontal plane it not necessarily be horizontal plane

in general, it can be up and down motion also and then whatever the material that caught between the jaws that will be crushed into the smaller sizes okay.

So this this moveable jaw is supported with a shaft here so this one I know reciprocates in a kind of one particular direction as per the design. So when it moves then whatever the material trapped between that one that will be crushed when this moveable jaw is coming towards the fix jaw whatever the material is trapped that will be crushed, that will be crushed by the compression and then the reduced material will be taken from the bottom.

In general the maximum feed size can go up to 1500 mm that is 1.5meters in general that you can get such larger particles also you can handle in this kind of Jaw crushers. So, jaw crushers that is the reason the crushers that is known as the primary crushers and then directly we can take the materials from the mines whatever the big-big lumps that we get directly you can rake into the jaw crusher and then break them.

After crushing this big lumps by compression between this two jaws the product that you get you get minimum size of 150mm. It is not possible to get a product less than 150 or 100mm in general okay. You cannot expect that you know to have a any kind of intermedicator or find deduction in this jaw crushers. Jaw crushers are primarily for only for a coarse reduction where the feed and product both are in some mm or cm range. Then capacity it can handle less than one ton per day as well as it can handle up to 1000 per day. So such wide range of capacity this equipment can handle.

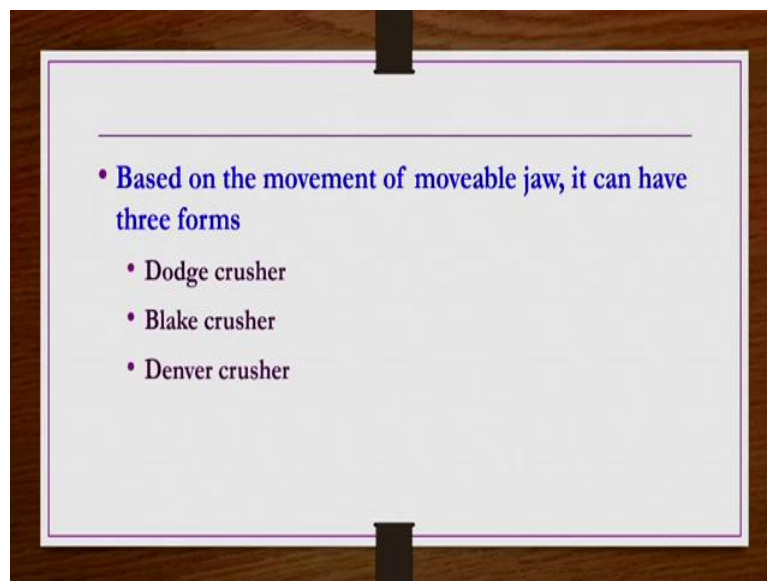
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This jaw crusher having several types of advantages the very important one is the high and constant capacity. Capacity is very high 1000 ton/day is a kind of very high capacity in general, and then high operational reliability. So, it is rare that during the operation there will be kind of shut down or any kind of breaking or something like that. Because the design is so simple that in general the operational break is not expected is not going to happen in general that is the high operational reliability is there.

Long lifetime, lifetime is also long you do not need much to pay for the maintenance and all that in general easy replacement of wear and spare parts the design has been done in such a way that whatever the some kind of parts like spare parts wear some kind of part if you need to replace so then a replacement found to be easy for this jaw crushers. Because of their design and then I already mentioned the maintenance is very low. Low maintenance requirement is there you do not need to pay high for the maintenance of this kind of equipment these are the very much important advantages of this crusher.

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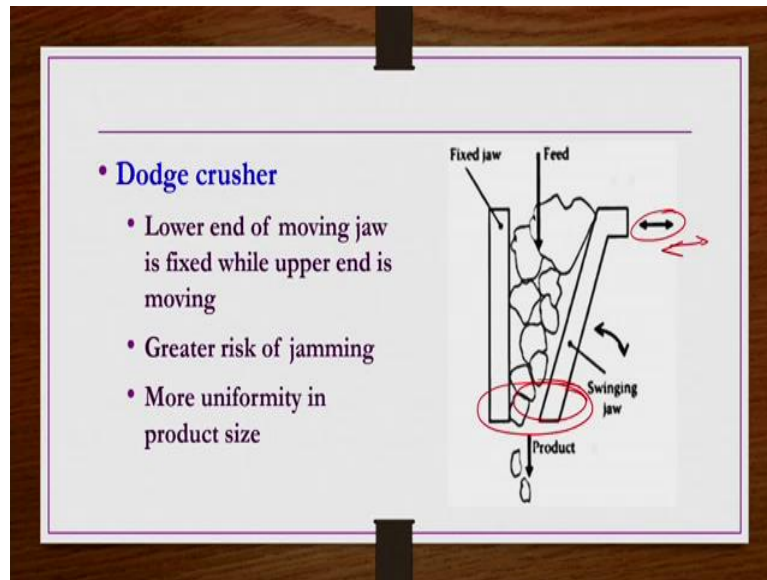


Then based on the movement of movable jaw it can have three forms. Let us say now as I already mentioned this is a kind of I know fill this one is a kind of fix jaw this one is a kind of moving jaw. So now here when I am moving hands you know bottom is, you can see that the knee is a kind of fix and then palm side is kind of moving. But it is also possible that the top it can be fixed and then bottom may be moving like this. So this are the two possible.

So sometimes it is also possible that you know it may come in a kind of flattered direction and then it can move up and down like this also. So based on the different types of movement there

are different form of jaw crushers are available rather saying types different forms of jaw crusher are possible that is dodge crushers and then Blake crusher and then Denver crushers.

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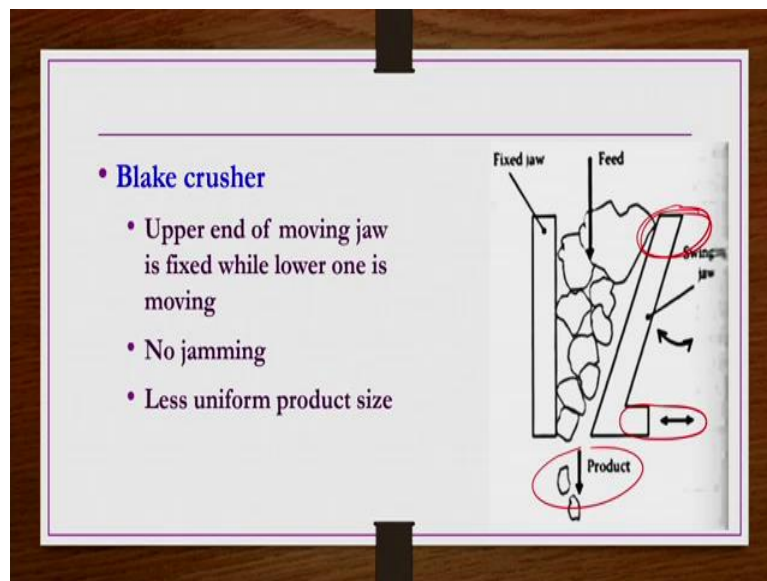


So dodge crushers, in the dodge crushers lower end, lower end of the moving jaw is fixed while the upper end of this movable jaw this you know reciprocates in this direction here and there, so that whatever the material is coming here that will you trapped and broken down. But you know what happens the bottom one is kind of fixed one so there is a problem of jamming right. It is not it is not freely moving so then you know, the whatever the product that is coming. It is possible that you know that is jamming and then discharge may not be the rate as expected okay.

So this kind of form of the movable jaw or this kind of movement where the bottom is bottom end of the movable jaw is fixed and then top end of the movable jaw is moving. So such form of jaw crusher is known as the Dodge crushers. In this one since the bottom end of the movable crusher is in a, you know fixed there is a problem of jamming of the product because the product are the discharges not comfortably going out.

However in this kind of Dodge crushers you can expect a kind of more uniform product size in general because you know it is being crushed for more time degree of crushing is more because at the bottom it is jamming kind of thing it is some kind of jamming is there at the bottom it will further try to move in such a direction that they more crushing will take place so then obviously you can have a kind of more uniformity in product size.

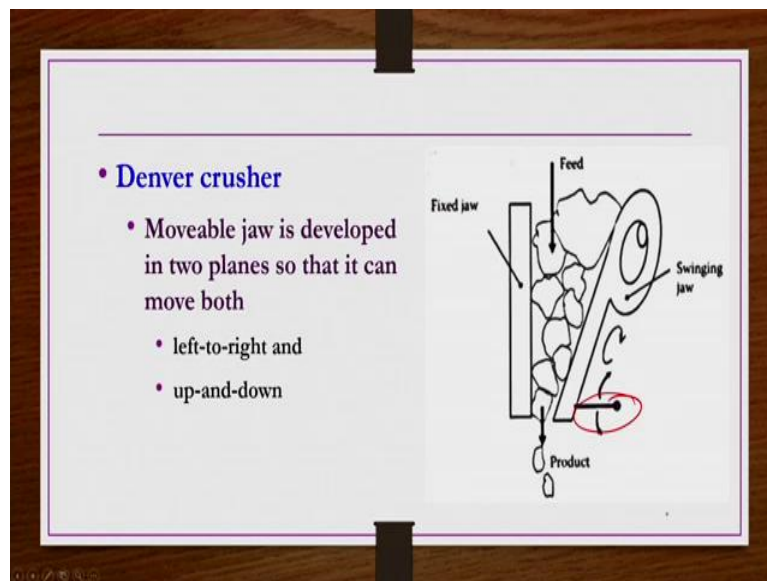
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Then Blake crusher so here what happens the top end of the top or upper end of the movable crusher is fixed whereas the lower end of the crushers is a kind of a reciprocating in the horizontal direction so that you know the crushing is taking place as I mentioned right. So the top one is fixed and then bottom one is moving like this. So whatever the material is coming and then being trapped that is broken and then it can go comfortably it can go comfortably like this.

So then there will be not any kind of jamming because bottom end of the movable jaw is not fixed so then product can comfortably discharge can go out. So, that is the reason you may not have a kind of jamming problem. So, Blake crushers are having upper end of a moving jaw as fixed while the lower end is moving. There is no jamming problem and however less uniform product size is there because you know depending on the speed of the motion of this movable jaw so some of the material without being crushed that may also go down. So the uniformity of the size may not be maintained.

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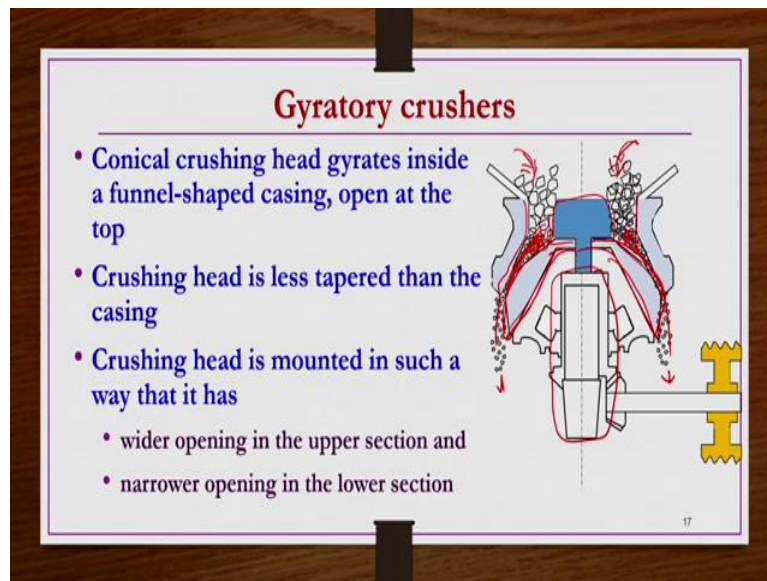
- **Denver crusher**

- Moveable jaw is developed in two planes so that it can move both
 - left-to-right and
 - up-and-down

Whereas the Denver crushers it is having this kind of thing it is the movable jaw is developed in two planes so that it can move both left and right as well as the up and down so that you know you one can have one can avoid jamming as well as one can get the uniformity of the product. So this combines the both the advantage and the disadvantage of the two other types of crushers that is Dodge and Blake crusher.

So those problems whatever are existing with the previous one are not there here, in the Dodge crushers there is a jamming problem in the Blake crusher there is a problem of non-uniformity of the this product size. So those both of them are taken care by the this design where the moveable jaw moves in both direction like you know left to right as well as the up and down. So like this like you know this center may thing come here this may come like this also it may go up and down. So that is the reason the jamming will not be there as well as the, you know uniformity will also be maintained.

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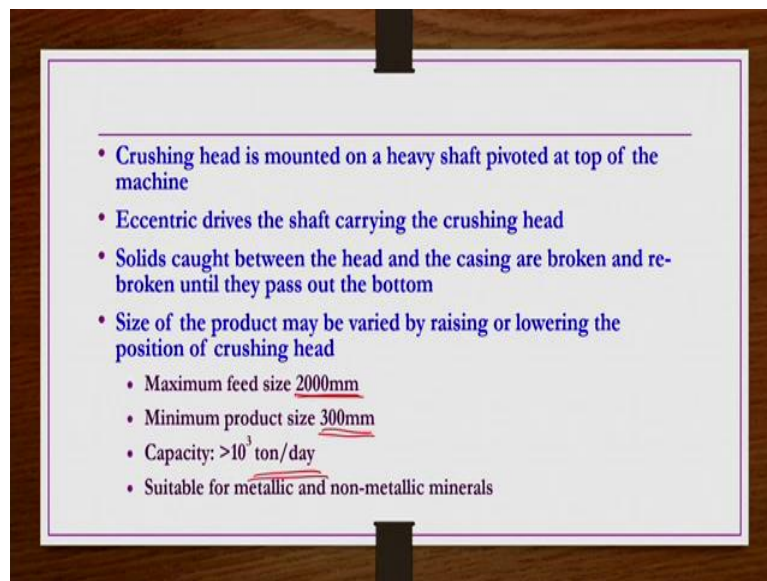
Then Gyratory crushers, here Gyratory crushers are you know usually crushing head is there the conical crushing head, gyrates inside a funnel shape casing which is open at the top right so let us say we have a kind of crushing head here so this is a kind of a crushing head. This is the conical shape crushing head is there it is actually mounted on a kind of shaft mounted on a kind of shaft is shown here. So this particular session what happens when the shaft rotates then this most this you know crushing head moves up and down, and then we can see here the crushing head is less tapered compare to the casing.

And then it is tapered such a way that it is wider at the top and then narrower at the lower end right so that more feed can come comfortably from the top here more feed can comfortably and then more reduction can take place here in this narrower section and then the size reduced material can be taken from this two sides. This is the basic principle of the Gyratory crushers. So here we have a conical crushing head as shown here this crushing head conical crushing head right.

Inside this funnel shape this is a kind of funnel shape casing kind of thing is there we have shown an only kind of thing which is required here okay. This casing is open at the top so that from here we can get the feed into the feed into the space between the, or the clearance between the crushing head and then casing right. So this clearance one can adjust so that one can get the product of required size.

One can go for intermediate products or one can go for the kind of coarse reduction product also by changing the spacing the, or the clearance between this two crushing head and then casing. Here as I already mentioned crushing head is less tapered than the casing, crushing head is mounted in such a way that it has wider opening in the upper section as I already mentioned and then narrower opening in the lower section so that you know feed can also come comfortably and then reader after entering between the clearance between the casing and crushing head “d” is size reduction can also take place comfortably.

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So here crushing head is mounted on a heavy shaft pivoted at the top of the machine. Eccentric drives the shaft carrying the crushing head. Solids caught between the head and the casing are broken and re-broken until they pass out the bottom because not only the trapping, so as long as they are between the, trapped between the clearance space that is the crushing head and then casing the material will keep on undergoing this size reduction because of this Gyrotory motion that is shaft is moving this crushing head up and down.

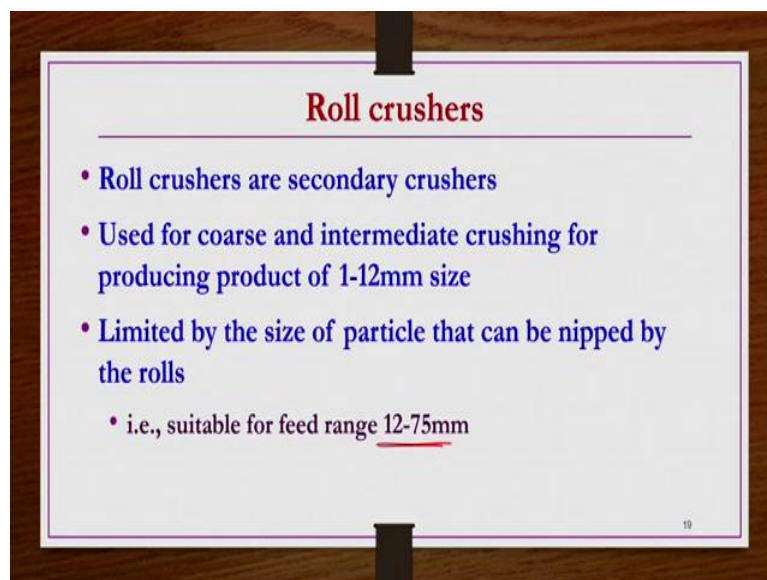
So until the material escapes the gap between these two that will keep on under grow or kind of a crushing. So in breaking and re-breaking keep on taking place until the material passes out at the bottom. Size of the product may be varied by increasing or decreasing the clearance between the crushing head and the cone casing okay or funnel case, funnel shape casing that we have, okay.

So that is by raising or lowering the position of crushing head. So because the whatever the funnel type casing is there, this funnel type casing whatever is there that is fixed only this cone

shape crushing head is only movable, if you move up then you know the clearance between the funnel shape casing and then crushing head would be reduced and then you may have the more finer product come from then expected, if you move it down the clearance between these two will increase and then you may have a kind of coarse product, in general.

So by varying the position of this crushing head one can vary the product size distribution as well. Here one can go feed size up to 2000mm, such large particles, such large lumps can also be handled by these Gyratory crusher and then product size you may expect up to 300mm okay you may not expect to have a product size less than 300mm. And then capacity, it can be more than 1000 tons per day it is very high capacity and then suitable for metallic and non-metallic minerals as well.

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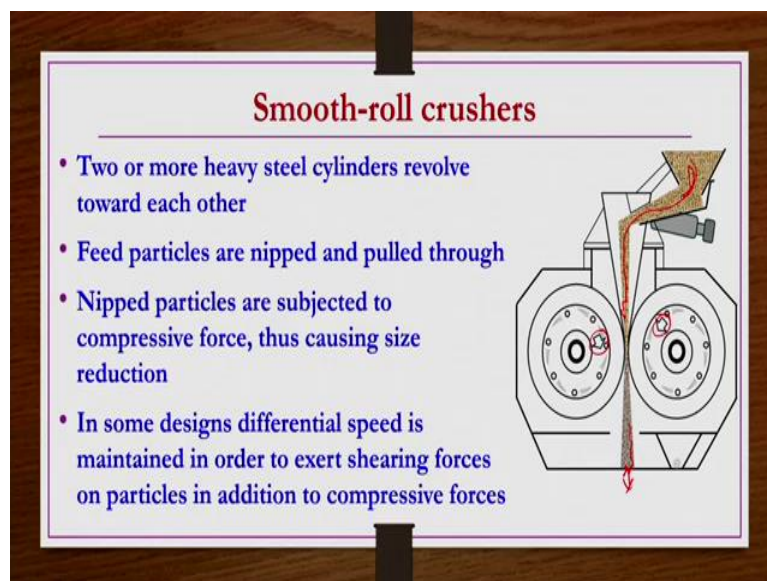


Then roll crushers, these roll crushers, as I already mentioned they are a kind of secondary crushers, secondary crushers in the sense the feed for the secondary crushers are the product from the primary crushers that is from the primary crushers whatever the product that is jaw crushers, Gyratory crushers that you have, from them whatever the product you get, that product you can take it as a kind of feed to this secondary crushers. That is the reason this roll crushers are known as a kind of secondary crushers, because their design is in such a way that you cannot handle a kind of bigger size particles like you know 200mm or more than 300mm something like that, so here the roll crushers, that is the reason are known as the kind of secondary crushers.

They are used for both coarse and intermediate crushing for producing product of 1 to 12mm size, 1 to 12mm size product you can get in general by this secondary crushers. However the feed is limited by you know the size in general the feed is limited by size that 12 to 75mm feed only you can give a material, a solid material which is having the average size between 12 to 75mm only. Because of that restriction these are a kind of secondary crushers, they are not grinders anyway they are crushers only, so only because of this they are secondary crushers.

Primary crushers can handle very big size particles as well, like you know the 1500 or 2000mm particles as well, we should not call them as particles, lumps such a big lumps like 1500mm or 2000mm, big lumps can also be handled by the primary crushers whereas the secondary crushers cannot handle lump size more than 75 or 80mm in general. Whereas the product from the secondary crushers you can get between 1 to 12mm, not less than 1mm, less than 1mm, mm is not possible in general

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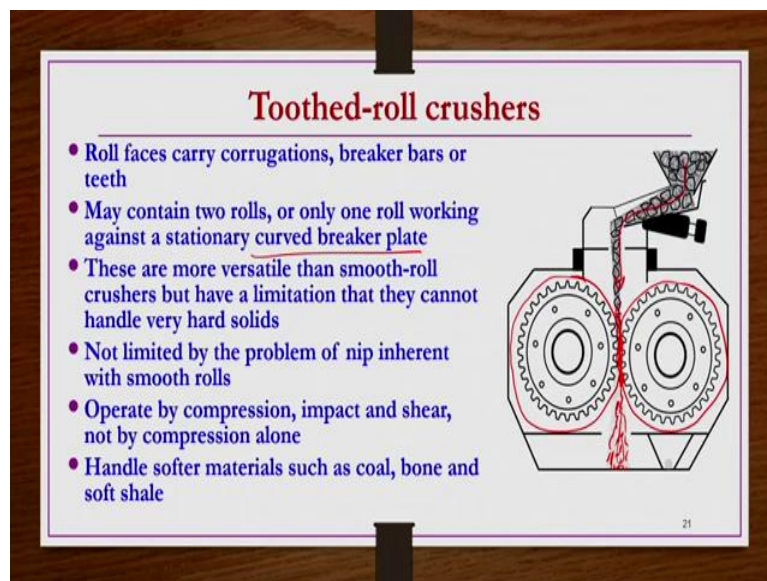


So these roll crushers are 2 type crushers in general these crushers, roll crushers are you know there are 2 or more cylinders are there, they are rotating in against to each other. So that you know whatever the material trap between these two cylinders, they will be crushed okay. So basically we have a kind of cylinder as shown here, one cylinder now this is rotating in kind of a clockwise direction and then this is rotating in kind of anti-clockwise direction the material that is the feed material that is coming over here right. That material whatever being trapped between the cylinders right.

So that will be broken that size reduced material would be collected from the bottom. This is the basic principle we call smooth roll crusher because some cylinders are having corrugation also. So those kind of roll crusher are known as the kind of a tooth roll crushers. So smooth roll crushers they have usually two or more heavy steel cylinders revolve toward each other. Feed particle nipped and pull through between these two and then whatever the nipped particles are subjected to compressive force thus causing size reduction here. The force that is being I know by the kind of compressive forces only size reduction is taking place.

That is the reason this are known as the kind of a crusher but not any kind of grinders. However one can also try to generate in shearing kind of force in addition to the compressive force. How that can be done that can be done by applying the differential speeds of you know of this revolving cylinders. That is in some design differential speed is maintained in order to exit shearing forces on particles in addition to compressive forces that can further enhance the you know the size reduction operation.

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Other type of roll crusher is tooth roll crushers here you know we, in the previous case smooth roll crushers we have a kind of smooth surface but now here a kind of corrugations are teeth kind of thing that we can see on both the cylinders right. So it is the process exactly the same whatever the things happening in a kind of smooth roll crushers the same thing is happening here only the surface of the cylinder is not smooth here we can have a kind of corrugations are on teeth kind of thing on cylinders right.

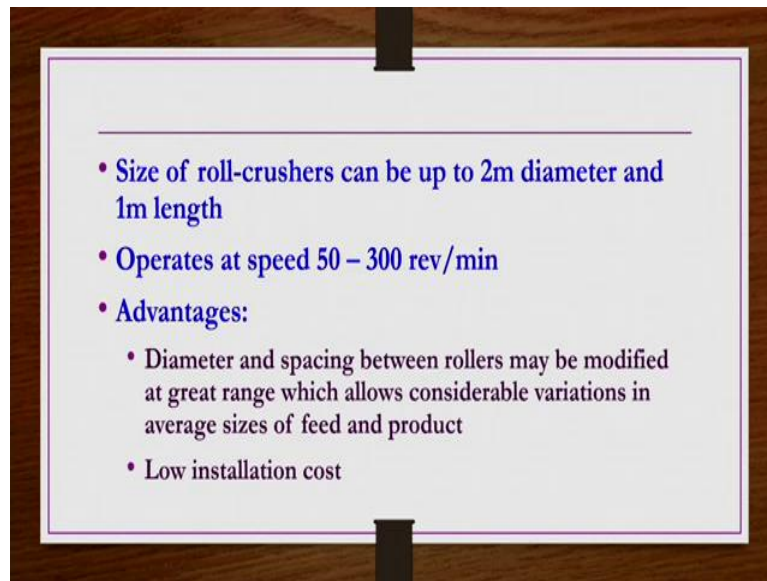
Otherwise when they move towards each other whatever the material that is coming from the top the feed material that will be trapped between and then because of the compression again here they will be reduced and then size reduced material is collected from the bottom like this. The principle is same as smooth roll crushers but only thing that you know the cylinders having corrugations or breaker bars or teeth kind of design.

They may contain two rolls not necessarily you always need to have two rolls you can have one roll also working against a stationary curved breaker plate. You can have a kind of you know curved breaker plate like this and then within this you can have a kind of cylinder that may be rotating. So when it is rotating you know whatever the particles are there when it is rotating in this direction the particle is trapped between this casing and then this you know corrugated cylinders that those particles will be going through some kind of or experiencing some kind of compressive forces and then size reduction will take place.

That tooth roll crushers are more versatile than smooth roll crushers but however they have a limitation that this tooth roll crushers cannot handle a very hard material in general whereas the smooth roll crushers can also handle you know this kind of a hard material as well. However, in this case tooth roll crushers they do not have any limitation or problem of nipping of the particle which is inherent with the smooth roll crushers.

Here this tooth roll crushers they operate not only just by compression but in addition to the compression here we can also experience we can also have a kind of impact and shearing forces in addition to the compression we can also have impact and shearing forces in order to have a kind of higher degree of size reduction to compare to this smooth roll crushers. But only problem with this tooth roll crushers that they cannot handle very hard material. So these are suitable for softer material such as coal, bone and soft shale etc.

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In general, for this roll crushers both smooth and then tooth roll crushers the size of the roll crushers can be as big as we can have a 2m diameter and then 1m length cylinders rotating for kind of required size reduction. They operate at speed 50 to 300 revolution/minute. They have the advantage that one can change the diameter and spacing between rollers so that this change whatever the diameter and spacing between rollers may be modified at a greater range such that considerable variation in average sizes feed and product can be handle okay.

So let us say if you are feed material having bigger lumps in general so then you know you can increase the space between this rolls right. So that you know you can handle the bigger lumps as a kind of feed material okay. If the feed material is smaller one then you can reduce the space between them right, so that you can have a smaller kind of particle smaller lumps particle so that you know for the reduction take place.

So this distance that you know you can varies at a wider range so because of that one both the feed distribution as well as the product distribution that you can handle by this roll crushers you know they are in general variation are very high considerable variation can be maintained or the you know feed and product size where we have the distribution or the particle have very large size can also be handled and the product also get the medium size particle as well as the smaller size particles.

So this is the, an important advantage and then further another important one is the low installation cost it does not cost much for the installation of this kind of roll crushers. So this is about the crusher different type of crushers primary and secondary crushers how they operate

etc., right. So in the next class we will be discussing about the grinders different types of grinders the details you know the operational details with schematics we will be discussing.

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The reference that have followed for this particular lecture are this books McCabe, Smith and Harriot, Ortega Rivas, Richardson and Harker, Geankoplis, Brown et al, Badger and Banchero but primarily the detail are taken from this two books McCabe, Smith and Harriot as well as the Ortega Rivas. Thank you.

