Iron Making

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Lecture - 07
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So, we will take another example now on the coke consumption related to blast furnace.

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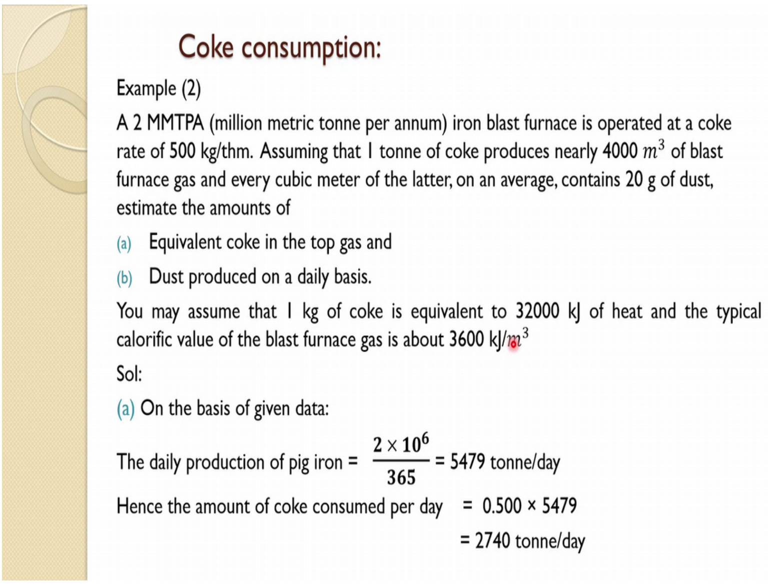

So, that is a 2 million metric tonne per annum iron blast furnace is operated at a coke rate of 500 kg per tonne of hot metal. Assuming that 1 tonne of coke produces nearly 4000 meter cube of blast furnace gas and every cubic meter of the latter, on an average contains 20 gram of dust.

So, estimate the amount of equivalent coke in the top gas and dust produce on a daily basis. So, one can assume 1 kg of coke is equivalent to 32000 kilo joule of heat and the typical calorific value of the blast furnace gas is about 3600 kilo joule per meter cube. So, on the basis of these data we can easily calculate the daily production of pig iron 2 million metric tonne per annum.

So, 2 into 10 to the power 6 tonnes it comes and because it is per annum. So, this is on per day 365 it will come 5479 tonne per day. So, the amount of coke consumed per day is its about 500 kg which is about 0.5 tonne into the daily production of pig iron which will come at about 2740 tonnes per day.

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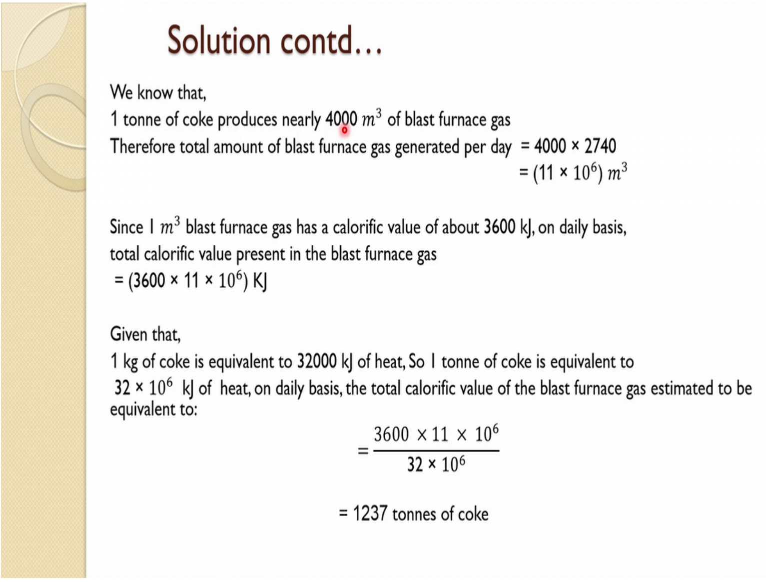

So, and now we know it is given that 1 tonne of coke produces about 4000 meter cube of blast furnace case.

So, 2740 tonne will give you about 11 into 10 to the power 6 meter cube blast furnace gas. And also it is given that 1 meter cube blast furnace gas has a calorific value of 3 thousand 600 kilo joule. So, total calorific value of this blast furnace gas if we say on the per day basis would be quite high; so, 3600 into this. Now 1 kg of coke is equivalent to 32000 kilo joule of heat.

So, 1 tonne of coke is equivalent to yeah 1 tonne of coke would be equivalent to 32 into 10 to the power 6 kilo joule. So, this is kg ah; so, 1 tonne is about 10 to the power 3 kg. So, which will gives you 32 into 10 to the power 6 kilo joule of heat.

So, on daily basis the total calorific value of the blast furnace gas can be estimated. So, it would be 3600 into 11 into 10 to the power 6 which that gas which we are getting it divided by this equivalent heat. So, it gives you about 1237 tonnes of coke. So, this sort of coke is required per day for the blast furnaces.

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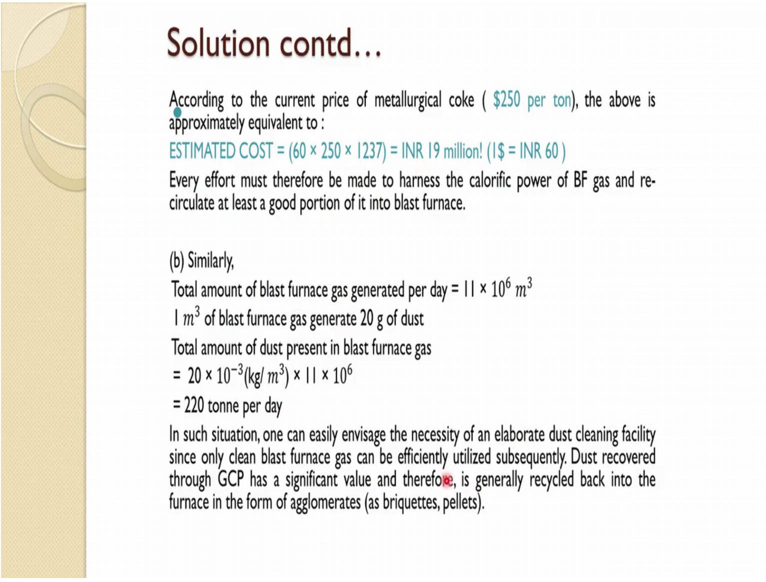

So, if you assume that and if we assumed current price of coke is about 250 dollars per tonne the cost of it would be 250 into 1237 and if we converts with dollar into rupees. So, exchange rate if we take 60; so, it comes almost 19 million Indian rupees or about 0.3 million US dollar; so, that is a huge amount.

So, a small saving in this can result a big saving in the price and that is how people are trying to decrease the coke consumption or save it. Now we come to the blast furnace gas which is generated, we have already calculated 11 into 10 to the power 6 meter cube and it is given that 1 meter cube of blast furnace gas generates about 20 gram of dust.

So, the total dust would be 20 into 10 to the power of minus minus 3 kg per meter cube convert into this. So, it will and convert it into tonnes; so, it will gives you about 220 tonne per day. So, in that is a huge amount in a days you are generating the dust you can imagine now that how much dust if we take that a very miniscule amount to 20 gram, you are generating 220 gram just and the blast from that blast furnace.

And you need a very elaborate dust cleaning facility for that and this dust also; you cannot just throw it you have to and it has a value a quite a lot carbon and some mostly ion ore and you cannot throw it has a value. So, you have to use it and that is where the agglomeration process comes into picture l; so, we will come to the agglomeration.

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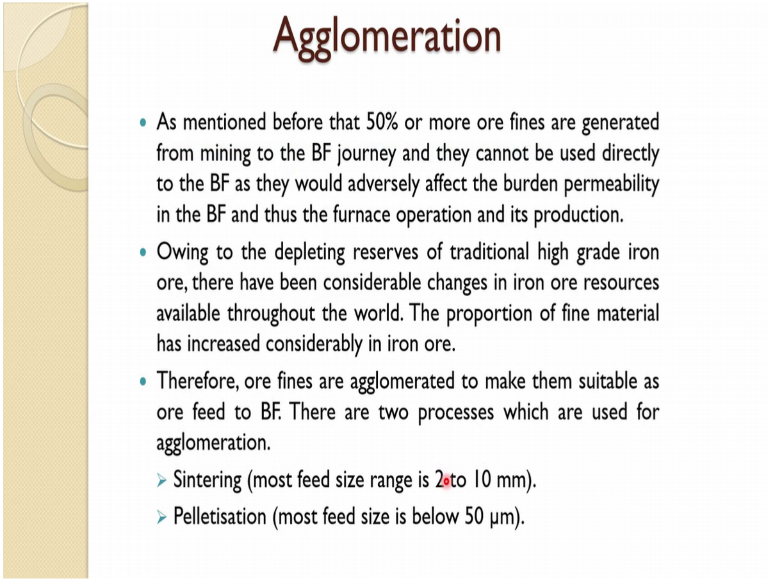

So, we had mentioned before in this course that about 50 percent or more fines are generated from mining to the blast furnace in transportation crushing, grinding, beneficiation. So, all this lead to more than 50 percent fines generation and they cannot be used directly to the blast furnace as they would adversely affect the burden permeability in the blast furnace and thus the furnace operation and its production. So, owing to the dip at the another also region the deeply a depleting reserves of traditional high grade iron ore there has been considerable changes in iron ore resources available throughout the world, the proportion of fine material has increased considerably in iron ore

So, now we are really dealing more and more fines than the lumpy ore. So, we have to really switch to the agglomeration process because these fines cannot be used directly. So, therefore, ore fines are agglomerated to make them suitable as ore feed to blast furnace and there are two processes for this; one is sintering and another is pelletisation.

So, sintering is restricted in the size range of this. So, when size is less than or 10 millimeter or less it is up to 2, 3 millimeter you can go for sintering. Pelletisation actually it is a in fact, for very fine; so, usually the feed size is less than 300 micron, but majority of it 50 percent or more should be in this range and you go for pelletisation.

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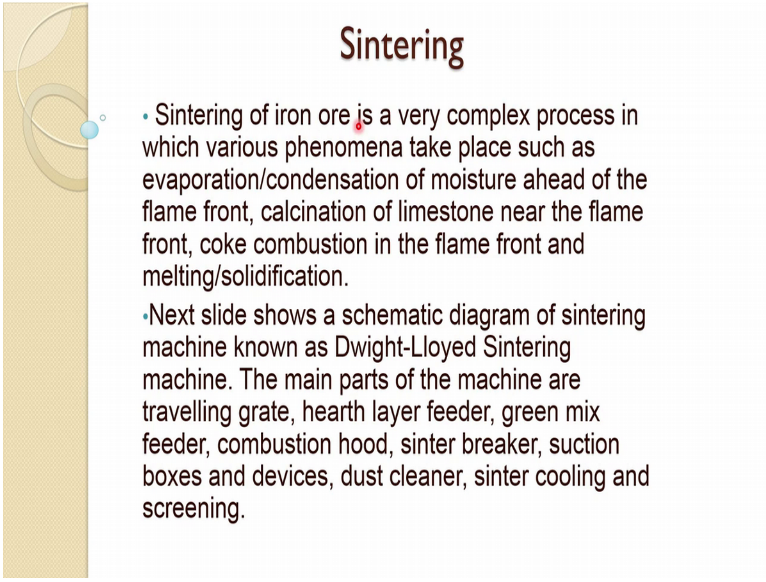

So, we will come to this sintering; so, sintering of iron ore is a very complex process in which various phenomena take place such as evaporation, condensation of moisture ahead of the flame front calcination of limestone near the flame front coke combustion in the flame front, melting solidification. Next slide shows a schematic diagram of sintering machine and the main part of the machine are traveling great, hearth layer feeder, green mix feeder, combustion hoods, sinter braker, suction boxes and devices, dust cleaners, sinter cooling and screening.

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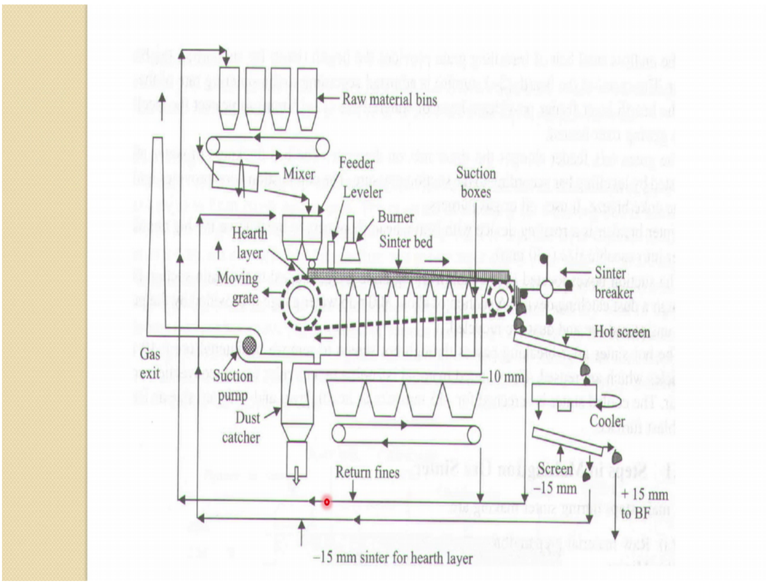

So, this is a moving great sintering machine. So, we feed the raw material we will describe each of these separately, but I thought before we go to these separate thing, it is necessary for you to understand the sintering process and sintering machine. So, then you can correlate what we are talking if we talk about the raw material or if we talk about the sinter strand or any other or mixture or granulation, you can easily correlate this one with the actual sintering process.

So, in this one you have a raw material bin where you have a ore fines, then you have coke limestone blue dust or some other material and waters; you put it in a mixtures make the granules here. So, this fine comes in the granules of pellet form which is more than 12 to 15 more than 12 millimeter in size the idea is to have a narrow distribution and these you feed it into the feeding bins and which drops them onto a great moving great. So, this is a moving grate which is continuously moving and on this one; the green pellet which has a moisture also you put it there, but because sintering occurs at high temperature. So, the bottom layer is protected by the is some return sinter you put it in this one which is called the hearth layer.

So, it protects over heating of the bottom layer or on this moving great. So, on grate hearth layer you put the green mixture and there is a lever which leveled off the feed material and so, the bed height of this about 40 millimeter it is not 40 millimeter is about 40 centimeter.

So, this is a it varies from 30 to 45 centimeter in the range and after leveling it off it directly comes under the ignition hood this is called ignition hood where you supply the energy through the burners which can be used for gas or oil or other things. So, this burner supply the heat and which is around 13, 1400 degree Celsius or 30 around 1300 and because this is a top layer is subjected to this heat.

So, coke which is inside in this in this pellet; it get burn and a flame front get established. So, once this pellet comes out under the ignition hood already; the flame front is established. And because the suction is applied from the bottom of this great; so, due to the suction of this air this flame front travels towards down.

And the downward you are having all green pellets which has coke. So, it keeps on moving down and the hole strand keeps on moving. So, once it comes out from the ignition hood then its expert to the as much period top one at the top and air is withdrawn or sucked through these wind boxes which are located at the bottom.

So, as the air is sucked into these the flame front moves downward and the top layer gets sintered and a you travel further because it is exposed to the atmospheric pressure. So, top layer get cooled down and while the time it comes to the last wind walks; this whole product across the depth gets sintered here and so, by the time it comes out at the end of this great everything is sintered and it is through broken into the pieces using sinter breaker. So, sinter breaker because this is like a cake which has to be broken into small pieces. So, this interpreter helps that to break it and then you have a hot screen.

So, where the very fine coke to the sinter return the oversize comes again here; where you have a cooler and other thing to cool it down further and again another screening. So, plus 15 millimeter size of sinters you send it to the blast furnace and minus 15 millimeter; actually goes as a hearth layer to make which we were talking about here to make the hearth layer that actually goes there to make it. So, this is a moving great and this wind box it the collect a airs or compressible air and dust comes through this.

So, you can get these are so, get collected. So, this is very fine returns and this goes to the one of the bin here to make use again for making the granules and pellets. And after dust catching the dust gas dust goes out to the chimney. So, this is a brief description of this sintering machine and we will be talking in detail about the each of these process; how the mixing occurs. How the sintering is occurring and how does it affect get affected by different parameters.

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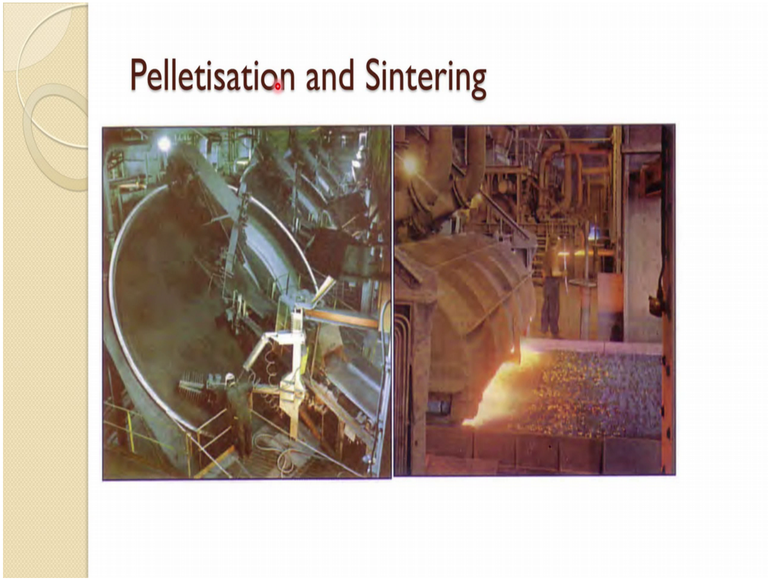

So, this figure actually in fact, the right one is showing about the sintering machine actual one. So, this is the ignition hood as you can see and this is once it is coming out from under the ignition hood; first layer is already very hot and get sintered and you can see probably a bit this red hot underneath of the first layer which means flames front has already established and traveling down at the gas is getting sucked from the bottom.

So, the flame front is moving downward across the depth and the this sinter at the top is getting cooled up by the cold air. And this is actually the other figure about the pelletisation to make the green pellets or granulation what we were talking; we will come to this. Also this is at you feed the iron ores and mixture and other things at one place, at other place you feed the water and this is a disc pelletizer

So, it rotates and this is a scrapers. So, whatever material get stuck it is through that one and with after some rotation and layering of the fins; you get granules of the size of 10 millimeter plus 12 millimeter like that; so, this is sort of a pelletisation process.

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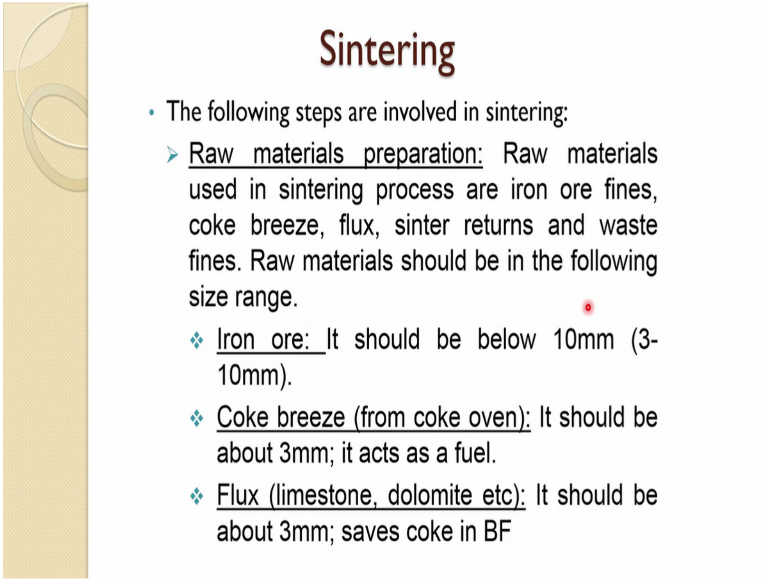

So, we will come to this little later we will. So, there are various types in the sintering the first one is the raw material operation as you have seen the process start from there. So, the raw material you have iron ore fines, coke breeze, flux, sinter returns we have seen all those any other waste fines if there we put that.

So, the there should be a strict size control for this. So, for iron ore it should be below 10 millimeter; usually between 3 to 10 millimeter, coke breeze about 3 millimeter and because it act as a fuel; when the air is being sucked from the bottom. So, you know it is a self sustaining flame front.

So, there that is self sustaining flame front comes from by mixing this coke into the pellet. And the size of this is also very important because that can affect the sintering process ah; not just the sintering process even the sinter which will get produced. Flux that limestone, dolomite; limestone mostly calcium carbonate, dolomite is c o m g o.

So, it contains magnesium oxide also and some other aluminum and other flux one can use it, but mostly these are lime or manganese based. So, again this should have also a right size range. And you put it including this granulation, the flux because and in this one you was using not a very high quality coke or even sometime called you use it. So, you were really saving the coke in the blast furnace when you was using it in the granulation here.

So, you are really saving the coke in the blast furnace because for limestone and dolomite dissociation, you need the energy; in the blast furnace it is supplied by coke. And here already it get dissociated via this low quality coke and other things; so, in that way you say coke in the blast furnace.

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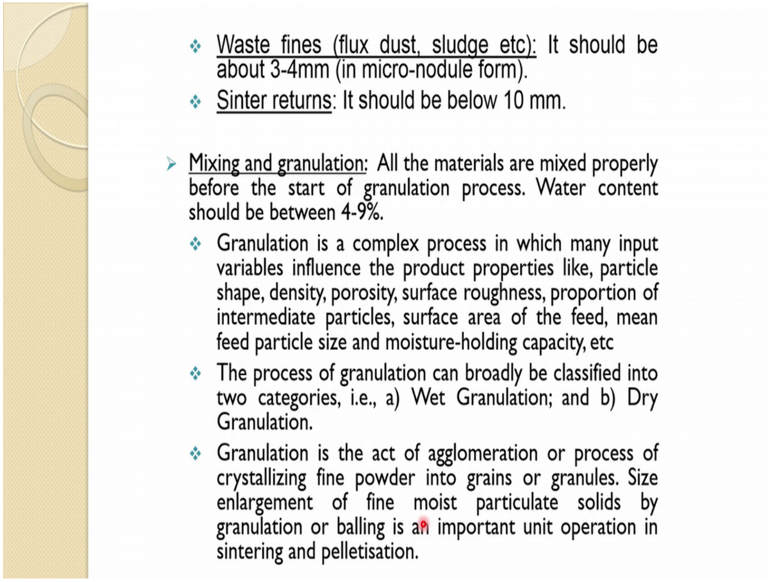

Waste fines these are the flux; dust sludge etcetera from which it comes and again it should have a size of 3 to 4 millimeter. So, because these are really fines mostly used for pelletisation, but want to use for sintering then you make a little micro induced form of this and make sure it is in this range.

Then sinter return as we have seen the below 10 millimeter goes to this bin with raw material. The next stage comes about the mixing and granulation this is very important stage in the sintering. So, because that is where you are making the pellets of right size. So, all the materials are mixed properly before the start of granulation process; so, granulation of pullet pelletisation.

So, water content should be between 4 to 9 percent as usually about 8 percent or; so, 7, 8 percent they keep it. So, granulation is a complex process in which many input variable influence the product property. Like particle shape, density, porosity, surface roughness, proportion of intermediate particles, surface area of the feed, mean feed particle size and moisture holding capacity. There is others also these are very important parameter in granulation.

The idea of granulation you have to get a narrow sized range product and it should be more than 12 millimeter 10 to 12 millimeter and narrow range because that will give the permeability to the bed. If you look at let us say in this figure of this when you are putting on these pellets over here and the suction is being applied from the bottom.

So, bed should have a good permeability if bed does not have a good permeability; your sintering will not occur in a proper way and it will affect the productivity and efficiency. So, to make sure you have a optimum a good permeability of the bed here ah; it is very necessary that proper granulation has been should be done. So, and granulation process itself can be divided into two categories wet granulation and dry.

Usually in iron making we do not use granulation; granulation is an process where this fines you are making in the form of noodles or granules of this size of 10 millimeter or like that or more, but in the. So, these are used for even in chemical pharmaceutical sector quite a lot in drugs and tablet making. But here mostly we using iron steel making the wet granulation. So, granulation is the act of agglomeration or process of crystallizing fine powders into grains or granules. So, size enlargement of fine moist particulate solids by granulation or balling is an important unit operation in sintering and pelletisation.

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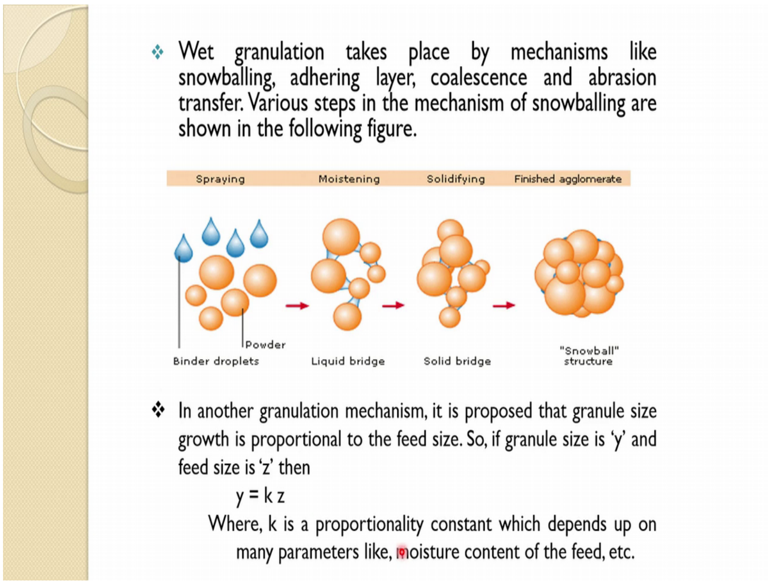

So, mostly the mechanism of wet granulation is snowballing, adhering layer, coalescence abrasion, transfer and you have the. So, many mechanisms are there where you have this droplet; binder droplet, it could be water, it could be molasses or anything and then surface tension and capillary effects comes into picture which finally, together bound into sort of a snowball type of structure in a finish agglomerate. And one of the mechanism also says that the fee product size or the granule size the final granule size is directly proportional to the feed size what you are feeding it.

And which can be given with this it is the way of why the granule size the product and there is the feed size in case the proportionality constant and that depends on the many parameter moisture content of the feed and other thing. So, there are various mechanism, but there is no sort of a I would say the determine mechanism or established one; which one can use it confidently. So, it still population balance is one of the another one of the mechanism to describe the granulation process. Idea is to make the edge narrow range as possible from this granulation process. So, the bad permeability can be improved and sintering can be done efficiently.

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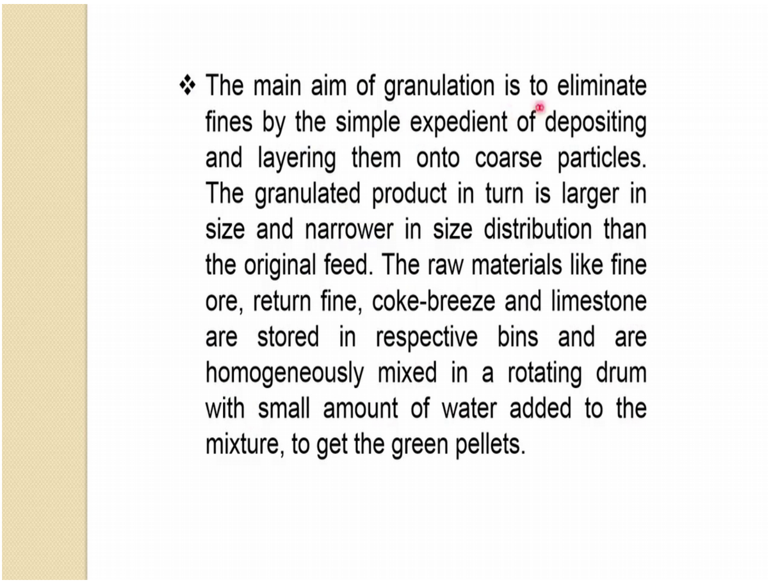

So, the main aim of granulation is to eliminate fines by simple expedient of depositing and layering them onto coarse particle. The granulated product in turn is larger in size and narrower in size distribution than the original feed. The raw material like fine ore, return fines, coke breeze and limestone are stored in respective bins as we had seen in the that figure and are homogeneously mixed in a rotating drum with the small amount of water added to the mixture to get the green pellets.

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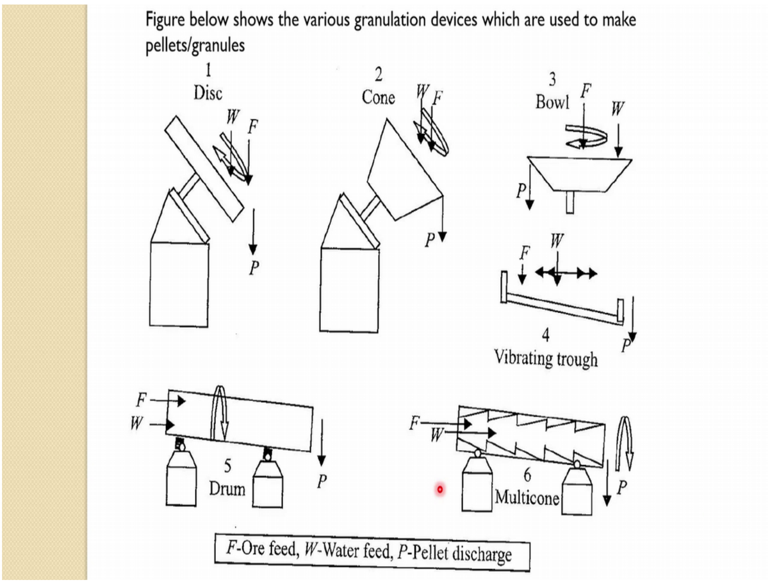

And there are various type of equipment which are available to do that; for sintering and the granulation mostly we use this drum pelletizer or the drum granulation.

So, where the feed and the water put together and it keep on rotating with a certain rpm and we get the product from the other end. Disc pelletizer we have seen in that photo also; so, this is a disc pelletizer where you feed the material at one end and water at another and rotate with a certain RPM and the granules or pellet comes out.

Similarly you have cone bowl vibrating multi cone sort of equipment to make the pellet. But these two are the main one which are used this one mostly used in sintering and this is quite this is used more in the pelletisation when very fine ore is there.

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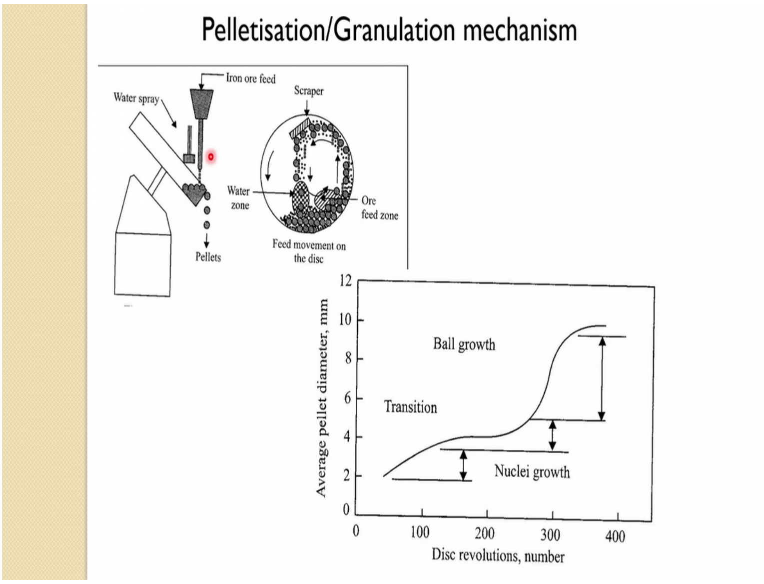

And mechanism of it you look at in the starting there is a nuclei nucleation of the, because the fines is there very small fine material which act; so, some of these particle act as nuclei. So, nucleation mechanism is there and once this nuclei establish the layering of small particles other fines then start happening with the help of what you are putting water or molasses or any other some things of that surface tension and capillary force come into picture and it keep on layering with each rotation and size keeps on in increasing.

So, in the starting it is a nucleation growth mechanism then there is a transition period where this nuclei are not strong enough sometime, they break and at and sometime they keep on growing. So, this is their transition period and once this is over then of course, the growth of the ball start happens; So, then all material keep on depositing fine on the big granules and that is increases the size of the granule.

So, this is showing a bit idea how does it go and this is showing where you put the feed and water and scraper which we saw this remote whatever material got stuck at the bottom and make sure it follows the right direction these pellets. So, that is how the pelletisation and granulation occur.

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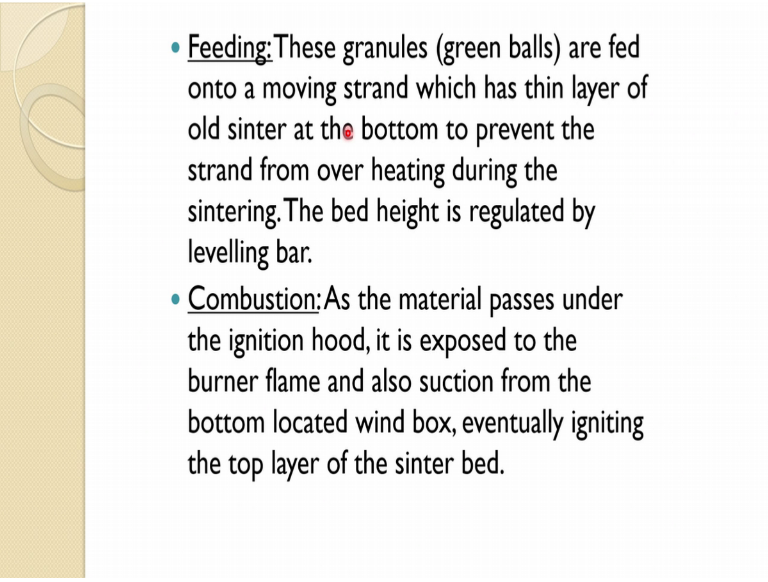

So, after the once this mixing and raw material is over as we have seen in that figure sintering figure that it goes to the feeding. So, these granules or green balls are fed on to a moving strand which has thin layer of old sinter at the bottom to prevent the strand from overheating during the sintering process and the bed height is regulated by leveling bar.

So, these all things, nothing much in that and after that that because the sinter strand is a moving one moving sinter strand; so it comes under the ignition hood and it is exposed to the burner flame. And also suction from the bottom located wind box; so eventually igniting the top layer of the sinter bed.