Iron Making and Steel Making
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Module - 05
Lecture - 21
Burden Distribution

This lecture discusses the Burden Distribution in blast furnace.

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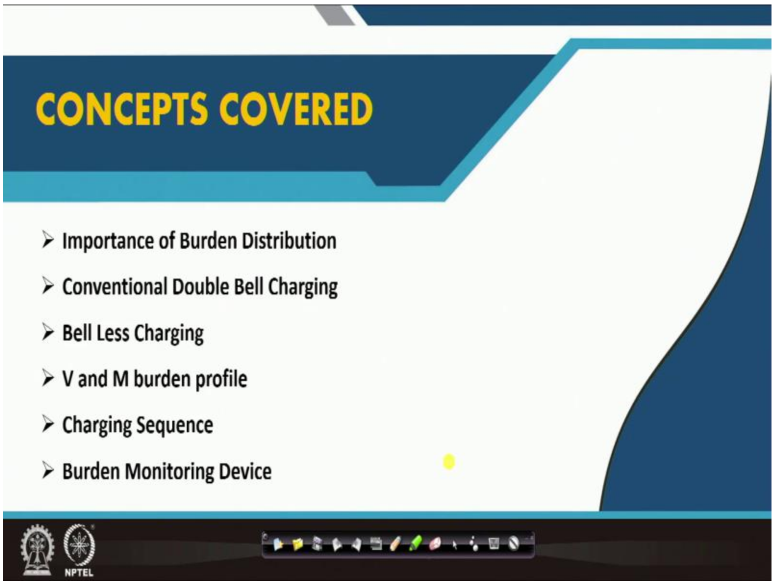

Takeaway from this lecture are importance of the burden distribution, conventional double bell charging, bell less charging and different type of stock profile like V and M burden profile, charging sequence and the burden monitoring devices.

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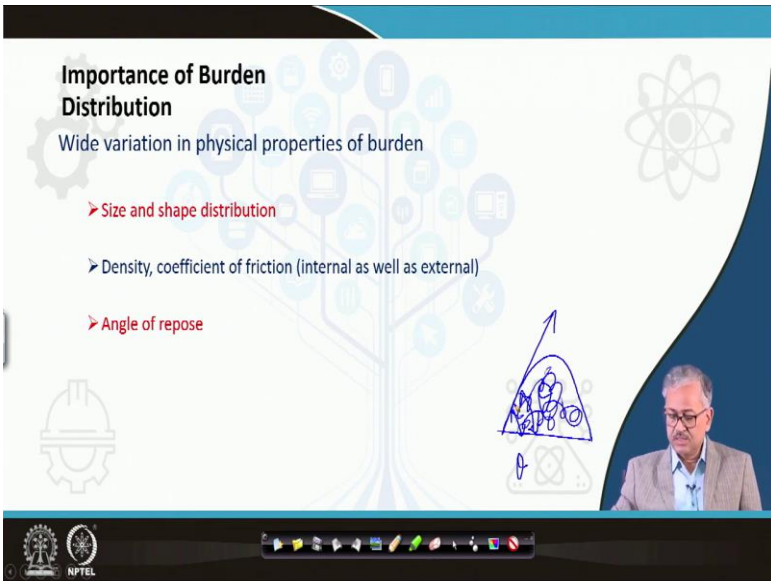

Why should we bother about this burden distribution and what is the role of burden distribution in the performance of blast furnace operation. Burden material in blast furnace has a wide difference in size and shape distribution and also they vary widely in terms of physical properties. Therefore, it is very difficult to maintain uniform permeability across the coroosection. Here burden distribution play a major role in distributing the burden in such a way that can ensure a more uniform bed permeability across the cross section of the bed leading to effective utilization of furnace gas. Iron ore size varies form 10 to 40 millimeter; where the coke size may vary from 40 to 90 millimeter.. Shape also differ significantly; sinter is irregular in shape, pellets are spherical, coke are elliptical, lumpy ore also irregular. Iron ore is much heavier compared to the coke, approximately by 5 times.

Ore have more internal friction than coke; so ore make ridges while coke roll down; in other-words ore has high angle of repose, while coke has low angle of repose. When you lay some material on a flat surface, they make a certain angle to the horizontal making a ridge. The angle is called the angle of repose and it depends on the internal coefficient of friction. It varies from raw material to raw material and specially if raw material has wide size and shape distribution, moist, and heavy, they usually try to form a ridge with a higher angle of reposeFor example, coke will have a low angle of repose and the moist, heavy iron ore with fines and wide size distribution will try to make high angle of repose.These are called the natural angle of repose and in fact in the blast furnace when you charge material, it does not form the natural angle of repose because other factors like wall vicinity of wall, inertia from falling stream of material also influences angle of repose. So, angle of repose formed by material inside the blast furnace, may be termed as apparent angle of repose, which is also influenced by vicinity of wall and falling stream, in addition to falling stream. .

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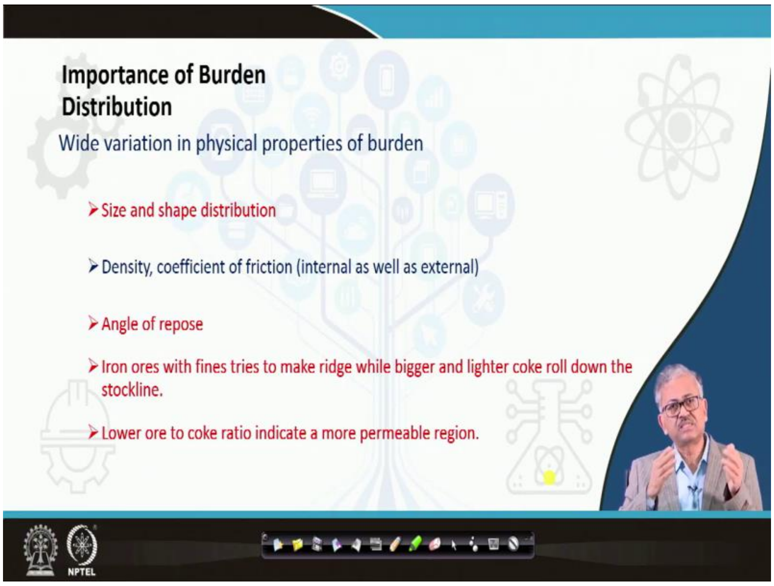
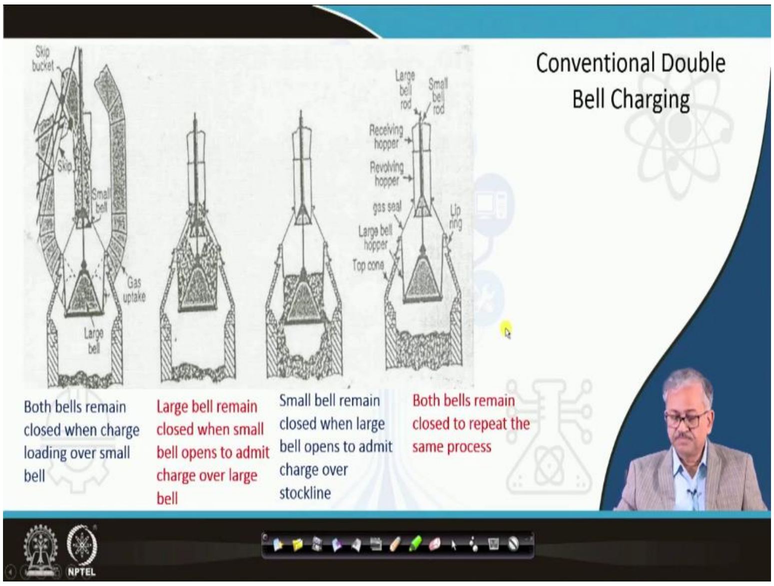


Iron ore fines iron ore with fines tries to form a ridge; while the bigger and lighter particle like coke try to roll down the stock line. So, if coke after being laid on the stockline, those will try to roll down. So, different material after being laid on the stock line they behave differently. They either may roll down or they may try to stick to the location where they fall at the point of fall. So, as a result you can expect a lot of segregation to happen, leading to variation of ore to coke ratio from center to the periphery.

Ore to coke ratio is a very important parameter; where the ore to coke ratio is high, the region is likely to be offer more resistance to the gas flow compared to the place where the ore to coke ratio is less; because bed with coke is permeable to gas. (Refer Slide Time: 07:29)



Let us discuss now the charging mechanism and start with conventional double bell charging.

During charge distribution, the important factors are the sequence of charging, point of fall are important to restrict segregation. Segregation does not only take place at the stock line, it initiate in the distributor also; so aim here to restrict the segregation to the maximum possible extent, which otherwise can not be eliminated totally..

There are basically 2 charging systems; one is the conventional double bell charging, and the other is recent bell less charging.

In double bell charging, you have two bells; one is the upper bell, and the other lower bell. Small bell is the upper bell and big bell is the smaller bell. How does it works? Initially both the bells are closed. By closed it means bells are up such that the gap between the wall and the bell is zero sealing any solid and gaseous movement during closed condition.

First, material are charged over the small bell directly from the skip cars. When sufficient material are charged over the upper small bell, it is lowered to allow the material to fall over the lower large bell, which remain in closed condition. When charging over lower big bell is completed, it is lowered to allow the material to be laid over the stock line in the furnace. During big bell charging, the upper small be is moved up to seal solid and gas passage between wall and small bell.

So, when material is charged from upper bell to lower bell, lower bell remain closed and during material charging from lower bell to stockline, the upper bell remain closed. Thus during charging operation there is no scope that blast furnace can pass through the charging device. In face blast furnace is is passed through through two uptake tubes attached from the freeboard of the stockline. Gas passage through these uptakes could be controlled through valves to control the top pressure in the blast furnace.

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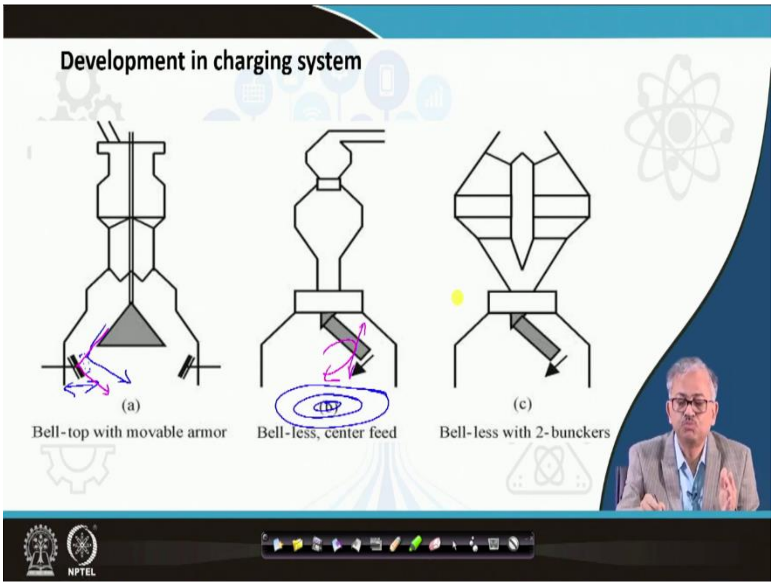

Now, let us see the development in the charging system. Initially we have only double bell charging. The control on charging is only limited by controlling the width of passage between the wall and the lower bell edges. If the width of passage is increase by lowering the lower bell, the material projectile will hit the stocklile further away from the wall. But such control was not much effective. Besides, as the material projectile directly hit the wall, wall erosion also becomes a concern. Then came movable throat armour (MTA). It had two purposes; one thing to protect the refractory and second thing is that it can move forward and back and deflect the material at different distances away from the wall.

So, it moves forward it will deflect the material more towards the center and when it is moved backward , material will deflect less and fall near the wall. So, by moving the armor back and forth you can charge the material at different distances from the wall; of course to a limited extent because of limitation of the width of passage between lower bell and the wall.

Now, then came the bell less charging. Here material is finally distributed by a rotating chute. It can rotate through 360o and it can also have vertical movement. So by it adjusting its vertical position, it is possible to charge material at any concentric circles across the cross section; meaning you have full access across the cross section to lay the material. The material from skip cars is first charged on the hopper and then the material moves to the chute through a down-commer and finally material is distributed on stock line through the rotating chute. Initially bell less charging was based on one hopper, when charging was intermittent. Because during charging on the hopper, discharging from chute was not possible. Then bell less charging is modified with two hoppers that makes the charging continuous.

When you have two hoppers, while you are charging one hopper; the other hopper will feed the chute that subsequently continuously feed the stockline.

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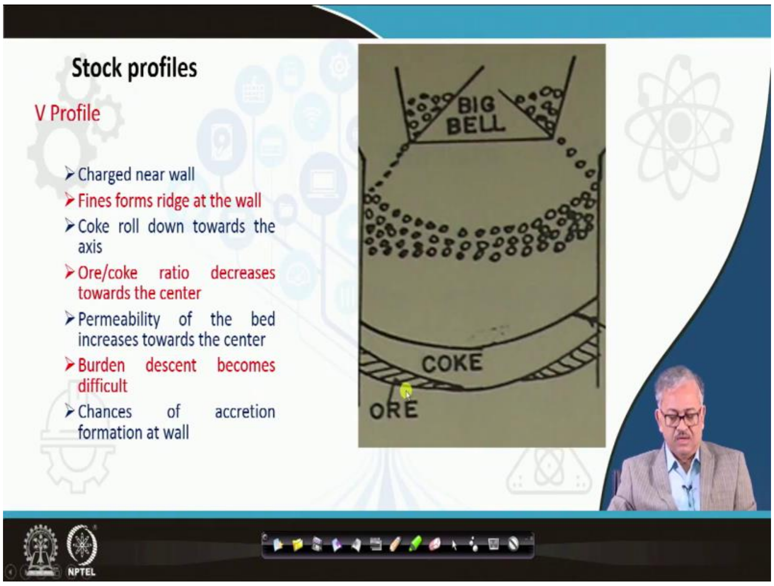

Let us now discuss stock profile.. There are two kinds of stoke profile. One is called the V profile another is called the M profile.

When material is laid near the wall stock forms a ridge near the wall because as we have mentioned ore does not move much and has a steep angle of repose; although the coke roll down towards the center. The ore percentage decreases towards the center and as a result the ore/coke raio becomes high near the wall and it decays towards the center. Consequently the stock become more permeable near the center and less permeable near the wall and gas prefers to flow through the central region. Peripheral flow becomes less. Peripheral gas flow acts as lubricant over the wall that ensure smooth descent of the burden. In absence of such peripheral flow, V stock profile obstruce the smooth descent of the burden. Besides lowe gas flow on wall reduces heat transfer to the wall and increases the temperature there, which might fuse the fines on the wall and form accretion, or scab.

Such scab formation further restricts the downward motion of the overburden. This may lead to sudden breakdown of inadequately heated solid charge to the wet zone, leading to chilling of hearth.

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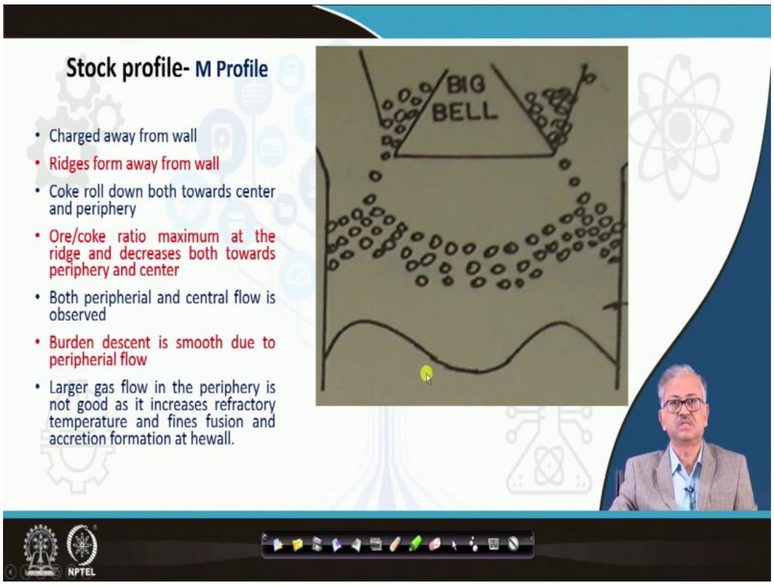

Now, let us discuss the M profile, which is considered the better stock profile in blast furnace. Such profile is formed when material is laid on the stock line away from the wall. So, ridge will also form away from the wall, leading to a stock profile with M shape as shown above. MTA is used to deflect the material away from the wall. Although ore material forms ridge at the point of fall; coke roll down both towards the center and periphery. As a result ore coke ratio decreases from the ridge region towards both the periphery and the center. Consequently, both the central region and periphery region becomes permeable and both central and peripheral flow can be obtained, leading to better utilization of gas. Besides, peripheral flow provides a smooth descent of the burden.

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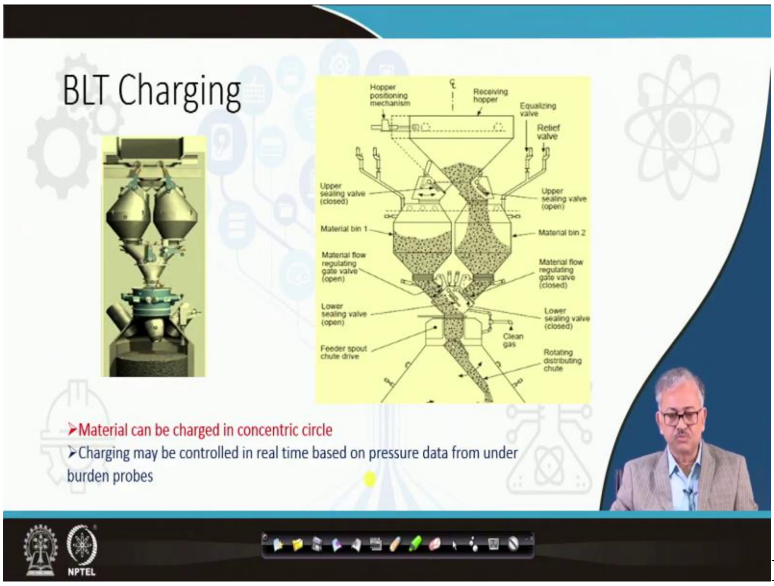

Now, let us discuss bell less charging. As we have mentioned, the rotating chute in bell less charging can lay the material in concentric circles, accessing the whole cross section of the furnace. Advantage of such charging is that you can charge permeable burden in places where flow resistance increases. During the burden descent along with chemical reaction, burden degradation and fine generation continues and the permeability of the bed evolves dynamically, which can be monitored by under burden probes measuring the pressure distribution. BLT can be coupled with the under burden probes, to identify the location of high pressure drop and rectify it by charging permeable burden like coke at those location.

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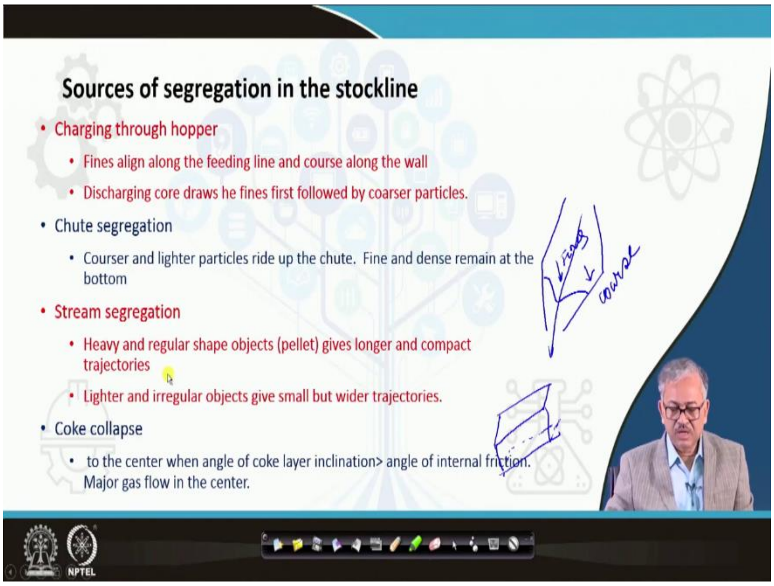

As I have mentioned, solid segregation not only takes place at stock line; it initiates in the distributor itself. In this section we will discuss the sources of segregation in the stockline. Segregation starts at the hopper. When the material flow through the hopper, it draws the fines through the center line, where solid velocity is maximum and the coarse are aligned along the wall (see figure in the slide above). So, when the material comes out of the hopper, fines comes first followed by the coarse particles. So, some segregation is taking place in the hopper itself.

In the distributing chute also some segregation takes place. In the rotating chute, the course and lighter particles will ride up and the heavier and finer particles will stay on the bottom wall.

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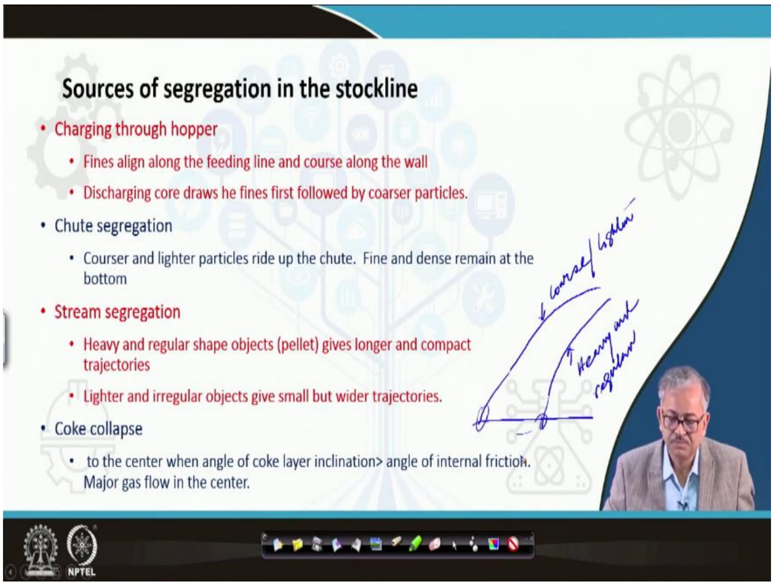

When the material will come out of the chute, those will form projectile during free fall on the stockline. The lighter and coarse particles will follow the longer path and the heavy particles will follow the shortest path (see the figure in the slide above) encompassing the wide projectile width. It may be termed as stream segregation. Then there is stockline segregation due to different angle of repose of different material, which further get aggrevated being induced by falling stream and vicinity of wall. Solid percolation through the bed, ore shift and coke collapse also add to segregation. If the angle of coke on the stockline become higher than that of internal friction, coke can collapse towads the center-called the coke collapse 9see figure in the slide below).

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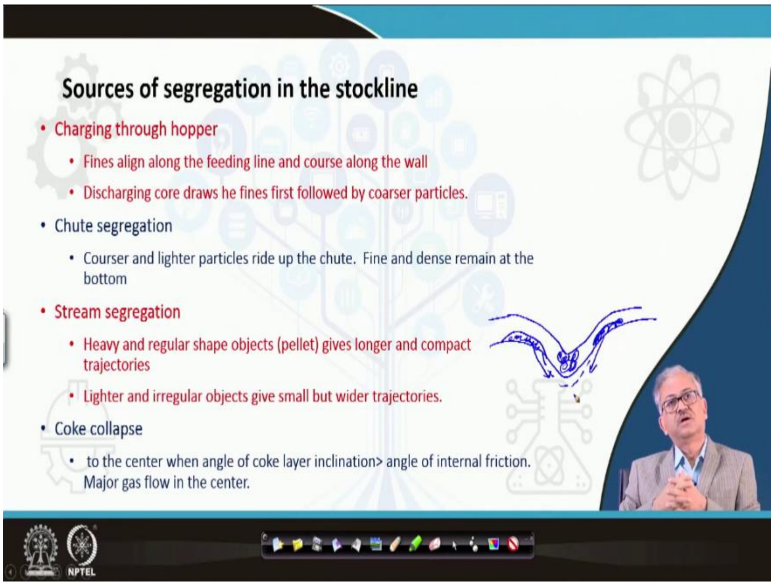

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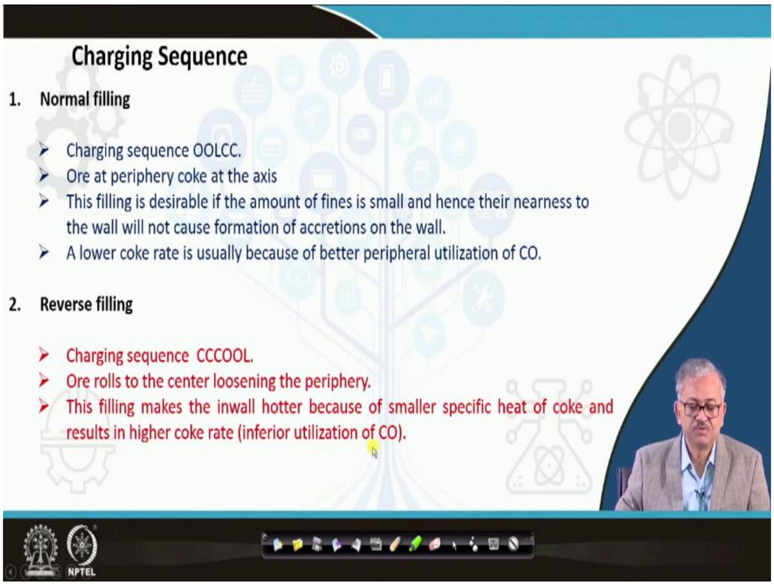

So, now we will have talk about little bit of the charging sequence using bell charging. Charging sequence refers to the sequence of skip charging the ore, coke and the limestone. So, charging sequence OOLCC means 2 skips of ore(O) followed by one skip of limestone (L) and then two skips of coke ©.

With this charging sequence, you get the ore at the periphery and coke goes to the central region and such sequence is desirable if the amount of fines is less; otherwise fines loading at the periphery will stop the peripheral flow, leading to lower gas utilization and unsmooth burden distribution.

And with reverse charging CCCOOL, ore will rolls to the center loosening the periphery and this filling may make the inner wall hotter. Besides, due to veru low ore to coke ratio near periphery, the large gas flow near the periphery remains mostly unutilized.

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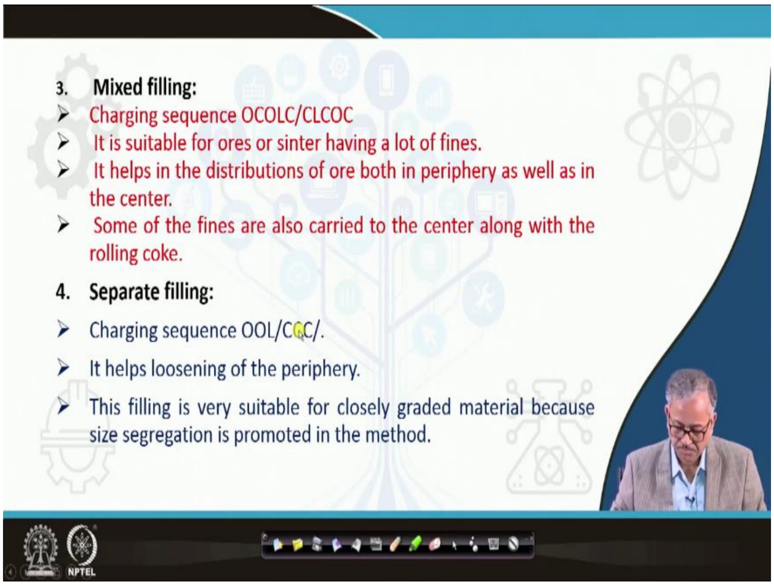

And then you have a mixed filling.. In this case, you charge ore only, followed by coke only. OOL/CCC means you charge two skips of ore and one skip of limestone in one go. When these material is laid on the stock line, another three skips of coke is laid over the stockline.

This charging sequence helps in loosening periphery. This filling is very suitable for closely graded material because this type of charging promote size segregation.

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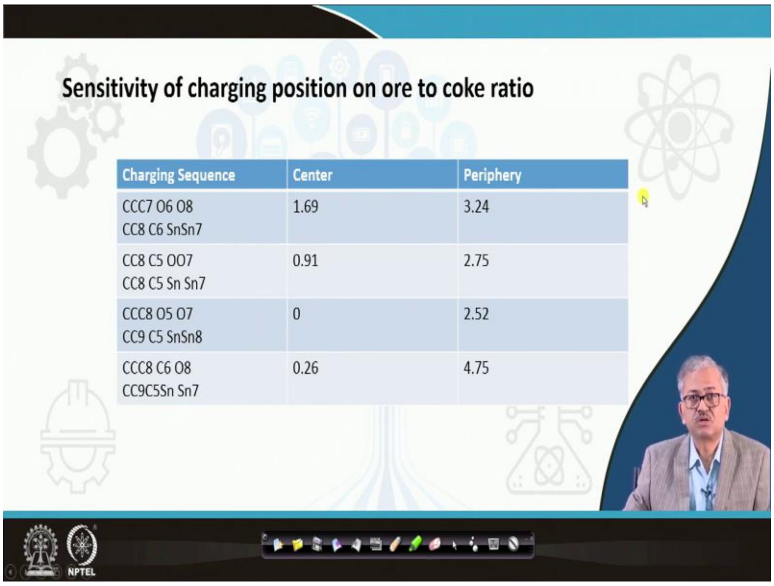

Now, the table above in the slide, depicts the ore/coke ratio to the center and periphery for different charging sequence using bell less charging. CCC7O6O8CC8C6SnSn7 represents that three skip of coke is charged on 7th concentric circle (8 represents periphery and 1 center), followed by one skip ore on 6th circle followed by another skip on 8th ciecle location, dfollowed by three skips of coke at 8th location, then one skip at 6th location and finally two skips of sinter at 7th location. It provides ore coke ratio in the center and periphery high, indicating better gas utilization. Higher ore to coke ration also makes the region more impervious. So, noting the value of this ratio , it is observed that center is more open to periphery.

The third sequence makes the center very open but gas utilization becomes zero in absence of ore there. Again, with the fourth sequence, periphery becomes impervious with very high ore to coke ratio.

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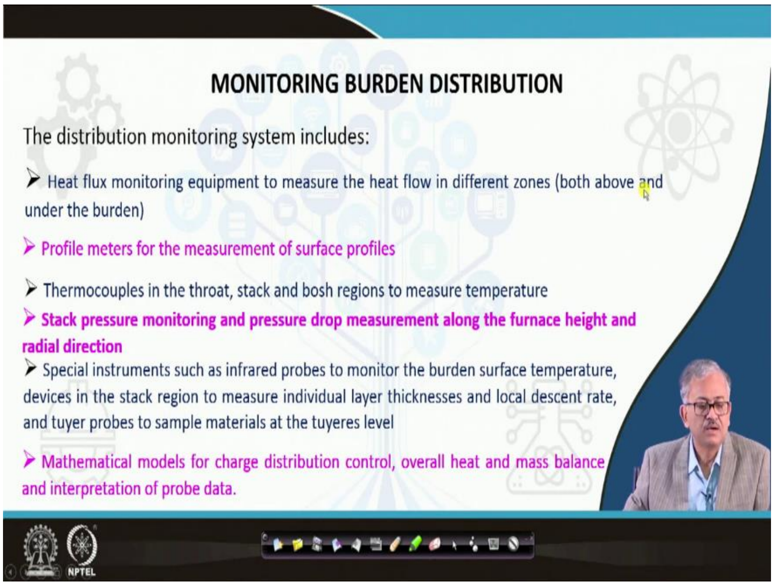

Now, I will talk about the monitoring of the burden distribution in the blast furnace. We can monitor burden distribution in terms of heat flux, pressure distribution, temperature, surface profile using under burden probes.

- Profile meters are used for the measurement of surface profiles
- Thermocouples in the throat, stack and bosh regions to measure temperature
- Stack pressure monitoring and pressure drop measurement along the furnace height and radial direction
- Special instruments such as infrared probes to monitor the burden surface temperature, devices in the stack region to measure individual layer thicknesses and local descent rate, and tuyer probes to sample materials at the tuyeres level
- Mathematical models for charge distribution control, overall heat and mass balance and interpretation of probe data.

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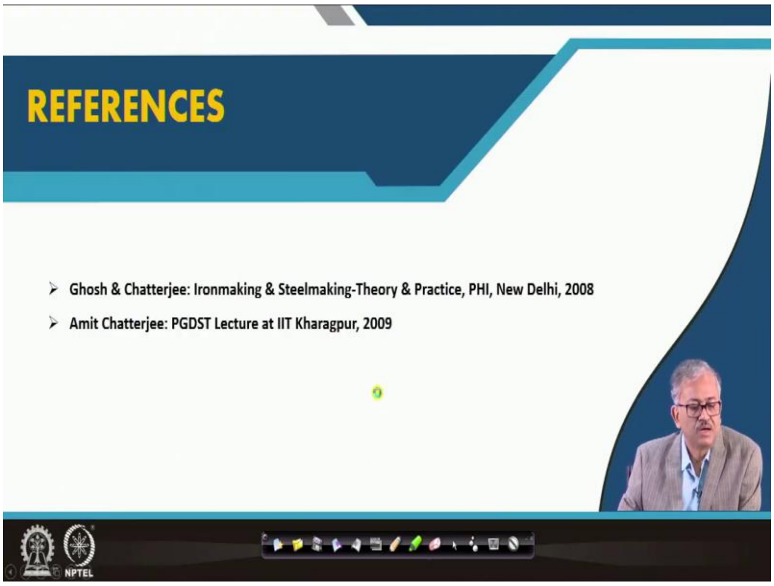

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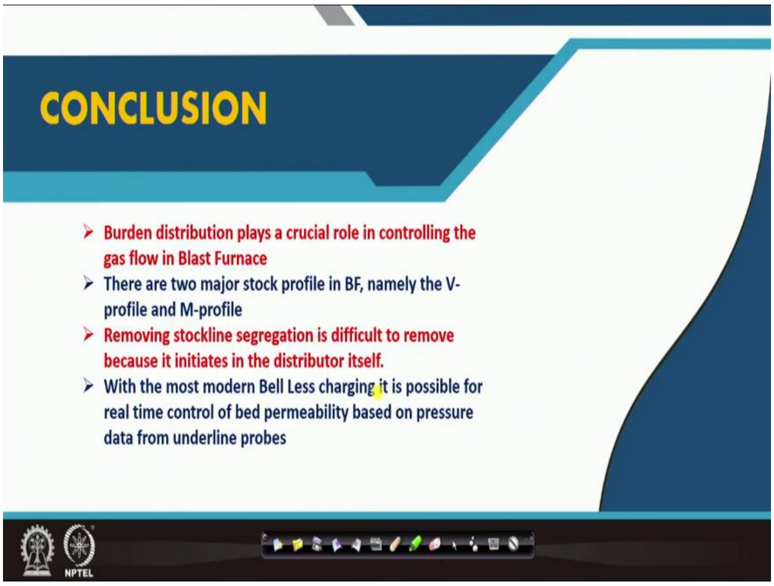

Conclusion: Burden distribution is required to make the bed more uniformly permeable across the cross section.

Two major stock profile exists, V and M profiles; and M profile provides the better bed permeability and gas utilization.

Removing stockline segregation completely is difficult as segregation starts at the distributor and continues in the stockline too.

With bell less charging it is possible for real time control of bed permeability using underburden probes.