Iron Making and Steel Making
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Module - 04
Lecture – 18
Pelletization of Iron Ore

Welcome. I will talk about the Pelletization of the Iron Ore in this lecture. We are talking about agglomeration of iron ore. In the last lecture, we talked about sintering and in this lecture, we are going to talk about pelletization.

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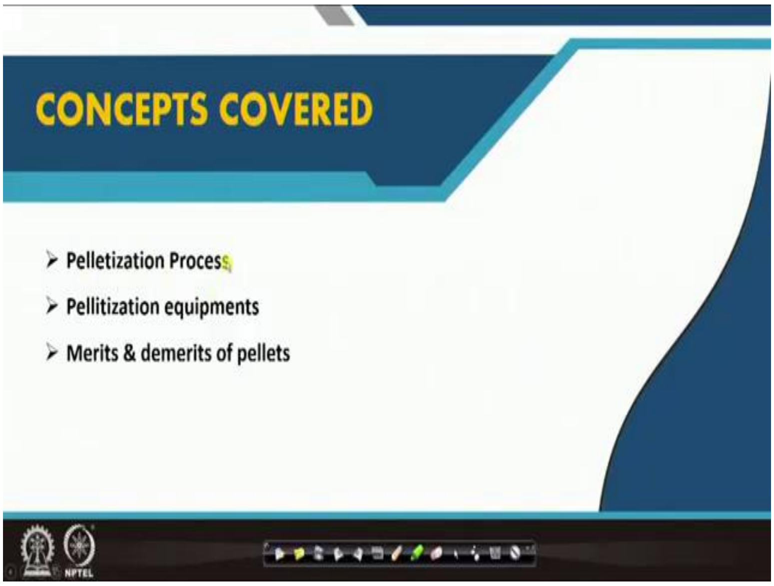

So, topics that will be covered here are the need of palletization, process equipments for pelletization, mechanism and merits and demerits of the pellets.

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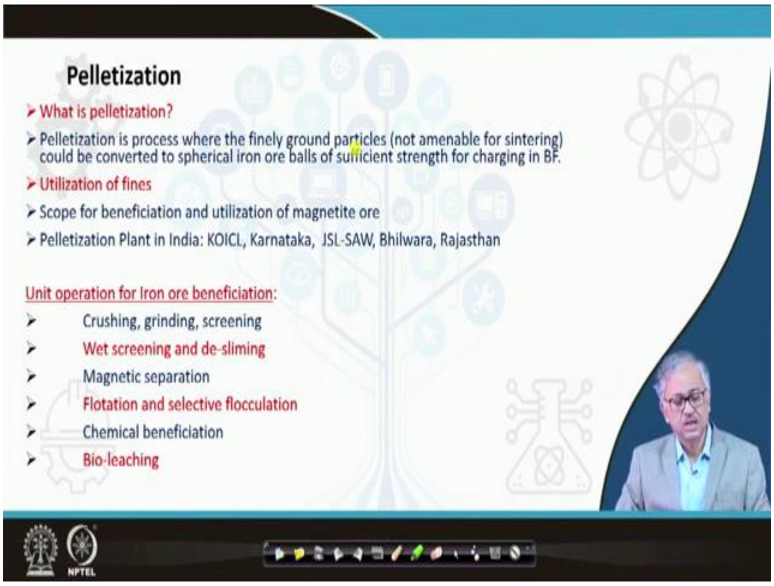

So, what is the need of pelletization? In case of the sintering we can also agglomerate fines. But due to process limitation sinter machine can not utilize ultra fines less than 150μm; similarly palletization can not use fines coarser than 150 μm. So, Sintering and palletization are complementary to each other. Sintering takes place in a granulated porous bed of sinter mix (granulated size less than 10 mm) through which air is sucked. Ultrafines is not favourable for the granulation of sintermix to a size less than 10 mm.

Another point is that palletization offers scope for beneficiation of the ore; it is very important. Basically, we have lot of low grade iron ore reserves and those really need beneficiation. We generates lots of iron ore fines during mechanized mining due to fragile nature of ore; as I have mentioned that we mine approximately 220 million ton of ore every year out of which 100 million tones is fines. Goa has lot of such off grade hematite deposits of iron ore (<60% total iron). Such ore can further be grinded, beneficiated and pelletized for subsequent use. Besides, In estern part of India (Noamundi, Joda), we have also some virgin deposits of iron rich ultra fine powder, called the blue dust; those can be directly pelletized. In India we have large deposits of magnetite ore (around 11 billion tones) in the western part of India like Rajasthan, Goa, Karnataka. But magnetite ore is usually low grade with total iron content may be as low as 40%. So, those type of ore has to be beneficiated and subsequently pelletized. KIOCL (Kudrimukh iron ore company limited, Karnataka) is such a pellet making public sector company. KIOCL was set up to mine magnetite in Karnataka for subsequent beneficiation and palletization. However, it produced several waste tailing ponds that raised environmental concern. Subsequently, after the supreme-court bans on mining of low grade magnetite ore, KIOCL stopped mining and started importing overseas ores, converting them to pellets and exporting again. However, JSL in Bhilwara, Rajasthan is producing pellets from magnetite deposit there, which is relatively of higher grade and following the government norms. So, through palletization, off grade magnetite ore, blue dust, and beneficiated off grade hematite iron ore fines can be effectively pelletized.

Let us discuss some basic unit operations for beneficiation? I will not go much details into it, but you must know the unit operations are involved here. First, the crushing, grinding and screening this is the basic beneficiation tools for liberating the gang, and then wet screening and de-sliming for separating gangue. There two steps are common for high grade as well as low grade ore. Another important operation for treating low grade ore is the magnetic separation. Magnetic ore respond to separation by magnetic action. And then, flotation is there for ore concentration by surface modification of the iron ore fines making those hydrophobic, separating those by attaching to bubbles and collecting in the froth at the top; leaving the gangue in the liquid. Floation kinetics is little slow. Sometimes selective flocculation is used; here some chemical is used to flocculate the iron ore fines and precipitate. Low grade hematite is also chemically beneficiated through reduction roasting to magnetite followed by magnetic separation. Another technique is bioleaching, which has been applied to goethite ore by selectively leaching; the iron ore is leached into the liquid and then from liquid you can extract it by successive process. In hydrometallurgy, problem is that its kinetics is little slow; and you have to deal with large amount of liquids, and effluent.

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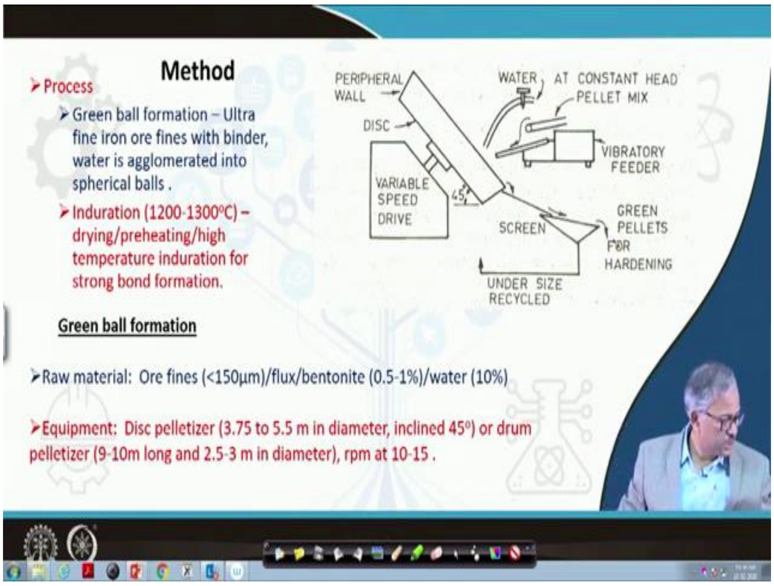

Now, what are the methods for pelletization? First, is the green ball formation. Here ultra fines of iron ore is mixed up with some kind of binder, and optimum amount of water. This is the two major constituents. Also, you may add flux sometimes to make the flux pellets.

These raw mix constituents is then given shape of spherical ball, called the green ball. Two types of equipments are there for green ball formation; one is called a disc pelletizer and its size usually varies from 3.75 to 5.5 meter in diameter. And it is inclined at 45 degree to the horizontal and rotate at RPM of 10 to 15. In case of the drum pelletizer, it is 9 to 10 meter long, and around 2.5 to 3 meter in diameter. And it also revolves with 10 to 15 rpm.

Figure 18.1 shows the schematics of disc pelletizer. Powder iron ore is fed to the disc through vibratory feeder continuously at a constant speed. Water is sprayed over the powder through water tap. Disc inclined at 45 degree, rotates at certain rpm. The RPM and inclination may be controlled to provide the desired size to the pellets. It is then screened here and after screening, pellets of appropriate size goes for hardening.

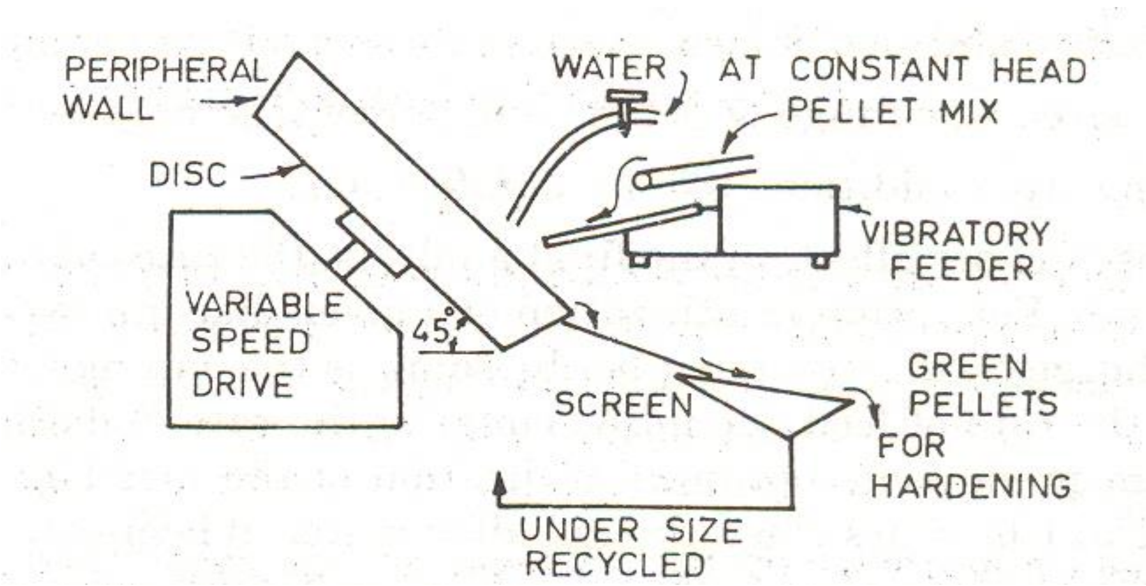

Figure 18.1 Schematics of disc pelletizer (Courtesy: Ghosh & Chatterjee[1])

Undersize pellets are recycled back to the disc pelletizer and it works in closed circuit.

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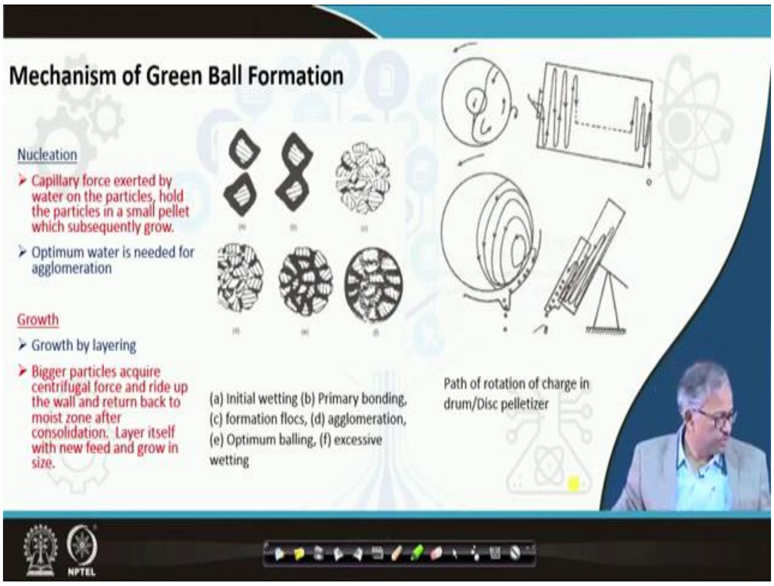


Let us discuss the mechanism of green ball formation. The first step is called the nucleation. How does it happens? Figure 18.2 shows the schematics of nucleation of pellets by capillary action. First, the perimeter of the particles get wetted by the water. This black line represents water and the white hatch region represents the particle. So, particle perimeter has been just wetted by the water and then they come close together and primarily some initial bonding take place here.

The force represents the surface tension through capillary action of water. You can see some particle come and floc together. This is the flocking stage and then you can find that some agglomeration has taken place.

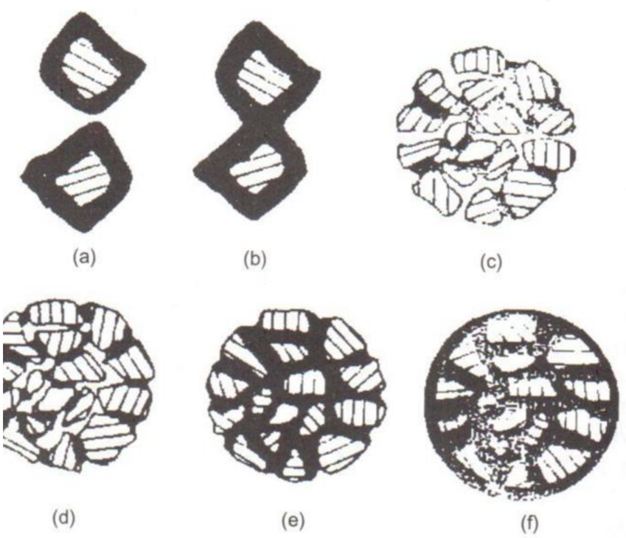


Figure 18.2 Schematics of nucleation of pellet by capillary action. (a) Initial wetting (b) Primary bonding, (c) formation flocs, (d) agglomeration, (e) Optimum balling, (f) excessive wetting (Courtesy: Ghosh & Chatterjee [1])

There are some water inside into the pores and some pores are vacant also. Finally, you come to a stage where you can find all the pores are connected by the water. So, all particle perimeters are perfectly wetted and connected by the water line through pores forming a complete network of water around the particle perimeter. If you have excess water then water will wet the whole surface of the particles and those will loose this capillary action. So, optimum amount of water can ensure nucleation, which is around 10 percent. This the way, initially a tiny pellet nucleates, which subsequently grow by layering. And how it does?

Figure 18.2 shows the path of rotation of charge in the disc and drum pelletizer; both the top and side views are shown. In case of the drum pelletizer the particle rides along with the wall under centrifugal force and then the drop from the wall to the bottom under gravity and then again ride through the wall and the drop from the wall.

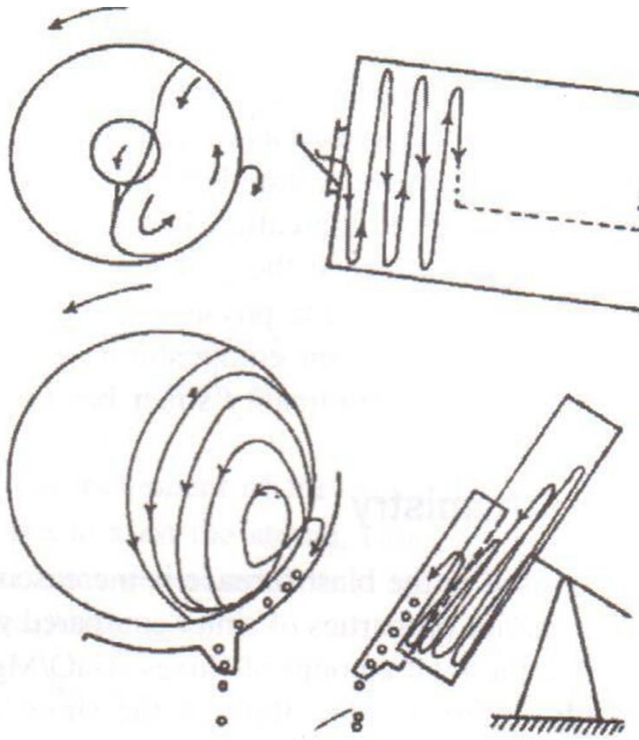
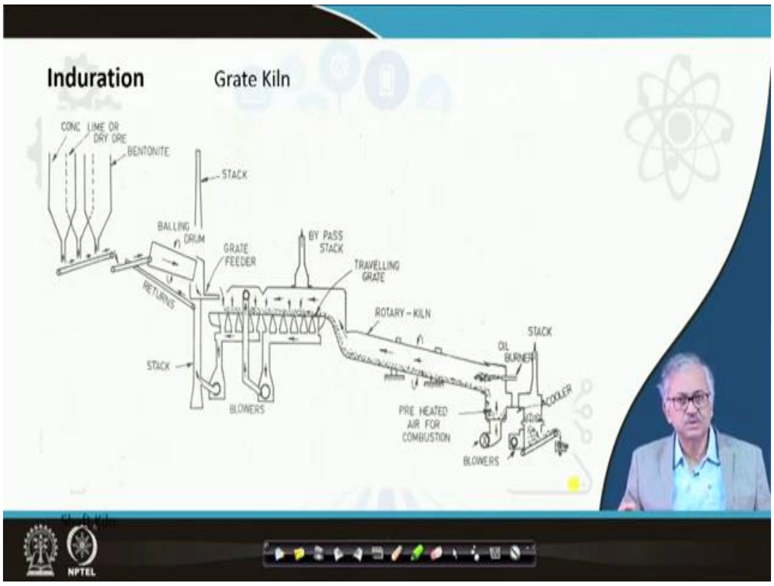


Figure 18.3 Schematics of the path of rotation of pellet in disc pelletizer (Courtesy: Ghosh & Chatterjee [1]).

In case of disc pelletizer, particles move along the wall and then return back to the original location by interacting with a scraper. During the ride along the wall layering and consolidation takes place and when they fall that also help in consolidation. Then they acquire a fresh coat from fresh powder and water and so on. When nucleus form a little bigger pellets; their mass increases, contact resistance decreases as those become spherical. (Refer Slide Time: 21:18)



So, this is the mechanism of green ball formation.

Next, green pellets are indurated at high temperature to form bonds that make the sinter stronger. Induration is done in a Grate Kiln type of machine (Figure 18.4) The grate looks like a sintering machine; the hot gas from the kiln is sucked through the green pellets, which subsequently dried, preheated before being charged to the rotary kiln. Gas after heat exchange with solid is left to stack. Rotary Kiln is a cylindrical vessel that rotates and heated by gas burner. The rotational motion of the kiln renews the surface of the pellets. So, every pellets is exposed to the hot atmosphere to receive the heat and it improves the kinetics of heat exchange.

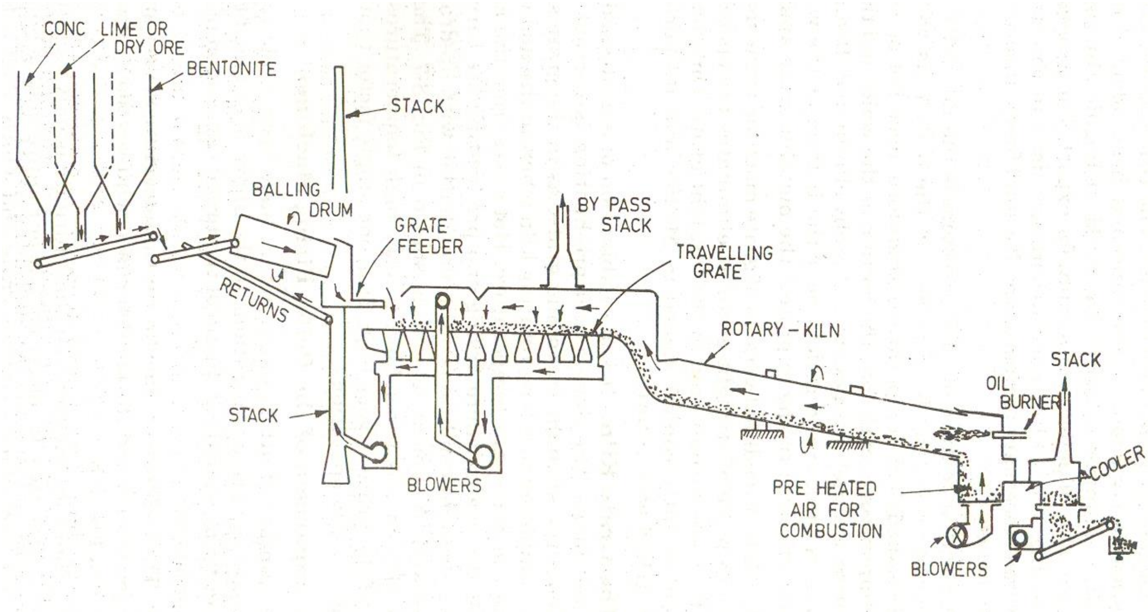


Figure 18.5 Schematics of Grate kiln furnace (Courtesy: Ghosh & Chatterjee [1])

The induration temperature is around 1300 degrees centigrade. At this temperature both the fusion as well as diffusion bonds form and pellets become very strong. Pellets are much stronger than sinter and can be transported long distance. Finally the pellets passes through turbo cooler and stored.

And this hot gas from the kiln, moves up and passes through grate to preheat the pellets before it leaves to atmosphere. Grate Kiln is the most popular induration machine for pelletization.

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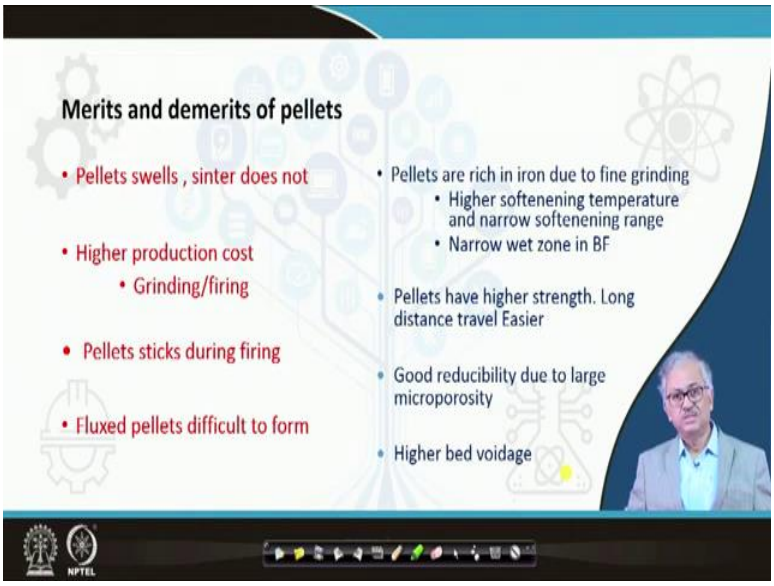

So, now we discuss about some merits and demerits of the pellets. Pellets swells, sinter does not. Besides, pellets are costly due to energy involved to fine grinding and induration at high temperature. These are two major dis-advantages of pellets that makes sinter more popular to pellets. Otherwise, pellets are more stronger and reactive, and provides better bed permeability in the reactor where it is used. High temperature bonding, especially diffusion bonding makes pellet much stronger than sinter. Due to presence of micro-poroes it is reactive also. Pellets can be transported to longer distance, due to higher strength and therefore, pellet plant can be situated near the mines. Besides, because of its higher strength, it does not generate much fines during descent and chemical degradation in blast furnace and provides better permeability of the furnace. Of course if pellets does not swell; some pellets, especially in presence of alkaline metals, undergoes catastrophic swelling during reduction that generates lots of fines and likely to choke the furnace. Otherwise, if it does not swell, it offers excellent bed permeability. Its spherical morphology also provides large and uniform gas channels through the bed.

Pellet also sticks to each other, especially the fluxed pellets. Therefore it is difficult to form the fluxed pellets.

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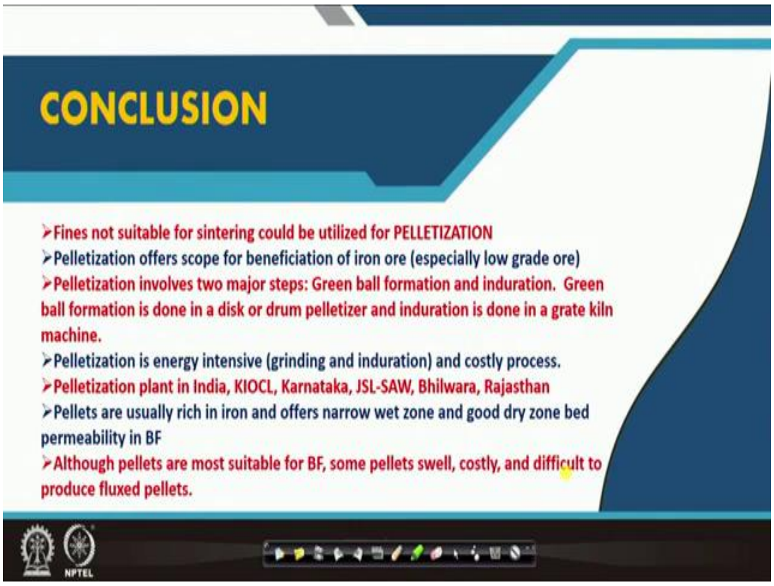

Conclusion: Non-swelling pellets are superior feed for blast but it is costly. Therefore, sinter get an edge over pellets. Pelletization provides an option for beneficiation off grade ore before palletization. In India KIOCL in Karnataka and JSL in Rajasthan are engaged in pellet production.