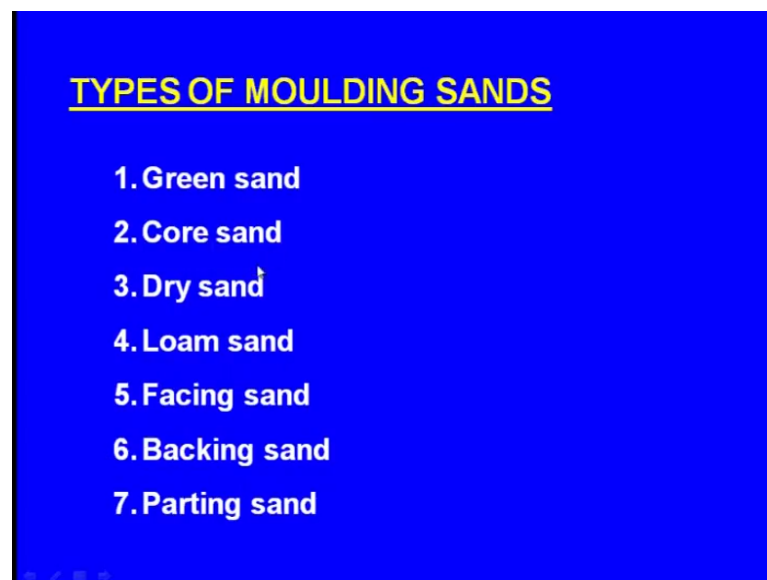


Metal Casting
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Module - 02
Sand Casting Process
Lecture – 03
Moulding Sands and Design-II

Welcome back friends. In the previous lecture, we have seen the moulding sands and their design.

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We have seen that the different types of the moulding sands. We see in the green sand and we also see the core sand and the next, the dry sand, loam sand, facing sand, backing sand and finally, the parting sand. We have seen the importance of these different sands, we have seen in the previous class.

Next, we have also seen that, green sand is the most important sand in the sand moulding. What is this green sand? Green sand means, the sand which contains the moisture. When the moisture is present, we call it as the green sand.

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GENERAL COMPOSITION OF GREEN SAND	
INGREDIENT	PROPORTION (WEIGHT)
Base sand	85 to 90 %
Binder (Clay)	6 to 11 %
Additives	2 to 8 %
Water	2 to 5 %

Upon pouring the molten metal, part of the binder becomes inactive and is termed as '**dead clay**'.

Dead clay becomes a component of green sand.

So, we have also seen that, this is the general composition of the green sand. The green sand contains the base sand; the base sand could be silica sand, zircon sand, chromite sand or the olivine sand and it is present up to say 85 to 90 percent and the next ingredient of the green sand is the binder. It is also known as the clay, it presents from 6 to 11 percent. Next one, the green sand also contains the additives and these additives are present from 2 to 8 percent. Finally, the water is present from 2 to 5 percent.

Now, these are the ingredients which we mix from our side. But, after we make the mould after we pour the molten metal, what happens? The molten metal comes in contact with the sand. Now, the clay with that we are adding are the binder, part of this binder becomes inactive, when its temperature is raised above 500 degree centigrade or 600 degree centigrade. Then, though it is physically present, it loses all its properties, binding properties it loses. In such a case, we call it as the dead clay.

So, that is how the dead clay also becomes a component of the green sand, again this sand we will be reusing. So, part of the clay has become dead. Before we make the further moulds, we have to add the new clay and again in that new clay part of that will become dead clay and like this dead clay keeps on increasing as we keep on using it again and again. So, that is how we have seen that.

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So, these are the green sand components. The green sand components are the base sand. Next one; next component is the binder or the clay. Next component is the additives. Next component, water and the final component is the dead clay. This dead clay, we are not mixing from our side, but it is forming because of the molten metal that we pour into the mould and part of the clay loses its property that is why it becomes the dead clay.

And, in the previous class we have seen the base sand. We have seen different types of the base sands. These are the silica sand, zircon sand, olivine sand, chromite sand and aluminum silicate sands. So, these are the base sands and we have also seen in the previous class different binders. What are these binders? These are the bentonite, fireclay, illite, limonite, kaolinite. Among these, bentonite is the most popular binder or the most popular clay. So, because of its popularity instead of using binder or clay, people call it as the bentonite or in the place of binder they even use the word bentonite. So, bentonite has become that much popular.

And, the next component of the green sand is the additive. Now, let us see these additives in this class. These additives water and dead clay we will be learning in this lecture. Now, the first question is base sand is present, that is the silica sand, zircon sand, olivine sand or the chromite sand and we are adding to improve the cohesion we are mixing the binder or the clay and of course, to temper the sand we mix the water then why this dead clay sorry why this additive?

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Why additives ?

- To prevent burn-on defects.
- To develop a smooth surface on the casting.
- To prevent metal penetration defects.
- To prevent oxidation of the metal from the mould atmosphere.

Why we are mixing additive? To prevent the burn-on defects; Yes, when we pour the molten metal into the mould, the molten metal is at an elevated temperature, may be for the non-ferrous alloys it is about to 700 to 800 degree centigrade, the pouring temperature, whereas, for the ferrous alloys the pouring temperature is between say 1600 to 1800 degree centigrade. At such high temperature the molten metal may burn the surface of the mould cavity. In such a case what happens the sand burns. Once the sand burns, even the surface of this solidified casting, burns. That is how we get the burn-on defects. So, this problem has to be tackled. So, to minimize this burn on defects we mix the additives.

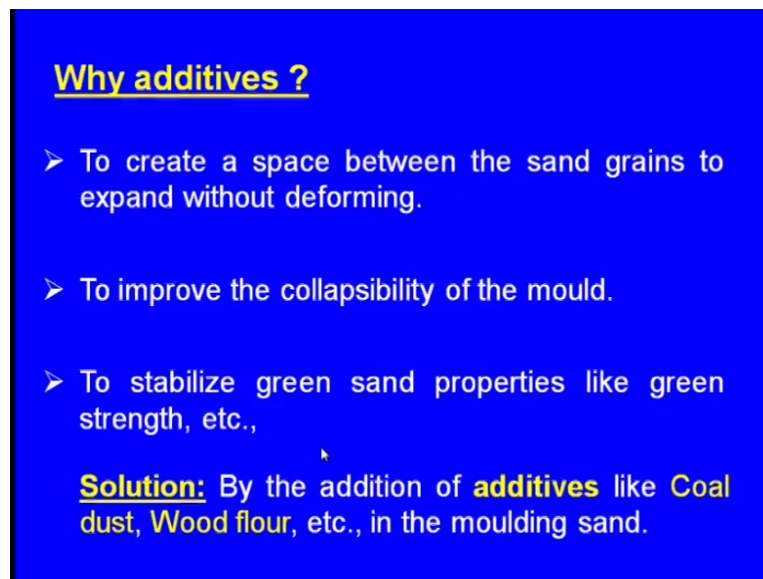
Next one, to develop a smooth surface on the casting; for that purposes also we add the additives. Now, remember that in the sand moulding, the sand mould is made up of sand. What about this surface of the cavity? It is composed of the sand grains and these sand grains will have some irregularities and into these irregularities, if we pour the molten metal, what will happen? Molten metal solidifies accordingly and even on this solidified casting these regularities will be there and finally, we get a rough casting. So, to minimize this roughness on the solidified casting, we mix the additives, to develop a smooth surface on the casting.

Next one, to prevent metal penetration defects, what is this? Now, again the mould is made up of the sand grains. Sometimes the sand grains will be little larger. The

neighboring sand grains let us consider that are present on the surface of the cavity, now what happens on the neighboring of grains there will be a small clearance will be there. Now into this small clearance the molten metal flows and forms the penetration defects and finally, it will be forming some kind of fins and unwanted projections on the casting which we do not want. So, this is known as the penetration defects. So, to minimize the penetration defect, we mix the additives.

Next one, what is the next purpose - To prevent the oxidation of the metal from the mould atmosphere. Now we pour the molten metal into the mould, the molten metal is at a very high temperature and the oxygen is present in the mould. Oxygen is around the mould. This oxygen will readily and quickly come and react with the molten metal and forms and develop result into the oxidation. Once this oxidation takes place the casting loses all its properties and strength. So, at any cost we have to reduce the oxidation that is why we mix the additives.

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Why additives ?

- To create a space between the sand grains to expand without deforming.
- To improve the collapsibility of the mould.
- To stabilize green sand properties like green strength, etc.,

Solution: By the addition of **additives** like **Coal dust, Wood flour, etc.,** in the moulding sand.

There are some more objectives why we are mixing the additives. To create a space between the sand grains to expand without deforming, now what happens, in the moulding sand, the base ingredient is the base sand, the main ingredient is the base sand. These base sands are commonly this silica sand, zircon sand, chromite sand or the olivine sand.

So, these are the sand grains and when we tightly compact the sand around the pattern and we withdraw the pattern. Now, what happens, the sand grains are close to each other and into this mould when we pour the molten metal what happens? Each sand grains will be expanding. Now, when each sand grain is expanding they will be expanding and because they are close to each other, there is no provision for the free expansion. Then what will happen, the mould deformation takes place. When the mould deformation takes place or the mould enlargement takes place that happens casting cannot observe that kind of development, that kind of expansion, the castings cannot observe. The casting has already solidified. In such a case, a crack will form on the casting.

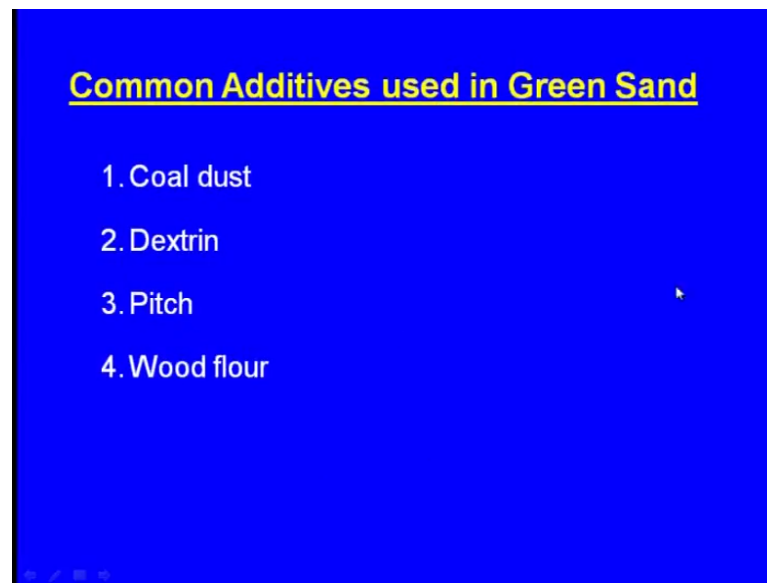
So, that is the adverse effect of the expansion of the sand grains. Why this is happening, because, there is no space between the adjacent to sand grains. So, we mix the additives, now what happens between the neighboring the grains this additive will come and create a space between the neighboring sand grains. So, when these neighboring sand grains are expanding this additive is a soft one, so, as they expand the additives enable them to expand and see that no mould deformation takes place. That is why we add the additive.

Next one, to improve the collapsibility of the mould: Now, we add the what are the ingredients of the moulding sand we add the base sand like the silica sand, like zircon sand or the chromite sand. Then we add the clay, moisture and additives of course. Now, what happens after the solidification we break the sand and we want to take the casting outside. Again this sand will be taken and it will be tempered with water and again another mould will be made with the same moulding sand. The problem comes after the solidification when we want to break the sand, sometimes it becomes very hard. This breaking of the sand is known as the knockout.

Now, if it is too hard to break the sand then it requires hard efforts, laborious efforts and that increases the cost of the labor that increases the cost of production that increases the more time. So, at any cost we have to see that the mould is not too hard after the casting has solidified. It should be easily collapsible, it should be easily breakable. What to do that is why we add the additives. There is another purpose why we mix the additives; to stabilize green sand properties like green strength, dry strength, dry compression strength and so on. So, when we add these additives, these kinds of properties will be enhanced.

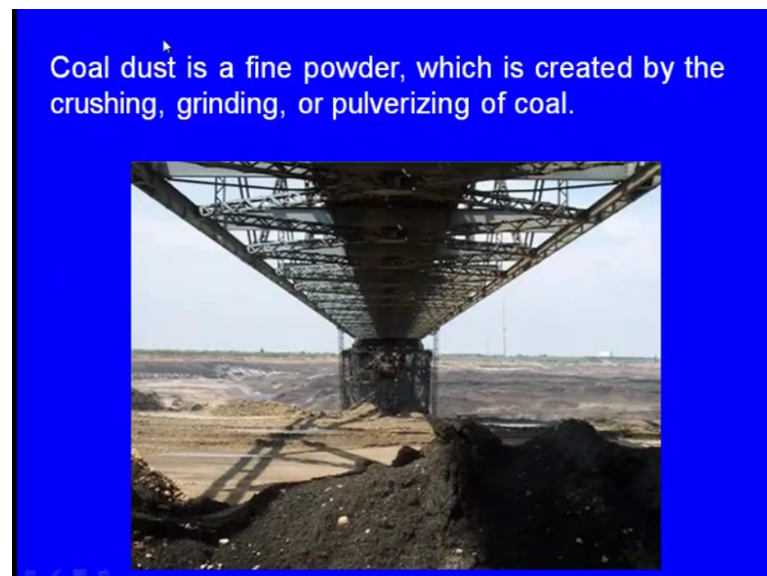
So, how to achieve these? By the addition of additives like coal dust, wood flour etcetera in the moulding sand. When we mix the additives like coal dust, wood flour and starch and so on, whatever problems we have discussed the earlier will be minimized. So, that is the purpose of the mixing additives.

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Now, let us see the common additives used in the green sand. One is the coal dust, next one is the dextrin, next one is the pitch and finally, the wood flour. Let us see all these additives one by one.

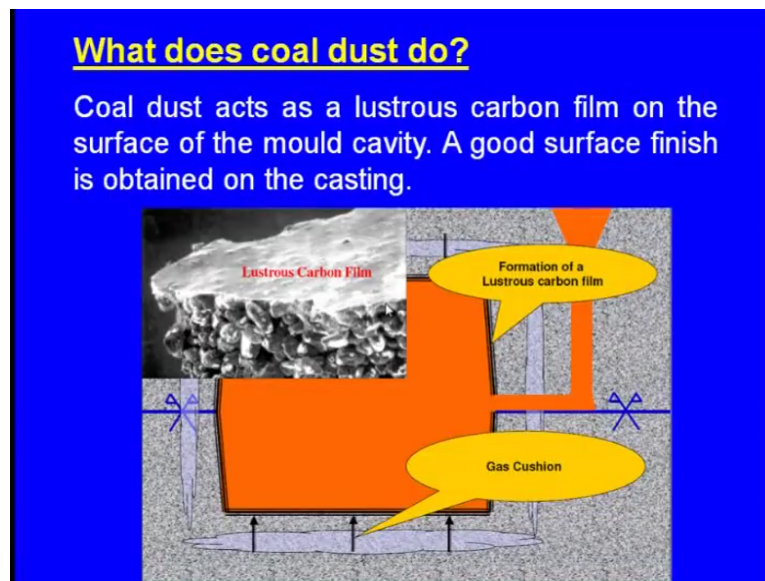
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First, let us see the coal dust. Coal dust is a fine powder which is created by the crushing, grinding or pulverizing of coal. So, this is the coal dust which is obtained by pulverizing the coal, you can see, after the coal is pulverized, it looks like this.

So, this is the coal dust. So, this coal dust is added to the moulding sand along with the base sand and the clay.

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What does coal dust do? What happens when we mix the coal dust with the moulding sand.

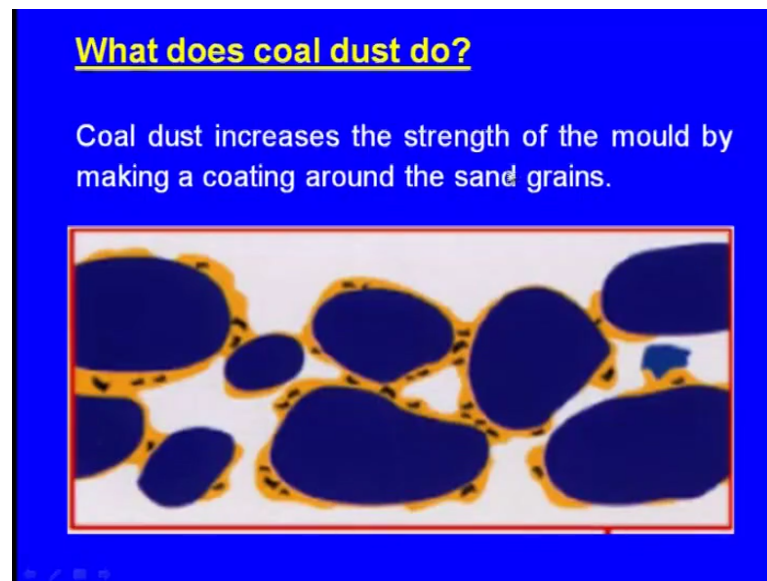
Coal dust acts as a lustrous carbon film on the surface of the mould cavity. As a result a good surface finish is obtained on the casting. Just now we have seen that one of the problems is we use the sand grains and the neighboring sand grains will be projected upwards, because of that there will be a rough texture on the surface of the cavity. Now, when we mix the coal dust with the moulding sand this coal dust acts like a lustrous carbon film, now you can see this is the moulding sand. So, these are all the sand grains, of course, through this way we pour the molten metal and now this is the cavity, surface, internal surface.

Now, because we have mixed the coal dust, see it has made lustrous carbon film here, you see, into this cavity on which there is the lustrous carbon film, when we pour the molten metal what happens, the irregular surface texture of the sand grains will be no

more dominating, because, there is a lustrous carbon film because of that the molten metal comes in contact with this lustrous carbon film and solidifies within that film and we get a smooth casting.

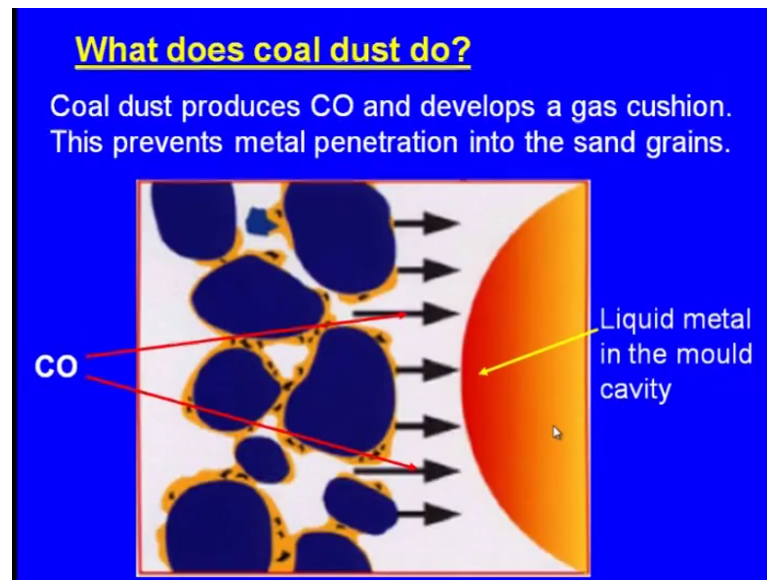
So, that is the best benefit when we add the coal dust to the moulding sand and we get the very good surface finish.

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There are more things which this coal dust can do for us. Coal dust increases the strength of the mould by making a coating around the sand grains. Now you see these are all the sand grains; this coal dust is forming a thin layer around all the sand grains. Because of that the strength of the sand grains is increasing that is another advantage which we can get by mixing the coal dust to the moulding sand.

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Now, this is another advantage. So, what happens, coal dust produces carbon monoxide and it develops a gas cushion. This prevents metal penetration into the sand grains. Just now we have seen that these are the sand grains in the mould, compacted mould and see this side we have pour the molten metal and the molten metal is coming in this direction means from right side to left side it is a trying to come inside.

Now, see now you can notice there is a clearance between the neighboring sand grains. Here, you can see some clearance is there and here you can see some clearance is there and here you can see some clearance is there between the neighboring sand grains and this molten metal is ready to penetrate into these clearances. In such a case, we get the penetration defects, unnecessary fins on the solidified casting which we do not want and if we have to remove them, it takes a lot of time and that result in the increased production.

So, which we do not want, now how to minimize this penetration? When we mix this coal dust, this coal dust contains carbon and this carbon immediately it reacts with oxygen and forms the carbon monoxide and this one side the molten metal is coming from right side to left side which wants to penetrate into the sand grains, but, here you can see this is the carbon monoxide. This carbon monoxide is pushing the molten metal from left side to right side. Ultimately, the molten metal cannot penetrate into the clearance between the sand grains. That is how the metal penetration will be minimized.

So, this is another benefit which we obtain by mixing the coal dust with the moulding sand.

There is another benefit which we can get by mixing the coal dust with the moulding sand. Coal dust produces carbon monoxide and prevents oxidation of the metal. Just now we have seen that carbon monoxide is produced and this carbon monoxide pushes the molten metal which is trying to penetrate into the sand grains. That is not the only thing which this carbon monoxide does; it prevents the oxidation of the metal.

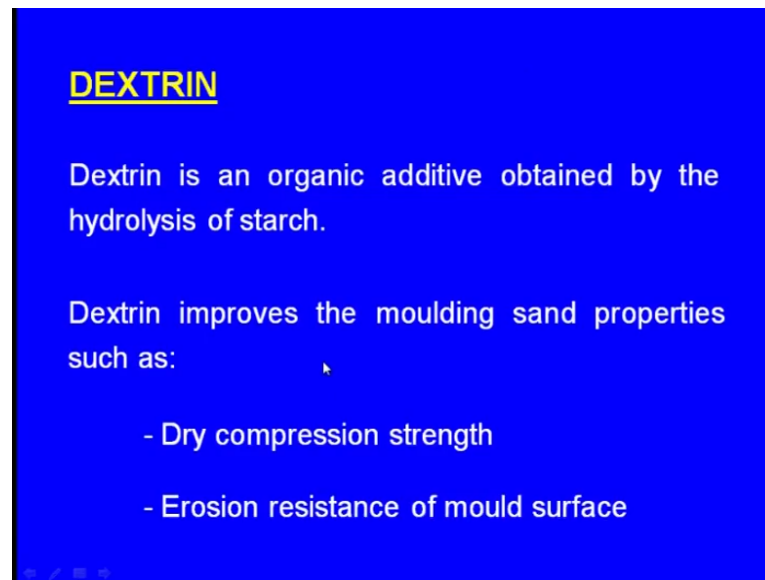
Now, this is the liquid metal and this is the mould and this is the mould cavity surface. This molten metal can come and it may react with the oxygen which is present in the surroundings, but now carbon monoxide is there. This carbon monoxide causes the reduction, it's a reducing agent, it would not allow oxidation to take place. So, no oxidation takes place because of the development of carbon monoxide. So, this is another benefit which we can get by mixing the coal dust with the moulding sand. The oxidation of the molten metal will be minimized.

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So, we have seen, among the additives we have studied about the coal dust and it is important, what say benefits we have seen.

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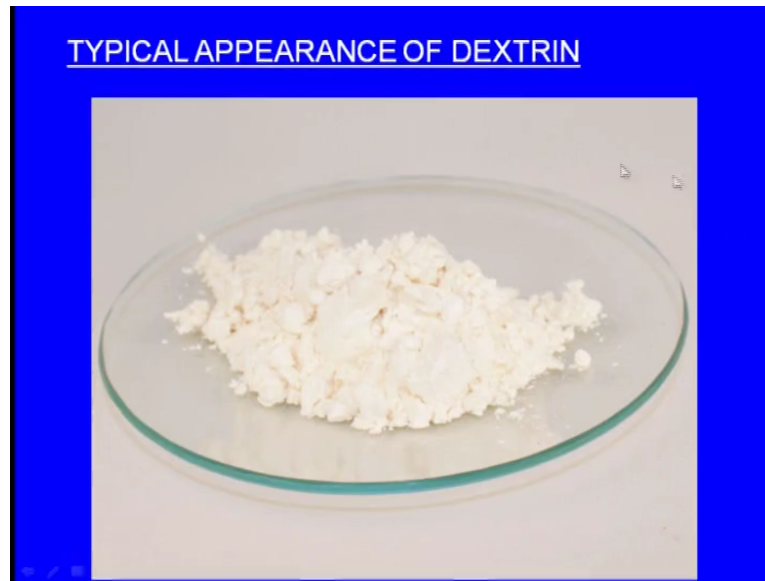


Next, let us see the dextrin. What is dextrin? It is an organic additive obtained by the hydrolysis of starch. Dextrin improves the moulding sand properties such as dry compression strength and erosion resistance of mould surface.

The sand generally it contains the compression strength in the green state means when the moisture is present it contains the required compression strength, but the moment we pour the molten metal, all this moisture will be evaporating and it goes out, then the moulding sand becomes dry. In such a state some sands may not contain or may not develop the compression strength, but when we add the dextrin even after the moisture is completely dried out, the sand will continue to possess the dry compression strength.

Next one, by adding the dextrin we also make the sand to develop erosion resistance of the mould surface, because of the presence of the dextrin it has a resistance against the erosion. As the molten metal is flowing into the cavity, it is possible that the mould cavity may erode some sand particles, because of the addition of the dextrin, this erosion of the sand particles will come down. So, that is the, these are the benefits that we can obtain by mixing dextrin which is another additive along with the moulding sand.

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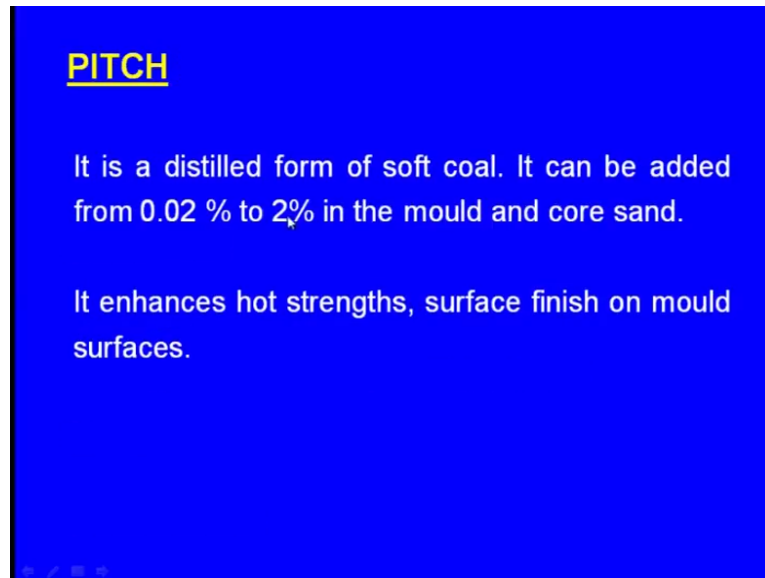
So, this is the typical appearance of the dextrin, this is obtained by the starch.

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Next one, let us see the pitch, which is another additive.

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It is a distilled form of the soft coal. It can be added from 0.02 percent to 2 percent in the mould and also in the core sands. It enhances hot strengths, surface finish and mould surfaces. Again this is the hot strength, just now we have seen that by the addition of the starch what happens by the addition of the dextrin, the dry compression strength is improved.

Now, after some time what happens, the sand becomes not only dry, but it becomes hot because the molten metal is in touch with the mould surface for a long time. So, no doubt, in the beginning itself it has become dry, now it has become hot means its temperature has gone up. In such a case, it is possible that the moulding sand may not possess the strength in a hot state, but by adding an additive like pitch we can see that the moulding sand possess the hot strength even at the hot state, even at the elevated temperature and also it enables to get a good surface finish on the mould surfaces. So, that is the importance and benefit that we can obtain by mixing pitch along with the moulding sand.

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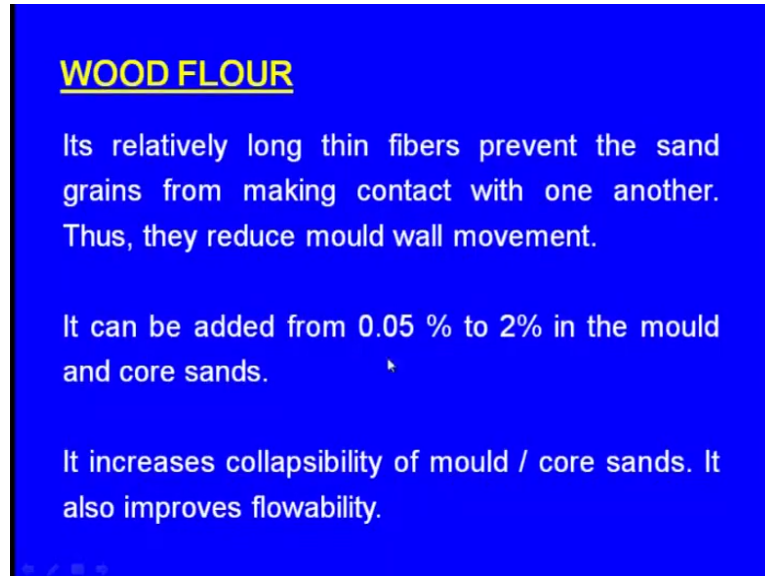
Next one let us see the last additive. Among the last additive that is the wood flour. This is the wood flour; wood flour is finely pulverized wood, just like we have seen that to coal dust. Coal dust is for pulverized coal similarly wood flour is the finely pulverized wood. Its particle range from a fine powder to roughly to the size of a rice grain. So, it looks like this. So, again say there will be fine powders will be there, coarse powders will be there, but they look like this. So, this is obtained by pulverizing the wood.

Its relatively long thin fibers prevent these sand grains from making contact with one another. Thus, they reduce the mould wall movement. Just now we have seen that the mould contains the sand grains may be the silica sand grains or the zircon sand grains, if they are close to each other they cannot expand because all the grains are expanding finally, if there is no space between the adjacent neighbor you know say neighboring sand grains there will be deformation of the mould.

Now, when we mix this wood flour, this wood flour its particles will be fine powders sometimes there will be long fibers, as long as a rice grain. So, they will be placed between the neighboring sand grains and these are soft grains. So, when the neighboring sand grains want to expand these soft grains allow the neighboring grains to expand without causing any mould deformation. That is how there would not be any mould wall movement. When there is no mould wall movement, no damage to the casting, no crack

on the casting. So, that is the important benefit that we can obtain by adding the wood flour to the moulding sand.

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Next one, it can be added from 0.05 percent to 2 percent in the mould and also in the core sands. It increases the collapsibility of the mould and the core sands. Just some time back we have seen in some cases it is very difficult to break the sand. After the casting is solidified we have to break the sand. This is known as knockout. Sometimes it becomes, more efforts, it requires a more labor now what happens when we add this wood flour because this wood flour is very soft it enables easy breaking of the mould after the solidification is over.


So, it increases the collapsibility of the mould and also the cores and also it improves the flowability. Flowability means its ability to flow around the pattern during the compaction process. So, these are the different benefits that we can obtain by adding wood flour in the moulding sand.


So far we have seen these are the sand what say green sand components. We have studied the base sand, we have studied the binders, just now we have completed the additives.


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WATER

➤ *One of the most influent element.*



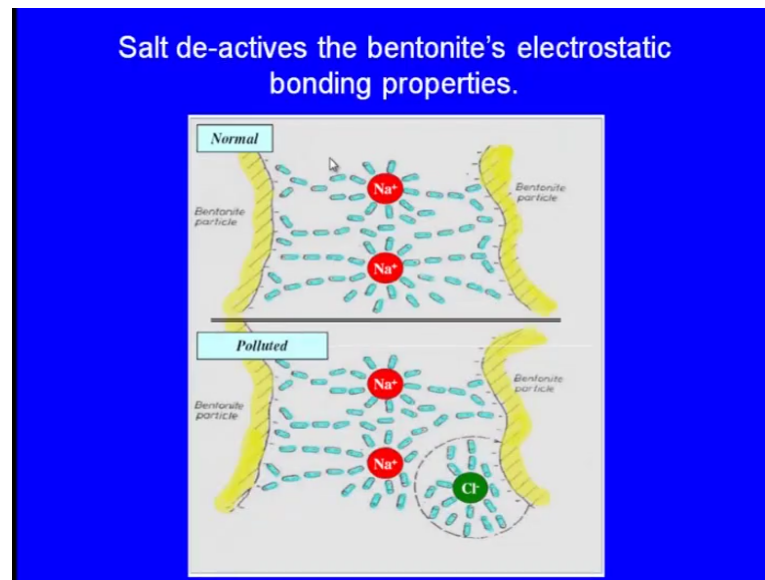
 *Development of the Moulding Sand Properties*

 *Contains impurities that affect the bentonite properties*

Next one let us see the water which is the fourth component of the green sand. So, this is water and one of the most influent elements. So, sometimes it contains the cat ions and sometimes it contains the anions. If there is cat ions there is development of moulds and properties whereas, anions it contains the impurities that affect the bentonite properties or that affects the binder properties.

Now, what happens is what kind of water to add in the moulding sand? We have seen that water can be mixed from 2 to 5 percent, but can it be any water or only particular water we have to mix.

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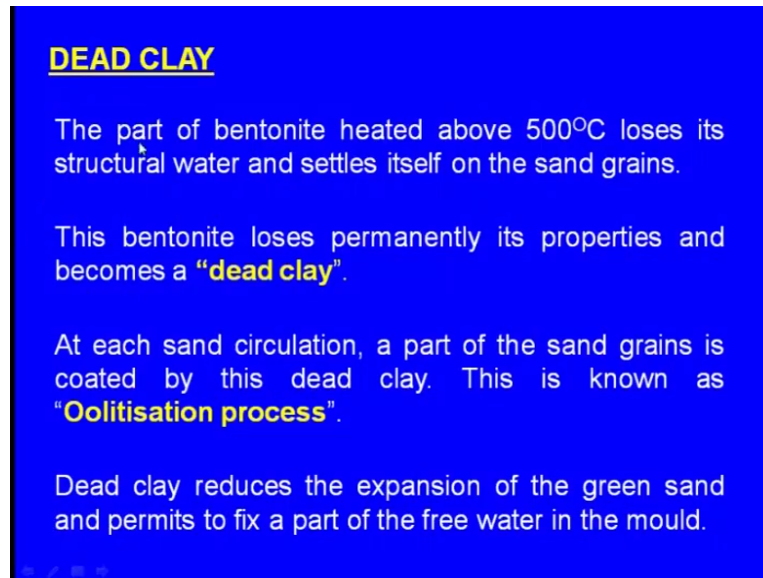


There is a reason, we have to add the normal water not the salty water, because salt deactivates the bentonite's electrostatic bond properties. You can see this is the case when normal water is added without means no salt is present in that, now say this in the bentonite there is sodium ions are there. The sodium ions they will be improving the electrostatic bond property of the bentonite.

Now, let us see the next case, this is the polluted water. Let us assume there is some salt is present say for example, some sodium chloride, now what happens, we can see sodium ion is there and sodium sorry here is the chlorine ion which comes because of the impurity. This chlorine and sodium have got the highest affinity and because of that they come close to each other, they make a bond, ultimately the electrostatic bond property of the bentonite comes down. That is why; salty water or polluted water decreases the electrostatic bond property of the moulding sand not the clay. So, we have learnt about the water, also we have seen what kind of water to add and we have seen that we should not use the polluted water and we should not use the salty water.

Next one, the dead clay. So, this dead clay is not added deliberately from our side. We never add dead clay. We add only the right clay or the live clay we add, but what happens during the process of pouring, part of the active clay becomes the dead clay because it loses its properties, but still it is physically present. So, this is known as the dead clay. So, this becomes the last component or the fifth component of the green sand.

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DEAD CLAY

The part of bentonite heated above 500°C loses its structural water and settles itself on the sand grains.

This bentonite loses permanently its properties and becomes a “**dead clay**”.

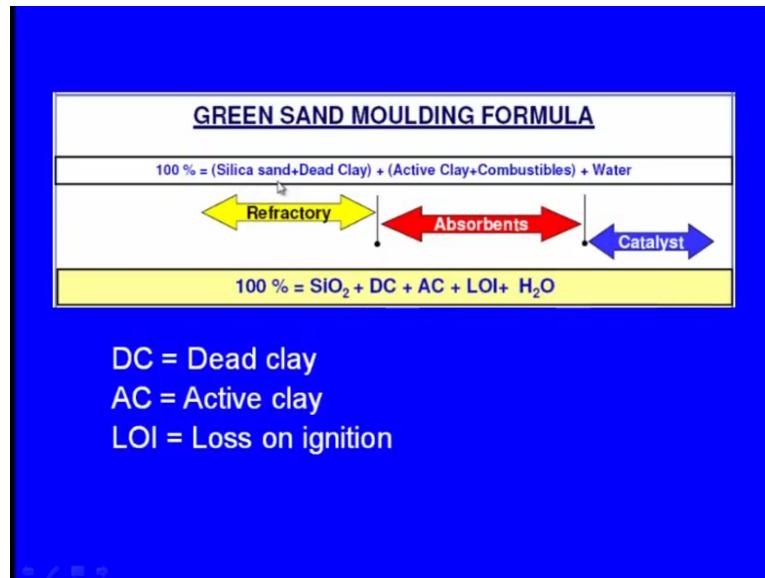
At each sand circulation, a part of the sand grains is coated by this dead clay. This is known as “**Oolitisation process**”.

Dead clay reduces the expansion of the green sand and permits to fix a part of the free water in the mould.

What is this dead clay? The part of the bentonite or the clay heated above 500 degree centigrade loses its structural water and settles itself on the sand grains. It loses all its properties. This bentonite loses permanently its properties and becomes a dead clay. Once it loses permanently all its properties, but it is physically present then it is known as the dead clay whereas, the clay which has not lost its properties is known as the active clay that active clay only we add as the binder.

Next one at each sand circulation, a part of the sand grains is coated by this dead clay. This is known as oolitisation process. Dead clay reduces the expansion of the green sand and permits to fix a part of the free water in the mould. So, this is the dead clay and here we can see high utilization and low utilization.

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So, this is the green sand formula. We can see here, we can see the silica sand or we can say this is the base sand plus dead clay will be there. Next one, active clay will be there then there will be additives will be there plus water. Now, how can we say 100 percent the total green sand is this one, this is the what say a silicon dioxide or the silica sand or the any base sand plus DC. DC means dead clay and next component is the active clay and there is another component that is the LOI Loss on Ignition. Some sand or some clay is burnt and it is lost, so this is the loss on ignition. So, that is also countable finally, here is the moisture.

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PROPORTIONS OF GREEN SAND FOR CAST IRON

CAST IRON CASTINGS

COMPONENT	PROPORTION (WEIGHT)
Base sand	75 to 85 %
Active binder	6 to 10 %
Dead clay	5 to 8 %
Loss on ignition (LOI)	3 to 5 %
Moisture	2 to 4 %

Proportions of green sand for cast iron: So, how to make the green sand for cast irons? So, base sand is present from 75 to 85 percent. Active binders or the binder which we add freshly or the active clay is from 6 to 10 percent. Next one, dead clay, this we are not adding that comes by automatically, that is generated during the process of pouring and re moulding, it is generated. It is between 5 to 8 percent. Next one, loss on ignition, this also not from our side, it is generated or developed. This is from 3 to 5 percent. Finally, the moisture is 2 to 4 percent. So, this is the proportion of green sand for the cast iron castings.

Next one, proportion of green sand for steel castings. The base sand is from 75 to 85 percent. Active binder or the binder or the clay or the fresh clay is 8 to 12 percent. Dead clay is from 6 to 9 percent, loss on ignition LOI it is from 2 to 3 percent. Finally, the moisture is 2 to 4 percent sorry the loss on ignition is 2 to 3 percent.

Next one, metal to sand ratio: until now we have seen how to prepare the green sand? What are the ingredients of the moulding sand? We have seen, what are the components of the green sand, we have seen. What are the different clays we have seen, what are the different binders? What are the different additives? What are the benefits that we can obtain by mixing the additives to the moulding sand we have seen and we have seen the importance of the moisture and the concept of the dead clay we have seen.

Now, the next question is metal to sand ratio the moulding sand or the green sand is ready, maybe you are going to make a casting of 10 kgs. For 10 kgs how much sand is to be used say again the quantity or the consumption of the green sand must be optimized. It will not be too much. If you use too much more than required it is a loss to the industry.

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TYPICAL METAL TO SAND RATIOS

FOR FERROUS CASTINGS

Metal to Sand ratio = 1:9

FOR NON-FERROUS CASTINGS


Metal to Sand ratio = 1:5

So, let us see the optimum metal to sand ratio for. This is the typical metal to sand ratios for ferrous castings. Metal to sand ratio is 1 is to 9 means if we are making a casting of weight 1 kg we have to use 9 kgs of green sand. Similarly, for non-ferrous castings, the metal to sand ratio is 1 is to 5 means if we are making a casting of weight 1 kg we have to use 5 kgs of moulding sand. Now this is the mixing of the green sand.

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MIXING OF GREEN SAND

- Uniform mixing of all constituents is important for each sand grain to be **coated uniformly with the additive.**
- This is achieved by putting the ingredients through a **Sand Muller** which rolls and stirs the sand.



So, how to prepare this green sand? We have seen that the ingredients of the moulding sands are the base sand, the binder, additives and the moisture, how to prepare them? So,


we have to put all these ingredients in the right proportion into a Sand Muller. So, this is known as the Sand Muller. You can see here there are 2 rollers are there, here is one roller and here is one roller and there will be 2 blades will be there, here is one blade and here is one blade. So, the all these ingredients will be dumped inside and this will be rotating maybe for about 15 minutes and after that say all these ingredients are nurtured thoroughly and we get a very good mixture of this green sand.

So, this is achieved by putting the ingredients to a Sand Muller which rolls and stirs the sand. Now, this process is known as mulling. After the mulling is over, each sand grain is coated with the clay; each sand grain is coated with additives and moisture, so they are that much nourished and mixed.

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MIXING OF GREEN SAND

- It can be continuous and batch-type muller, which use blades and wheels for mixing.



Next one, it can be continuous and batch-type Muller. Sometimes in some industries this sand mixing is continuous, they keep loading and at the same time at the bottom they used to keep unload and this process goes on or sometimes it can be done in a batch wise. Production maybe whenever there is a requirement these ingredients can be kept inside the Muller and they can be mixed and that sand can be taken and after sometime again it can be operated. So, this can be operated in your batch type and also continuously.

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And, you can see this is bigger Muller, you can see inside. So, this is here with the door is opened and here we can see there are so many blades are there. So, this is a larger Muller, Sand Muller.

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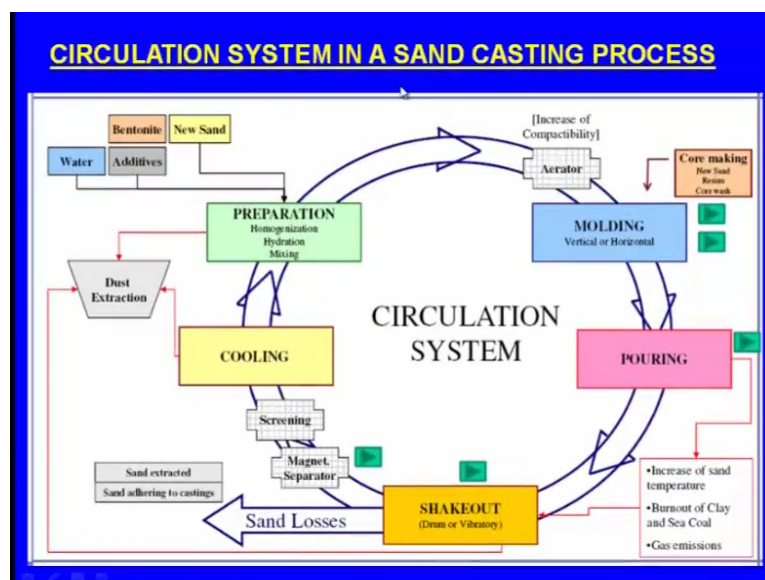
And, this is the green sand preparation system for a large scale industry. They look like this.

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Now, once this sand is prepared, if it is small industry, it is carried manually, but in large scale industries, this will be carried automatically by the conveyors. There will be pneumatic sand conveyors will be there. So, this is a pneumatics sand conveyor. Through this conveyor the sand will be taken from the moulding shop to the or the sand shop to the moulding shop and these are all the storage systems.

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So, this is the circulation of the system in a sand casting process and here we can see this is the preparation of the moulding sand. So, we are mixing the base sand and the binder,

additives and the water are mixed here and here we are mixing. This mixed green sand is going to the mould shop and here of course, parallelly we also make the core; remember, core means an object which is kept inside the mould to create some hollow cavities inside the castings.

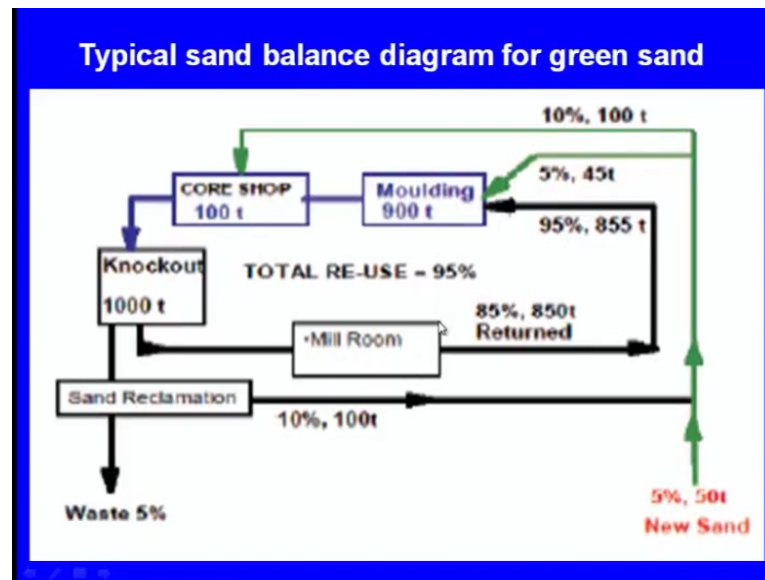
So, here a core is made. So, this core is also made and the moulding is done and inside the mould the core is kept. Now, it is the pouring. We do the pouring. And after sometime the poured metal solidifies and we will be breaking the sand. So, this is known as shakeout or knockout. There will be some sand loss will be there and the gas emission will be there here, we can see and burning out of the clay and sea coal means that is the additive, burning of the binder and additive will be there. Then sand losses will be there, then we take the casting outside.

Now, this sand will be again going to the sand preparation shop where it will be again tempered with the water, again it will be remixed. The problem is, it may contain some unwanted metallic objects inside the sand; maybe, the penetrated metals or sometimes we use the chills. These chills or some other components, metallic components or hard sand lumps may be present inside, they have to pass through the screening here and there would be a magnetic separator will be there. So, when the sand is; sand which we obtain from the shakeout when it is passing again going to the sand shop, it has to pass through the magnetic separator. If there are any unwanted metallic objects are there in the sand, they will be absorbed; they will be caught by the magnetic separator.

Next, there will be screening to screen the very hard sand lumps. Finally, it will be cooled down, again, it will go to the sand preparation shop and this is the there is another system parallelly; dust extraction system will be there. So, when you break the sand, when we do the shakeout or the knockout lot of dust will be arising.

So, there has to be a system to tap, collect the dust. So, this is the dust extraction system. Again, the sand continues to circulate in the same cycle. In between, these people add the clay or the binder, because part of the clay becomes the dead clay.

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So, remember, this is the typical sand balanced diagram for the green sand. So, remember always there is a sand loss, for example, let us consider a small case. This is the moulding shop and this is the core shop and say for example, here a 900 tons of moulding sand is prepared on a particular session and here for making the cores 100 tons of core sand is prepared. Now, mould is made. After the mould is made, there will be knockout. Knockout means after the casting is solidified, we break the sand and take the casting outside. This process is known as knockout. Now again it is going to the mill room and you can see we are not getting the 100 percent sand. By the time, we see it comes to the again moulding shop; it is only 95 percent of sand we are getting. There will be sand loss will be there.

So, waste is 5 percent and again we have to add the new sand. Generally, about 5 percent of new sand is added and along with that a proportionate amount of the binder or the clay is also added, again when you are making the or when we are re-tempering the moulding sand. So, remember always there is a sand loss in the circulation system.

Friends, with this we are concluding this. We have learnt about the moulding sand design and we have seen that the moulding sand contains the certain ingredients. The moulding sand mainly contains the base sand. This base sand can be silica sand or chromite sand or zircon sand or the olivine sand. So, these are the popular base sands. So, this base sand is

the main ingredient of the green sand. Next one, we add the binder. This binder we add to develop the cohesion between the sand grains.

So, among the binders bentonite is the popular binder and the third ingredient is the additive. Additive is mixed for obtaining several benefits to reduce the metal penetration or to reduce the oxidation or to reduce the mould wall movement, to improve the collapsibility of the sand after the solidification is over, or to get a fine surface finish or a lustrous finish on the mould coating we add the additives.

Next, we add the moisture. And, we have seen that the moisture should not be contaminated moisture, it should be free from the salts. If there are salts are present what happens, these salts react with the sodium which is present in the bentonite and they reduce the binding action of the bentonite and we have also seen that we every time when we add the clay, part of the clay becomes dead clay, after it comes in contact with the molten metal. This is known as the dead clay. So, every time we have to compensate this. So, we have to add little more clay every time when we reuse this. So, this is all about the green sand design.

Thank you.