Fundamentals of Manufacturing Processes
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Lecture – 16
Casting: Sand Moulding II

Hello, I welcome you all in this presentation related with the casting. And in the previous presentation, I have talked about the main ingredients of the moulding sand; and what are the properties which are moulding sand should have in order to produce the castings of the desired size, shape and a free from the defects.

Now, we will see among those properties, what are the factors that affect the properties of the moulding sand?

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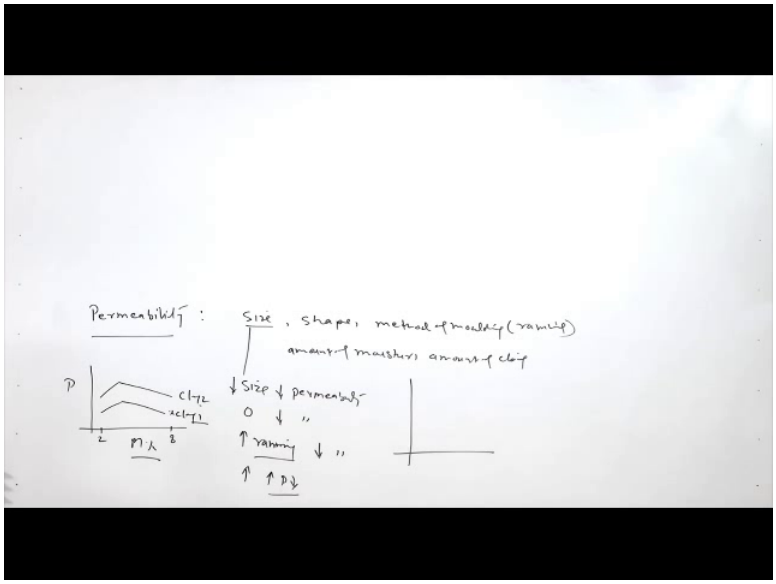

So, considering like permeability; which is about the ability to allow the escaping of the gases, which are present in the mould? So, like size, shape, and the method of moulding; basically it is about the ramming, how the ramming is being done. The amount of moisture amount of clay which has been added;

So, we know that very fine size, very low size particles basically reduce the permeability very round shape will be leading to the reduced permeability and increased ramming, basically how much packing of the moulding sand is done during the moulding that in

turn actually reduces the permeability. And then amount of the moisture, and the amount of the clay both these affect; like increasing amount of the moisture first increases the permeability and then decreases.

So, if we will try to draw the permeability versus moisture percentage relationship, then it comes out to be like this here; first there will be increase in the permeability and then it reduces depending upon the amount of the clay which has been used; higher the amount of the clay. So, it gives you means the clay percentage one and the clay percentage 2 so, the clay amount affects also affects the permeability increase the amount of the clay will be leading to the reduced permeability.

Similarly, so this is how we can say the amount of the clay; as well as the method of the moulding the size and shape of the sand grains affect the permeability or the pours which will be determining the capability to escape the gases present in the mould; either due to the rejection from the molten metal or the gases generated during the mould metallic direction.

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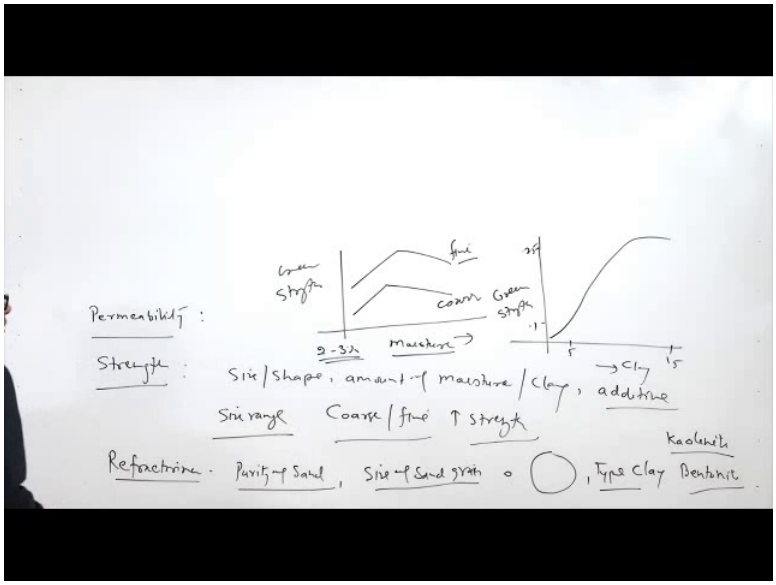

Another factor is the strength. So, strength is also affected by the size and the shape of the grains, the amount of moisture and a clay both; and the kind of the additives which have been used they also determine the strength of the mould effectively.

So, here if we see the size and shape, basically the size range is more important in case of the strength and the permeability as well. So, combination of the good coarse and fine size said particles results in the increased packing close bonding and so increased strength of the mould; on the other hand the effect of the moisture and the clay on the strength of the mould can be seen from these plots; like say the clay here revering from the 5 to 15 percent. So, and here we have a; the green strength means the strength of the mould when there is a moisture.

So, the green strength changes like say 0.1 to 0.25. So, here it increases rapidly, and then it starts it becomes stable. So, this is what we can see increase in amount of the clay actually increases the green strength, because of the increased bonding between the powder particles and here we have moisture. So, moisture and the strength or the green strength of the mould the same trend is also observed in this case where the strength first increases up to a limit with the increase of moisture and thereafter it starts decreasing. So, depending upon the size of the sand grains the different amount of the moisture it can accommodate for the maximum strength.

So, finer is the particle more amount of the moisture it can absorb, as compared to the coarse ones. So, accordingly the strength is affected. So, basically as we have said that like 2 to 3 percent amount of the moisture is needed to activate the clay; so that the bonding can be or facilitated and the next property is the refractoriness. So, refractoriness depends basically upon depends on the purity of the sand; reduction impurity like presence of aluminium oxide, magnesium oxide, etcetera reduce the refractoriness. So, the very pure; the silica results in the very good refractoriness; as and then coming to the size of the sand grains.

So, fine size particles or the sand grains results in the reduced refractoriness, because the we will start getting fused easily as compared to the large size sand particles. On the other hand the type of the clay which also has been used in the mould like a the type of the clay as we have mentioned. Kaolinite is of the higher melting point as compared to the Bentonite. So, Bentonite we will be fusing much earlier as compared to the kaolinite, bentonite has the melting point around at the 12, 30 to 13000 as compared to the which is much lower as compared to that of the kaolinite.

So, these are the factors related with the moulding sand, which will be affecting the properties like strength, refractoriness, and the permeability of the sand mould.

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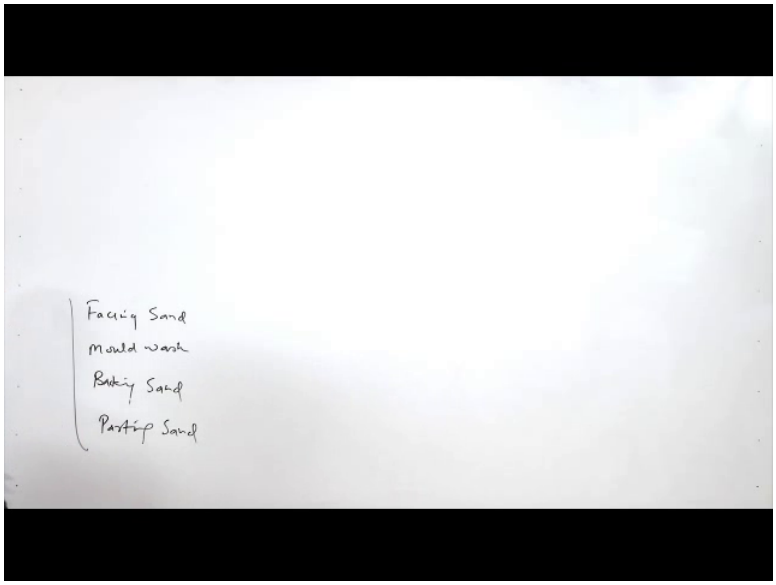

Now we will be talking about the different types of the sands which are used one of them is like the facing sand. Then another is mould, wash and then baking; backing sand and here is parting sand.

The role of each sand is different and the different things are used for this purpose.

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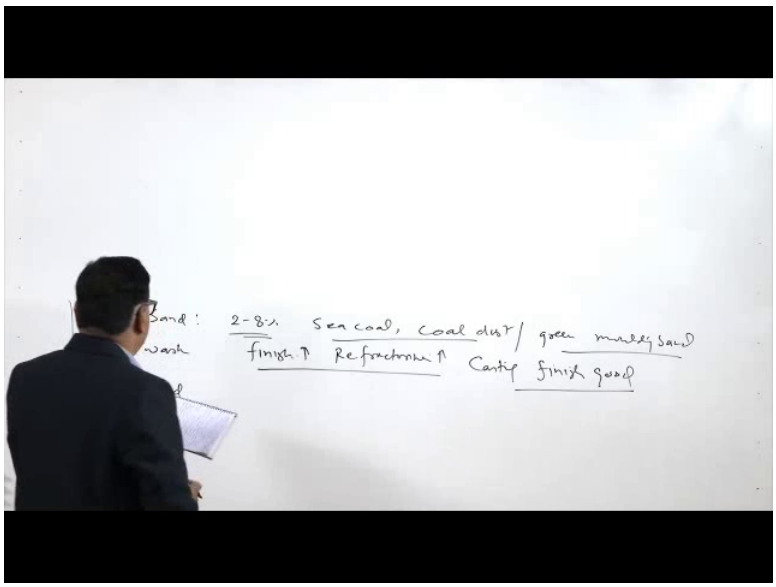

Like the facial sand is used in 2 to 8 percent; basically this is the sea coal or the coal dust. These are the 2 types of the things; which are used basically these are mixed with the green moulding sand. And they are they will be next to the pattern. So, they form the desired basically these are very fine inside. So, basically the mould surface finish is a good refractoriness offered by the facing sand is high. So, because of these 2 purpose; because of these two characteristics the casting finish is good, and it is refractoriness is good. So, it does not result in the fusion of the mould wall and which in turn offers the good and the sound casting.

So, this is what is there in the facing sand, the moulding sand mould wash.

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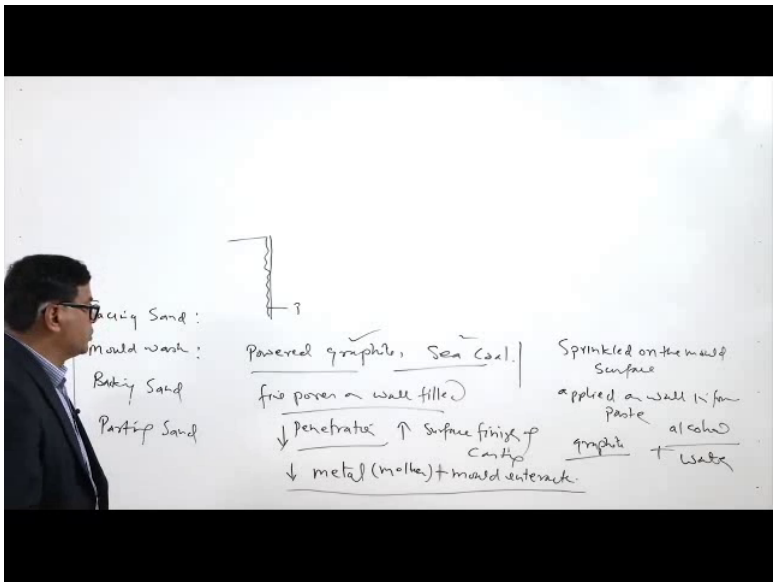

Mould wash is basically the powdered graphite and sea coal. These are the two things which are used in very fine form. Basically; these can be applied in the two ways; one is either they are; is sprinkled on the mould surface or mould walls or they are applied in with the brush applied on walls in form of paste. So, paste is prepared using like say alcohol all or water can be used; water plus these like say graphite powder or sea coal. And then these are applied over the surface of the mould wall.

So, purpose of applying this is that whenever it is applied. So, fine pores on the wall or field. So, this filling in reduces all the irregularities which are present on the mould wall and it smoothens the surface. So, the issues related with the penetration of the molten metal into the mould wall surfaces reduced with the application of the mould wash and

which in turn improves the reduced penetration will be increasing the surface finish of the casting, which is prepared. This is the one purpose and another one; since basically these are of the coal family. So, these will be reducing the molten metal which is in molten state molten metal mould interaction.

So, a harmful or evolution of the excessive gases due to the molten metal mould inter reactions; that is; reduced with the application of the mould wash which in turn will be reducing the tendency for the gaseous defects in the castings like blow hole, porosity. So, it is good in that way to apply the mould wash in the sand mould in order to reduce the casting.

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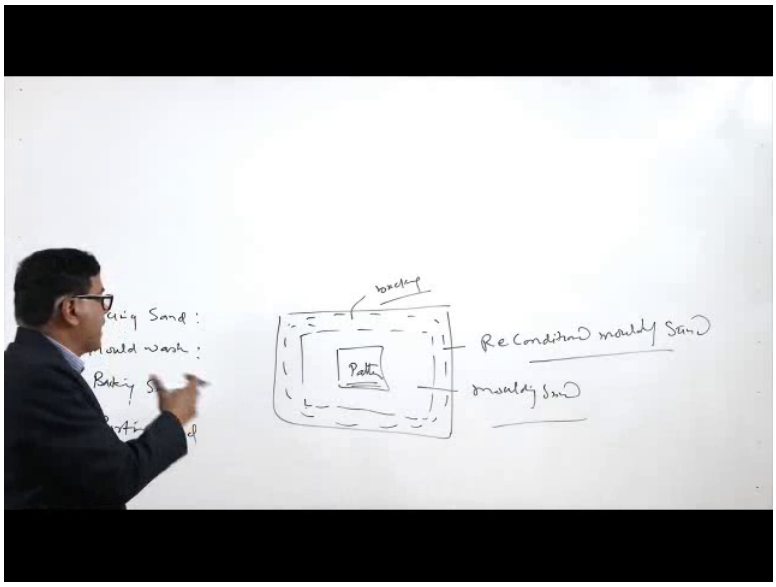

Basically the backing sand is like a; this is the flask. So, and here we have pattern in the top view then the filling of the mould or the flask is achieved through the backing sand.

So, basically it provides required backing to the main moulding sand. So, that moulding sand which is next to the pattern this is pattern. So, backing sand is basically the reconditioned moulding sand; which is used which is basically used to provide the required backing to the main the moulding sand which is next to the pattern. So, this basically helps in reducing the cost; when the reconditioned the moulding sand is used as a backing sand and then parting sand.

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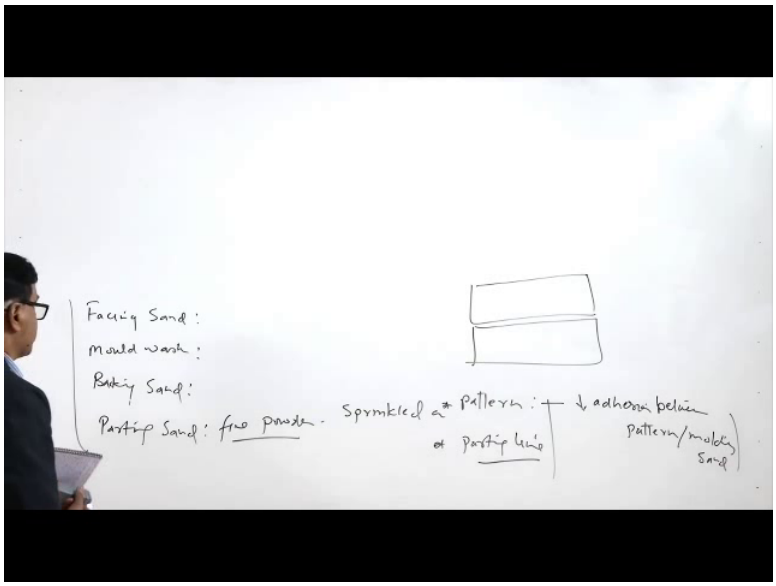

Parting sand is basically this is a very fine powdered sand, which is basically a sprinkled over two things. One is pattern and another is parting line.

So, when parting sand this I sprinkled over the pattern. So, it facilitates the easy withdrawal of the pattern out of the mould. So, the chance for the damage of the mould walls is reduced. So, basically it helps to reduce the adhesion between the pattern and moulding sand, because if the moulding sand clinks or get adhered with the pattern, then you will have the increased tendency of the damaging the mould wall.

Similarly, the parting line between the cope and drag so, it will be sprinkled on the parting line. So, the suppression of the cope and drag without the damage will be easier; when the parting sand is a sprinkled over the surface of the pattern. And on the parting line so, that the damage during the withdrawal of the pattern as well as during the suppression of the cope and drag is reduced. So, when the parting sand is used. So, these are the different types of the sands which are used in the foundry industry.

Now, we will be coming to another important property which matters for the development of the sound casting is the fluidity.

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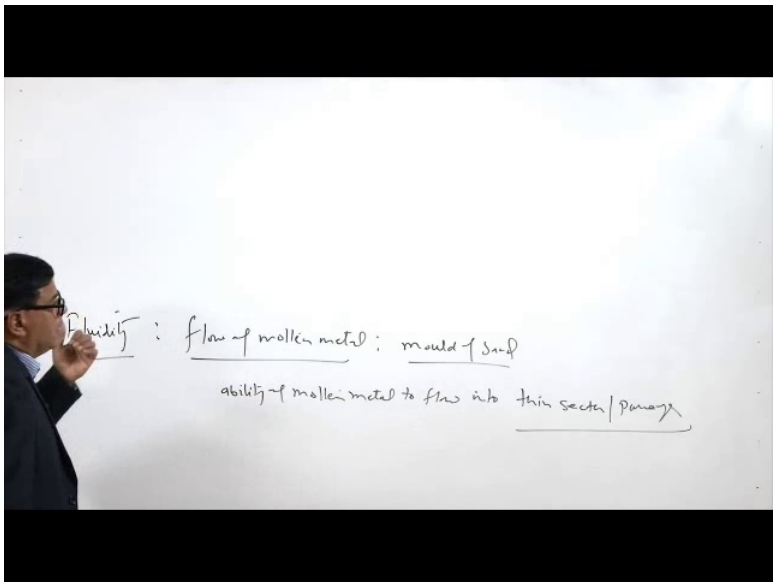

Fluidity is about the flow of the molten metal; of course, this flow is important in the mould of sand. So, and not just under the open conditions; this fluidity is important which will be determining the ability of the molten metal to flow into the thin sections thin passages. So, once if this is realized by the molten metal, because of its good fluidity, then the molten metal will be filled in the mould cavity efficiently, effectively in less possible time, and all these thin sections will be effectively filled in. So, that the casting of the desired complicated and even of thin sections can be realized by the fluidity, but, the fluidity depends upon the on the number of characteristics or number of the features related with the casting.

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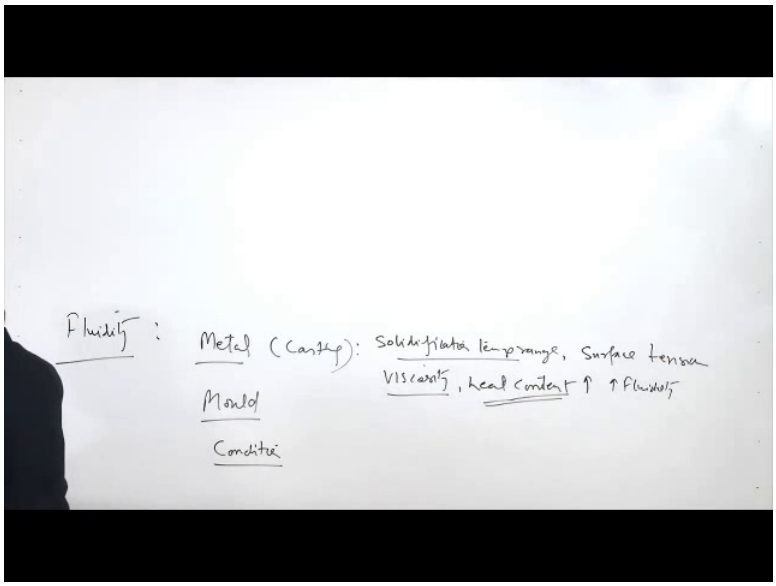

And this includes the metal being used for the casting purpose; this is one. Then another important is the mould on which; in which the molten metal will be flowing. And then conditions in which the molten metal is poured.

So, these are the three important things; which will be governing the fluidity. So, the properties are related with the metal which will be affecting the fluidity includes the solidification temperature range. It is always desired that the range is as less as possible; wider is the range lesser will be the fluidity. So, the pure metals and the metals of the eutectic systems results in the much better fluidity as compared to that of the alloys with the wider solidification temperature range. And the reason for this is; since these sort of these the alloys having the wider solidification temperature range in these systems, the solidification starts much earlier while the remaining liquid is in is still in remaining the metal is still is in liquid state. So, the formation of the wind dendrites and these dendrites distributed in the molten metal mass in the solid state actually reduce the solid reduce the ability to flow.

So, solidification temperature range is one and then a surface tension lower is the surface tension greater will be the fluidity or viscosity lower is the viscosity greater will be the fluidity of the molten metal and it is affected by the temperature. So, higher is the temperature of the molten metal which is being poured greater will be the lower will be the viscosity and higher will be the fluidity. Then the heat content heat content higher is

the amount of the super heat of the molten metal which is being poured where is the amount of heat which it is carrying greater will be the time it will take to solidify. So, greater will be the extent up to which molten metal will be able to flow. So, basically higher is the heat content, greater will be the fluidity of the molten metal.

Next is the specific weight. Specific into higher is the specific into weight greater will be the means; the or resistance for the flow. So, which in turn will be adversely affecting the fluidity? Next are the mould properties.

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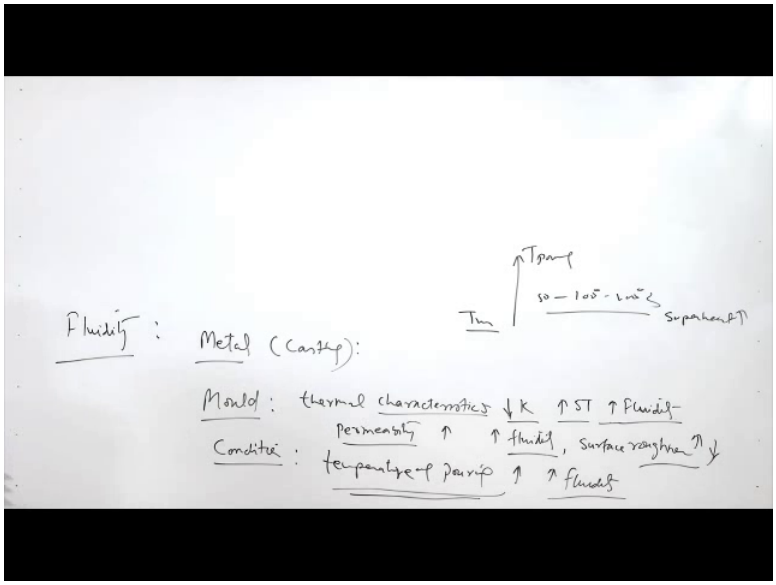

The mould property is important because it is properties like thermal characteristics or the thermal conductivity thermal characteristics. So, higher is the thermal conductivity faster will be the heat extraction from the molten metal. And earlier will be the solidification. So, the molten metal will not be able to flow for long and therefore, fluidity will be reduced.

So, the molten metal or the mould wall has mould surfaces having the lower thermal conductivity. This will be leading to the increased solidification time and increase the solidification time will actually be increasing the distance up to which molten metal will be can flow before the commencement of the solidification.

So, thermal properties of the mould; walls will definitely be governing. High thermal conductivities will be reducing the fluidity. High thermal conductivity of the mould wall

we will be leading to the reduced fluidity of the molten metal in the mould. Permeability of the mould will also be affecting. So, high form permeability actually results in the higher fluidity of the molten metal. And then of course, the factor which will be affecting is the surface roughness of the mould wall. So, greater is the surface roughness; lower will be the extent lower will be the fluidity or lower will be the distance up to which molten metal will be able to flow may before the solidification completes.

Then here; another property is the condition in which molten metal is poured. So, it is basically the temperature of temperature of pouring the temperature at which molten metal is poured. So, if we see there is a particular melting point of the metal. So, what is the difference in which the pouring is done? So, this temperature difference may be a 50 degree or 100 degree or 200 degree centigrade. So, this difference the temperature at which molten metal is poured? And the temperature of the melting point of the metal this is termed as superheat. So, higher is the superheat means greater is the temperature difference of the pouring temperature and the temperature at which solidification will be starting or the melting will be taking place. So, greater will be the fluidity. So, the temperature of the pouring is important; higher is the temperature greater will be the fluidity of the molten metal.

So, this is how we can say apart from this the come for some empirical relations also have been developed in order to estimate the fluidity of the molten metal of some of the category. So, one typical empirical relation, I will be mentioning here related with the fluidity which is for the gray cast iron.

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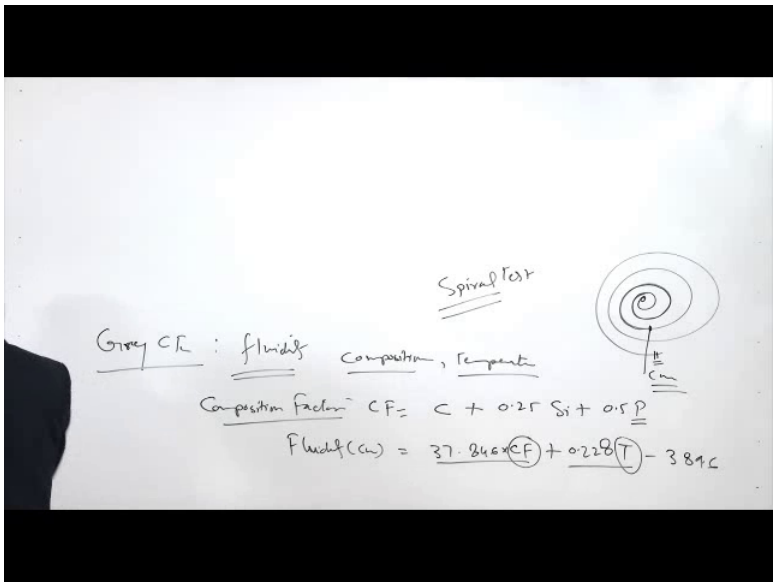

This has very good fluidity under the low melting point that is why it is very easy to develop the castings of the way cast iron and it largely depends upon the composition apart from the temperature. So, composition temperature for the mould of the given for a given mould this what we can say.

So, what we determine in this case; basically composition factor is first determined to see that, how the composition is affecting? And for this; empirical relation have been developed like C F is equal to carbon percentage it is weight percentage of the carbon plus 0.25 of the silicon plus 0.5 of the phosphorus. So, these symbols will mislead these symbols represent the weight percentage of the carbon or weight percent of silicon and weight percentage of the sulphur; which is to be used for calculating the factor C F, then the fluidity is to be measured in terms of the length in centimetre.

So, I will come to that, how it is a measured. So, fluidity in terms of the centimetre is obtained using the formula like 37.846 C F it is the composition factor this is one term, plus 0.228 T. T is the pouring temperature of the molten metal minus 389.6. So, we know the composition factor and we know the pouring temperature by putting in the value of the fluidity in terms of the cm can be obtained. And for this one of the very commonly used a spiral test is used to measure the fluidity. In this test the mould of particular geometry is made in a spiral form; and the molten metal is poured at the centre. So, that it will be flowing into the mould and following this path.

So, depending upon the fluidity it will be able to cover certain length. So, that length is used as criteria to measure the fluidity. So, that length is actually measured in terms of the centimetre greater is the length covered by the molten metal before the solidification completes after the pouring from a particular temperature higher will be the fluidity. If the molten metal is able to reach up to than; means it is of extremely high fluidity as compared to those which will be able to cover the shorter length or somewhat lesser lengths.

So, this is the how we can determine the fluidity? It is important to avoid certain defects in the castings especially the defects like misren kind of defects are formed when the fluidity is limited. And in that case some of the zones and regions of the mould are not filled in completely by the molten metal due to the lack of fluidity.

Now, coming to the certain characteristics which a sand mould should have;

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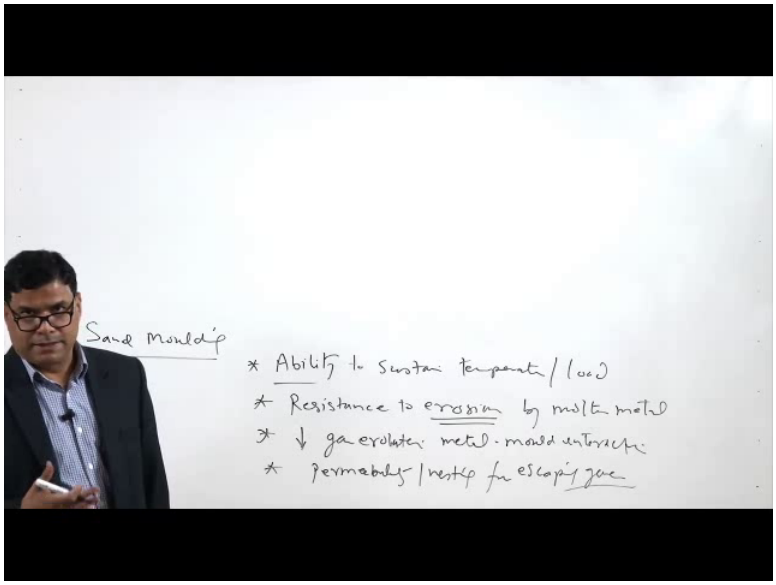

So the sand mould should have certain features in order to provide the sound casting and among this is ability to sustain the two things temperature and load of the molten metal if this mould sand mould cannot sustain temperature then its wall will be fused and the shape will be modified. And similarly if the load cannot be sustained by the mould walls then the shape will be modified due to the shift of the moulding walls. And the two it should not erode resistance to erosion by molten metal. We know that when molten metal is poured into the mould a lot of turbulent conditions exist. So, they may be they will be

rubbing to the surface turbulently and this may cause the erosion of the sand mould which will be modifying the geometry of the mould. And then another important thing which is a desired is that the gases the minimum evolution of the gas gases due to the evolution of the gas evolution by the metal mould interaction.

So, the undesirable gases should not be generated much and due to the mould metal intersections; and even if these are generated or even if the gases are present in the mould wall, then it should provide enough permeability oblique venting for escaping of the gases. So, that undesirable gaseous defects and the gaseous porosity and inclusions blow holes, etcetera are not formed in the casting which ultimately will be making the casting sensitive for the defects; coming to the different types of the mould.

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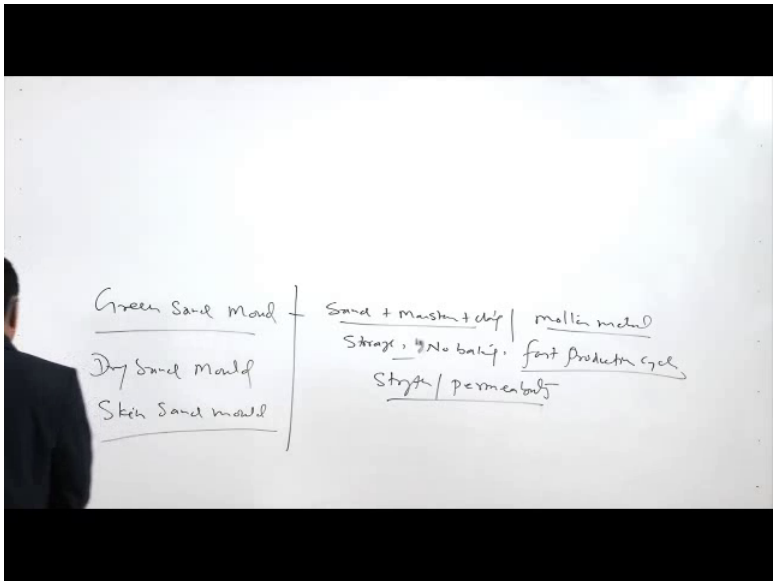

So, among the types of the mould like one is green sand mould, then dry sand mould and then skin sand mould.

So, each one of the type has its own advantages and disadvantages over the other. In case of the green sand mould the green sand means the sand plus moisture plus clay whatever has been used once the mould is prepared; immediately without drying the molten metal is poured into the mould and it is used immediately. So, in this case you see there is no storage no baking and a very fast production cycle you see just prepare the sand green sand mould pour the molten metal and get the casting, but in this case what is important

that is proper strength is kept in mind proper permeability is controlled. So, those undesirable defects in the castings are not made.

But in that way it is a; it is very cheap in the sense that we just prepare the mould pour the molten metal and after the solidification just break it and again repeat the same thing. So, this results in the faster production cycle and very effective use of the space, because no storage no baking is needed; however, it needs that it is required that proper strength; strength of the wall mould as well as the permeability of the mould is controlled properly. So, this method is very effective and very cheap and it is a very low cost for the faster production provided the properties are controlled properly.

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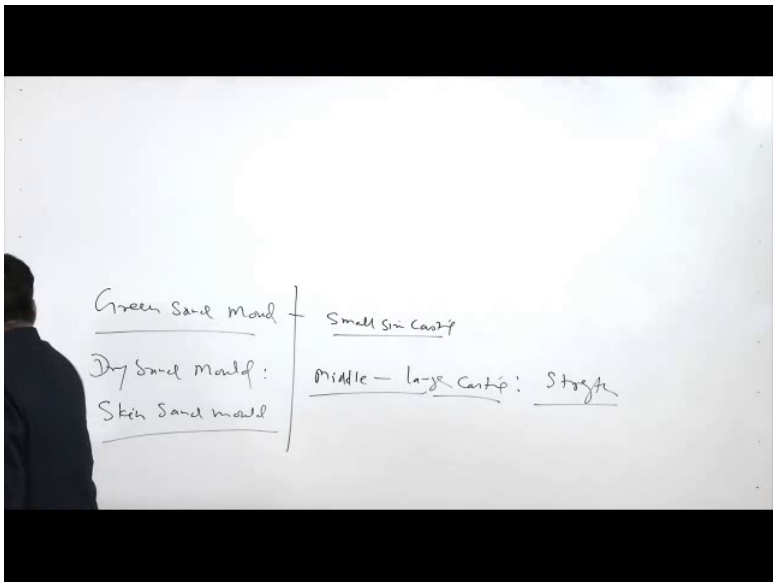

But this is especially good for the small sized castings, where even those somewhat pure strength can also sustain the shape of the mould. In case of the middle to the large size castings large casting it is necessary that a strength is crucial in order to retain the size and shape of the mould. So, for that purpose it is required that whatever mould has been prepared that is properly dried.

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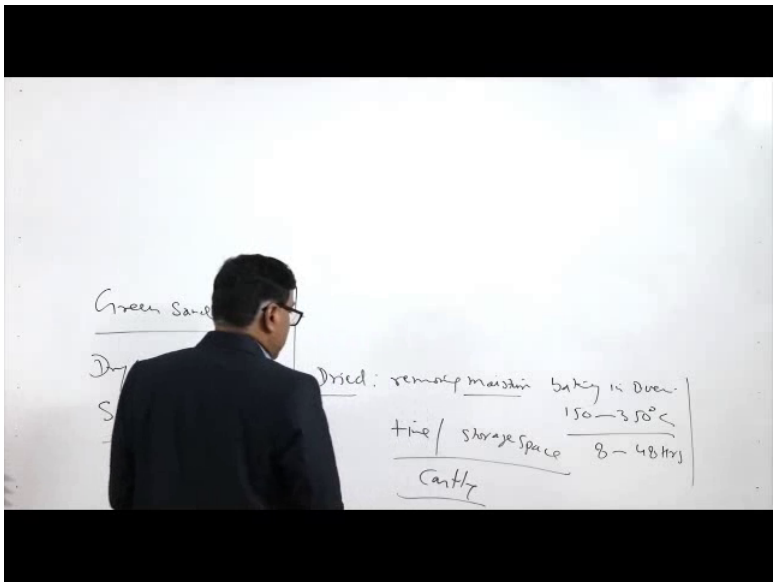

Dried drying is done for removing the moisture and this is done by baking in oven and this baking is done in the range of temperature are 3 and 150 to 350 degree centigrade for a longer period which may range in the range from the 8 hours to 48 hours. So, this needs lot of lot of time for preparation of the mould and lot of storage space is needed.

So, this method is basically costly and expensive and justified when the casting size is large, but we know that in this case; since the moisture is has been driven out. So, the chances for means the amount of the gasses which will be released as a result of the evaporation of the moisture or the mould metal interaction that is reduced.

So, though defect tendency formation is reduced in case of the dry sand mould, but this one is very costly; and it needs lot of efforts for the drawing the mould. So, what is done? Basically in between or middle path of the 2 is choosing.

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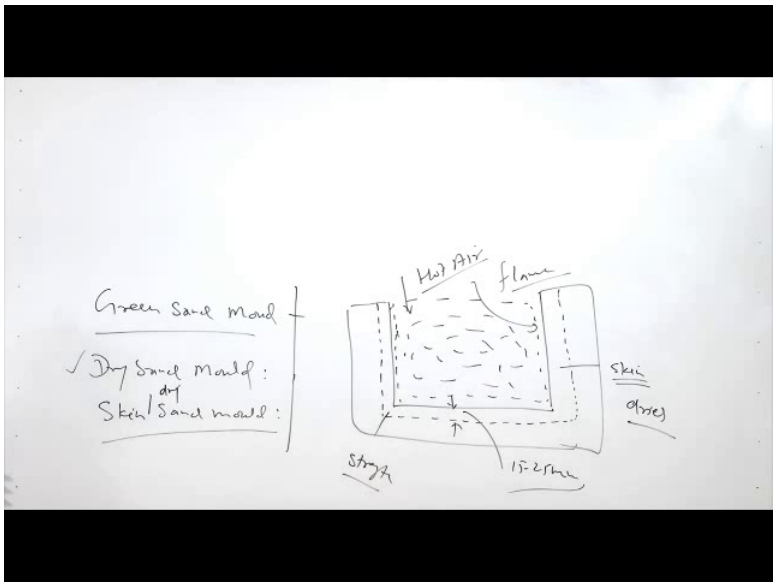

We know that in case of the green sand mould it has the moisture and in the dry sand mould all moisture is driven off; so, but since the dry driving of the moisture needs lot of efforts time.

So, in order to have a compromise between the two what is done only the skin of the mould up to like say 5 to 25 mm depth of the surface this depth may vary from say 5 or 15 to 25 mm depth. This is skin is dried; this is you can say a skin the surface just below the mould surface or the mould region just below the mould surface we termed as this skin this is dried and for the drying purpose it may use the flame like oxy acetylene flame or some other low temperature flame can be used or hot air can be blown in order to dry out just the skin of the mould. So, that the moisture next to the molten metal is driven off this is the region which will be when the molten metal is filled in the skin of the mould or the surface of the mould which comes in contact with molten metal is actually dried and it offers the desired strength.

So, by having the skin drying the skin we try to gain the desired strength and we drive off the moisture so that the molten metal and mould interaction and the reaction gas evolution all those possibilities are reduced by drying out the skin.

So, this is a good compromise in that way of the green strength and the dry gray the green sand mould and the dry sand mould by having the skin dry sand mould basically this is skin dry sand mould.

Now, I will summarize this presentation. In this presentation I have talked about the concept of the fluidity, and how do we measure the fluidity in case of the gray cast iron; using the empirical relations and what are the important characteristics which the green sand mould or the green sand mould should have for developing the sound casting. And thereafter we have seen the different types of the moulds like the green sand mould, dry sand mould and skin dry sand mould.

Thank you for your attention.