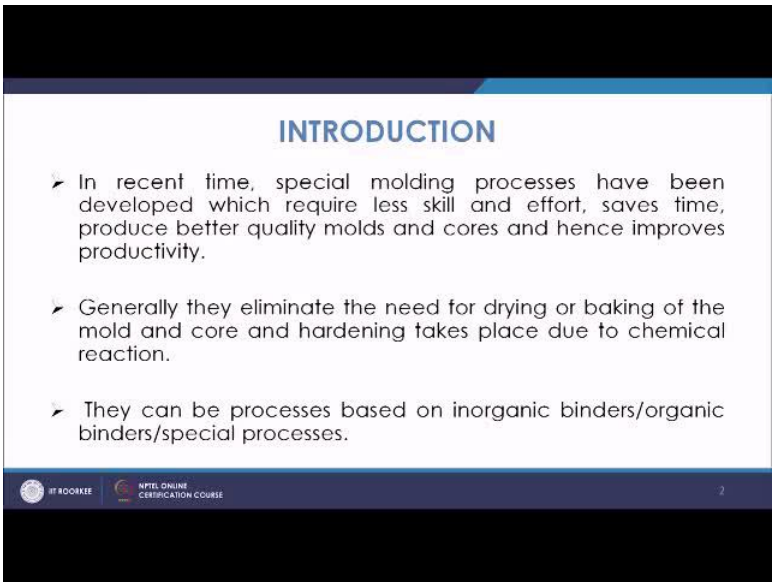
Principles of Casting Technology
Prof. Pradeep K. Jha
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture- 13
Special Sand Modeling Processes
Processes based on inorganic binders

Welcome to the lecture on special sand molding processes. So, in this lecture we will discuss about the processes of molding and core making based on inorganic binders. So, far we have studied the use of clay, which is also an inorganic binder for molding and core making, but a apart from clay as the technology have advanced and depending upon the drawbacks of the clay system, there has been different type of inorganic binder which have been proved to be every effective in molding and core making towards improving the productivity. So, in this lecture we will discuss about the processes of molding and core making based on inorganic binders.

(Refer Slide Time: 01:17)



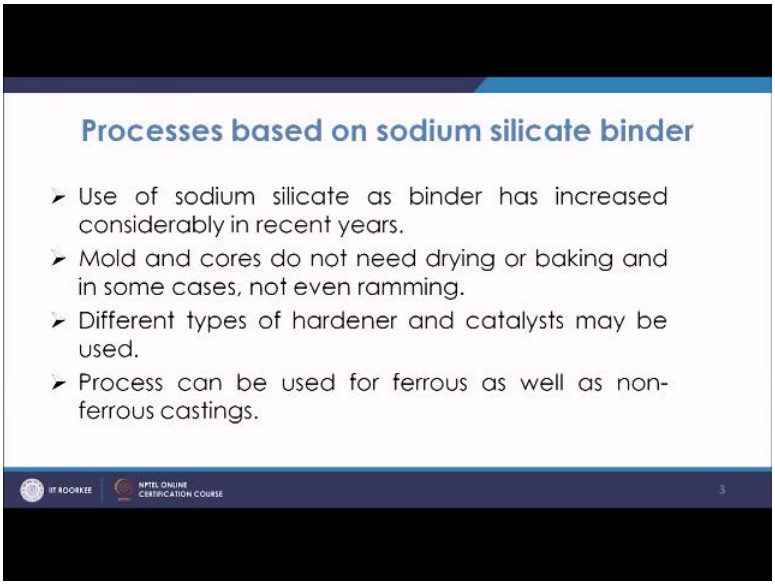
So, what we have so far studied, then we are seen that special molding processes are required to be developed, which require less skill because in the case of molding or core making in core making any way do not use the clay, but the molding while we use the clay, but in the molding while we use the clay you need a person with good skill and also the rate is not so fast and the effort is quite high, you need to have processes where so

less skill is required, because the main problem is related to the hardering process. So, in the case of clay as binders, you need to mix the clay properly and then you need to bake it, you need to dry it and that requires to you know time you have to use many others means to dry it so that it develop atomic strength. So, in that case more skill full labour are required for basically the remover of pattern from the mold or backing it.

So, you need to have the those methods were with less skill, you can have a better processes which gives you save of time and you are getting better quality of molds and cores, so this way of productivity will be improved. Now in these cases we aim that the need of backing or drying should be eliminated, because the most of the time is spent on baking and drying and if the baking on drying is not proper, that leads also to many kinds of defects. So, if you can device those binders or that system, were you can avoid this baking or drying by heating mechanism or in other way in that case it will be better. So, in these processes, you avoid the need of drying and baking and the hardening will takes place mainly due to the chemical reaction. So, that processes will see later in the little slides.

And these processes can be based on either on in organic binders or organic binders. So, and there are special process that we will discuss even later on. So, first of all we are going to discuss about those processes which used the sodium silicate as a binder.

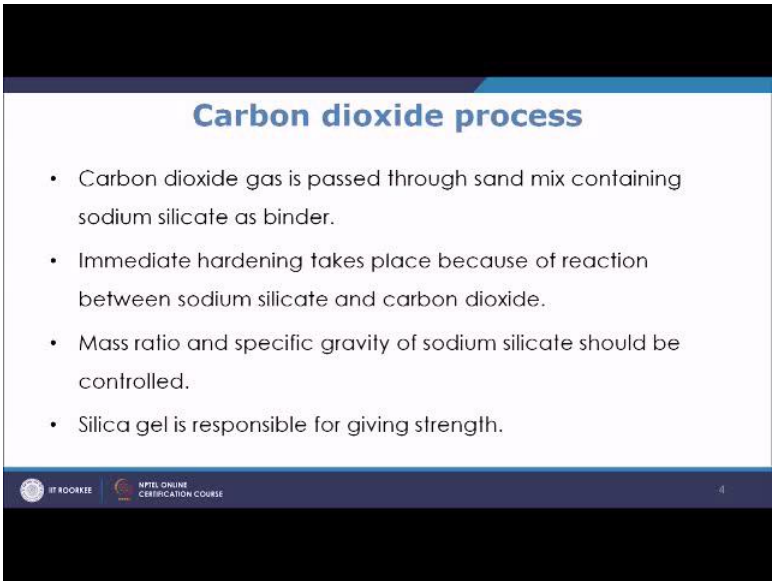
(Refer Slide Time: 04:11)



Now use of sodium silicate, as binder has increased considerably in recent years. So, sodium silicate has found to be very useful material as far as the binding material is concerned, here mold and cores do not drying or baking and in some cases not even ramming. So, this way because we will see different processes where sodium silicate is used as binder and you do not need for the drying or baking of the mold or core and even not ramming by use of certain chemicals forming, chemicals sometimes when ramming is not required, the flowablity of molding material is such that it automatically goes into all the portions like a fluid and so ramming is not even required you get the hard and mold or core.

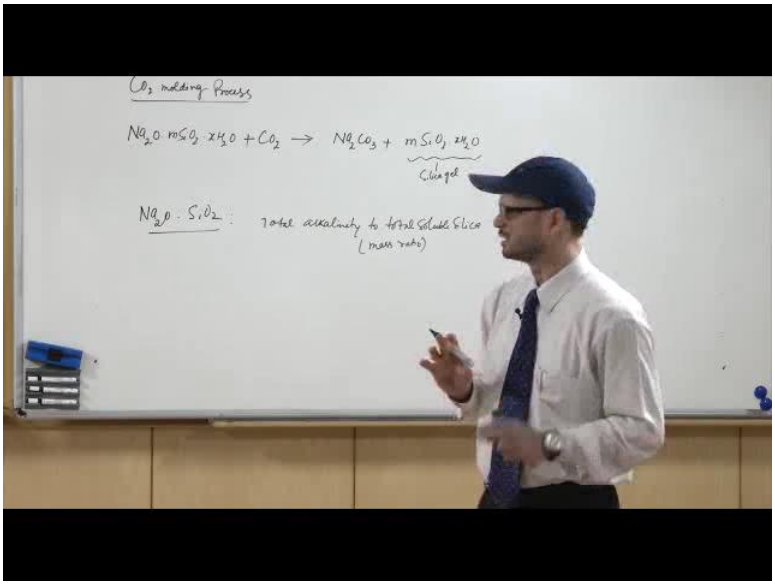
Different types of hardeners and catalysts are used and that is signified different kinds of processes, where the same binder that sodium silicate is used. So, we will discuss about do with different processes and this can be applied for ferrous as well as non-ferrous castings. So, let us go to the first process which is was versatile which is mostly used in medium and large scale foundries even in small scale foundries and that is carbon dioxide process. So, it is also known as Co 2 Process of molding, Co 2 Process. Why it is known as Co 2 molding process? Because in this case as we known discussing about that system, which uses the sodium silicate as the binder; so binder is fixed, but the Co 2 words have the hardener. So, Co 2 gas is passed through the sand mix with the binder and once it is passed it automatically gets hardened in very short amount of time.

(Refer Slide Time: 06:10)



So, immediate hardening takes place because of reaction between sodium silicate and carbon dioxide. So, what happens the Co 2 in the case of this carbon dioxide process, the sodium silicate will react with carbon dioxide and it forms a hard response mass basically and this formation or this action of cohesiveness or the strength is because of the formation of a reaction product that is known as silica gel.

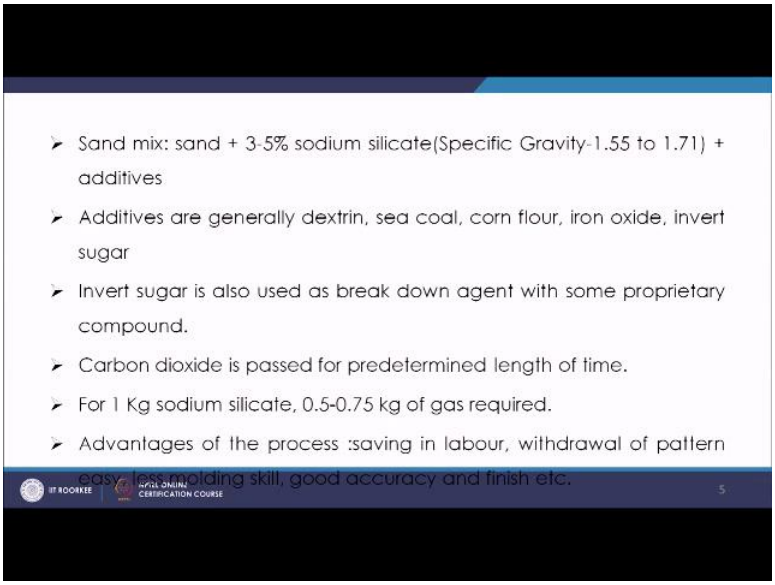
(Refer Slide Time: 06:56)



So, this silica gel is responsible for giving the strength. So, if you look at the reaction what happens that in the case of Co 2 molding, you have the sodium silicate, so sodium silicate is nothing but Na 2 o, m SiO 2, x H 2 O and this reacts with C o 2. So, that makes Na 2 C o 3 plus m S i O 2, x H 2 O. So, this reaction takes place and this reaction taking place basically this is known as silica gel. So, this silica gel is basically responsible for giving you that strength. So, that binds and as soon as the carbon dioxide is passing through it, the hardening started start taking place. So, even if you leave this mold in the open atmosphere, it fix up the carbon dioxide from their atmosphere and slowly it will harden, but to save time we pass through torch or with some other mechanism the gases through it and the reaction takes place and the hardening takes place. Now, in the case of the sodium silicate there are two things important, once is mass ratio and specify gravity. So, mass ratio in nothing, but the ratio of N a 2 o is to Si O 2. So, this ratio is known as mass ratio or its inverse is known as the molar ratio. So, this mass ratio or this specific gravity that talks about the property of particular sodium silicate. So, specific gravity

also somewhere closed to 1.5 is maintain 1.3 to 1.35 or sometimes in certain process we even use of 1.5. So, that will discuss later.

(Refer Slide Time: 09:20)



So, what is the process? The process is that sand mix that is sand plus 3 to 5 percent sodium silicate by the weight of sand. So, in the sand we are mixing 3 to 5 percent of sodium silicate, whose specific gravity should be 1.55 to 1.71 in this case we are keeping the specific gravity from 1.55 to 1.71. So, basically the specific gravity depends upon the mass ratio and the amount of water which is present. So, the mass ratio again further can we altered by suitable addition of any were. So, if u wants change the mass ratio. So, mass ratio is nothing, but this ratio N a 2 O to Si O 2. So, it is nothing, but this is the ratio of total alkalinity to total sodium silica. So, this is known as mass ratio and it inverse is known as the molar mass. So, basically you can change this increase this by adding NaOH. So, this way you can change it and even the gravity specific gravity can be changed, because that basically is the function of mass ratio and water. So, this way this specific gravity can be altered somewhat altered and it has to be kept in certain limit while using.

Further you can also change the even the mass ratio or the gravity, so sometimes we use certain agents to change this characteristics of this sodium silicate by using certain (Refer Time: 11:21) invert sugar. Now additives also are used like dextrin, sea coal, corn flour, iron oxide, invert sugar, these are the additives which are basically required to increase

the collapsible property of the mold, one of the drawback of this carbon dioxide molding is that the collapsibility quite poor. So, in that case we use certain additives and this additives are like this and to improve the temperature property is hot strength or so you use the iron oxide, the inverts sugar it is also a break down agent. So, basically it also increases the collapsibility of this mold, where we use the carbon dioxide to harden it. So, it is basically usually the certain proprietary agent or proprietary compound and then it is used in that mixture, so that the collapsibility is increased.

Now, carbon dioxide has to be passed for pre determined length of time. So, what happens carbon dioxide ones you pass it has to be passed for certain amount and for certain time and edge a time is reached you will have certain optimum strength, after that basically the strength decreases. So, there must be a pre-determined length of time up to which this mold should be gassed. So, this carbon dioxide should be allow to pass through the mold, on an average 1 kg of sodium silicate, requires 0.5 to 0.57 kg of gas required.

So, this is the typical composition of sand plus sodium silicate and based on once you know the sodium silicate, you know that how much gas is required to be blown into and that way that much gas can we allow to pass through the mold by placing the nozzle at different locations and allowing the gas to pass through it. It has also been seeing that if you allow the gas to pass through at a slow rate the hardening is better, then the case when you allow the gas to pass through it at a fast rate. So, you should try to maintain an optimum rate of even flow of the carbon dioxide gas through the mold.

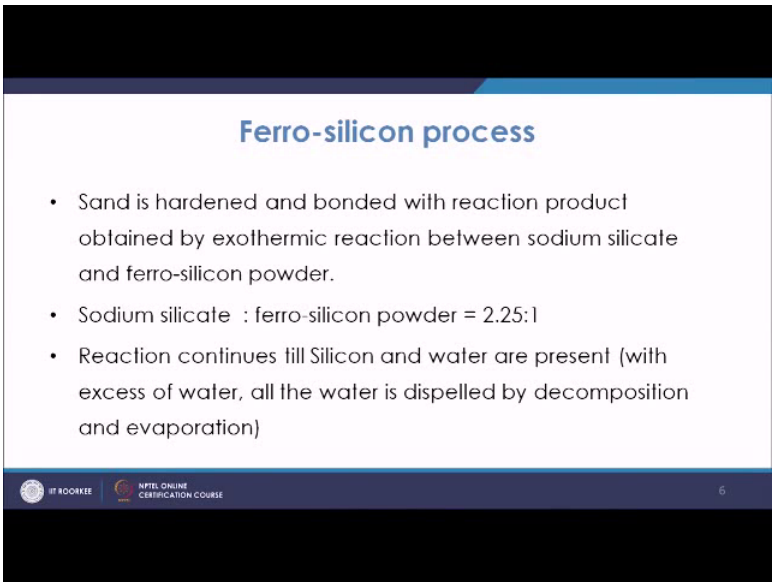
Now, what are the advantages of this process? Before that, we will talking about the gasification of this mold in that case basically, you have certain drawing rate of the gas and this drawing rate of the gas depending upon the vapourizing ability of the gas. So, drawing rate can further we increased by using the vapourizing agents or so. Now, advantages of this process are many and among them you have saving in labour, what happens in this process what you see is in other case you will have to mix the sand with clay and binder properly, here also you mix with sodium silicate, but then simply you pass the gas through it.

So, there is not much of the skill is involved, there is not much of labour involved. So, labour and scale are basically quite less involved, in this case what happens since you are

this drawing the pattern because the baking is continues as you pass the carbon dioxide gas through it, the baking takes place. So, since the baking takes place in that case the withdrawal of the pattern is better. So, withdrawal if pattern becomes easy, you did lower level of skill in this case as compare to that in the case of other processes like using clay as the binder, accuracy and finish is quite good in this case.

Because you can use, you can have you know that while taking the pattern of is not much of problem, you can control the sand grinds and you can get adequate strength. So, because here in this case you get adequate strength and the mold stability is quite. So, in that case your finish is quite in these cases. So, they are basically used for different kind of castings, mostly for small medium and large scale castings use these types of processes in industries, all the automobile pads are basically manufactured nowadays using this carbon dioxide holding processor if they use the inorganic binders. Now, the next process, where the sodium silicate binder is used is the ferrosilicon process. So, in the ferrosilicon process what happened, the sand is hardened and bounded with reaction product obtained by exothermic reaction between sodium silicate and ferrosilicon powder.

(Refer Slide Time: 16:59)



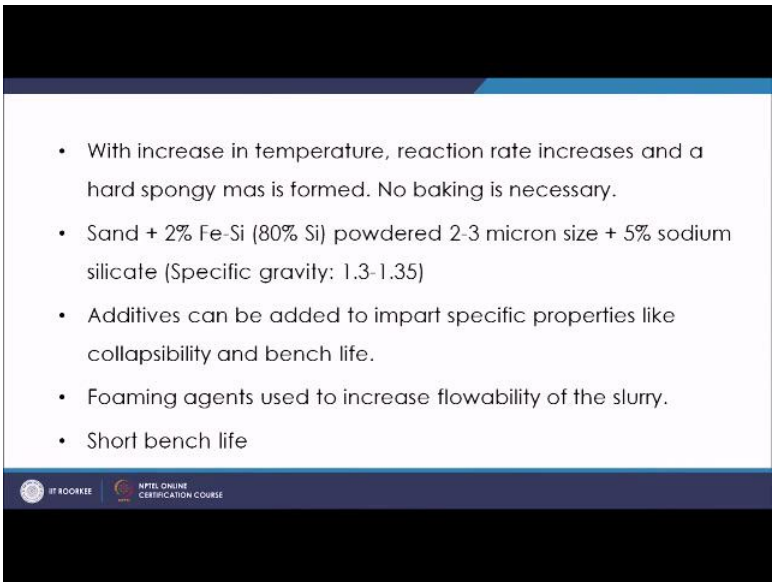
So, what happened here without use carbon dioxide gas to pass through it, so what happened here is we use this ferrosilicon powder; so once this ferrosilicon powder is used this reacts with this sodium silicate and this reaction is a exothermic reaction and in

that reaction, you have the release of hydro gel and because of this exothermic reaction the temperature increased and temporally increased to the level of about 90 degree C.

So, once the temperature increased at that time normally the boiling takes places in the mixture and this due to this boiling the forming takes places. So, what happens due to that basically, the sand has a quite a good flow ability property and it goes into all the portions of the mold and then it hardens. So, this is the point to be noted in this ferrosilicon process. So, here also you have binder as sodium silicate, sodium silicate and ferrosilicon powder is taken in the ratio of 2.25:1 and this reaction continues till silicon and water represent. So, as long as silicon and water is present, the reaction goes on and as since the temperature increased the water vapor is the spelled of; if the axis of water is there all the water is dispelled by decomposition and evaporation. So, basically that is dispelled of because of the decomposition and evaporation.

So, what we do is as the temperature is increased, reaction that increases and hard response mass is formed. So, as the temperature will increase a hard response mass is formed and that basically strengthens the mold. So, in this case no baking is required, no passing of any gas is required it automatically gets baked up and automatically it gets a large strength.

(Refer Slide Time: 19:32)



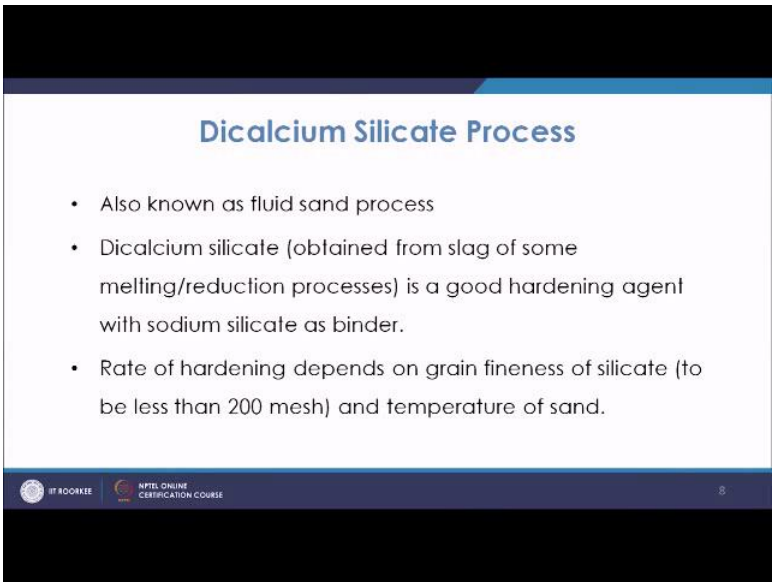
So, in this case what we do is, sand will be added with 2 percent ferrosilicon which has 80 percent of silicon in that ferrosilicon; which is powder 2 to 3 macron size. So,

ferrosilicon powder is there which is about 2 to 3 micron size quite small size particles are there, plus 5 percent sodium silicate is used, which is specific gravity is seeing to be maintained around close to 1.3 to 1.35. So, this way you can have the sodium silicate basically you can use the inverts sugar to change this specific gravity by without changing the mass ratio of the sodium silicate. So, ones you do that the reaction takes place and slowly ones the reaction go I mean if you increase the temperature the reaction will be at faster rate, but even at normal temperature it will go on because it will a it is an exothermic reaction. So, temperatures will certainly we increased. Now, in this case also additives can be added to impart specific properties like collapsibility and bench life.

So, as we move the bench life becomes shorter, as we have discussed even in the case of carbon dioxide molding the bench life is elimination, you cannot live the mold which has I mean which have been prepared by mixing the sand with sodium silicate in normal atmospheric, in the normal atmospheric itself it will be baked or it will be dried in certain time and get lot of a strength. So, in this case also you have. So, collapsibility as well as bench life, so bench life is a problem in those cases because you cannot keep it for long, in this case again the bench life is shorter and there is a problem of collapsibility, so for that we are using the different types of additives which should control the collapsibility as well as the bench life.

Foaming agents are also used to increase the flow ability of the slurry. So, certain flowing foaming agents are used in that mix, so that flowablity is further increased and as we know you have a shorter bench life here, even shorter as compare to the Co 2 molding. So, you need to see that you are quickly using the sand mix to get the mold and the core. Next in the line is the process known as dicalcium silicate process.

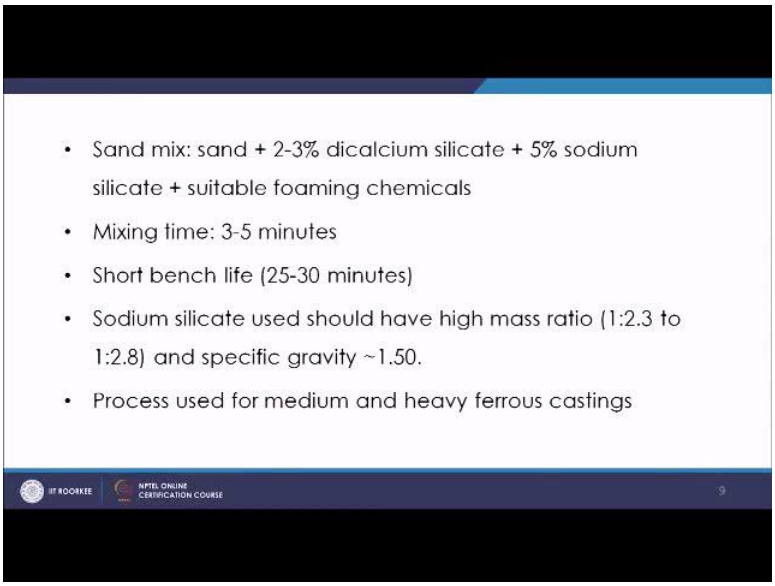
(Refer Slide Time: 22:24)



So, what happens? It is also known as a fluid sand process, the sand base is becoming fluid and it is given a name dicalcium silicate, because dicalcium silicate basically it is obtained from slag of some of the melting or reduction process like hot blast cupola or furnishes (Refer Time: 22:49) lined furnishes, all these places you get the slags, these slags are basically having adequate amount of dicalcium silicates. So, this dicalcium silicate is used as fine powder. So, it is basically used as a hardening agent here. So, in case instead of using ferrosilicon, we are using the Dicalcium silicate. Now in the earlier case what we have seen is that when we use the ferrosilicon powder, the temperature while exothermic reaction so temperature increased. But in this case the temperature need not be increased, once you mix the dicalcium silicate with sodium silicate. So, what will happens. So, this dicalcium silicate is seen to be a good by good hardening agent with sodium silicate as binder.

So, when sodium silicate is used as binder and dicalcium silicate is mixed, dicalcium silicate is access as a hardener. Rate of hardening depends on grain fineness of silicate. So, you have to have less than 200 mesh size of the dicalcium silicate and also it will be depend upon the temperature of sand higher the temperature more and more quickly it will harden so that is there.

(Refer Slide Time: 24:24)

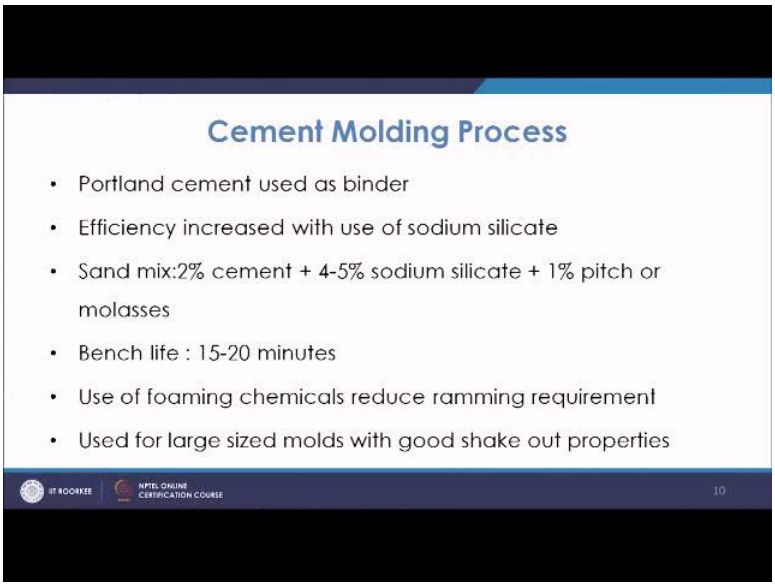


So the process is like this, you have a sand mix which is nothing but sand. Plus 2 to 3 percent of dicalcium silicate powders by the weight of the sand, plus 5 percent by the weight of sand you are using the sodium silicate plus suitable foaming chemicals, you are mixing for 3 minutes and it words as a slurry, as a moving slurry as like a fluid. So, it without doing going for any ramming it goes into all the cavities, internal cavities everywhere in all the corners it goes like a fluid sand and that is why it also known as a fluid sand process, its bench life is about 25 to 30 minutes so, here also will bench life is short, you have to use it quickly.

Sodium silicate which should be used must have a high mass ratio of about 1:2.3 to 1:2.8 specific gravity should be maintained somewhere close to 1.5. So, this way you can have the control of sodium silicate which is too used it is used for medium and heavy ferrous castings.

The next process is cement molding process, now in this case Portland cement is used as a binder and it has been seen that if the sodium silicate is used with Portland cement instead of water, if you used the sodium silicate you get better properties of the mold that is known as cement molding process.

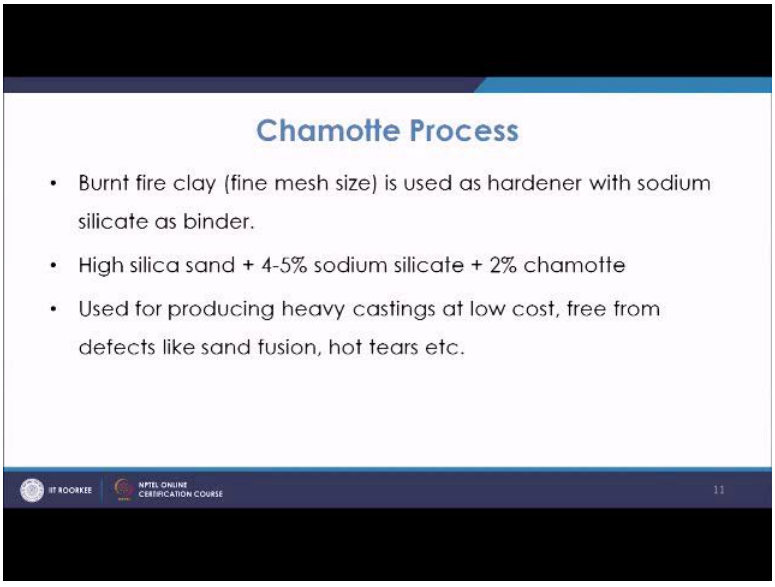
(Refer Slide Time: 26:01)



In that is you have sand mix 2 percent, cement plus 4.5 percent, sodium silicate plus 1 percent pitch or molasses to give the specific property and in this case you are getting the cement mold which has a bench life of 15 to 20, you can use the foaming chemicals, so that ramming requirement is decreased and the mold normally it is used for large molds large size castings and good seek out properties.

So, this way the cement molding also here you use the sodium silicate as binder with Portland cement giving you a very good process for very large size castings.

(Refer Slide Time: 26:53)



There is another process known as Chamotte process. So, this burnt fire clay, which is also known as Chamotte that is basically used as a hardener with sodium silicate as binder. So, in that case high silica and will be list with 4.5 percent of sodium silicate and 2 percent Chamotte is used that basically gives a very good strength to the mold and it is used for producing very heavy castings at low cost free from defects like sand fusion hot tears. So, this is mostly use for a very extremely large ferrous castings and it has means seen that it gives very good property at a very low cost and the defects like sand fusion or hot tears are not seen.

So, these are the different kinds of processes which are based on the use of inorganic binders and mainly the use of sodium silicate, this are which are mostly used and these are the common methods which are used by small medium and large scale foundries which have the edge. So, these process have the edge of her those processes where the clay as a binder is used, because of is inherent advantages like low cost, less skill required, good surface, finish good accuracy and all that, in the next lecture will discuss about the processes based on organic binders.

Thank you.