Manufacturing Processes - I
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Lecture - 4
Module – 2
Metal Casting

Good morning, Metal casting, we have been learning in the previous episodes that metal casting was the primary manufacturing process. This manufacturing process was in practice even thousands of years before Christ. The people who lived during stone ages, they used this process to make arrow, arrowheads and other weapons. People who lived during ancient Mesopotamia, they used this process for their art items for making art items and jewelry items, this manufacturing process was used.

Today, the metal casting has emerged as the technology. Several components are manufactured by metal casting, space craft components, automotive components, engine heads and many domestic and industrial components are manufactured by metal casting. The principal is as follows. We have already learnt that whenever we want to create a component, similar cavity we create in a sand medium or some other molding medium. The shape of the cavity will be similar to the shape of the component which we require. We melt the mould metal and the molten metal is poured into the cavity. The molten metal solidifies in the cavity and after sometime, we break the molding medium. Then, we take the casting outside, and we have seen that to create that hollow cavity, we have to use a model which we call it as pattern.

This pattern is made up of wood. In most of the cases, it is made up of metal, it is made up of plastic, it is made up of plaster, it is made up of wax and we have seen the pattern allowances in the earlier episodes, and we have also learnt about the molding medium. In most of the cases, the molding medium is the green sand and in the earlier episodes, we have seen the ingredients of the molding sand. We have also seen the different properties of the molding sand, and we have classified the casting processes.

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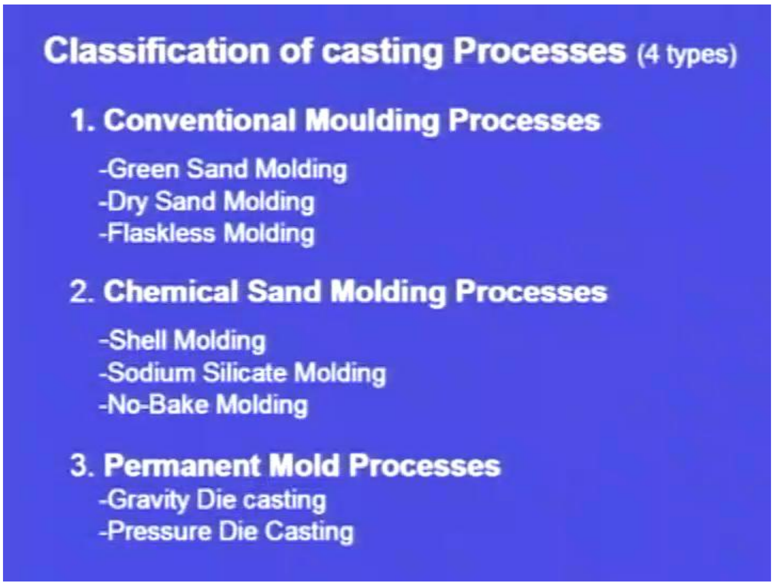

So, this is the major classification of the casting process. They are mainly divided into four types. Conventional molding processes, second one is the chemical molding processes, third one is permanent molding process.

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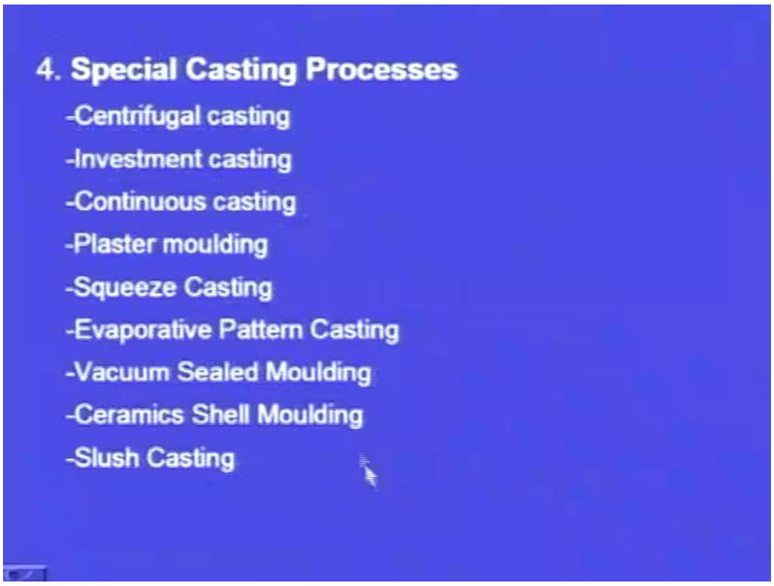

Fourth one is special casting processes and among the conventional molding processes, green sand molding is widely used. In fact, our ancestors have been using this green sand molding, and the molding medium is not costly and any big component can be manufactured. This is the advantage of the green sand molding, but it has got certain drawbacks.

The green sand contains moisture. If this moisture is not controlled properly, it leads to defects and it contains clay. If this is clay is not controlled properly, it leads to defects. That is why we have developed dry sand molding in which during or before pouring of the molten metal, we dry the mould. Again there are two types of dry sand molding in which we just dry the surface of the cavity using gas torches or intra red rays. In the other case, we completely dry the mould by placing the mould in ovens for few hours, and in the flask less molding, we do not use any molding flasks. We have seen the chemical molding processes and in the shell molding, we use a resin that is phenol formaldehyde and fine silica sand.

We use the mixture of these two and we use a metallic pattern, and the metallic pattern is heated up and this mixture of the resin and its fine silica sand is placed over the hot pattern. A thin layer of this mixture melts and it forms a shell. That is how we make two shells and we clamp them, and a hollow cavity is created. Then, we pour the molten metal. This process offers us good surface finish and good dimensional tolerance, but this process is limited only for small castings. Of course, it has got certain advantage that the shells can be stored for long time. If we are going to get an order after six months, a big order now itself we can prepare the shells and keep them ready, so that when the order comes to us, immediately we can clamp the shells. And we can pour the molten metal and we can get the casting, but only small castings can be made and this resin is costly. Another process among the chemical sand molding processes is the sodium silicate molding. What is this sodium silicate molding process? Let us learn in detail about this.

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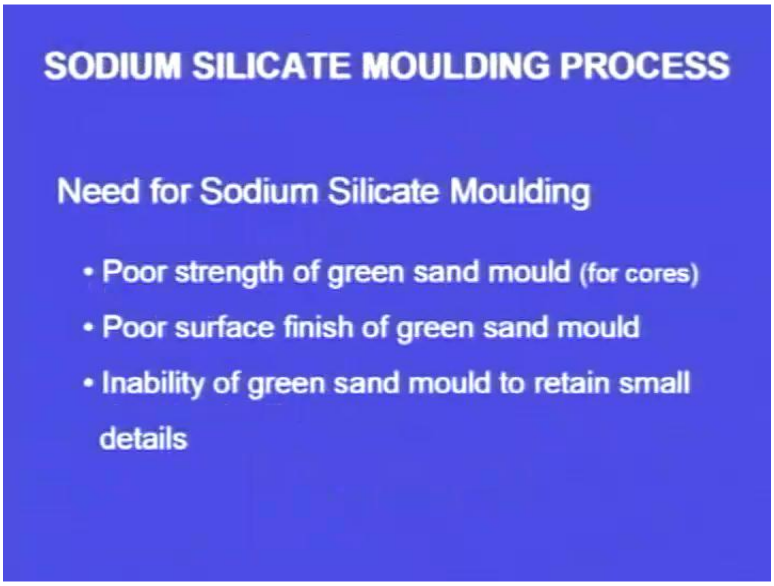

What is the need of the sodium silicate molding? In the conventional sand molding process, we face the problem especially when we make the core. We use the core. Whenever we want to make a casting with some hole or with some cavity, we make the core and we suspend the core and if the core is made up of the green sand, the core may break. So, this is one of the drawbacks of the green sand mould. Another drawback of the green sand is its poor surface finish. Green sand mould suffers from poor surface finish, and there is another important drawback of the green sand molding. If we want to cast a compound with small fins or with small details, the pattern also will be having small details; small fins and we mould the pattern in molding box. Then, we withdraw the pattern, the cavity where these small pins fins are located. That cavity will be damaged. We cannot cast these small fins successfully by using green sand molding. So, these are the important drawbacks of the green sand molding. It is that time we have to go for other alternative process that is the sodium silicate molding.

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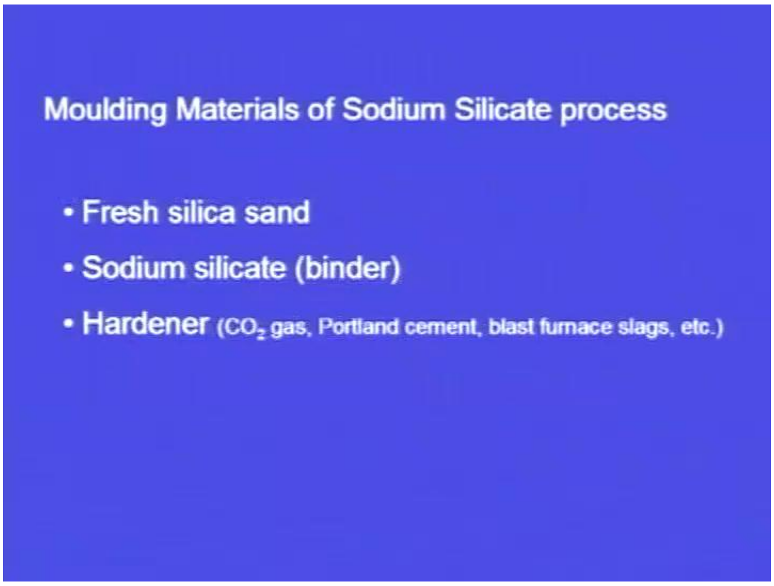

This sodium silicate molding, we can overcome the major drawbacks which we will be facing in the conventional green sand molding. What are the molding materials of the sodium silicate process? One is fresh silica sand, another one is sodium silicate. That is the binder and another one is the hardener. It may be carbon dioxide gas or Portland cement or blast furnace slag, etcetera.

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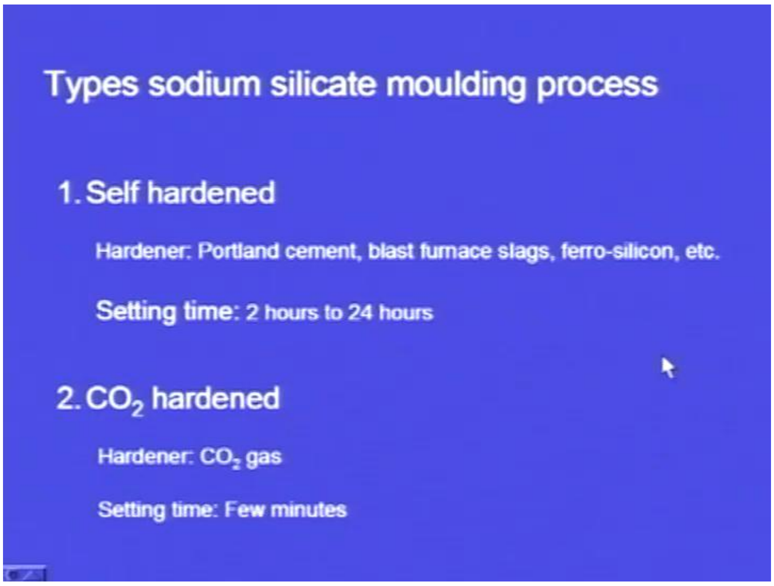

Let us see the types of sodium silicate molding process. There are two classifications. One is self-hardened sodium silicate molding process in which this molding sand is hardened by mixing up of Portland cement or blast furnace slag or the ferrosilicon etcetera, and the setting time will be from 2 hours and it takes even 24 hours, sometimes even more. This was developed long back, but later another process was developed that is the carbon dioxide hardened sodium silicate molding process in which we mix the binder, and for the hardening purpose, we pass the carbon dioxide gas. This carbon dioxide gas reacts with this sodium silicate and forms a strong gel, and this gel gives strength to the mould and the setting time is only few minutes. We have to pass the gas, carbon dioxide gas through the sand only for few seconds. Immediately it will be hardened. So, these are the two classifications of the sodium silicate molding process.

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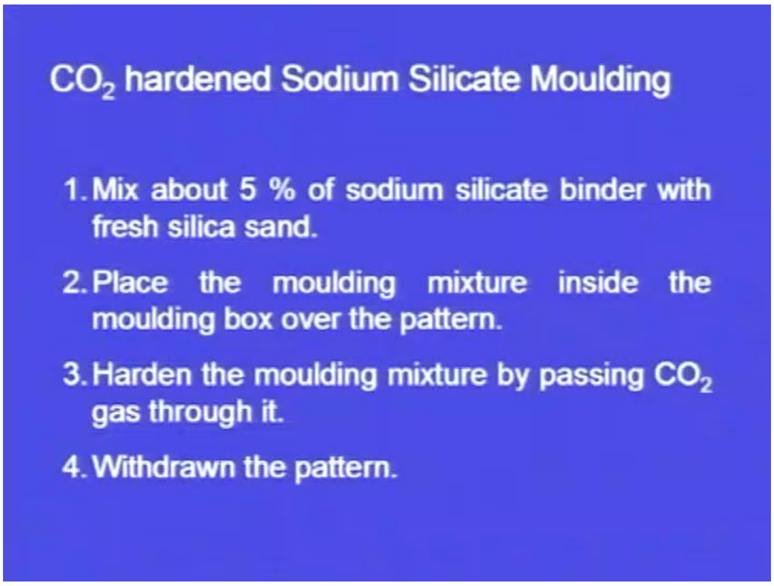

Next, let us see this carbon dioxide hardened is sodium silicate molding process in which we add 5 percent of the sodium silicate binder with the fresh silica sand, and this mixture of the fresh silica sand and sodium silicate binder will be placed over the pattern inside the molding box. After the compacting of this sand not tightly, not very tightly, we compact the sand. There we pass the carbon dioxide gas through the sand all over the surface. Then, the sand will be hardened and then, we have to withdraw the pattern.

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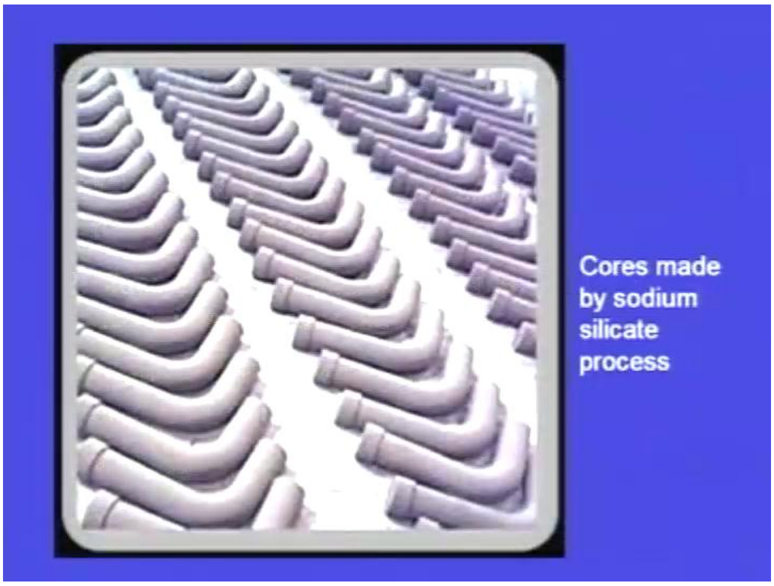

So, these are the cores made by sodium silicate process. So, we can see these are the cores, and these cores have got good surface finish. Not only that, the strength is good and the other process is the self-hardened sodium silicate molding process. So, in the self-hardened sodium silicate molding process, we add Portland cement or blast furnace slag to harden the sand. We also use ferrosilicon. So, we place this mixture over the pattern inside the molding box, and we have to leave it minimum for 2 hours. If we want additional strength, we have to leave it like the system for more than 24 hours and then, the sand will be hardened. So, that is the self-hardened sodium silicate molding process. Now, after we withdraw the pattern, the mould is ready for pouring.

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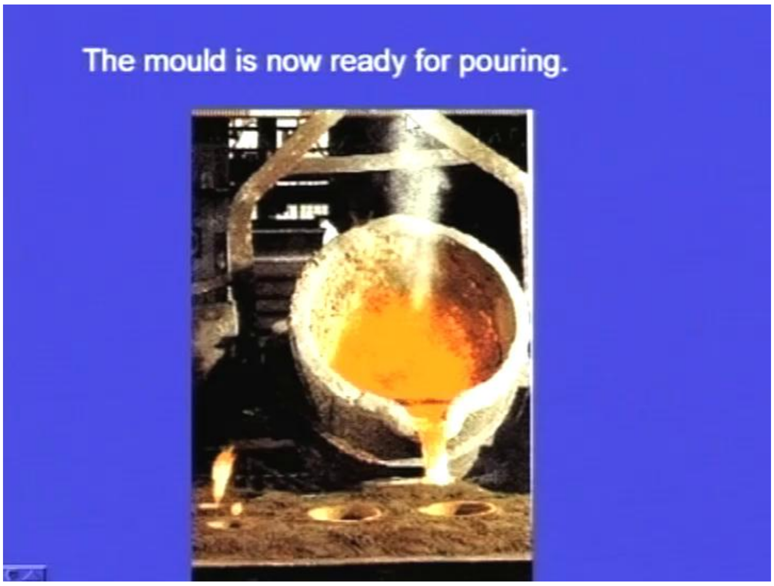

Most of the times using sodium silicate molding process, we make the cores.

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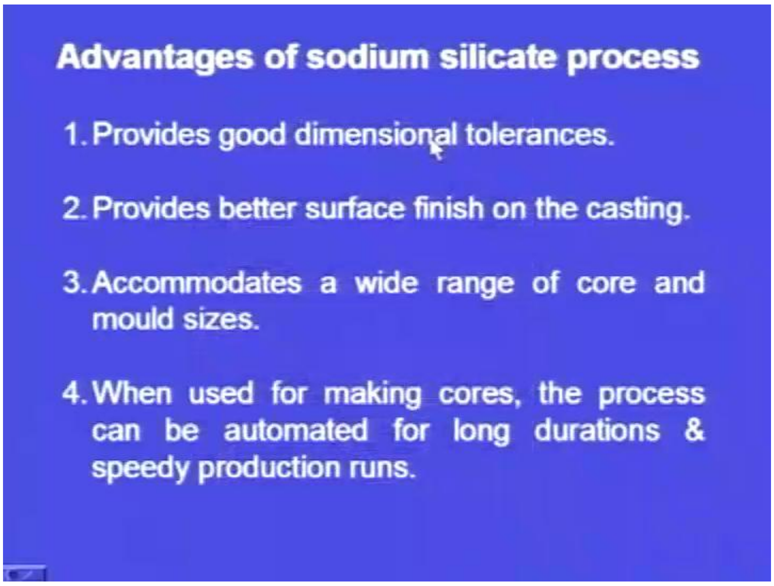

What are the advantages of sodium silicate process? It provides good dimensional tolerances. One of the drawbacks of the conventional sand molding process is we do not get dimensional tolerance. If we want a component of a particular size, we take a pattern little bigger than that taking certain allowances, and after we get the casting, the size of the casting will be bigger than the size which is required and then we have to machine it. We do not get good dimensional tolerances in the case of the green sand molding whereas, in the case of the sodium silicate molding, we get good dimensional tolerance.

Another advantage of the sodium silicate molding process is it provides better surface finish to the casting. Again, this is a good benefit in this process. In the conventional green sand molding process, the surface finish is not good because we have to machine it. We have to put more efforts, we have to use more labor, but if we make the mould using sodium silicate molding process, we get a better surface finish. This is another advantage and it accommodates a wide range of core and mould sizes. Different sizes of cores and moulds can be made.

Another advantage of this sodium silicate process is the cores can be made well in advance. If we make the cores by green sand, within few hours we have to use them. Otherwise, the moisture will be dried out and the core may be losing its strength and it will be breaking when we pour the molten metal whereas, a core which is made by sodium silicate molding process, it can be stored for several hours, even several days. So, if we are going to make so many castings, after 2 or 3 days itself, we can make the cores and they can be automated. If the industry is having automated system, the cores can be handled in an automated system. They can be stored well in advance and the production will be fast. We can use this for speedy productions, and though it has got certain advantages, this process has also got certain disadvantages.

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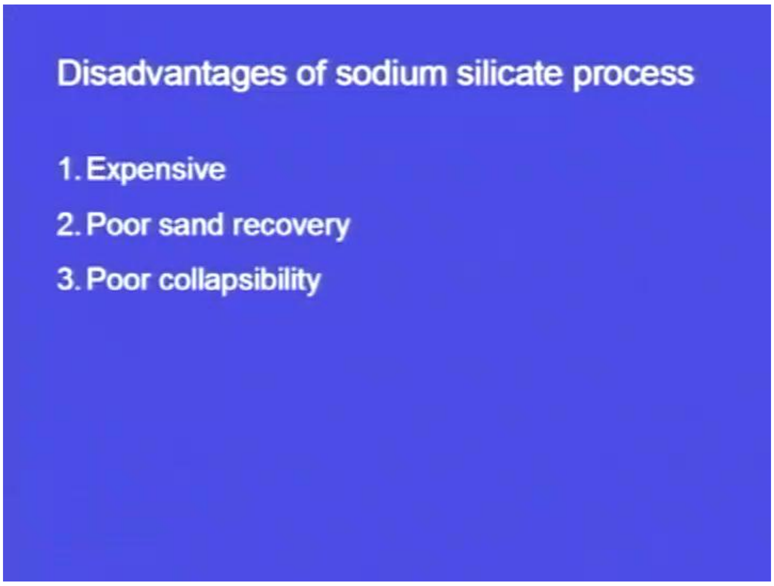

One is it is expensive. The sodium silicate is expensive and the sand every time we have to use fresh silica sand. In the case of green sand molding, after pouring the molten metal, after the molten metal is solidified, we break the sand and we take the casting outside. That sand again we can use to make another mould by adding moisture and by adding clay. That green sand can be used again and again with that can be recycled, but in the case of the sodium silicate molding process, it is difficult to use it again and again unless we use certain methods which are very costly. That is what I am telling that it has got poor sand recovery. In the case of green sand molding, it has got good sand recovery. Again we can recover the sand, and we can make another mould, but in the case of sodium silicate molding process, the sand recovery is poor.

Another disadvantage of the sodium silicate process is poor collapsibility. The advantage is it has got good hardness. That is also a problem. After the molten metal is solidified, after the casting is ready, we will be breaking the mould. It is that time the mould should be in a position to be broken up easily, but if we make a mould with sodium silicate molding, sometimes it becomes hard. If we pass the carbon dioxide for prolonged time, it becomes too hard and it becomes too difficult to break it. For that we have to put additional efforts which increase the cost of the production. So, this is the poor collapsibility of the sodium silicate process.

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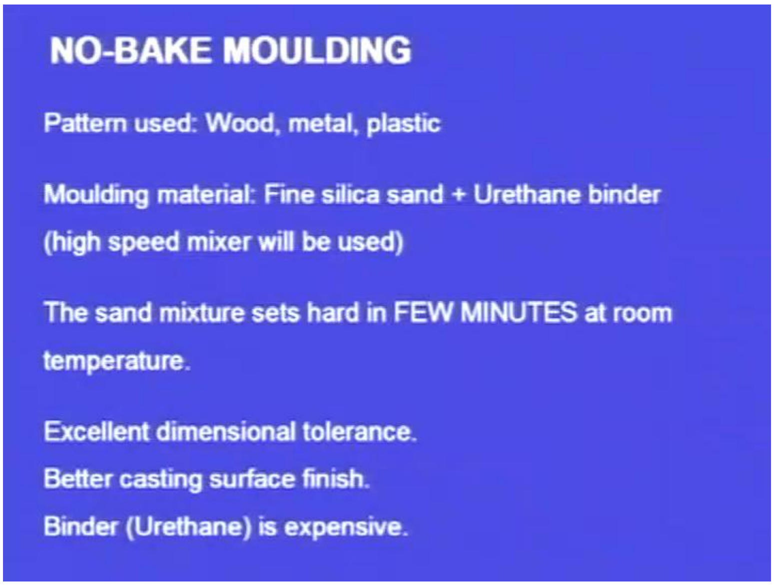

Next process is the no-bake molding. So, to overcome the problems of the green sand molding, people have developed the sodium silicate molding process. That is the self hardened and the carbon dioxide hardened. In the beginning, they have developed self-hardened sodium silicate molding process in which after preparing the molding sand, after preparing the sand which is mixed with sodium silicate, they used to store the sand in the molding box for several hours. To get additional strength, we used to do baking means they use to place the molding box in an oven for sometimes. Baking means we will put it in an oven. So, people were calling it as the baking molding system, but that was causing some problems. That was causing taking a lot of time. Later people developed carbon dioxide hardened sodium silicate molding process, but that was expensive.

Later people developed this no-bake molding in which we are not going to bake the mould. We are not going to place the mould in any oven. The pattern used is wood or metal or plastic. What is the molding material? Fine silica sand plus urethane binder. When we mix urethane binder with fine silica sand, it will be hardened within few minutes. So, we mix the urethane binder with fine silica sand, and we place the pattern inside the molding box and we place this silica sand and urethane binder mixture over the pattern. Within few minutes, it will be hardened at room temperature. We do not have to pass carbon dioxide; we do not have to bake it. Within few minutes, it will be hardened.

So, this is the advantage and the special feature of the no-bake molding system, and it offers excellent dimensional tolerance unlike the green sand molding, where there is no, the dimensional tolerance is poor, but in this system, the dimensional tolerance is very good and the surface finish is good, but the only limitation is the binder. This urethane is very expensive.

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We can see here this no-bake molding sand is prepared and because this urethane reacts with silica sand very quickly, within few minutes it will be hardened. So, the mould should be done quickly. Not that we can mix the sands for some time and we can leave it just like that for some time, because it will be hardened. So, once we prepare the sand, immediately we should prepare the mould.

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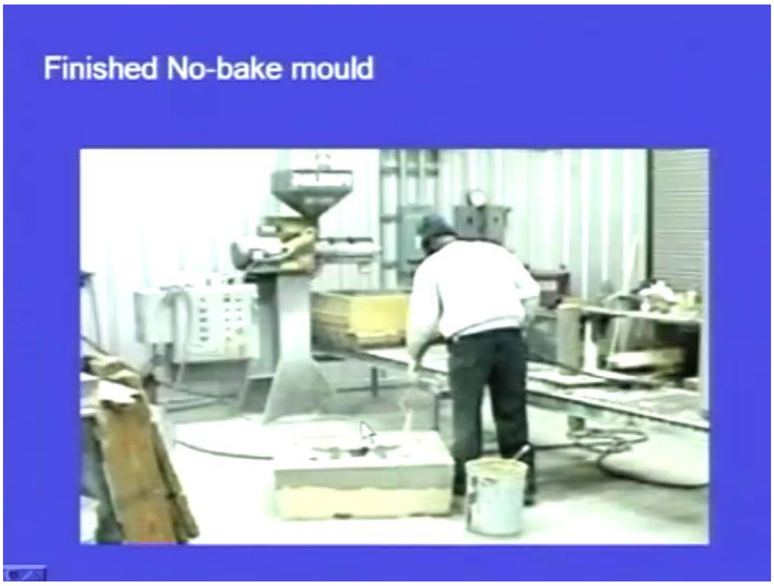

Here the mould is prepared and here, we can see the mould for even from its appearance, we can see it has got good surface finish and also, it offers good dimensional tolerances.

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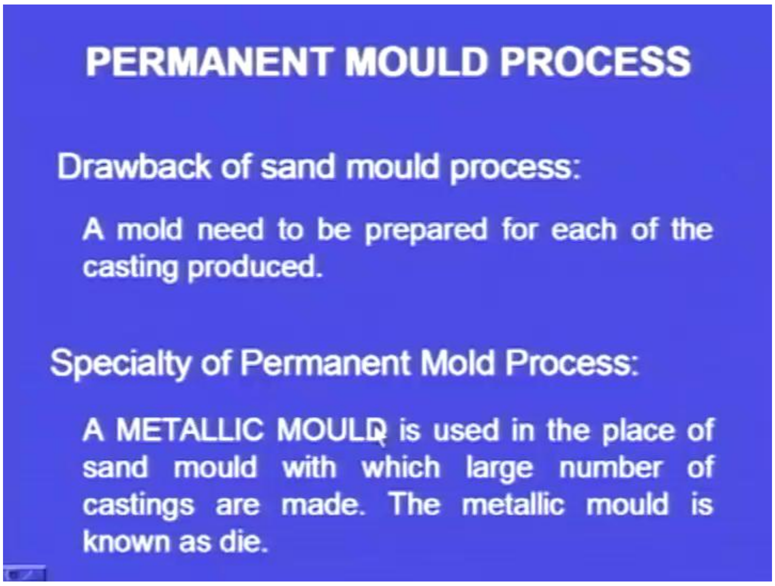

Next one is let us see, the permanent mould process. What is the drawback of the sand molding process? The major drawback of the sand molding process is we make the sand mould with the required cavity. Inside we pour the molten metal and after sometime, the molten metal will be solidified. After solidification is over, we break the sand and the casting is taken out. If we have making one more casting, we have to make another mould. The previous mould which we have prepared cannot be used for making another casting. In the green sand molding, the mould is not permanent. Every time we will be breaking it. So, making the mould that takes time aligning the boxes that takes time. So, we wanted to overcome this draw back. That is how this permanent mould process was developed.

So, in the permanent molding process, the molding material is made up of a metallic alloy. So, in the permanent molding process, a metallic mould is used in the place of the sand and this mould will be permanent. Unlike green sand molding, we are not going to break the mould after the solidification is over. After solidification is over, we will only withdraw the casting from the mould, and the same mould, same metallic mould we can use it for making another casting. After another casting is over, we can use the same mould for making another casting. Thus, we can make thousands of castings using a set of moulds, metallic moulds. So, this is the special feature of the permanent molding process and this permanent metallic mould is known as the die.

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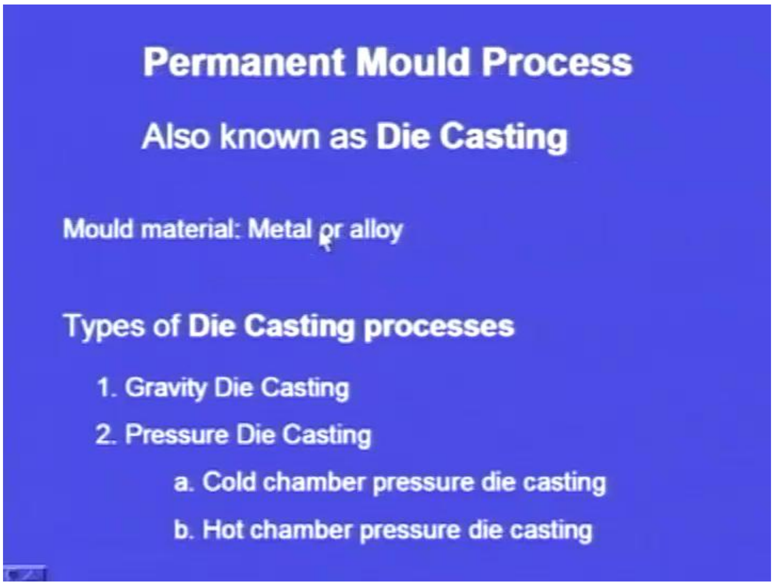

So, this permanent molding process is also known as die casting. Permanent molding process is also known as die casting and the mould material is metal or alloy. There are two types of die casting process. One is gravity die casting in which there will be a set of molding boxes, and we pour the molten metal and the molten metal is falling into the hollow cavity. Inside the molding boxes by gravity, we are not applying any external pressure. So, this is the gravity die casting, and the next type is pressure die casting in which there will be a set of molding boxes made up of metal or alloy, and the molten metal is injected by external pressure. So, this is the pressure die casting.

Again this pressure die casting is divided into two types. One is cold chamber pressure die casting, and the other is hot chamber pressure die casting. In the cold chamber pressure die casting, the melting furnace will be away from the system. The furnace will be away from there. We will be bringing the molten metal in a ladle and then, we will bring them, we will bring the molten metal to the cold chamber die casting machine and we pour the molten metal. In the case of hot chamber pressure die casting machine, in this system the furnace will be the integral part of the hot chamber die casting machine. We do not have to carry the molten metal from the furnace, which is far away from the die casting machine. So, this is the difference between the cold chamber die casting machine and hot chamber die casting machines.

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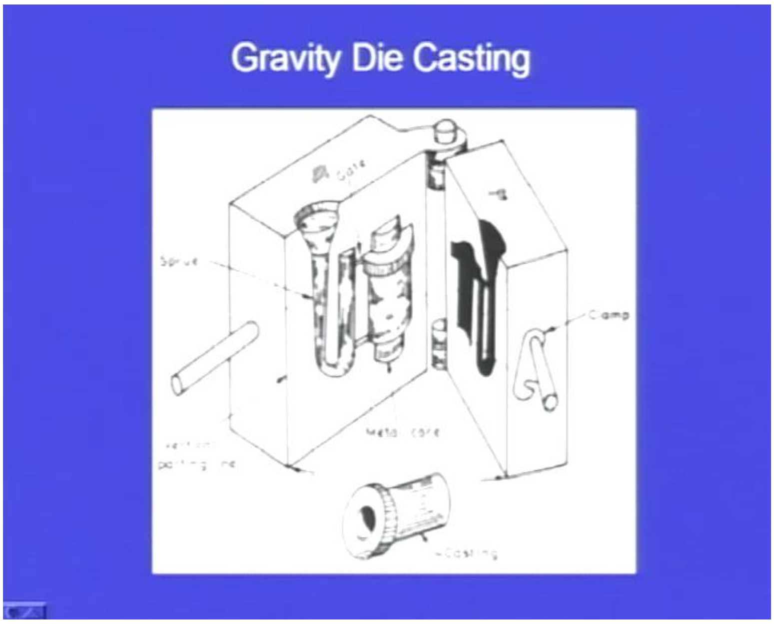

Let us see this gravity die casting. So, this is the component we want to make and these are the metallic moulds. We can see two metallic moulds, and the shape of the component which we want is engraved in the two molding boxes. Half of the gravity is engraved in this box, and half of the cavity is engraved in this box and there should be a provision to pour the molten metal which we call as sprue.

Sprue is the passage through which we pour the molten metal into the cavity. So, this is the sprue. Even the sprue is engraved. Half of the sprue passage is engraved in this box, in this one and half of the sprue is engraved in this and when we close this box, inside there is a cavity which is similar to the component which we want. Even the sprue and the pouring cup are there when we close the boxes and we pour the molten metal through the pouring cup, and the molten metal comes down and this is the gate. Through the gates, it will be passing into the cavity and after solidification, the boxes will be removed. They will be opened and the casting will be withdrawn.

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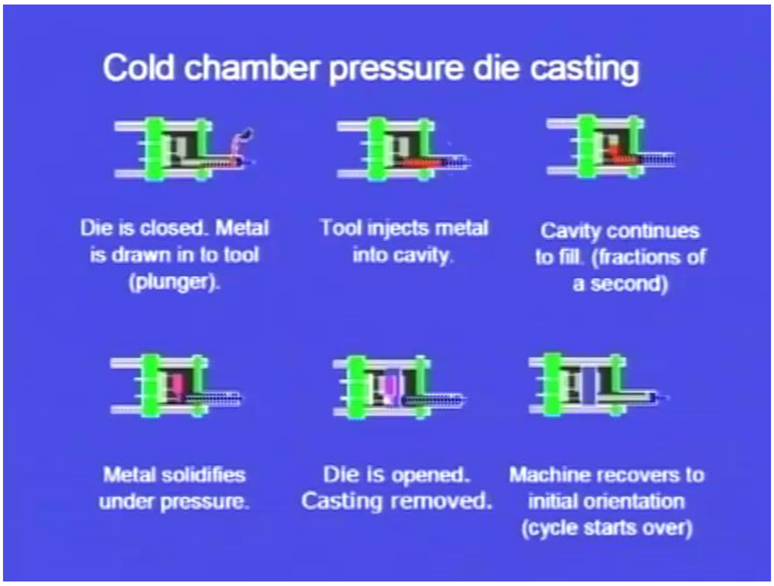

Next one among the pressure die casting machines I have already told there are two types. One is cold chamber pressure die casting machine and the other one is hot chamber die casting machine. Let us see this cold chamber pressure die casting machine. The feature, the important feature of the cold chamber pressure die casting machine is the furnace. Melting furnace will be far away from this die casting machine. So, we can see here this is the cold chamber pressure die casting machine and here, we can see these

black ones, these are the two dies and inside we can see the hollow cavity and the molten metal is brought from the furnace in a ladle, and it is poured here.
Of course, here the dies are closed. The two dies are closed. When we close the two dies, inside there will be a hollow cavity whose shape is similar to the component which we want and after the molten metal is poured here, here the molten metal is injected into the cavity and here, we can see the molten metal is entering into the cavity and this takes only fraction of seconds. After the molten metal completely enters into the cavity, here we can see it slowly undergoes solidification and after solidification is over, the die is opened and the casting is removed.

So, there will be some cooling system in which after the molten metal is injected into the cavity of the dies, the system will be cool and after the solidification is over, we withdraw the castings and this cycle will be repeated. Again the dies will be opened and the dies will be closed and again, we pour the molten metal, and we will inject it and it will be solidified and the solidified casting will be taken out.

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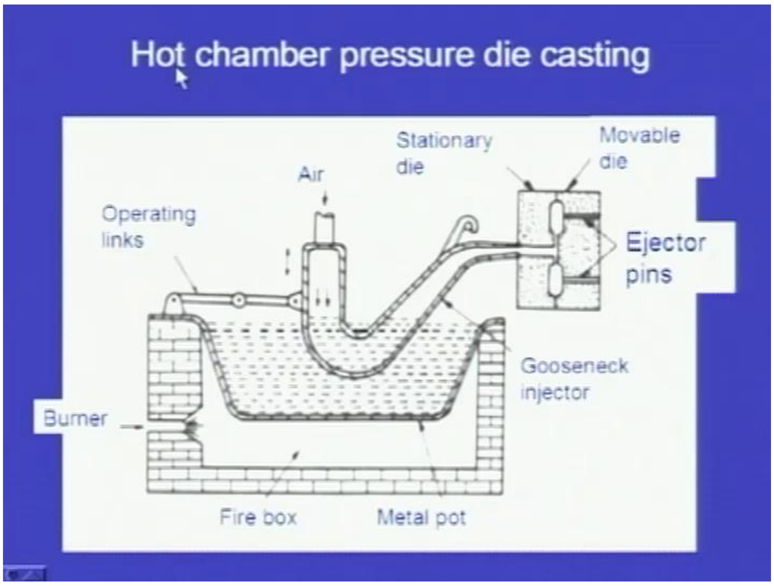

Here let us see the hot chamber pressure die casting machine. The important features of the hot chamber pressure die casting system is, here the furnace is the integral part of the system. The furnace would not be outside the system. So, here we can see this is the system, and these are the two dies and these two dies are closed inside. We can see

hollow cavity. This is shape which we want and here, there will be ejector pins. When we press this ejector pin, the casting will be coming over and here, we can see two dies.
One is stationary die and another one will be the movable die and this is the fire box. Here, we will be firing and here is the burner we will be firing, and this is the metal pot in which molten metal is prepared. The metal is melted, right and this molten metal is prepared here in this metal pot. After molten metal is ready, we pass pressurized air through this way. Because we are passing pressurized air, the molten metal will be injected into the dies. It will go and it will be occupying the hollow cavity. After solidification is over, we separate the dies and by using the ejector pins, the casting will be taken out.

So, this is the hot chamber pressure die casting system and here, one of the drawback is we are using pressurized air. This pressurized air is pushing the hot metal and it is injecting the hot metal into the die cavity, and the molten metal is at a higher temperature. If we are making an aluminum casting, the melting point of aluminum is 660 degree centigrade and we melt the aluminum about 750 degree centigrade. That is the pouring temperature. At that time when we are passing the air and there is every chance that the oxygen in the air reacts with the aluminum and it form oxides. So, this is one of the drawbacks of the system, where air is used to inject the molten metal into the cavity.

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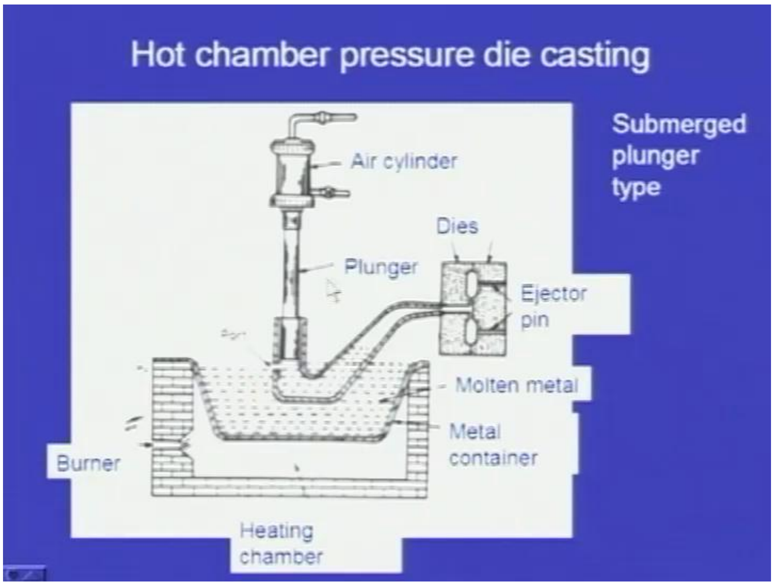

To overcome this drawback, another system has been developed and that is in which we do not use the pressurized air. So, this system is similar to the previous system. Here we can see a burner and here is the heating chamber, and this is the metal container and here, we are preparing the molten metal and these are the dies. Two dies are there. One is movable die, another one is the stationary die and these are the ejector pins, and here we are using a plunger. When this molten metal is ready, the molten metal will be going inside through this pore. Then, we press the plunger and the molten metal will be injected. After the molten metal occupies the cavity, after sometime it will be solidified. There will be cooling system. Because of the cooling system, the casting will be solidified at a faster rate.

After solidification is over, the dies will be separated and using the ejector pins, that casting will be withdrawn and here the previous problem is not encountering. In the previous case, the pressurized air is used and because the pressurized air is going inside the molten metal, it will be reacting with the molten metal. Here that problem is not arising. However, here we may face another problem. The plunger may be made up of different material and the metal may be of different material. When the plunger comes in contact with these molten metals, the material of the plunger, small traces of the plunger will be diffusing along with the molten metal. Sometimes the plunger is made up of hard materials like tungsten or molybdenum. Small traces of tungsten and molybdenum, they are defusing into the cavity. These small traces of tungsten and molybdenum, they make the casting very hard. It is difficult to machine the casting if the casting surface contains small traces of tungsten. So, this is another drawback, important drawback of this system.

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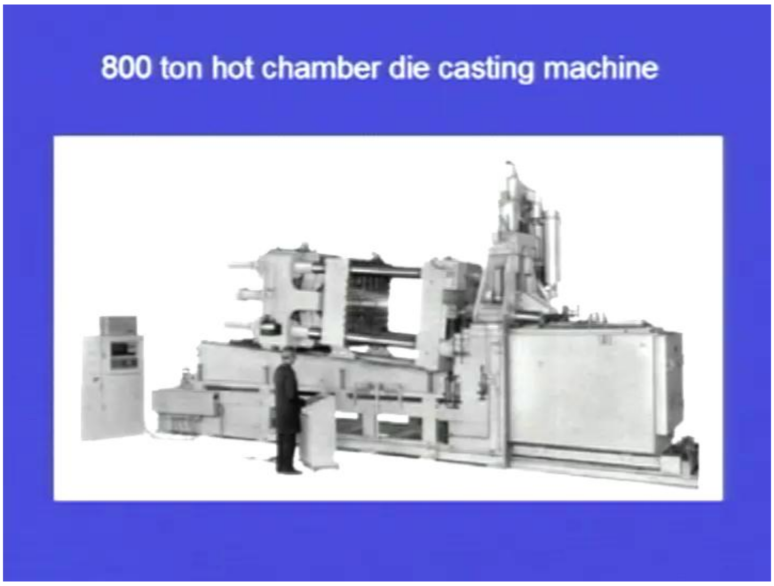

Here, we can see 8 ton capacity hot chamber die casting machine and here, we can see the dies, one die here, another die here and here, we can see the oven in which molten metal is prepared. So, its capacity is 800 tons. So, this machine has got automated controls. So, here we can see one operator is standing and he is controlling the different operations of this die casting machine. So, in this die casting machine, we have seen the classification.

The first classification is the gravity die casting system in which the molten metal close into the cavity because of the gravity. So, if that casting contains thin fins, molten metal may not flow into the thin fin cavities because the molten metal is flowing by virtue of gravity. So, we are using pressure die casting machines, we use cold chamber die casting machine and we use hot chamber die casting machine. In cold chamber die casting machine, the furnace is not integral part of the die casting machine. It will be outside. So, one worker has to carry the molten metal from the furnace in a ladle, and he has to pour it in the cold chamber die casting machine. By the time he carries the molten metal from the furnace to the machine, there will be a temperature drop and the same problem may arise which is arising in the case of the gravity die casting system. If the casting contains thin fins because there is a temperature drop, the molten metal may not occupy thin fins, the thin cavities.

That is why we have to go for hot chamber die casting system in which the furnace is integral part of the machine. Here itself we can see the machine furnace. The molten metal is heated up to the required temperature. When it is heated up to the required temperature, it will be injected into the dies. There is no temperature drop. So, if the casting contains thin fins, it can be successfully cast using hot chamber die casting machine. What are the advantages of these die casting systems?

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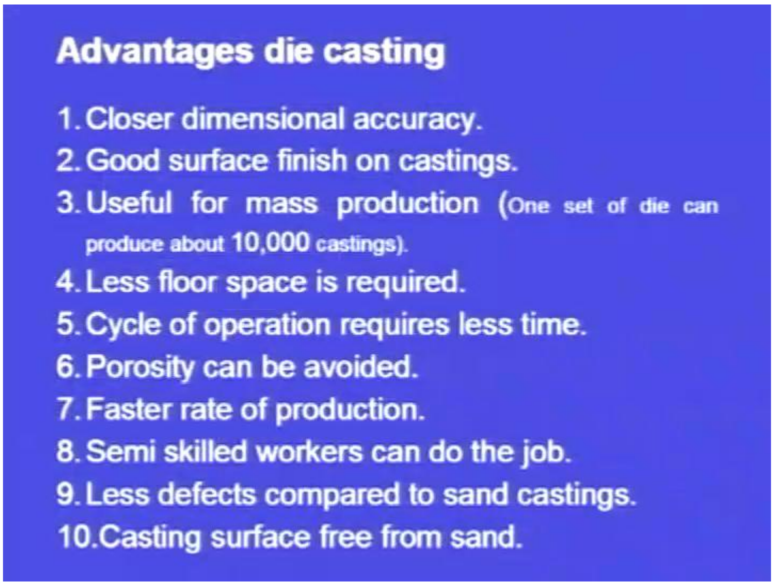

One is closer dimensional accuracy. Unlike the castings obtained in the green sand molding, here the castings have got closer dimensional accuracy. Another one is we get good surface finish on the castings. This is another advantage over the conventional sand castings. In the conventional sand castings, we get poor surface finish, but here we are getting good surface finish. Another advantage is we can use these machines for mass production. If we make one set of dies, about 10000 castings can be made. If we have to make 10000 of castings by conventional sand molding, 10000 moulds we have to make. That molding take time will be much more, but here there is no molding. Only one set of molding boxes we are using for 100 and 1000 of castings.

So, the production time will be very fast. The production will be very fast. Another advantage is less floor area is required. In the case of conventional sand casting, the floor area required will be more. There will be a shop for pattern making, there will be a shop for sand testing, there will be a shop for sand preparation, there will be a shop for molding, there will be a shop for melting, there will be a shop for pouring, there will be a shop for fettling. Fettling means the molten metal will be solidified in this sprue passage, and in the razor and in the gating system. These are the extra projections. These have to be cutout. So, in the fettling shop we cutout the extra portions and extra projections. So, for fettling there will be one more shop, for cleaning there will be one more shop, for inspection there will be one more shop.

So, the total floor area required in the case of the conventional sand casting system is very large, but here in the case of the die casting, what is the floor area required. There is no molding shop because we are not making mould every time. We are using a permanent mould unless we use cold chamber die casting machine and gravity die casting, there is no need for melting shop. Melting is done within the machine and that is how the floor area required is very less.

Another advantage is cycle of operation requires less time. This is another advantage over the conventional sand casting process. In the conventional sand casting process, what is the cycle required? We prepare the sand and we prepare the mould. We melt the metal, we pour the molten metal and then, we break the mould. We take the casting outside and then, we carryout fettling and then, we clean the casting. So, these are all the operations involved in the cycle of the green sand molding, and the time required for this cycle is very high, but here in the case of the die casting, the cycle of operation requires less time.

So, this is another advantage. Because of this the rate of production will be very high and in the case of green sand molding, the green sand means the presence of the moisture. Because of the presence of the moisture, there will be some defects. When we pour the molten metal, when the moisture in the molding sand comes in contact with the molten metal, it turns into vapor and this vapor has to escape out of the mould. If it does not escape, if it stays inside, the mould cavity leads to defects like blow holes and pin porosity. So, in the case of die casting, there is no question of moisture. In the mould we are using metallic moulds. So, the question of porosity or blow holes does not arise and the rate of production is very high.

Another advantage is even semi-skilled workers can do the job. In the case of sand molding, especially for making the mould and for preparing the green sand, it requires high skill. If the moisture is more, that results in problem. If the clay is not controlled properly, then that creates problem. The pattern after molding, it should be withdrawn carefully otherwise the mould cavity will be damaged. So, at every stage, skilled workers are required, but here that much skilled workers are not required to operate this machine. Overall less defects will be encountered in the die casting compared to conventional sand casting.

Another drawback of the green sand castings is after solidification is over, the sand casting surface will be having sand adhere to it because we have casted inside a sand mould. For that we have to clean it, but in the case of the die casting, the question of sand sticking to the casting does not arise. There is no sand mould. We are using a metallic mould. This is another advantage. So, it has got several advantages over the conventional sand casting process, yet it has got some limitations. Let us see the limitations.

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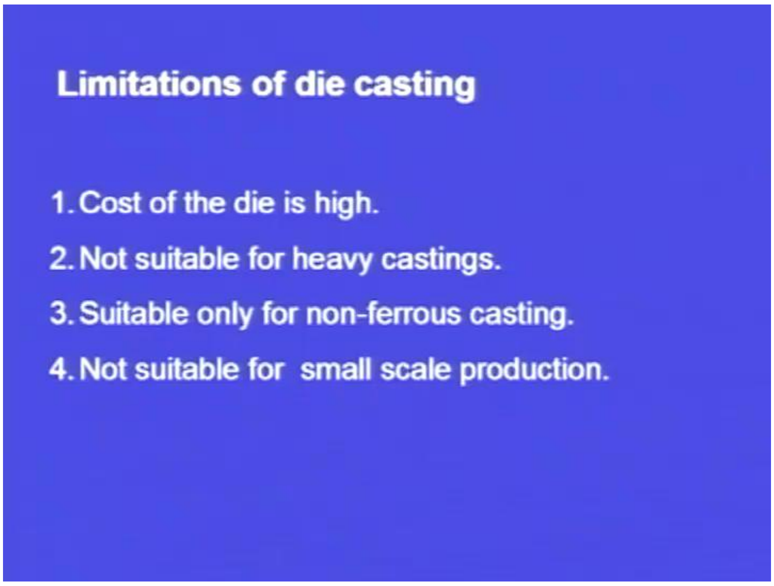

The cost of the die is very high because the die material will be some special alloy. We will be seeing the material of the die. So, the die material is very costly. In the case of the conventional sand casting process, the molding material is not costly. We are using silica sand clay and moisture. These are not costly, but here we are using some special steels which are very costly and even to make this die, we have to put lot of efforts. To machine the die, it is very difficult to make the die. It is very difficult. We have to put lots and lots of efforts, and it is not suitable for heavy castings. Big castings cannot be made by this die casting. In the case of conventional sand castings, size is the flexibility. We can make small castings, we can make medium size castings, and we can make very big castings. That is the big advantage of the conventional sand casting process, but here we can make only small castings and medium size castings, and this process is suitable only for non-ferrous castings like making aluminum castings.

We can use this process and this is not suitable for small scale production. If we have to make a casting say the numbers of pieces required are some 10 or 20, this process cannot be used because first we have to make the metallic mould. This metallic mould is made up of a special steel, and we have to engrave the required cavity in the metallic mould with much efforts, much difficulty, we have to create the cavity. After that if it has to be used only for 10 castings or 20 castings, it is not economical. These can be used only for large scale production and not for small scale production. What are the applications of the die casting?

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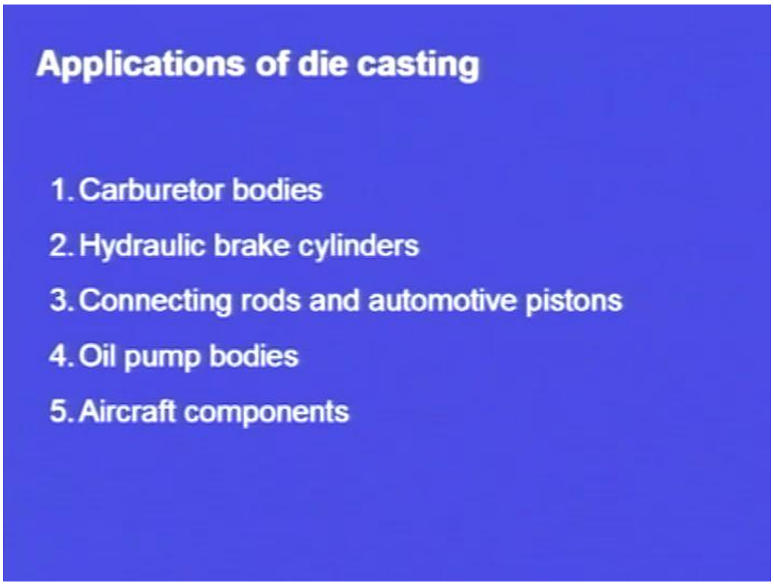

Carburetor bodies of the automobiles, they are made up of die casting. Hydraulic brake cylinders of the automotives are manufactured by die castings. Connecting rods and automotive pistons, they are manufactured by die casting. Oil pump bodies, they are manufactured by die casting. Aircraft components are manufactured by die casting. These are only few cases I have explained. In fact, there are many more applications of the die castings. There are many more domestic and industrial applications of die casting. Now, let us see the die materials.

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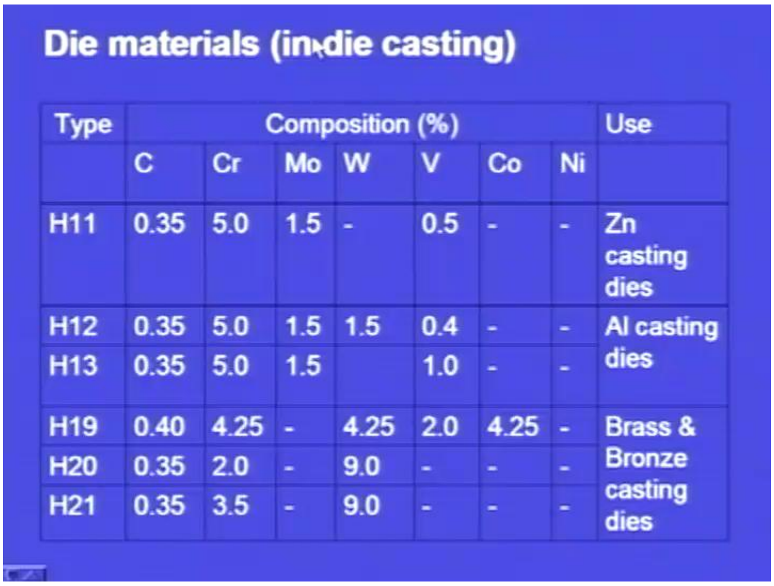

Die materials (in die casting)

Type	Composition (%)							Use
	C	Cr	Mo	W	V	Co	Ni	
H11	0.35	5.0	1.5	-	0.5	-	-	Zn casting dies
H12	0.35	5.0	1.5	1.5	0.4	-	-	Al casting dies
H13	0.35	5.0	1.5		1.0	-	-	
H19	0.40	4.25	-	4.25	2.0	4.25	-	Brass & Bronze casting dies
H20	0.35	2.0	-	9.0	-	-	-	
H21	0.35	3.5	-	9.0	-	-	-	

What is this die made up of? What is the material of the die used in the die casting? There are totally six types of materials are used. They are known as H11 steel, H12 steel, H13 steel, H19 steel, H20 steel, H21 steel. The composition of the H11 steel is carbon 0.35 percent, chromium 5 percent, molybdenum 1.5 percent, vanadium 0.5 percent. This die material used to make zinc castings. For making zinc castings, we use this die material and there is another steel. Of course, the balance material will be iron.

Here H12 steel and the carbon is 0.35, chromium 0.5, molybdenum 1.5, tungsten 1.5, vanadium 0.4 and the rest is iron. This H12 material is used for making the dies for aluminum castings. There is another steel known as H13 steel and its composition is carbon 0.35, chromium 5 percent, molybdenum 1.5 percent, vanadium 1 percent and the rest is iron. These die material is used when we have to make aluminum castings.

There is another steel called H19 steel and its composition is carbon 0.4 percent, chromium 4.25 percent, tungsten 4.25 percent, vanadium 2 percent and cobalt 4.25 percent. This die material is used for brass and bronze castings. Another one is H20 steel. The carbon percent is 0.35 percent, chromium 2 percent, tungsten 9 percent and the rest is iron. This die material is used for making brass and bronze castings, and there is another die material known as H21 steel. The composition is carbon 0.35 percent, chromium 3.5 percent, tungsten 9 percent. This die material is used to make brass and bronze castings.

So, these are the important die materials and these die materials are very costly. So, in this lecture, we have learnt about the sodium silicate molding process, and it is mainly classified into self-hardened and sodium hardened. In the self-hardened, we use Portland cement or blast furnace slags to harden the sand whereas, in the case of the CO2 hardened process, we pass the carbon dioxide gas through the sand which contains sodium silicate. We have also seen no-bake molding in which we mix urethane binder with the fine silica sand, and the sand sets in a very short time within few minutes. That is the advantage.

We have learnt about the permanent molding, which is also known as die casting. This die casting is broadly divided into gravity die casting and pressure die casting. Again we have seen this pressure die casting is classified as cold chamber pressure die casting and hot chamber pressure die casting. We have seen the advantages and limitations, and applications of these processes. In the next episode, we will be learning about the centrifugal casting.

Thank you.