Manufacturing Processes - I
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Module - 2
Lecture - 1
Metal Casting

Metal casting, metal casting is the oldest manufacturing technique. There are other manufacturing techniques, like machining, welding, forming and so on, but metal casting is the oldest manufacturing technique. This process was in practice even thousands of years before Christ. People who lived during the Stone Age, they were using this technique. They used this technique to manufacture arrows and weapons. People who lived during ancient Mesopotamia, they used this technique. They used this technique to make jewelry items. People who lived during ancient Egypt and ancient China, they used this technique. They used this process to manufacture art items, like jewelry items, statues, and so on.

Today, its applications include most scientific devices, like automotive components, aerospace components and many machine components and industrial components and its principle is very simple, yet it can produce very complex components. I will explain you the principle.

Whenever we want to prepare a component, a similar cavity we will create in a sand mould. Inside a sand mould, there will be cavity whose shape is similar to the component, which we want. Then, we will melt the required metal just above the melting temperature and then we will pour the molten metal into the cavity. After sometime the molten metal will be solidified, then we will break the sand, the solidified component will be taken out. So, these are the steps involved in metal casting.

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First, we have to make the mould with the required cavity we have to create. Then, we will heat the metal just above the melting point. Next, the liquid metal is poured into the mould and after sometime the liquid metal will be solidified. After it is solidified, we will break the sand and we will take the solidified casting outside. So, this is the simple principle involved in making a casting. And what are the mould materials? Means, as I already told, first step is we have to create a hollow cavity whose shape is similar to that of the component, which we want and what is the material of the that mould? One is sand. We can use sand to create that hollow cavity. We can use metal, we can use wax and so on.

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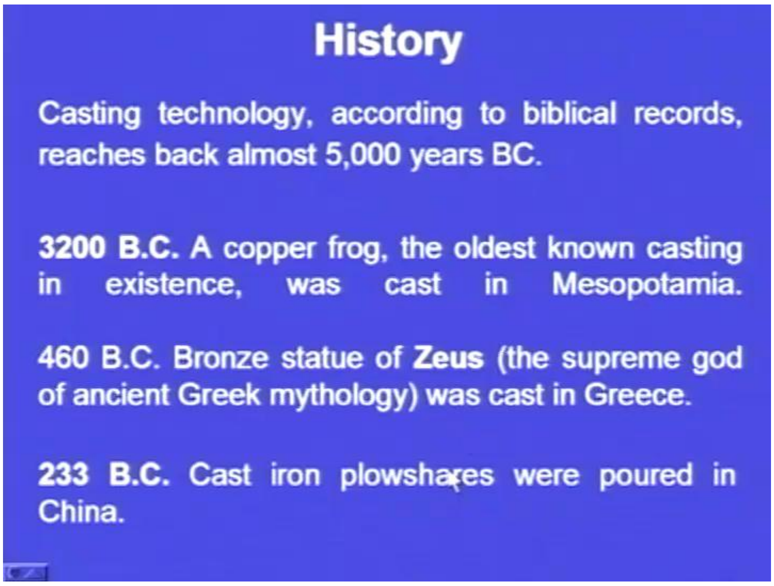

And before we proceed further, we, it is necessary to know the history of this process. And as per the bible records this was in practice 5000 years before Christ. As I already told, people who lived during the Stone Age, they used this process to manufacture the arrow heads and the weapons. And during 3200 BC, a copper frog was manufactured in ancient Mesopotamia. During 460 BC a bronze statue of Zeus, the supreme god of ancient Greek mythology, was cast in Greece.

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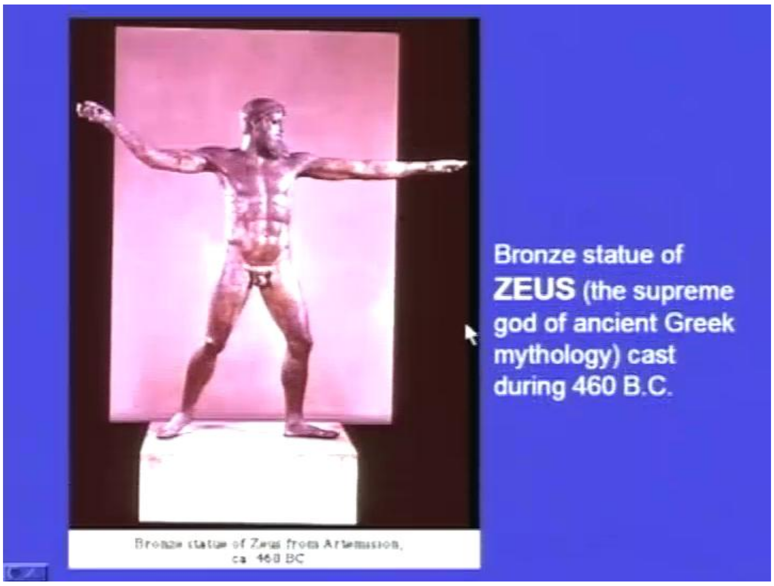

This is the bronze statue of Zeus who was considered as the supreme god of ancient Greek mythology. This bronze statue was cast during 460 and this was cast by metal casting. ((Refer Time: 04:06)) And during 233 BC, cast iron plowshares were poured in China.

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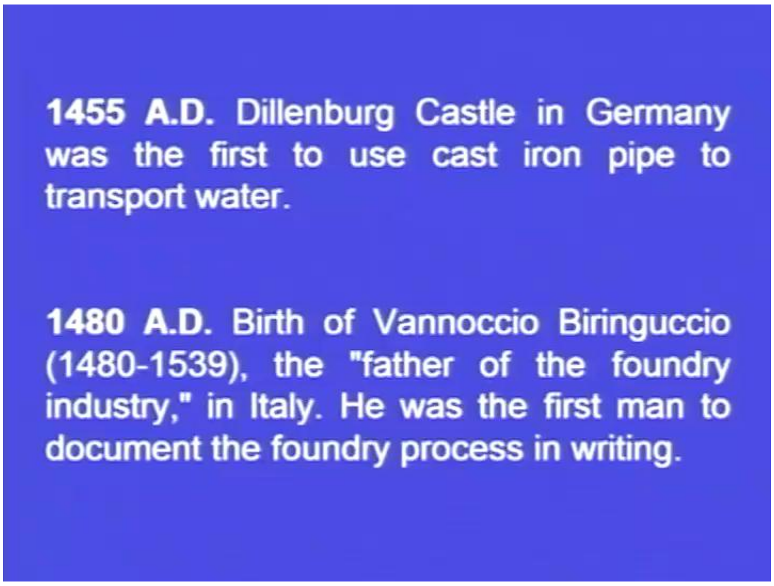

In 1455 AD, Dillenburg Castle in Germany was the first person to manufacture cast iron pipes using metal casting and these cast iron pipes were used to transport water.

During 1480 AD, the birth of Vannoccio took place. He was considered as the father of the foundry industry. He was born in Italy and he was the first person to document the foundry process in writing.

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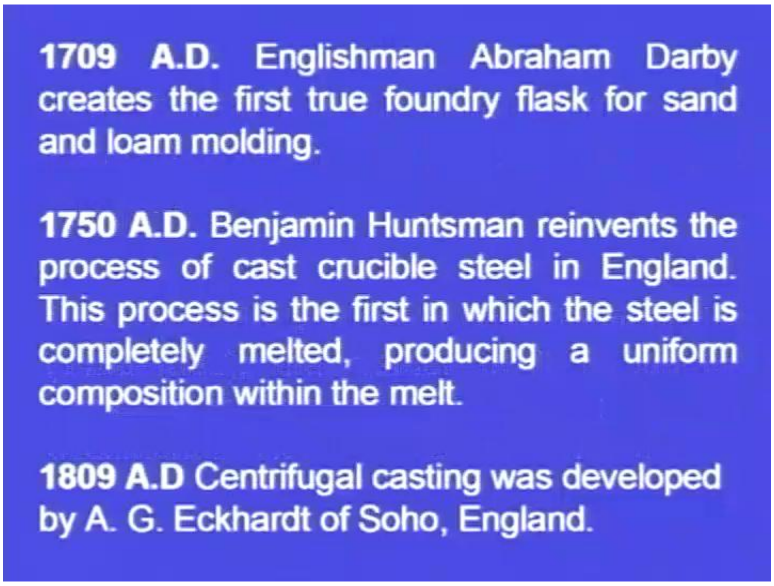

And in 1709 AD, Englishman Abraham Darby created the first foundry flask for loam moulding. In, in 1750 AD, Benjamin Huntsman reinvented the process of cast crucible steel in England. This process was the first in which steel was completely melted producing a uniform composition within the melt. In 1809 AD, centrifugal casting was developed by A.G. Eckhardt of Soho, England.

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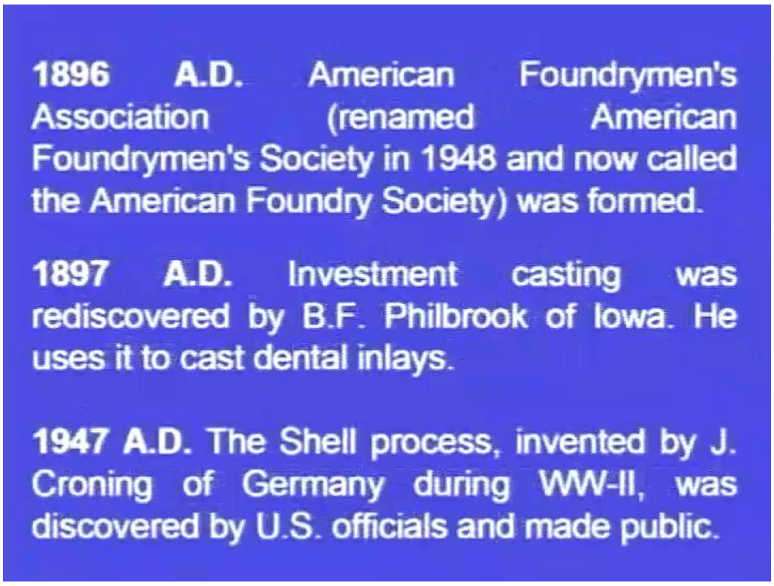

In 1896 AD, American foundry men’s association was formed. Later, it was renamed as American foundry men’s society in 1948. Today, it is called as American foundry society. In 1897 AD, investment casting was discovered by B.F. Philbrook of Iowa. He used this technique to cast dental inlays. In 1947, Croning of Germany discovered shell moulding process during world war-2. Later, this was made public by US officials.

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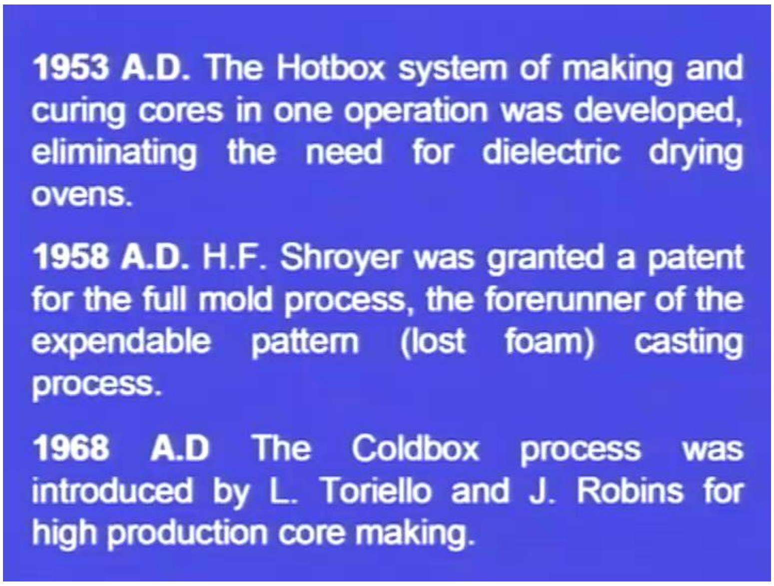

In 1953 AD, the Hotbox system of making and curing cores in one operation was developed, eliminating the need for dielectric drying ovens. In 1950 AD, H.F. Shroyer was granted a patent for the full mould process, the forerunner of the expendable pattern casting process. In 1968 AD, the Coldbox process was introduced by L. Toriello and Robins for high production core making.

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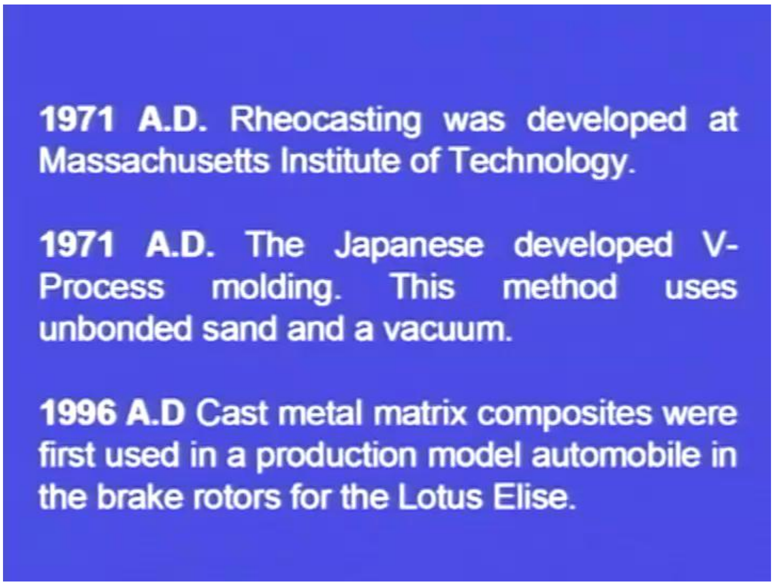

In 1971 AD, Rheocasting was developed at MIT. In 1971 AD, Japanese developed V-Process moulding. This method used unbonded sand and a vacuum. In 1996 AD, cast metal matrix composites were first used in a production model automobile in the brake rotors for the Lotus Elise.

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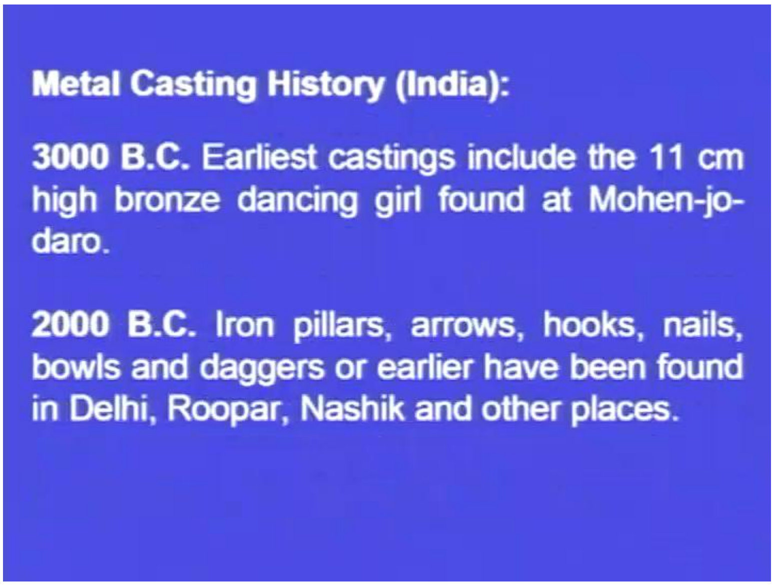

Metal casting history in India. Metal casting was in practice even in India thousands of years before Christ. If we consider during 3000 BC, earliest castings were found, like people found bronze casting of the shape of a dancing girl at Mohen-jo-daro. This was found during 3000 BC. And during 2000 BC, iron pillars, arrows, hooks, nails and many other items were found at Delhi, Roopar, Nashik and other places.

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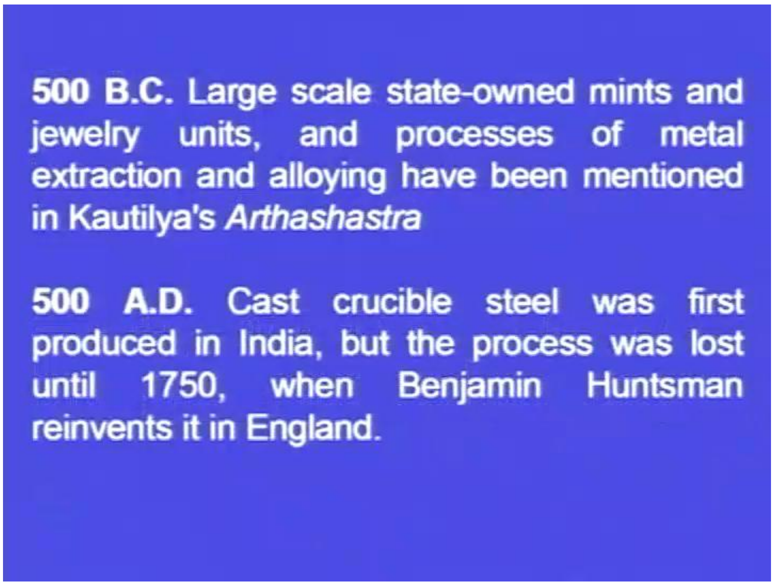

In 500 BC, large scale state-owned mints and jewelry units and process of metal extraction and alloying have been mentioned in Kautilya's Arthashastra. In 500 AD, cast crucible steel was first produced in India. But the process was lost until 1750 AD, when Benjamin Huntsman reinvents it in England. So far, we have briefed the history of casting process.

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So, we can conclude, that ancient people used this technique to use their weapons who lived during the time of Stone Age. And people, who lived during the times of ancient Mesopotamia, ancient Egypt and ancient China, they used this technique to manufacture jewelry items and art items.

But today, it is a technology. It has emerged as a technology where we manufacture complex shapes by metal casting. Automotive components, we are manufacturing by metal casting; space components, we are manufacturing by metal casting; many industrial components and domestic components, we are manufacturing by metal casting. There are innumerous number of components, which are cast by metal casting and which cannot be replaced by any other process. I would like to show you few examples of metal casting.

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One is machine tool structures. Here, we can see a machine and outside we can see a machine structure. This white color one is the machine structure. Inside, all the machine components will be there; outside, this hard casing, thick casing is the structure. This structure is made by casting.

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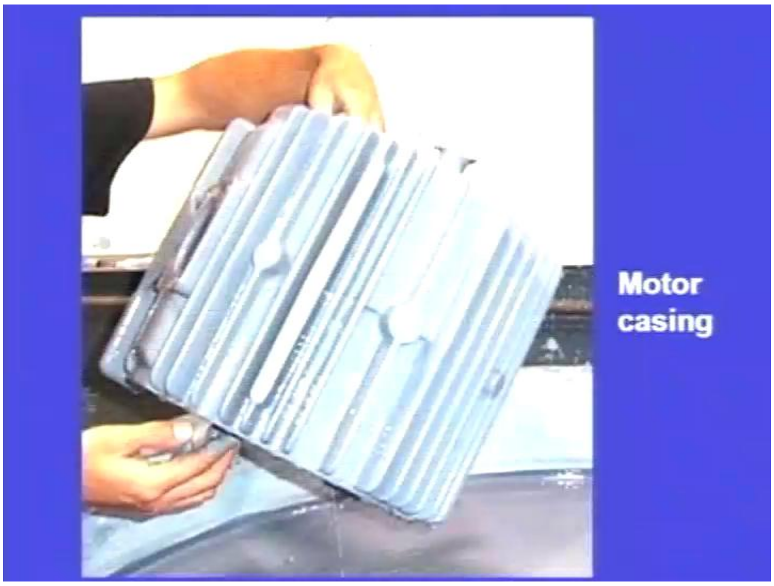

This is a motor casing. This is manufactured by metal casing.

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This is an engine block, V6 engine block. Here, you can see, three cylinder this side, three cylinders this side and this whole thing comprises an engine block. This is manufactured by metal casting.

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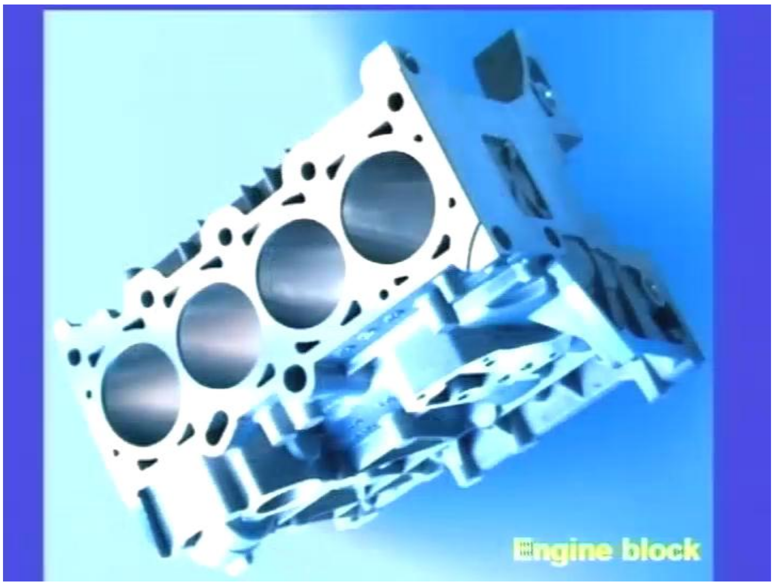

This is another engine block where we can see four cylinders. This complex shape is manufactured by metal casting.

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This is a crank shaft and it is manufactured by metal casting.

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And metal casting technique is used in railway components. And here, we can see, this is a goods wagon and here we can see one important component, that is, the side frame, which is lying about two axles, railway axles, and this is the side frame. This side frame is manufactured by metal casting. I will show you this side frame in a magnified view.

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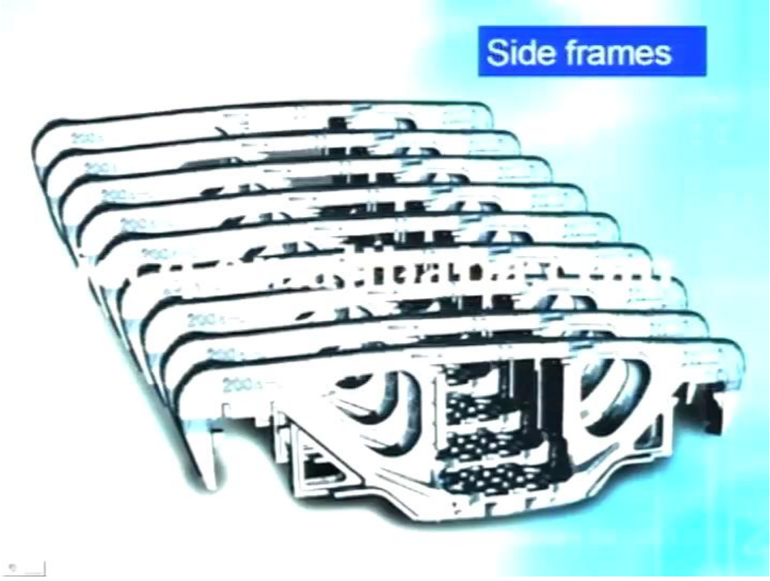

Yes, this is the side frame I am showing. So, many side frames are placed together. This side frame is manufactured by metal casting.

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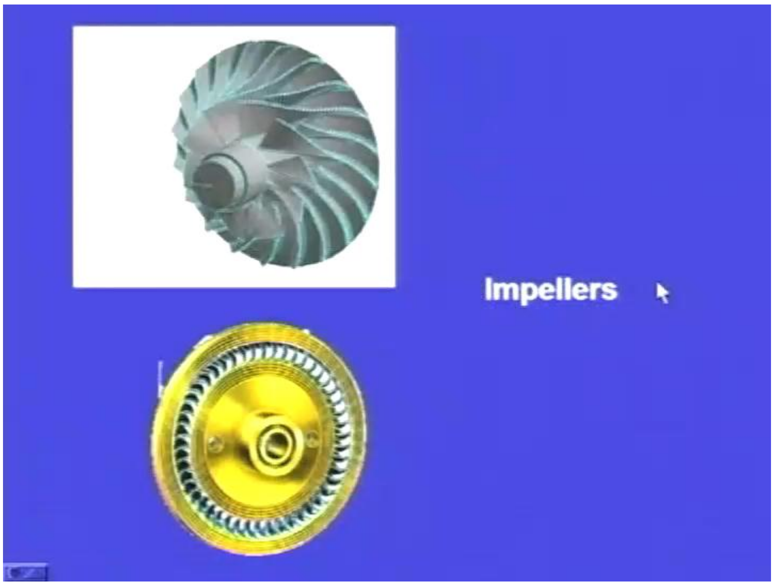

These are the impellers. These are manufactured by metal casting.

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These are the nozzles. These nozzles are manufactured by metal casting.

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Dumbbell, which is used to do exercise. These dumbbell is manufactured by metal casting.

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And we can see so many components, small components, tiny components, complex components, all these components are manufactured by metal casting. And these are, whatever I have taught is only few examples, there are many more examples where there are many components, which can be manufactured by metal casting.

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Now, let us see the advantages of castings. One is, intricate shapes can be made. Means, the most complex shapes, which cannot be manufactured by any other manufacturing process, can be manufactured by metal casting. Any complex shapes can be manufactured. Second advantage is flexibility of size and weight. Any big shape can be manufactured. Similarly, any small shapes can be manufactured. That is the flexibility in this process. If we see the other manufacturing process, this flexibility may not be found. When we have, when we are about to manufacture certain items using other manufacturing process, the size matters. If the job is too big, it is not possible; if the job is too small, it may be difficult. But in metal casting process, we can manufacture any big component and any small component. And final, third one, simple and inexpensive. The process does not require costly equipments. The process is simple and the cost involved in making a casting is not so high

Next advantage, any material can be cast, whether it is iron component or aluminum component or bronze component or gold component or silver component, any component can be cast and wastage of raw material is less. In other manufacturing process, the wastage of raw material will be more, but in the case of the metal casting, the wastage of raw material is less. And this is, this is the only alternative for certain materials. There are certain materials, which cannot be machined, but that can be successfully cast. There are materials, it is very difficult to manufacture by other processes, but using metal casting, they can be manufactured easily.

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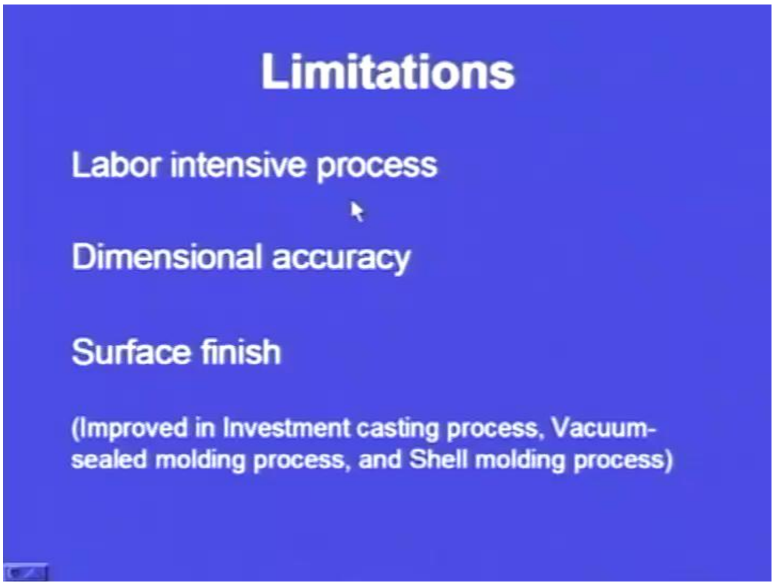

Yet, though this process is simple, though this process is inexpensive, it has got some limitations and it requires lot of labor. This is a labor intensive process.

Secondly, dimensional accuracy. Most of the times components manufactured by metal casting, they suffer from poor dimensional accuracy. For that we have to carry out finishing operations and machining operations. Again, the surface finish is another problem. Most of the casting process, they suffer from surface finish. Surface finish is not so high in certain casting process. Again, we have to put certain efforts to obtain surface finish.

Of course, this surface finish was a problem in the olden days, but later we have developed new process, like investment casting process. In investment casting process the surface finish is excellent. And in vacuum sealed moulding process and in shell moulding process we overcome this problem of poor surface finish.

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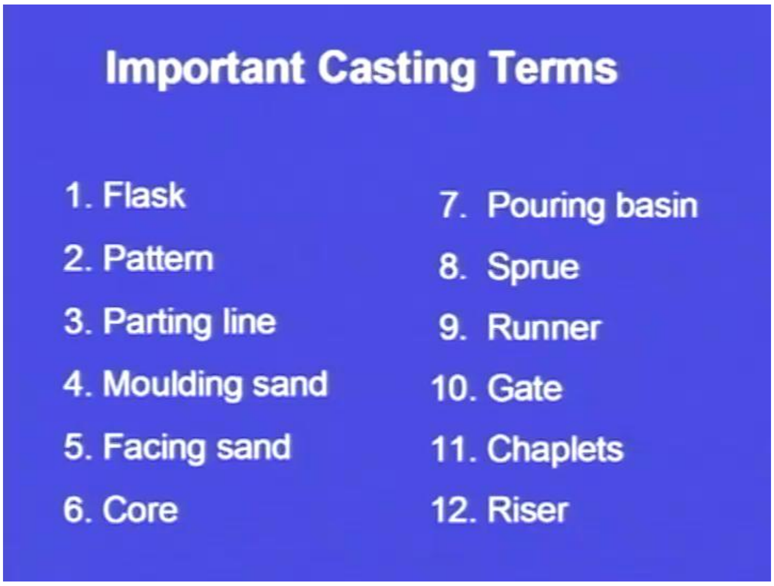

Let us see the important casting terms. One is flask; second one, pattern; third one, parting line; fourth one, moulding sand; fifth one, facing sand; sixth one, core; seventh, pouring basin; eighth, sprue; nine, runner; ten, gate; eleven, chaplets; twelfth, riser.

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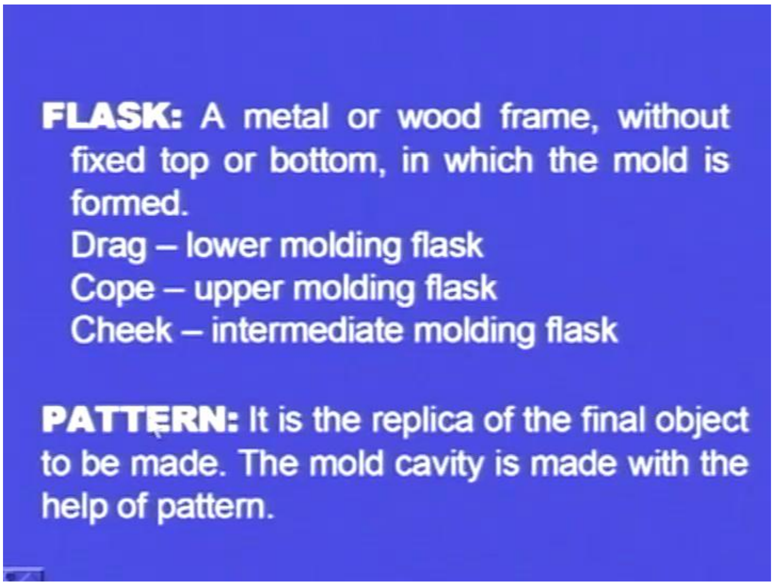

And the first one is the flask. It is a box made up of metal or wood. As I already told in the beginning, the principle of metal casting is, we will create a cavity in a compacted sand medium or any moulding medium and the cavity, cavity's shape will be similar to that of the component, which we will be manufacturing. So, this compacted sand medium will be made within this flask.

And we use two or three flasks and the lower flask, we call it as Drag and the upper flask we call it as Cope. And in some cases we also use third one. So, that third one we use in the middle, that we will call it as the intermediate.

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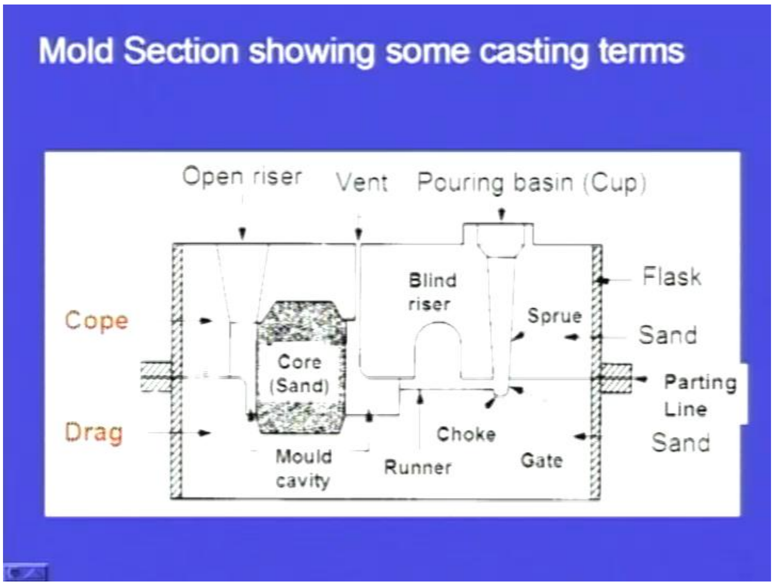

So, here we can see, this is a sand mould. And here we can see, outside there is, there is, this is the Cope and this is the Drag. Here, we can see two moulding flasks. So, this is the Cope and this is the Drag and inside these boxes, the sand.

So, this compacted sand medium will be made within this flask and we use two or three flasks, and the lower flask we call it as Drag and the upper flask we call it as Cope. And in some cases we also use third one. So, that third one we use in the middle, that we will call it as the intermediate moulding flask or the Cheek.

So, here we can see this is a sand mould. And here we can see, outside there is, there is, this is the Cope and this is the Drag. Here, we can see two moulding flasks. So, this is the Cope and this is the Drag and inside these boxes the sand is compacted and the mould is made.

And next one is the pattern. So, pattern is the replica of the final object or the final component, which we are going to manufacture. As I already told, the principle is, first we have to create a hollow cavity within a sand medium, compacted sand medium. So, to create that hollow cavity we need a model. That model may be made up of wood or metal or wax or sometimes plaster. So, this model is known as pattern.

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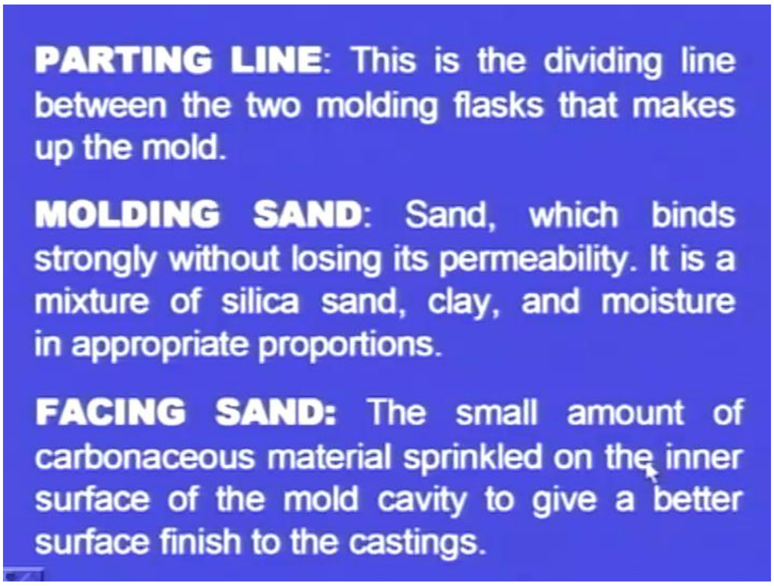

Next one, parting line. This is the dividing line between two moulding flasks ((Refer Slide Time: 19:52)) Here, we can see, this is the sand mould in which sand is compacted and this is the upper moulding box, that is the Cope, and this is the lower moulding box, that is the Drag and this is the line separating upper moulding box and the lower moulding box. So, this is this line, which separates these two moulding boxes, is known as the parting line.

Next one, moulding sand. Yes, we prepare a hollow cavity in a compacted sand medium in most of the cases and for that we need sand. And this sand binds strongly without losing its permeability. Means, when we compact the sand, still it should be in a position to pass the hot gases through it and it is a mixture of silica sand, clay, moisture in appropriate proportions. These proportions we will see later.

((Refer Time: 19:52)) So, this is a mould and this is the moulding sand. The whole thing is the moulding sand. Next one, facing sand. So, after we make the mould, the inner surface of the cavity may not be smooth. And to give a better surface finish to the inner surface of the cavity we sprinkle small amount of carbonaceous material sand, carbonaceous sand, which will be fine and it will be sprinkled. With that we will get a better surface finish on the cavity surface.

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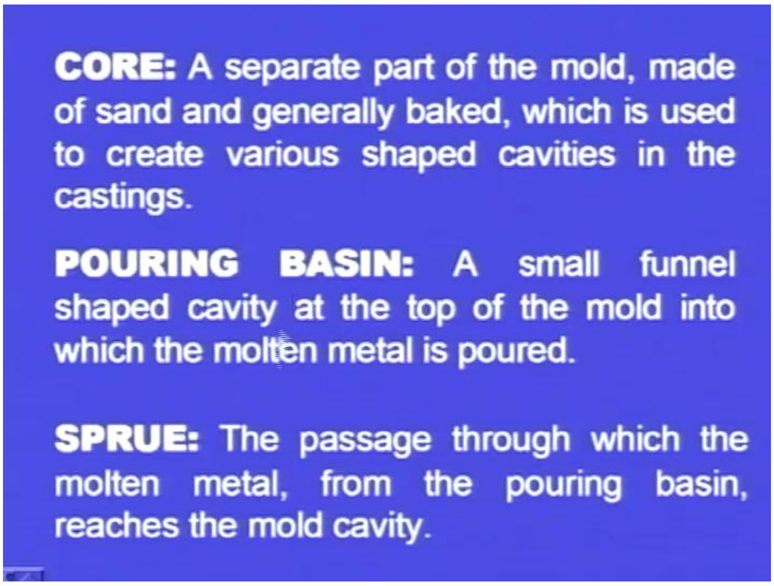

Next one, core. This core comes into picture whenever we have to make components with some hollow cavity. So, whenever components are to be made with cavities or some ((Refer Time: 24:32)) we have to use a Core. This Core is also again made up of sand and it will be baked to induce more strength.

((Refer Time: 19:52)) Yes, this is the sand mould. Again, this is the cavity, hollow cavity and here we wanted a cavity. So, we have kept a Core here and this is the way, this is the pouring basin. We pour the molten metal here and the molten metal will be passing and this is the cavity of the component. So, the molten metal will be occupying around the, around this Core and after solidification we remove this Core, so that there will be a cavity here.

And pouring basin, this is the small funnel shaped cavity at the top of the mould through which we pour the molten metal. ((Refer Time: 19:52)) So, this is the pouring basin and this is mould and we, through this basin we pour the molten metal. The molten metal will be falling and this is the Choke and it will be passing this way and it will be entering into the cavity and it will be raising up to here. Next one, Sprue. It is the passage through which the molten metal from the pouring basin reaches the mould cavity.

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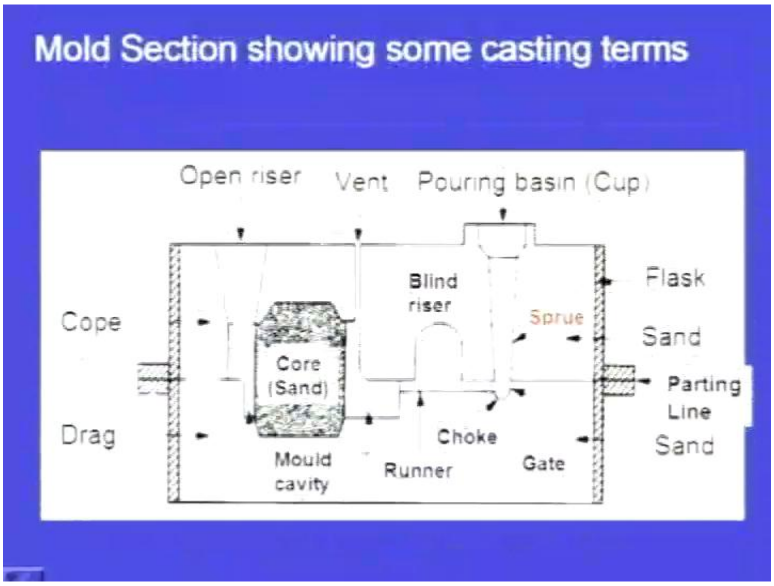

So, this is the Sprue. This is the pouring basin, this is the Sprue, the vertical passage, that is, the Sprue. The molten metal will be passing from the pouring basin, through the Sprue it reaches the Choke area then it will pass through the runner, then it will fall into the cavity.

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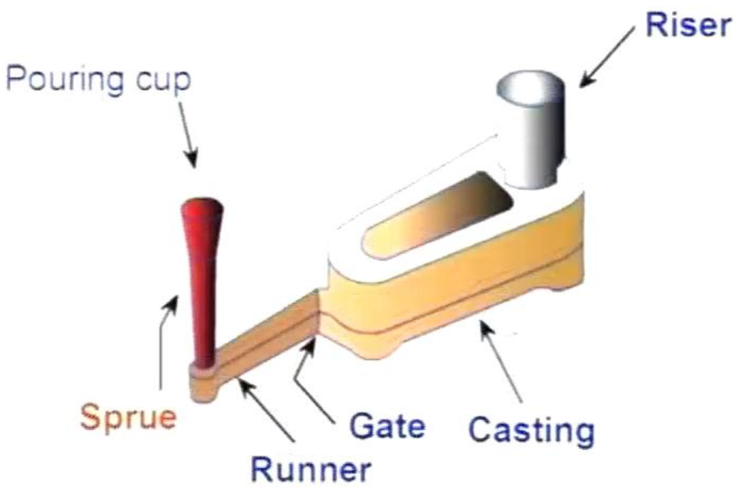

And this is another casting. Of course, this is shown without moulding boxes. So, this is the pouring cup, this is the Sprue, so this is the Runner. Initially, the molten will be pour in the pouring cup, then it will be passing through the sprue and it will be reaching the choke. And finally, it will be reaching the runner and finally, it will be reaching the casting.

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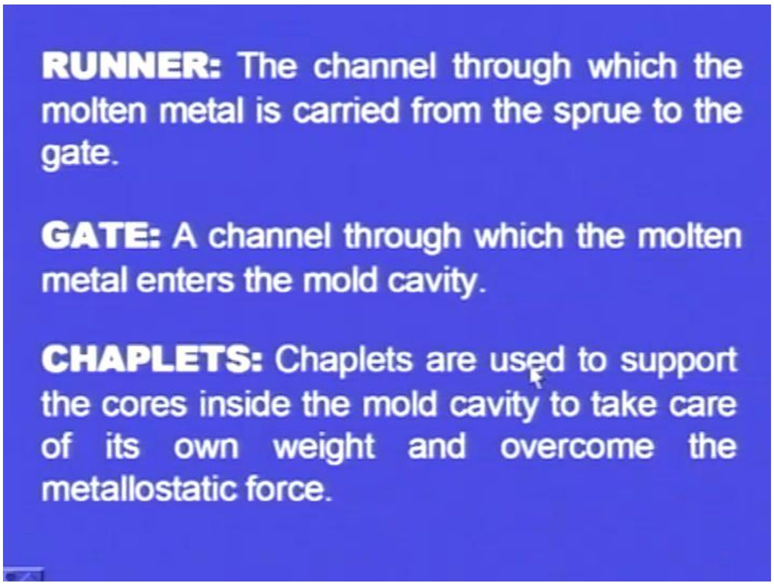

And next term, the Runner. It is the channel through which the molten metal is carried from the sprue to the gate ((Refer Slide Time: 26:37)) So, this is the runner. So, this is the choke, this is the sprue, this is the runner. Molten metal passes from the pouring cup, sprue, this is the choke and it reaches the runner and finally, it reaches the mould cavity.

Gate, it is the channel through which the molten metal enters into the mould cavity ((Refer Slide Time: 26:37)) So, this is the gate. Through this gate molten metal passes into the cavity. Chaplets, chaplets are used to support cores inside the mould cavity to take care of its own weight and to overcome the metallostatic force.

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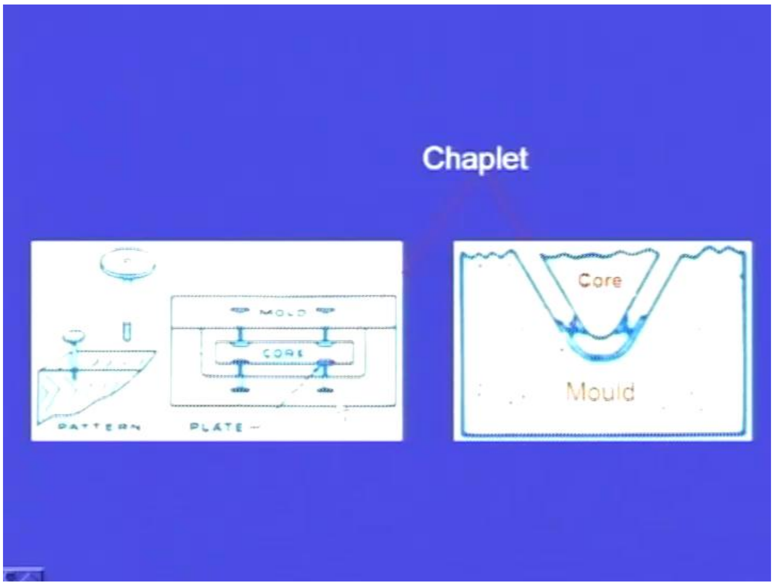

So, here we can see, this is the mould and this is a core and this is the chaplet. This is one chaplet and again, this is another mould and here is a core and here is one chaplet. We can see, here is one chaplet, here is an, of course, another chaplet, another chaplet. So, these chaplets, they support the core when the core has to be suspended inside the cavity and these cores are made up of the same material of the casting. When we pour the molten metal, the cores will be fusing and they will become part of the casting.

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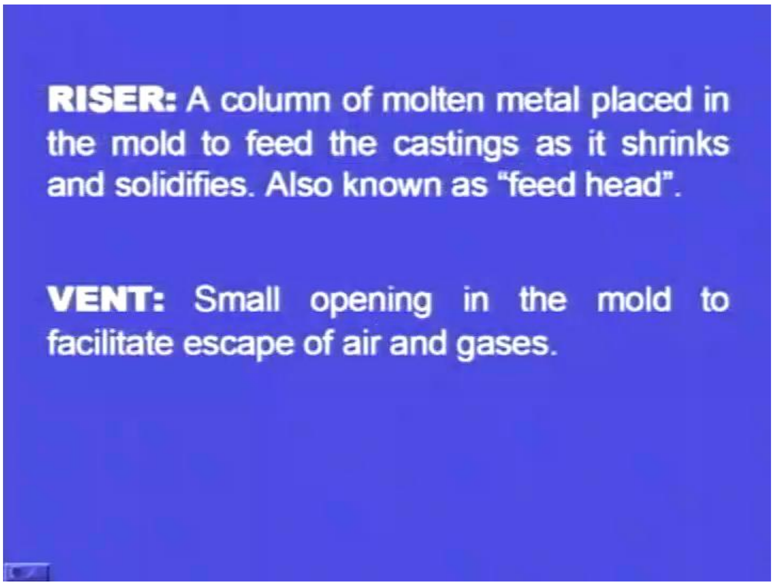

Riser, this is another important term. Riser, we can see, it is at the top of the casting. This is also known as feed head. ((Refer Slide Time: 26:37)) So, this is the riser, the molten metal passes through the pouring cup, through the runner, through the gate it enters into the mould cavity, finally it rises.

So, this riser has got three functions. One is, it gives us an indication, that the cavity is full with the molten metal. And when the molten metal is poured into the mould, hot gases are generated because the moulding medium contains moisture. When the molten metal comes in contact with the moisture, hot gases are formed, vapor and hot gases. This vapor and hot gases will escape through the riser. So, that is the second function of the riser.

And there is another important function for the riser. When the molten metal is full with the, in the cavity, after sometime the solidification starts. During the solidification, the size of the casting becomes smaller, means, it undergoes shrinkage. So, we have to counteract, counteract this effect. So, molten metal is kept in liquid state in riser by some method. The casting undergoes solidification, but the molten metal in the riser will be acting as the reservoir. It compensates the shrinkage, which is undergoing by the casting. So, this is the important function of the riser. It counteracts the shrinkage effect of the casting.

And vent of course, as I already told, riser helps us, so that the hot gases and vapor will be escaping from the mould. But to ensure more that the hot gases will be escaping from the mould, we create vent holes. So, these vent holes we create in the mould at certain places. These vents are holes of very small diameter. They will be extending from the surface of the mould cavity and to the end of the mould box. So, the hot gases also pass through these vent holes.

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And let us see the steps in making sand casting. There are six basic steps involved in making a sand casting. One is pattern making, second one core making, next one moulding, melting and pouring, cleaning and finally, inspection.

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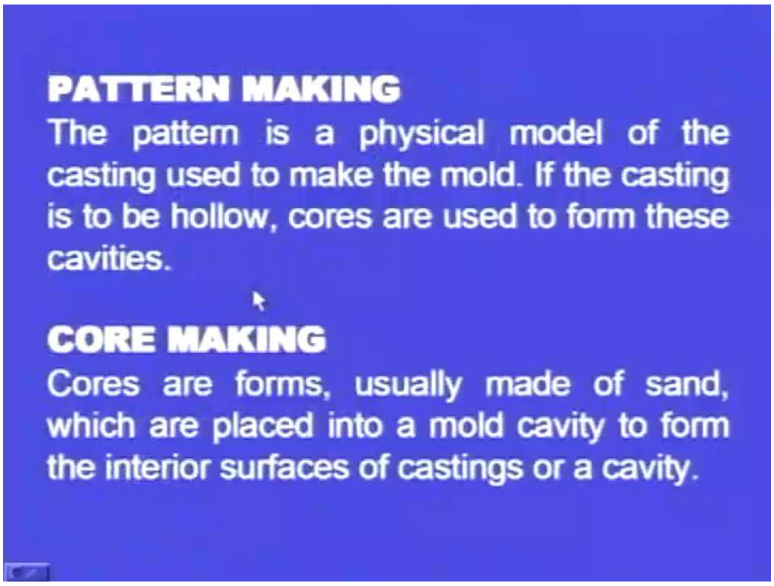

First one is, pattern making. What is this pattern to make a casting of particular shape? What we do is, we create a cavity in the sand medium. The shape of the cavity will be similar to that of the casting, which we are going to make. So, to make the cavity we have to use a model. This model is known as the pattern. So, first we have to create the pattern.

So, we can define this way. The pattern is a physical model of the casting used to make the model. If the casting is to be hollow, then we have to use a core. So, this pattern, most of the times it is made up of wood, sometimes it is made up of metal. Second step, that is, the core making. So, core is required whenever we have to make a casting with some hollow cavity or with some ((Refer Time: 33:59)). So, cores are formed and they are usually made up of sand.

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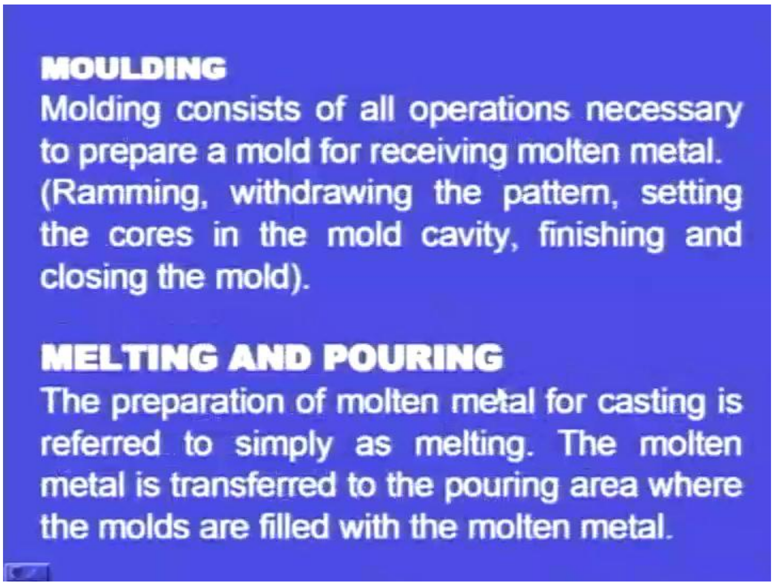

Next one, moulding. Moulding, it is the process in which we compact the sand in the moulding boxes around the pattern. Moulding consists of all operations necessary to prepare a mould for receiving the molten metal. So, moulding includes ramming, means compacting tightly. After compacting tightly we have to withdraw the pattern and we have to setup the cores and finishing the mould by this sand and finally, we will close the mould.

Next step, melting and pouring. So, the preparation of molten metal for casting is referred to simply as melting. The molten metal is transferred to the pouring area where the moulds are filled with the molten metal.

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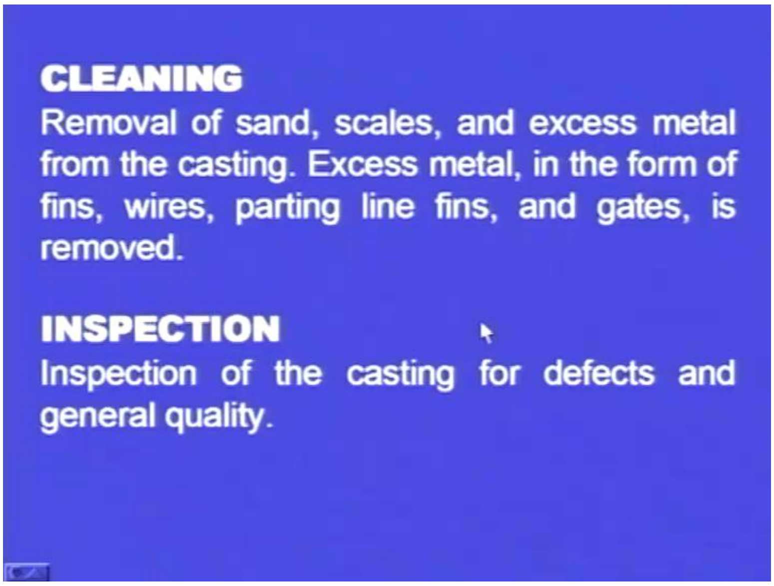

Next one, cleaning. After we pour the molten metal into the cavity, after sometime the casting will be solidified and so much of sand will be sticking to the casting. There will be so many scales and there will be, extra metal projections will be there. And we have to remove the sand, we have to remove the scales, we have to cut off the excess metal scales. So, this process comes under cleaning.

So, this can be done by, we use cleaning brush. By brush cleaning is also done by pressurized air, we call it as pneumatic cleaning and sometimes it is also done by water. We clean them by water and next step is inspection. After the casting is made we have to inspect the quality. Inside it may contain some defects. So, we have to examine the casting for identification of any possible defects. There are so many destructive methods and non-destructive methods for inspecting a casting.

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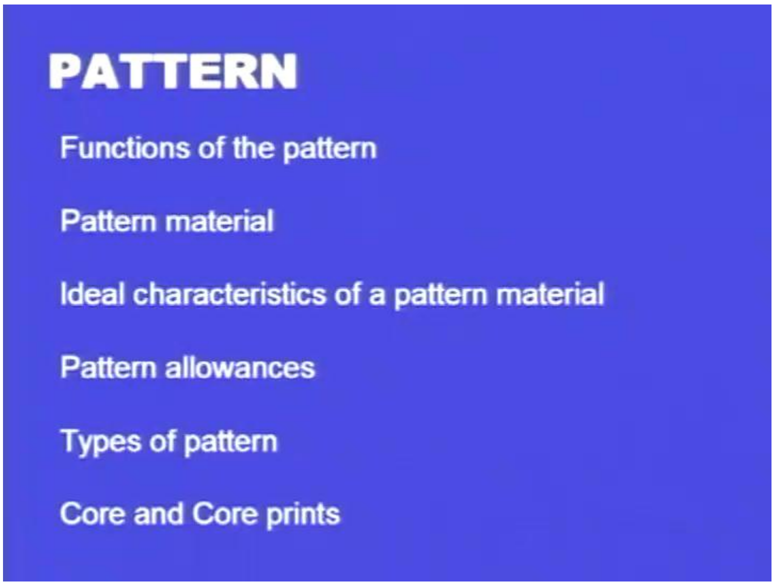

Now, let us learn something about pattern. So, let us study this way. First, let us see the functions of the pattern. Next, we will see the pattern material. Next, we will see the ideal characteristics of a pattern material. Next, we will see pattern allowances, next the types of pattern and finally, we will see the core and core prints.

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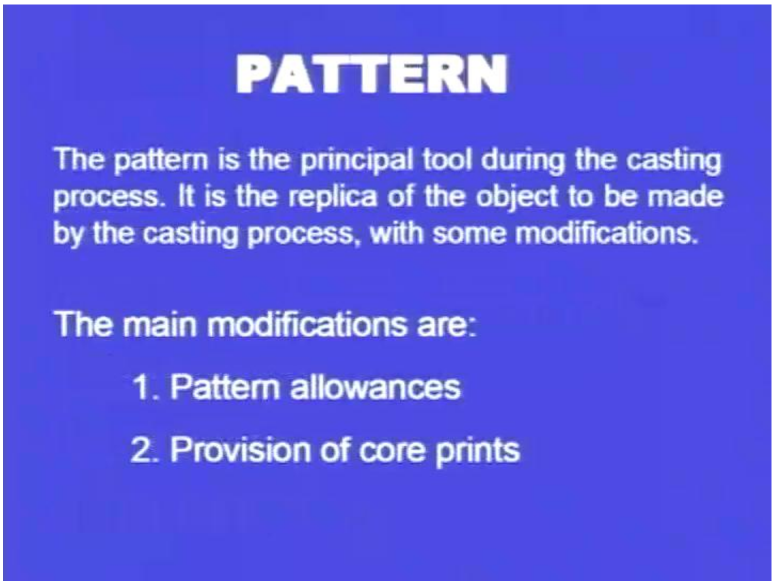

The pattern, so the pattern is the replica of the object to be cast. So, as I have already told, it acts as the model to create the mould cavity. So, whenever we want to cast a particular component we have to create a cavity whose shape is similar to that of the component to be cast. So, the model or the pattern which we are going to use should be similar to that of the casting that we are going to make.

However, the geometry of the pattern will not be exactly same as that of the geometry of the casting. It will be modified in certain ways and what are these modifications? One is, there will be some pattern allowances. So, because of this pattern allowances the geometry or the size of the pattern will be little different than that of the geometry of the casting.

And another modification is, we have to place the cores; so, cores are to be supported. For supporting the cores there should be some place. So, this place where the cores are to be supported, should be created by the pattern.

So, when we design the pattern, the pattern should be in a position to repair a place where the cores will be placed. So, in that context even the pattern geometry will be modified, so that it can accommodate cores. So, there will be two modifications for the pattern. First modification is because of the allowances. These allowances we will be seeing later, and second modification is in the context of core prints.

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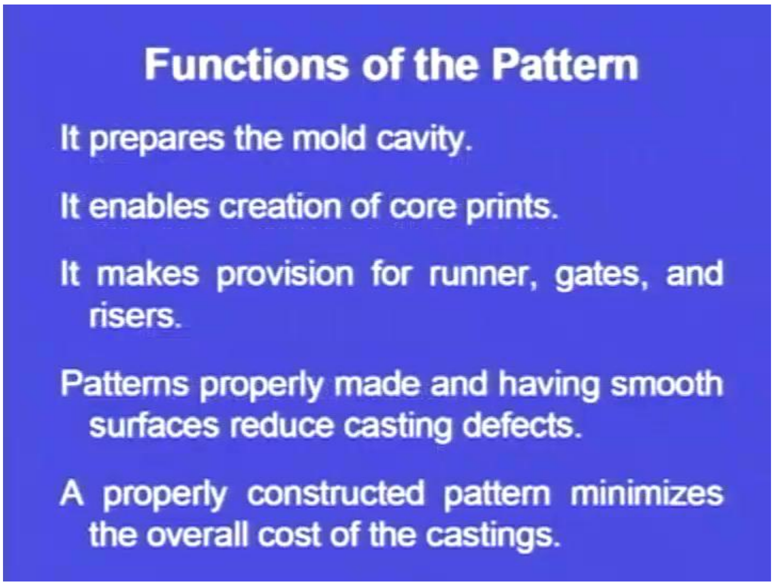

And what are the functions of the pattern? First function is, it prepares the mould cavity. Whatever component or whatever shape we are going to make, we use the pattern of a similar shape. And when we keep the pattern inside the moulding boxes and we ram the moulding sand, we compact the moulding sand. After compaction is over we remove the pattern and there will be a cavity whose shape is similar to that of the casting, that we are going to make. So, it prepares the mould cavity.

And second function is it enables creation of core prints. Yes, whenever we make a casting in which there is a hole, for that purpose we have to use a core, sand core. In some cases these sand cores are supported by chaplets, some cases these cores are supported on the ends, sometimes the cores are supported on the ends and as well as with the help of the chaplets.

So, when the cores are supported on the ends, it has to arrest at some place in the mould. That place has to be created, that has, that place has to be created by the pattern itself. So, the pattern will create the core print. This core print makes a place for resting of the cores.

And also, in a mould not only there will be a cavity of a component that we are going to make, but there will be a cavity for sprue, there will be a cavity for runner, there will be cavity for in gates, there will be a cavity for riser and the pattern has to create hollow cavity for all these elements. For runner it has to create a hollow cavity for sprue, it has to create a hollow cavity for gates, it has to create a hollow cavity and for riser it has to create a hollow cavity.

So, a pattern has to create a hollow cavity for the component itself, for the sprue, for the runner, for gates and for the riser. And patterns properly made and having smooth surface will reduce casting defects. So, a good pattern should be in a position to reduce the casting defects by smooth surface and properly constructed pattern minimizes the overall cost of the casting.

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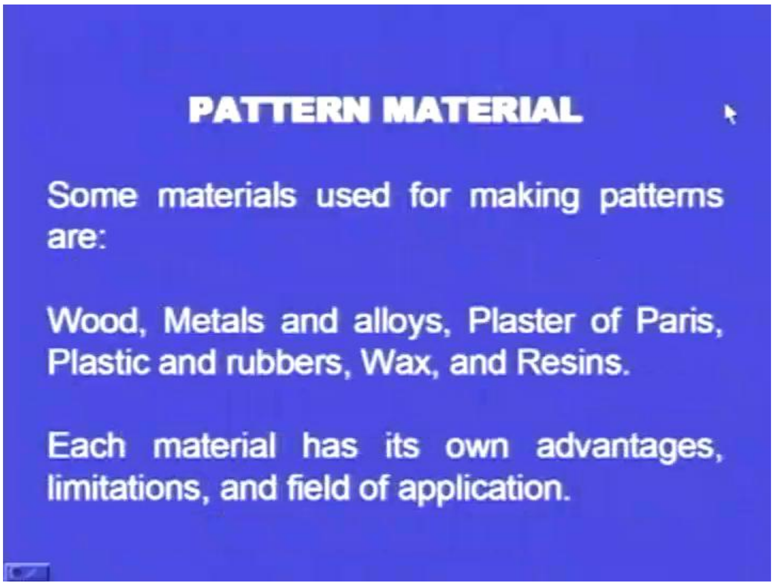

And what about the pattern material? Most of the times the pattern material is wood. In some cases it is metal, sometimes it is made up of alloy and Plaster of Paris is also used, where we achieve good dimensional accuracy and also good surface finish. We use plastic and rubber, we also use wax where we get excellent surface finish and also, we use resins. So, these are all the pattern materials.

Each material has got some advantages and limitations. For example, if we take the wood, wood is cheaply available. But when we make a mould with a wooden pattern, the inner surface of the mould cavity, it will be poured. The casting, finally, that we are going to obtain will suffer from poor surface finish that is one thing. And another thing is, we mould the medium with moulding sand in which there is moisture. This moisture when comes in contact with the wooden pattern, the wooden pattern bulges, the, its geometry becomes larger. So, this is one of the drawback of the wooden pattern.

And when we use metals, the surface finish is good, but there is a chance they may undergo corrosion. So, this is the drawback of the metal patterns. And also, metal patterns are expensive metallic patterns and alloy patterns are expensive.

And coming to the Plaster of Paris and it offers very good surface finish and also, it offers good dimensional accuracy, but it is expensive. And also, preparation of the mould, it takes time, it take takes more time. And also, we you, we can use plastics and rubbers and they offer us good surface finish. And we also use wax in investment casting where the surface finish is excellent, the dimensional accuracy is excellent, especially when we have to make castings of very thin cross-section we can go for wax pattern.

One another drawback of the wooden patterns is, if we have to make castings of very thin cross-section wooden patterns will not help us. But if we use the wax pattern, even a thin cross-section of the order 0.75 mm we can successfully cast. But this wax, each time when we prepare a pattern, that is only for one casting.

On the other hand, if we make pattern with wood or with a metal or with alloy, they, they can serve as patterns for making several moulds. But whereas, when we make a pattern with wax, it is only for one time. After we cast one casting, we have, that pattern is no more, it will be melting. And we can also use resins, but these resins are expensive.

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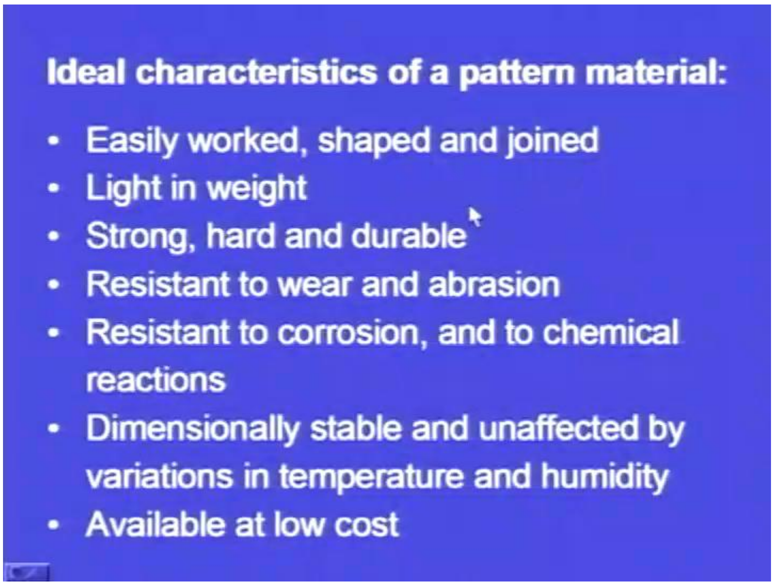

And what are the ideal characteristics of a pattern material. One is, they should be easily worked to give the shape. We should not find it so difficult to give the shape. We should be in a position to give the required shape easily. And second characteristic is, it should be light in weight and third, it should be strong hard and durable. When we make a pattern it has to serve as the pattern for several castings. So, that is the objective.

So, when we make pattern, especially with wood and metal or alloys, they serve as pattern for making several moulds and it should be resistant to wear and abrasion. So, this is very important.

When we place the pattern inside a moulding box, we, we start ramming the moulding sand and we compact the moulding sand with rammers. It is that time the pattern is subjected to wear and abrasion. And if the pattern material does not have resistance against wear and abrasion, within no time it will lose its geometry. It cannot serve as a model for making several moulds, whereas, an ideal pattern materials should have good resistance for against wear and abrasion, and the pattern material should have good resistance against corrosion.

This comes when we use metals and alloys as the pattern material. The compacting medium, that is, the moulding sand contains moisture. When we place the pattern inside the moulding box and when we start ramming the moulding sand, which contains the moisture, it is that time the pattern should have resistance against corrosion. If the pattern material does not have resistance against corrosion it will be rusting and within a short time it will be losing its geometry, and it should be resistant against chemical reactions also.

And next one, it should be dimensionally stable and unaffected by variations in temperature and humidity. Yes, when we make a pattern, it should be dimensionally stable and especially, when we use metallic patterns or alloy patterns, there is a chance, that they may expand if the temperature in the shop floor is high. If the pattern expands, even the casting will be of a bigger size that is not going to serve the purpose. And if the humidity is more and if the pattern absorbs humidity, again it will be bulging and it will be enlarging. Finally, the casting, that we are going to make, will be of a bigger size. It is not going to be of any use.

So, when we make a pattern, the pattern should be stable and it should have resistance against fluctuation, thermal fluctuations and humidity and finally, it should be available at a lower cost. If the pattern is of higher cost, it will increase the overall cost of the casting. So, the pattern material should be available at a low cost.

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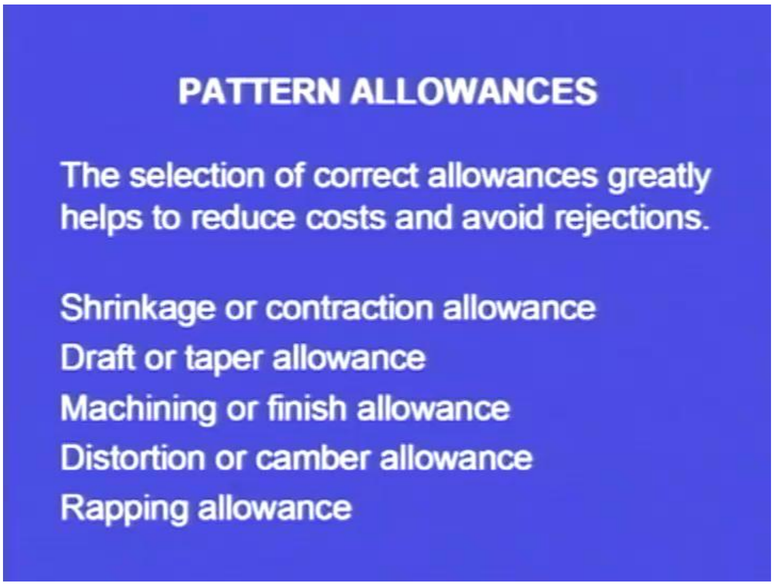

Next, let us see what are the pattern allowances. As I already told, the pattern is the replica of the final casting that we are going to make. However, it is modified in certain ways in view of the allowances. In view of the core prints it is already modified, that I have already told.

And what are the pattern allowances? One is shrinkage or contract, contraction allowance. Second one is draft or taper allowance; third one is machining or finishing allowance. Next, distortion or camber allowance. Finally, rapping allowance. Let us see these things one by one.

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Shrinkage allowance or this is also known as contraction allowance. What is this shrinkage allowance? Yes, when we make a casting during solidification, it undergoes shrinkage. If we want a particular size and if we make the pattern exactly as the size of the required casting and during the pouring stage, during pouring and during solidification the metal solidifies, it undergoes shrinkage.

And finally, after solidification the size of the casting will be smaller than the expected size of the casting. The size of the casting will be smaller than the size of the pattern. The pattern we might have chosen correctly. The pattern we might have chosen equal to the size of the required casting, but after solidification it has undergone shrinkage. So, its size become smaller than the required size.

So, to counteract this effect we have to make the pattern bigger than the required casting. So, this difference between the required size and the actual size of the pattern is the shrinkage allowance or the contraction allowance.

There are two types of shrinkage of metals, one is liquid shrinkage, another one is solid shrinkage. Yes, during the liquid shrinkage what happens? It undergoes reduction in the volume when the metal from the liquid state, it undergoes to solid state, that time it undergoes reduction in volume.

So, this will be compensated by the riser, the molten metal in the riser is kept in liquid state for more time. So, when the casting is undergoing solidification, when the casting is undergoing shrinkage, the liquid metal in the riser, it counteracts the effect of liquid shrinkage.

Another one is solid shrinkage. So, this solid shrinkage is caused when the metal loses its temperature during the solid state. We may require a particular size of a casting. And if we make a pattern exactly same size as that of the required size of the casting, then the cavity, mould cavity will have the same size as that of the required casting, we pour the molten metal.

The molten metal starts solidification. During the solidification, as the solid metal loses its temperature it undergoes shrinkage, the size becomes smaller. To counteract this effect we have to make the pattern size little bigger than the size of the casting. So, this is the shrinkage allowance.

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Table 1: Rate of Contraction of Various Metals

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet 2 feet to 4 feet over 4 feet	0.125 0.105 0.083
Cast Steel	Up to 2 feet 2 feet to 6 feet over 6 feet	0.251 0.191 0.155
Aluminum	Up to 4 feet 4 feet to 6 feet over 6 feet	0.155 0.143 0.125
Magnesium	Up to 4 feet Over 4 feet	0.173 0.155

So, this table gives us the contraction allowances or the shrinkage allowances of various metals. For grey cast iron, for these dimensions these are the shrinkage allowance; for cast steel, for these dimensions these are the shrinkage allowances; for aluminum, for these dimensions these are the shrinkage allowances; for magnesium, for these dimensions these are the shrinkage allowances.

And in this episode we have seen, that casting is the oldest manufacturing process. People who lived during Stone Age, they have used this technique to make arrow heads and weapons. People who lived during the time of ancient Mesopotamia, they used this technique to manufacture art items and jewelry items.

Today, it has emerged as the technology. We are making aircraft components, automotive components and many other industrial components.

We have also seen the advantages and limitations of casting process. We have seen different casting terms, the pattern and the pattern allowances. And the details of shrinkage allowance and the details of other allowances, we will be studying in detail in the next episode.