Manufacturing Processes - 1

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Module - 2
Lecture - 2
Metal Casting

In this metal casting, we have seen in the previous class that metal casting is the oldest manufacturing process, and it has started as an art. Today, it has emerged as a technology. We have seen introduction for the metal casting in the previous lecture, and we have seen that the metal casting lies in the principle of making a cavity of the shape of the component, which we are going to manufacture.

If we are going to manufacture a particular shape that kind of cavity we have to create in a sand mould, and then in that cavity we will be pouring the molten metal. For that we will be using a pattern which will be acting as the model. The pattern is the replica of the component which we are going to manufacture. So, this we will call it as the pattern. Most of the times the pattern is made up of wood, sometimes it is made up of metal, sometimes it is made up of wax and sometimes, it is made up of plaster of Paris.

So, we have seen the advantages and limitations of different pattern materials in the previous class. We have also seen that the pattern will be the replica of the component which we are going to manufacture. However, the geometry of the pattern is not exactly same as that of the component, which we are going to manufacture. The geometry of the pattern will be slightly different from the component, which we require. This difference comes because of certain allowances.

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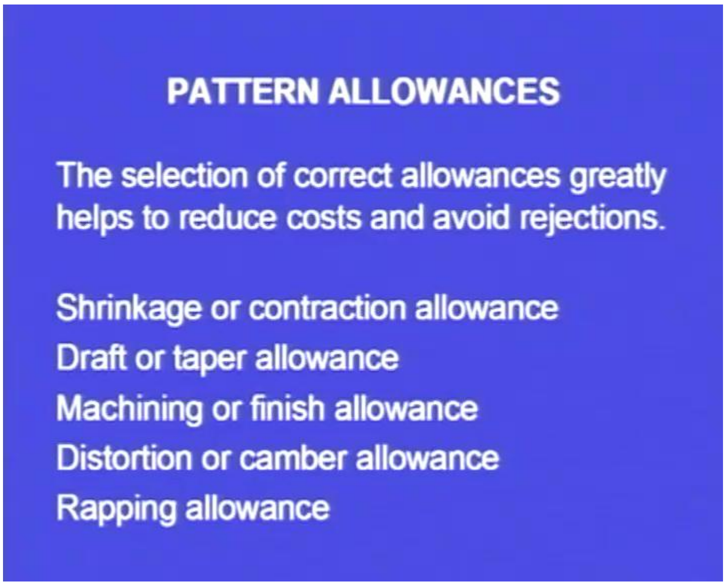

We need to give certain allowances to the pattern and these allowances, we have briefly dimension of the casting is 18 inches. Now, here we have to give 18.2 inches and the diameter of the hole is 6 inches, and now we have to give 5.93. The height of the casting is 8 inches. Now, we have to give 8.09 inches. So, this will be our final dimension of the pattern considering only the shrinkage allowance.

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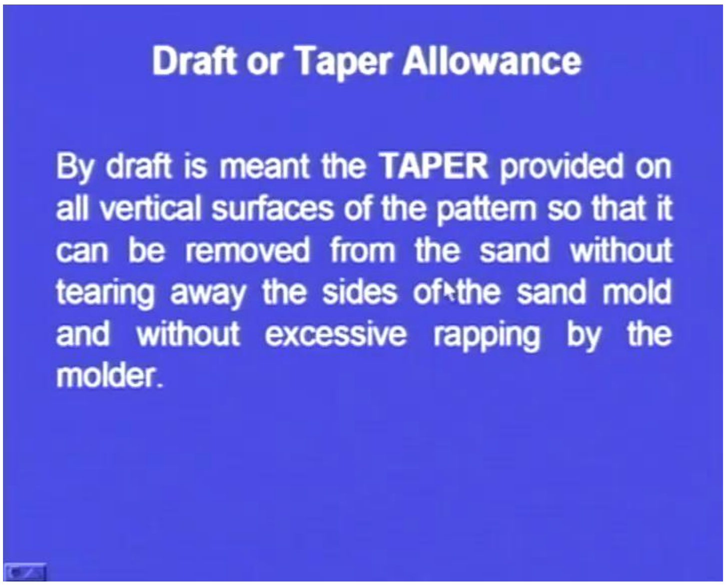

Now, next one is the draft allowance or the taper allowance.

What is the draft allowance? Yes, when we mould the pattern in the mould box, we ram the moldings sand and after compacting the molding sand, we have to withdraw the pattern. When we are withdrawing the pattern, there is every chance the vertical surfaces of the pattern may be sticking to the molding sand, and it is difficult to withdraw the pattern. For that purpose, we give a taper to the vertical surfaces. So, this is known as draft allowance or taper allowances. Let us see what happens when draft allowance is not given or what happens when draft allowance is given.

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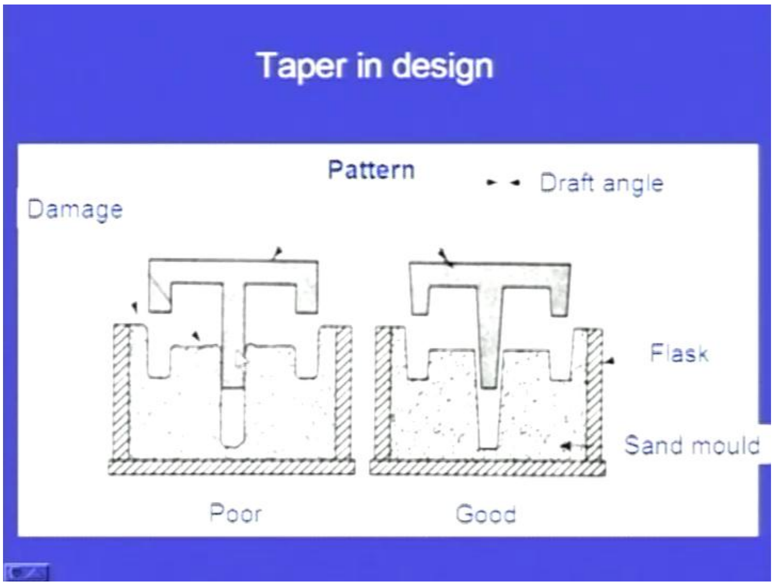

Let us see this molding system where in one case we are molding without taper. This is the pattern, this is the molding box and this is the molding sand, and here we have molded without any taper, and when we withdraw after compaction of the sand, when we are withdrawing the pattern, there is every chance it will be breaking the sand. The mould may be damaged. So, this is not desirable and the other case here, we can see the pattern where we have given the draft, the vertical surface is tapered.

Now, after the compaction of the sand is over, when we try to withdraw the pattern, this will become easy to withdraw the pattern. So, this is easier in this case. The mould will not be breaking. The mould will not be damaged. So, this is safe, this is desirable. So, in this case we have given taper allowance. This is desirable.

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Draft Allowances of Various Metals

Pattern material	Height of the given surface (inch)	Draft angle for external surface (degrees)	Draft angle -for internal surface (degrees)
Wood	1	3.00	3.00
	1 to 2	1.50	2.50
	2 to 4	1.00	1.50
	4 to 8	0.75	1.00
	8 to 32	0.50	1.00
Metal and plastic	1	1.50	3.00
	1 to 2	1.00	2.00
	2 to 4	0.75	1.00
	4 to 8	0.50	1.00
	8 to 32	0.50	0.75

These are the draft allowances to be given for various metals. So, this is the pattern material and height of the given surface, and if it is 1 inch, the draft angle should be 3 degrees. This is if it is external. If it is internal, it should be 3 degrees and when the height is 1 to 2 inches, the draft angle should be 1.5 degrees for external. For internal, it should be 2.5 degrees and from 2 to 4 inches, the draft angle should be 1 degree. That is for external and for internal, it should be 1.5 degrees and when the height is 4 to 8 inches, the draft angle should be 0.75 degrees for external, and for internal, it should be 1 degree and from 8 to 32 inches, the draft angle should be 0.5 degrees for external and if it is internal, it should be 1 degree.

When the pattern material is made up of metal or plastic, the draft allowance should be like this for 1 inch height, it should be 1.5 degrees if it is external. For internal, it should be 3 degrees and from 1 to 2 inches, the draft angle should be 1 degree for external and for internal, it should be 2 degrees. From 4 to 8 inches, the draft angle should be 0.5 degrees for external, and it should be 1 degree for internal. From 8 to 32 inches, the draft angle should be 0.5 degrees for external surface, and should be 0.75 degrees for internal surface.

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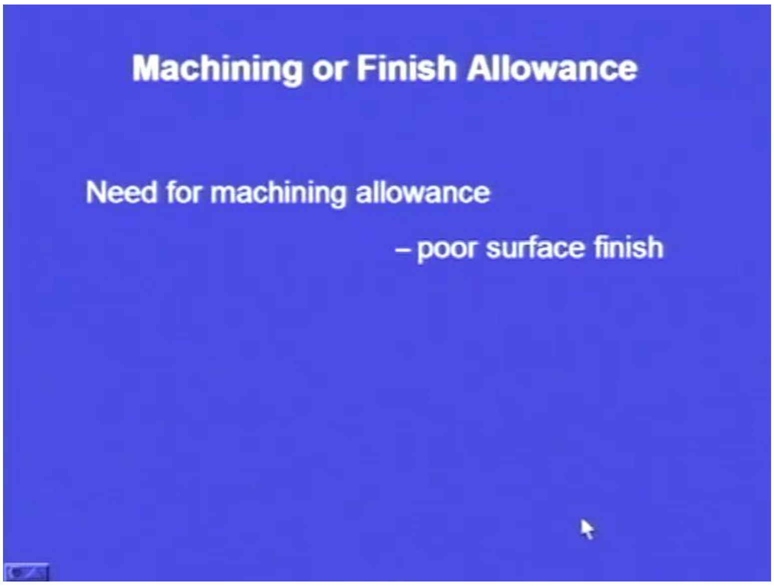

Machining or finishing allowance. What is this machining allowance? We know that the pattern material is made up of wood in most of the cases. If it is the sand material, sand material is rough and when we compact that pattern in the sand, the mould cavity, the external surface of the mould cavity will have a rough surface, and when we pour the molten metal, the molten metal will be occupying in the cavity and after solidification, the external surface of the casting will have a rough surface. This rough surface is not acceptable for any application.

So, to get a fine surface finish, we have to machine it. When we machine, its size becomes smaller. So, if you do not consider these surfaces and if we make the pattern size exactly same as that of the casting fine, the cavity will be same size as that of the casting component and during solidification, it will have a rough surface. After solidification and after machining, its size becomes small. Now, we have to counteract this effect for that purpose considering this effect, considering this machining, we have to make the pattern size little bigger than the required size of the casting. So, this is known as machining or finishing allowance.

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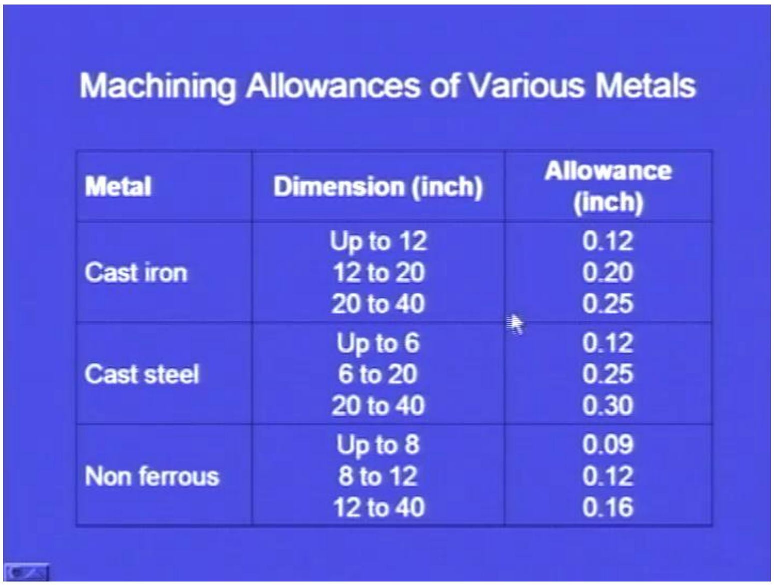
Machining Allowances of Various Metals

Metal	Dimension (inch)	Allowance (inch)
Cast iron	Up to 12 12 to 20 20 to 40	0.12 0.20 0.25
Cast steel	Up to 6 6 to 20 20 to 40	0.12 0.25 0.30
Non ferrous	Up to 8 8 to 12 12 to 40	0.09 0.12 0.16

The machining allowances of various metals are like this. Forecast iron up to 12 inches, the machining allowance should be 0.12 inch. From 12 to 20 inches, the machining allowance should be 0.2 inches. From 20 to 40 inches, the machining allowance should be 0.25 inches. Forecast steel up to 6 inches, the machining allowance should be 0.12 inches. For 6 to 20 inches, the machining allowance should be 0.25 inches. For 20 to 40 inches, the machining allowance should be 0.3 inches and for non-ferrous metals up to 8 inches, the machining allowance should be 0.09 inches. For 8 to 12 inches, the machining allowance should be 0.12 inches and for 12 to 40 inches, the machining allowance should be 0.16 inches.

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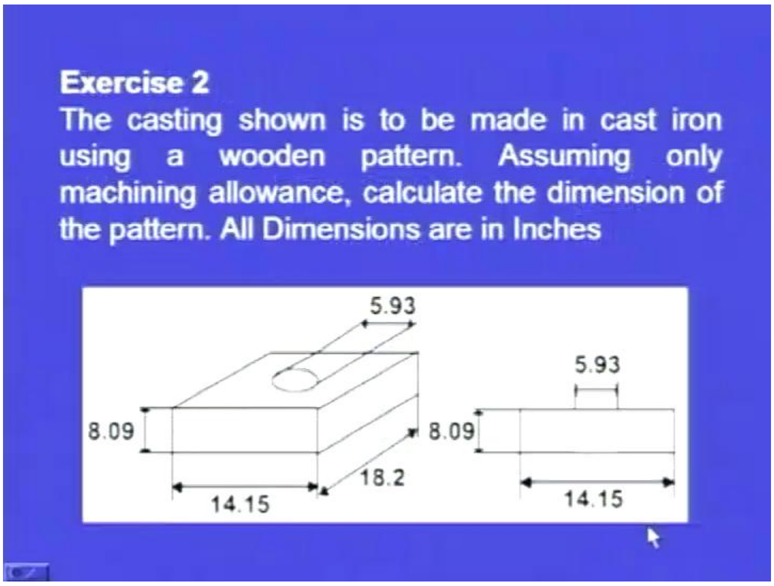

Now, let us solve one more problem. So, here this is the geometry of the casting which we want the casting shown is to be made by cast iron using wooden pattern, assuming only machining allowance. Calculate the dimensions of the pattern. So, here we can see one side is 14.15 inches, another side is 18.2 inches, and there is a circle 5.93 inches and the height is 8.09. How to take this machining allowance? How to calculate this machining allowance?

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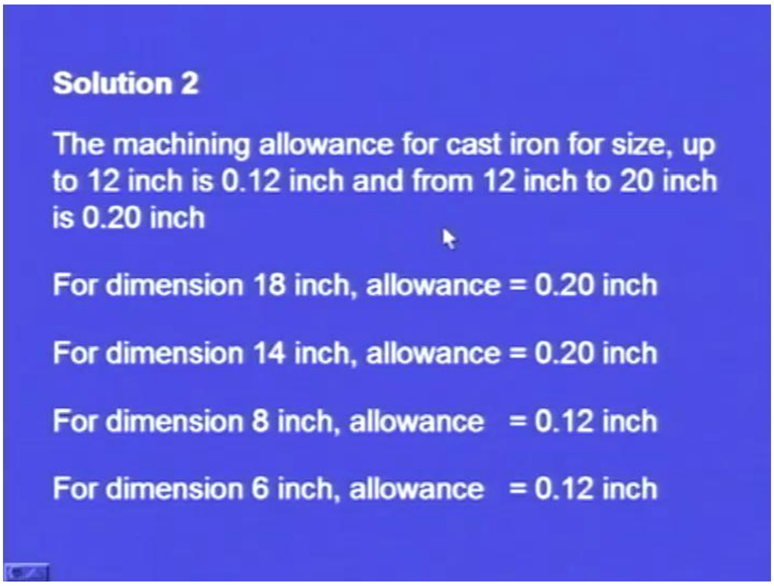

So, the machining allowance for cast iron up to 12 inches is 0.12 inches, from 12 inches to 20 inches it is 0.2 inches. So, for the dimension of 18 inches, the allowance is 0.2 inches. For dimension of 14 inch size, the allowance is 0.2 inches. For dimension of 8 inches, the allowance is 0.12 inches. For the dimension of 6 inch, the allowance is 0.12 inches.

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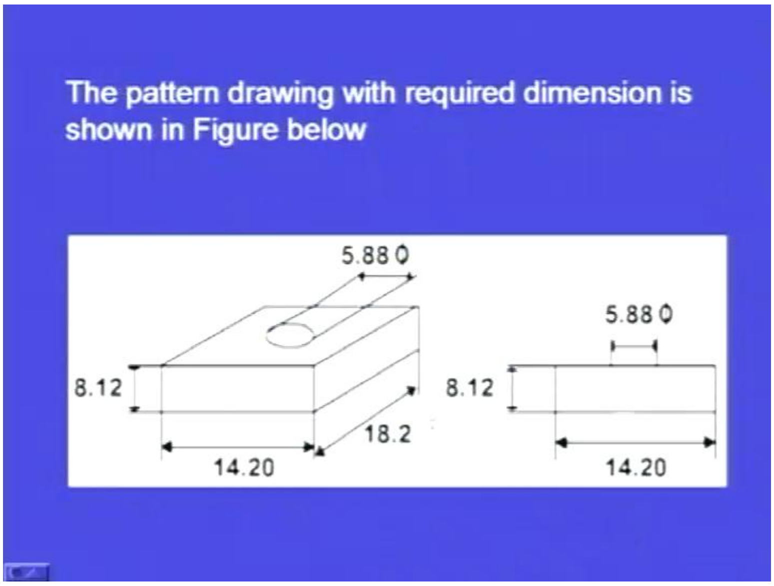

The pattern after giving the machining allowance will be looking like 14.2. That side will have the dimension of 14.2, and this side 18.2 and this side 5.88. Here it is 8.12. So, this is the final geometry of the pattern after considering the machining allowance also.

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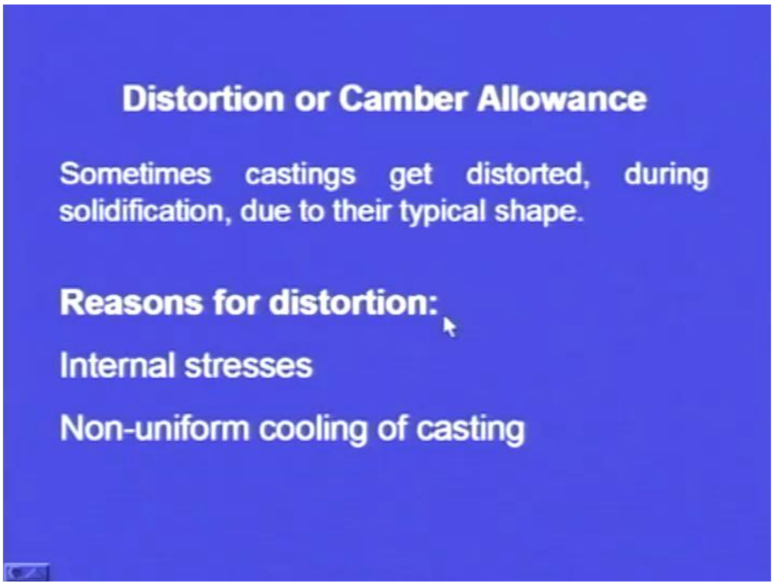

Next one is distortion or camber allowance. What is this distortion allowance? Distortion means damage. The shape will be spoiled; the shape will be disfigured in a disorderly way. What are the reasons for distortion? One is internal stress, and another one is non-uniform cooling of casting. When the casting contains different sections where the sections are of different thicknesses, one section will be solidifying fast and another section will be solidifying later, and there is a difference in solidification. This leads to residual stresses and this leads to non-uniform cooling of the casting.

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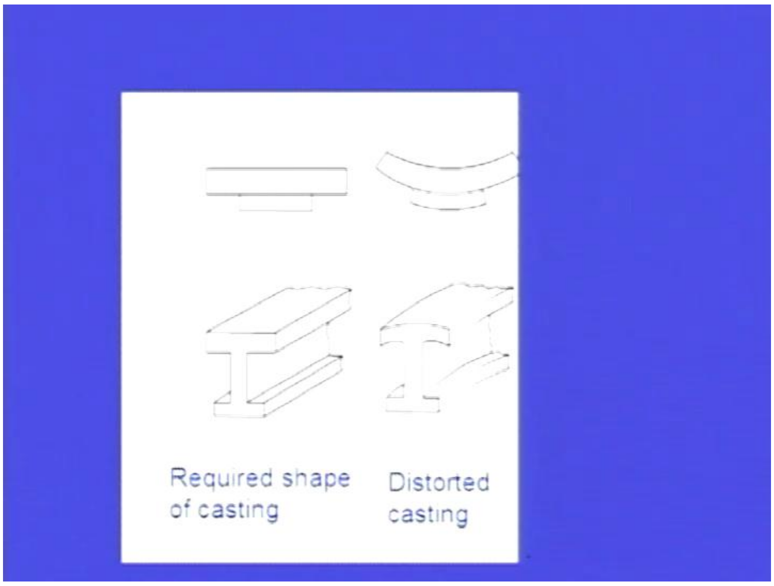

So, here we can see the example of a distorted casting. So, this is the required casting this high section, and because of this distortion, finally the casting is appearing like this. This is the actual requirement of the casting, but after solidification the casting is looking like this. So, this is the effect of distortion and when we are designing the pattern, we have to take this effect into consideration. We have to design the pattern such a way that this distortion will overcome how to counteract this distortion and measures to be taken to prevent distortion.

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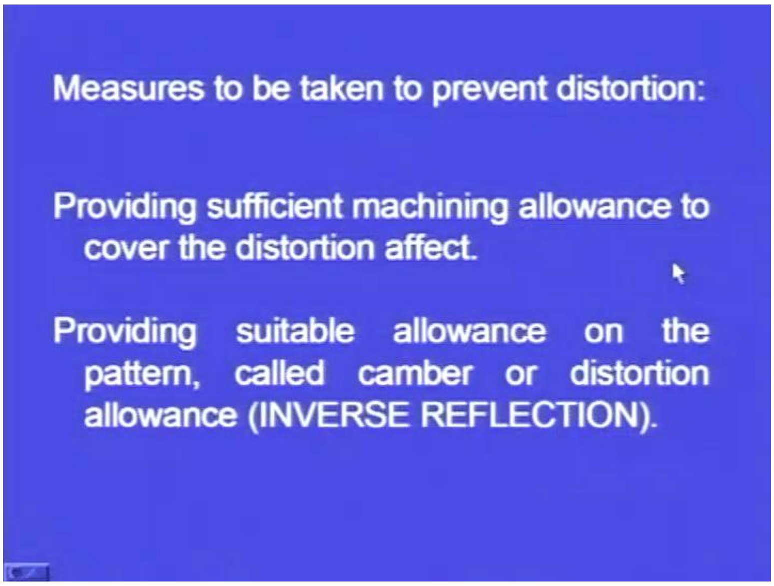

First one is, we will provide machining allowance, so that even if the casting undergoes distortion, wherever it has gone, we will machine until it gets the required shape. Another one is we will provide suitable allowance that is the inverse reflection. What is this inverse reflection? I will show you.

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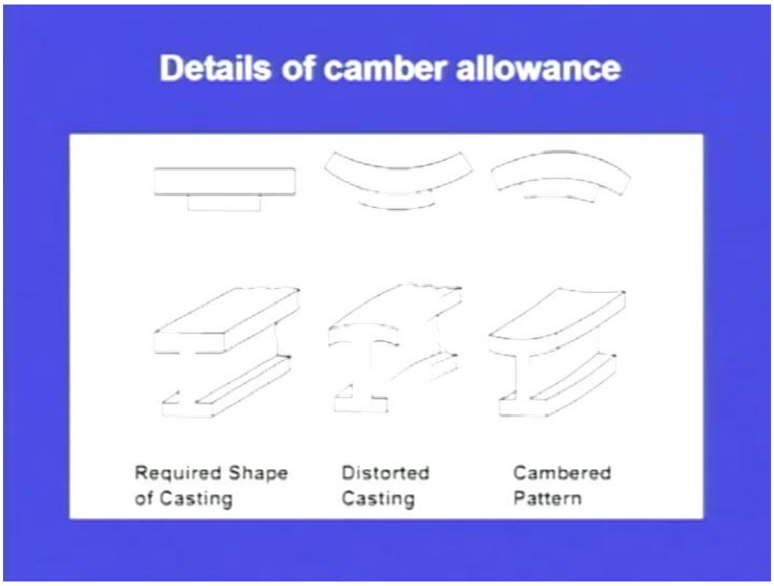

So, this is the required casting geometry, this is the required casting shape, and if we do not give any camber allowance, this will be the final shape of the casting. Now, we have already anticipated this camber allowance. So, we have designed the pattern like this, and we have designed the pattern like this, and with these patterns when we make the mould, when we pour the molten metal after solidification, it will be that distortion effect continuous to rule, but in its attempt for distortion, it will bring to the normal shape. So, this is how we can counteract the distortion effect. So, this is the camber allowance. We are anticipating the distortion and we are making the geometry of the pattern in the other direction. So, this is the camber allowance.

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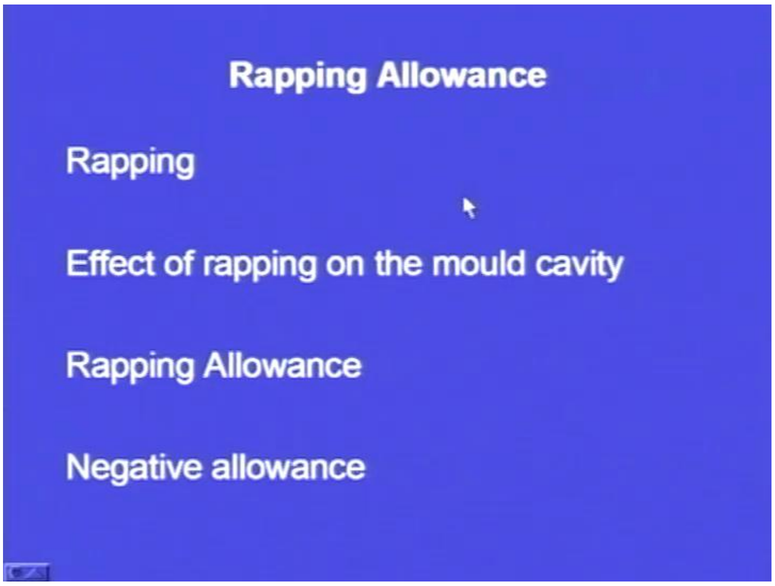

Next one is rapping allowance. What is this rapping? We have already seen that we use the pattern, which is the replica of the casting which we are going to manufacture. This pattern we will place inside the molding box, we will ram the molding sand, we will compact the molding sand and after compaction is over, we have to withdraw the pattern. For withdrawing the pattern, we have to rap the pattern. Rapping means shaking gently left side and right side will be shaking.

What happens when we rap the patterns or when we shake the pattern? What is the effect of rapping on the mould cavity? The mould cavity will become little bigger. So, if you want the casting of a particular size and if we do not consider this rapping effect, and if we make the pattern size exactly same as that of the casting, what happens after withdrawal of the pattern is the cavity is slightly bigger when we pour the molten metal. Yes we have already given shrinkage allowance, we have already given machining allowance, and because of this rapping the cavity has slightly become bigger and the casting is taken out its size is much bigger. To bring it to the required size, we have to do more machining. For that we have to put more efforts and this cost more. So, that is the effect of rapping.

So, we have to design the pattern in such a way that this rapping effect will be minimized. What we have to do to minimize this effect? We have to give the negative allowance means if we want a particular size casting, not that we will make the casting, not that we make the pattern exactly of the same size as that of the casting, but we will make the size of the pattern little smaller than the actual size of the casting. When we make the pattern size little smaller, then the casting size when we do this rapping, then it becomes little bigger than the effect will be nullified. So, this rapping allowance is the negative allowance. How much it should be and it is done in the shop floor and the people who are working in the molding shop by experience, they use to do this and they use to take care of this rapping effect. Now, let us see the types of patterns.

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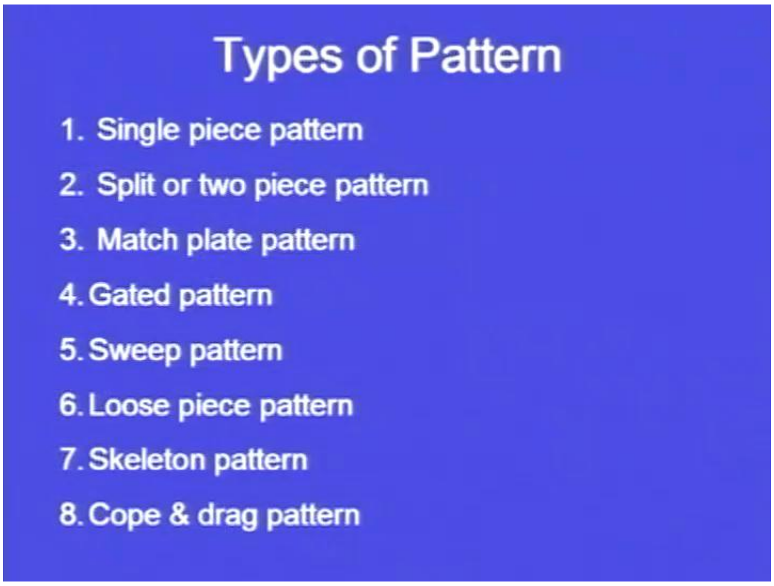

There are several types of patterns, and we will see some important types of patterns. One is single piece pattern, another one is split or two piece pattern, third one is match plate pattern, fourth one is gated pattern, fifth one is sweep pattern, sixth one is loose piece pattern, seventh one is skeleton pattern, eighth one is cope and drag pattern. Let us study this in detail.

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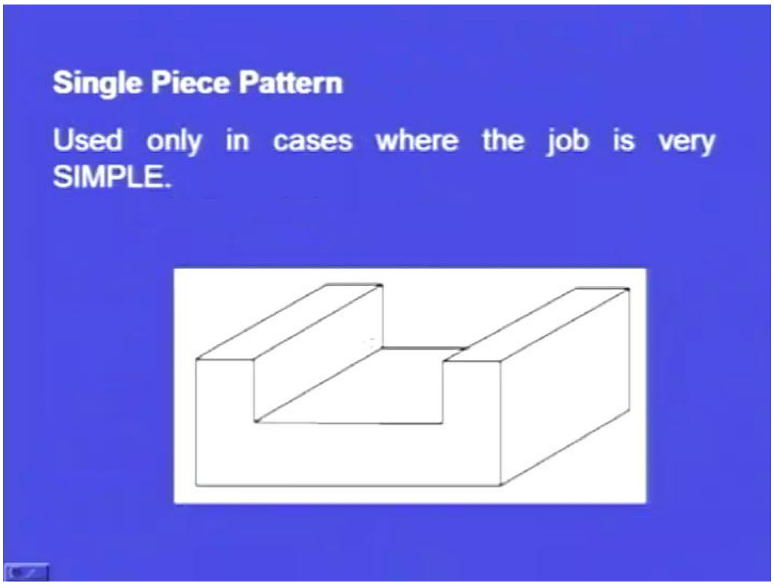

Single piece pattern: So, suppose this is the geometry or shape of the casting to be obtain, so the pattern will be like this. What is the shape of the casting is very simple. So, here we make only one piece. So, this will be molded in the drag box. Drag box means the lower molding flasks. In the lower molding flask, we will compact the pattern and we will get the required shape, required cavity and we pour the molten metal. So, this single piece pattern is used where the job is very simple.

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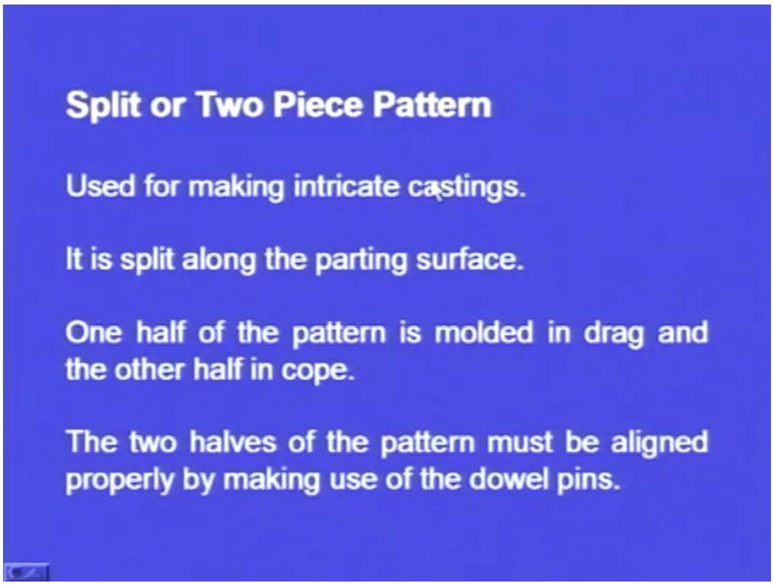

Next one split or two piece pattern. This split or two piece patterns is used when we are making castings of intricate shape. So, the pattern is split along the parting surface. It means in the middle, it will be split into two-halves. One half of the pattern will be molded in the drag box, and the other half of the pattern will be molded in the cope box. Then, these two molding boxes will be clamped carefully, so that they will be properly aligned. Then, of course we will make the provision for sprue runner and gating system and then, we pour the molten metal and I will show you an example.

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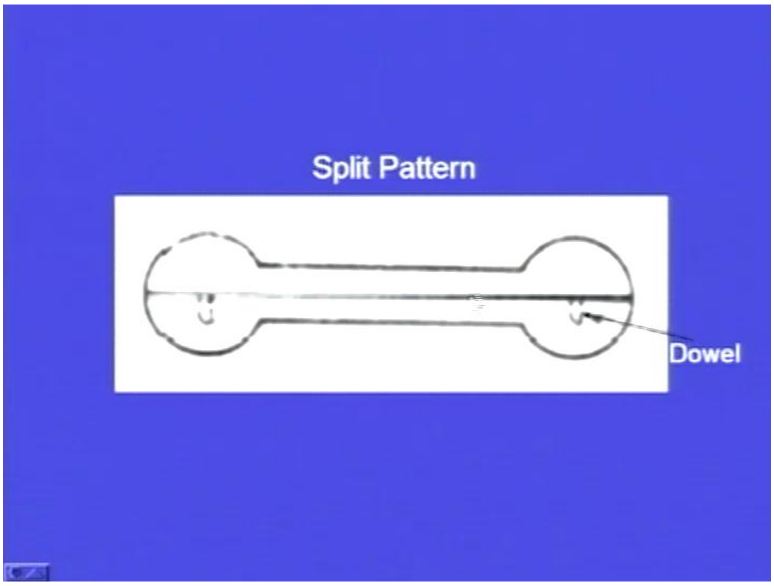

So, this is the split phase pattern. For example, this is the pattern required when we need to manufacture a dumbbell. So, this is the pattern the pattern. So, the pattern is split into two pieces, upper half and lower half and there will be one dowel pin will be there for the upper half, and there will be hole for the bottom one, lower one. The pin will have to rest in the hole and then, they will be properly aligned. So, this split pattern is used when integrate shapes are to be manufactured.

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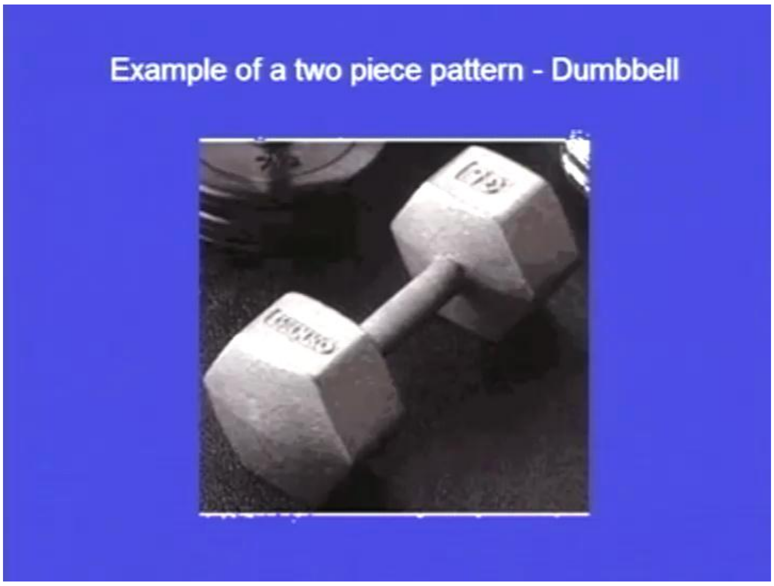

So, this is the dumbbell. This dumbbell is manufactured by casting and for this purpose, a split pattern has been used.

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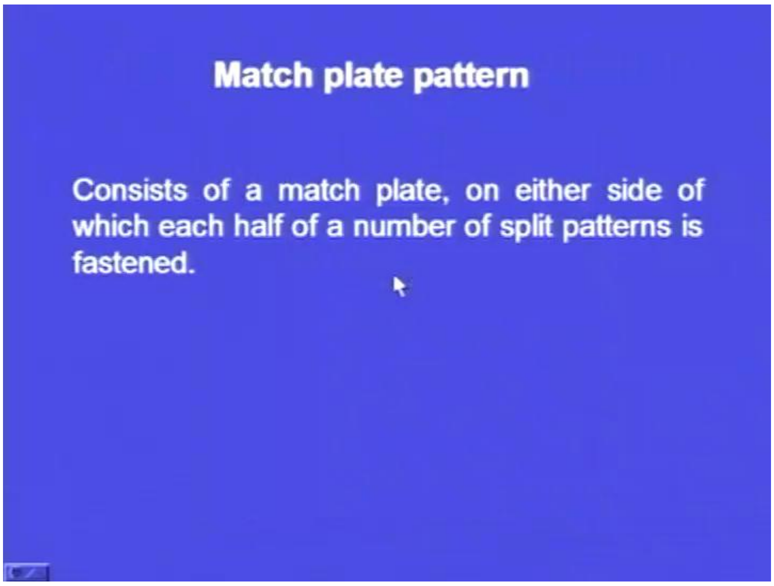

Next one is match plate pattern, and this match plate pattern consists of a match plate and like a split pattern, one half of the pattern will be clamped on upper side and other half of the pattern will be clamped on the bottom side. Not only one pattern, we can use more patterns and we can clamp them. One half on the upper side, and the other half of the bottom side we can clamp, and the upper half and the lower half will be clamped to a plate which we call it as match plate. So, this is the match plate.

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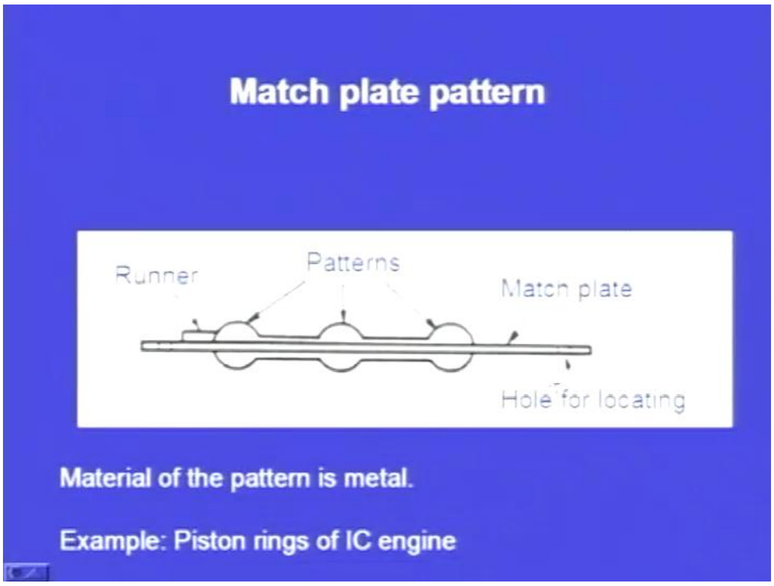

This one is the match plate and this is one pattern, this is one pattern, and this is one pattern. So, here we can see that patterns are already split. One half is clamped on the upper side, and other half is clamped on the lower side. Here also one half is clamped on the upper side, and the other half is clamped at the lower side here also. Now, what happens, initially we take the drag box and we place the molding sand and then, we place this match plate and it will be compacted. Then, over this we place the cope. Again we place the sand, and that sand will be compacted and while doing we have to take care that drag box and cope box are properly aligned. Otherwise, after the withdrawal of the pattern, there will be misalignment.

So, for that dowel pins will be there, so that they will be properly aligned and material of this pattern, match plate pattern is metal wood is not possible. Match plate pattern is always made up of metal and examples are piston rings of IC engines. They are made by match plate pattern.

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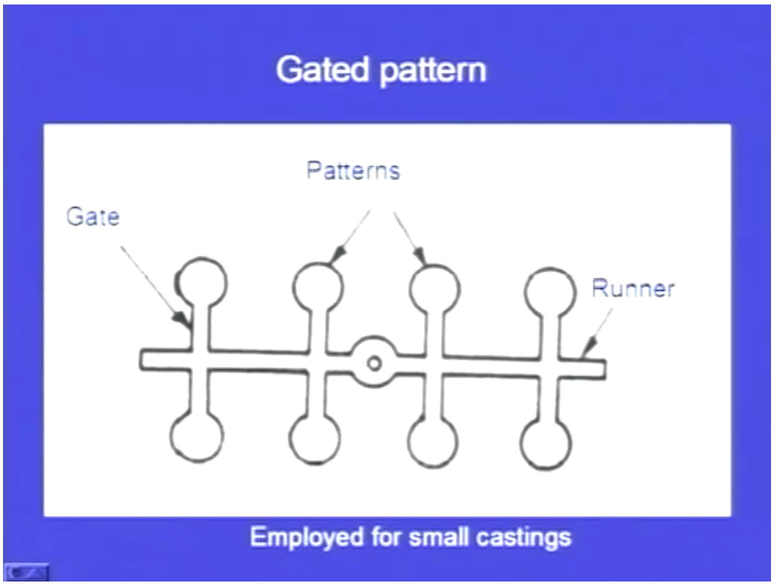

Next one is gated pattern. Here we can see so many patterns. Here is one pattern; here is one pattern, one pattern, one pattern, one pattern, one pattern, one pattern, one pattern, one pattern. All these patterns are connected. So, this is the runner. So, this is the gate, this is the gate, this is the gate. So, they are all connected and there is one common sprue. Here is one sprue through which we pour the molten metal. So, this is used for small castings.

So, for small casting whenever we want to make a small casting, for each casting if we have to make a mould that mould itself takes a lot of time, and at a time if we have to make some 20 small castings, 20 moulds, we have to prepare, it takes lot of time. Instead all these 20 patterns will be placed, they will be joined like this and we will design a gated pattern, and all this, the entire system can be molded at a time, so that the molding time will be minimized and there is another advantage of this gated pattern. Whenever we are making a mould, along with the mould we have to make a provision for sprue, for raiser and for the gating system.

Suppose, if we are making a casting of 1 kg, the cavity, the molten metal which is flowing into the cavity will be about 1 kg and the molten metal which will be occupying in this sprue which will be occupying in the runner, which will be occupying in the gating system that will be about 0.25 kg. So, if we have to make a 1 kg casting, we have to pour molten metal about 0.25 kg. So, that is the casting, yield casting.

Yield is the ratio of the weight of the casting divided by the weight of the poured metal into 100, so that in general the casting yield comes in between 70 percent to 80 percent, and for each casting if we have to design the gating system, designing that gating system takes time and when we pour the molten metal, the molten metal is occupied in the sprue and runner and the gating system in each case, there is a wastage of the metal. There is a loss of casting yield.

On the other hand, when we join this pattern like this when we make the gated pattern, when there is a common sprue, when there is a common runner, the molten metal which is wasted for the runner and for the gate is less. The molten metal, which is wasted for raiser is less. This in turn increases the casting yield; this in turn reduces the cost of the process. So, this is used for small casting. This cannot be used for bigger casting.

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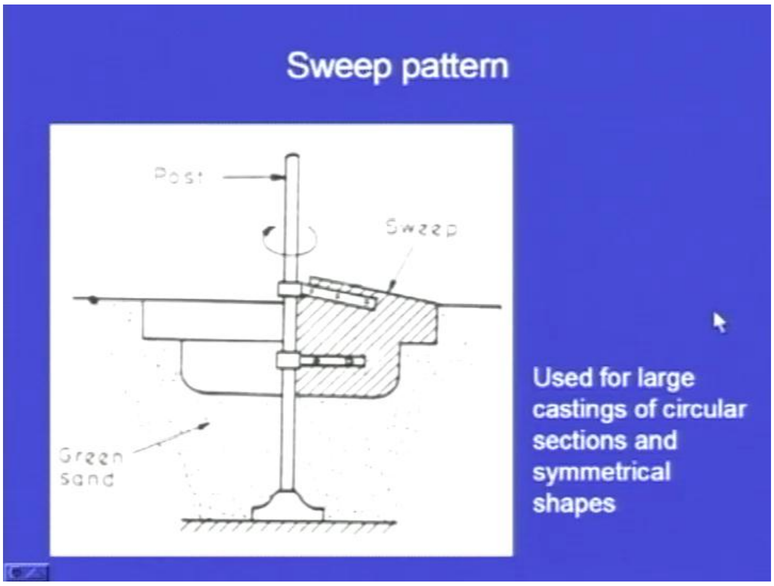

Next one is sweep pattern. This is very important pattern and very interesting pattern too. What is the principle lying behind these sweep patterns? This is a two-dimensional pattern. All the patterns are of three-dimensions, but this is a two-dimensional pattern. Here we can say this is the shape of a casting, a three-dimensional shape which is symmetrical. So, instead of using a solid pattern, what we can do is, we can use a plate. The plate, this hatched one is the plate just two-dimensional plate like this one. This one is the plate is clamped to a post, central post and it is kept inside the molding box and this is the green sand. Green sand means molding sand with moisture and we insert this sweep, we call this board as sweep.

So, we slowly start rotating about this post. We rotate as it is rotating. It removes the material, it removes the material slowly. We will increase the depth and it removes the material. Finally the entire sweep is inserted into the molding sand. Finally, the required cavity which is identical to the shape of the component, which we required is created and then, we withdraw the sweep. That is the sweep pattern withdraw pattern. Even withdraw this post whatever is done so far is done in the drag box.

Now, we will place the cope box over this. Then, we will make a provision for sprue, we make a provision for gating system, we will make a provision for raiser and then, we pour the molten metal and the required casting is obtained, but what happens here is the pattern which we have used is not a three-dimensional. It is two-dimensional pattern. So, this has got certain advantages in the sense we do not have to spend so much time for making the pattern. Especially, say when the casting has got some complex surface say symmetric and complex surface that time making. The pattern requires a lot of time. It requires lot of efforts, but here we are not making three-dimensional solid pattern. We are making only a two-dimensional sweep pattern. These are just a sweep. By rotating this, we are getting the required shape.

So, we are not spending so much time for making the pattern. We are not spending so much of time for making the mould. We are not spending so much money for making the pattern. So, these are the advantages of the sweep pattern, but it has got certain limitations. This can be used only for circular jobs or symmetrical jobs, where the jobs have some circular cross-section or some symmetrical cross-section. In such cases, only we can use otherwise it is not possible to incorporate the sweep pattern.

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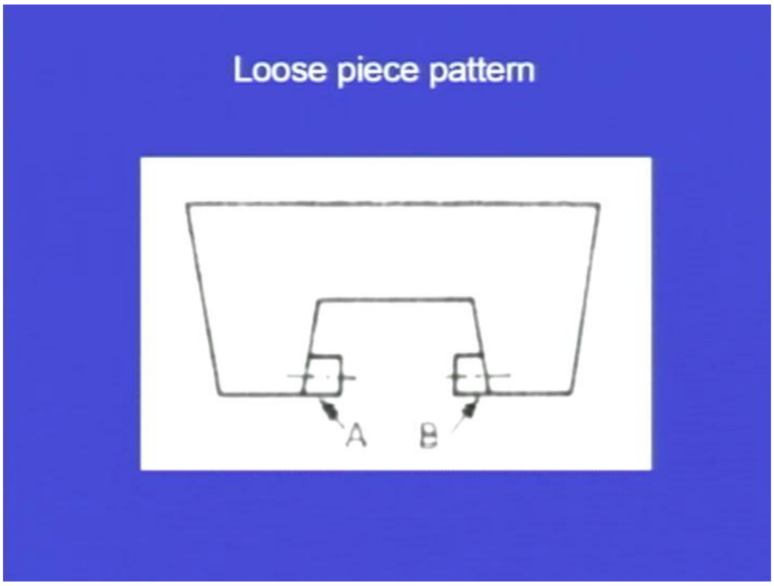

Next one is loose piece pattern. Now, let us consider a casting of this shape. It has got a section like this and here, there is a projection and here, there is a projection. Now, what kind of pattern can be used? Certainly it cannot be a single piece pattern and to make it split pattern is also difficult. Then how to make the mould for making this casting? So, here what we do is, here there are two projections A and B. What we do is, this A is separated, and this B is also separated. Whenever required, they can be placed nearer to the main pattern. This also can be placed nearer to the main pattern.

This whole system, the big pattern and two loose pieces will be molded in the drag box and this will be molded upside down means the projections A and B will be coming upward in the drag box, and after compacting of the sand is over, after molding is over, then we have to withdraw. Initially we withdraw this A. It is so easy that there is a tapper. So, very easily we can withdraw this A. Similarly, B also very easily we can withdraw from the drag box. We will be withdrawing from up, from top. This will be molded upside down and then, we will withdraw this pattern. So, this loose piece pattern has got certain advantages, where some loose pieces have to be molded. That time we use loose piece pattern.

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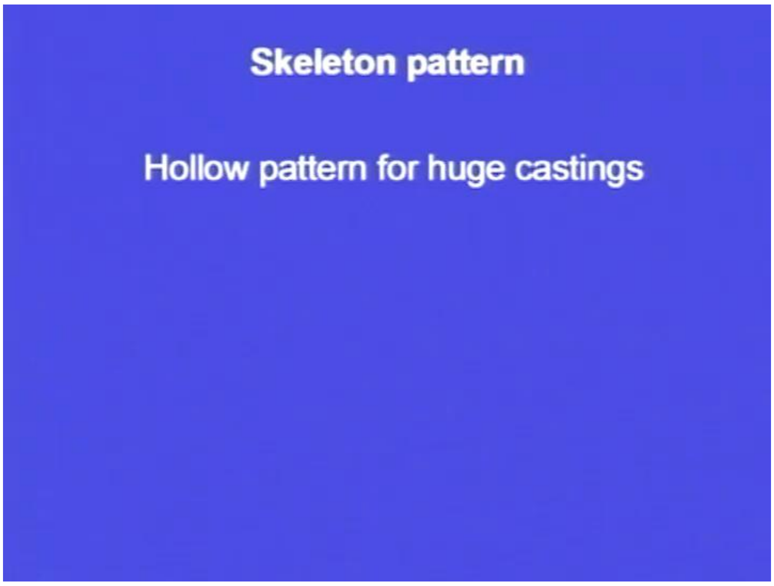

Next one is skeleton pattern. This skeleton pattern is used for making very huge castings. Suppose big turbine impellers are to be manufactured. These turbine impellers are very big. In such times, we have to use skeleton pattern means when the pattern requires lot of pattern material, instead of using the solid pattern, we can use hollow pattern. So, that is the skeleton pattern.

What we require? We have to make the outer surface of the mould cavity. For making the outer surface of the mould cavity whether we use solid pattern or hollow pattern, it does not matter. So, we use skeleton pattern which is the hollow pattern in which we save the pattern material. So, this is used only for huge castings. This cannot be used for small castings and medium size castings.

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Next one is cope and drag patterns. So, this is again used for making big castings. It is similar to split pattern, but in the case of the split pattern, the cope off and the drag off of the patterns are compacted in the cope box and drag box respectively, and the gating system that is the runner and the in gates, they are designed, they are molded in the drag box, but here even the runner and the in gates, they will be molded equally in the cope and drag. So, this is the unique distinction of the cope and drag patterns, where the size of the molding box is very big, where it cannot be done one by one person. So, it is done at different places. So, half of the pattern will be done will be molded at one place. Even half of the gating system and the other half of the pattern and the other half of the gating system will be molded at another place by another person. So, this is used for big castings.

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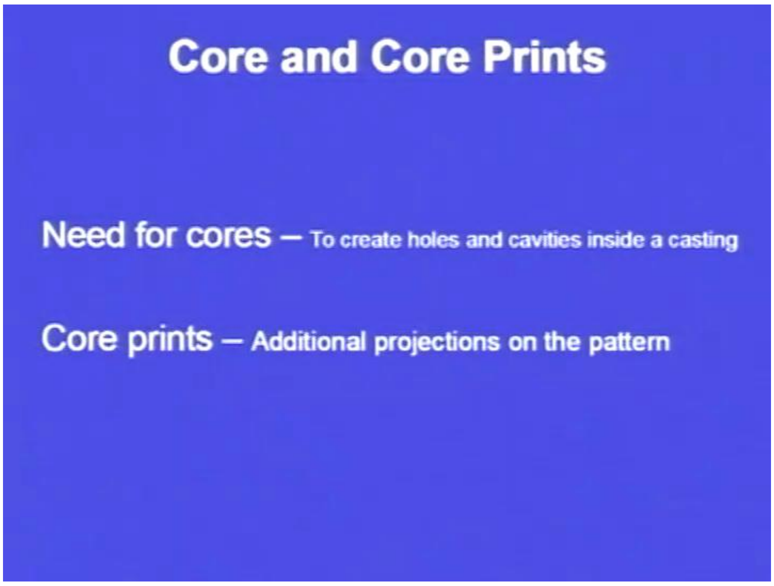

Now, let us come to this core and core prints. Need for cores: Why we have to use the cores to create holes and cavities inside a casting? Whenever we have to make a casting with some holes or some cavities, it is that time we have to use cores and there is we can see another term core print. Yes, when we make a core, there should be some place in the mould, so that the core will be resting. That place has to be created. To create that place where the core will be resting, we use core prints.

So, core prints are the additional projections on the pattern. On the sides of the pattern, there will be some projections. When we put the pattern inside the molding box and when we put the molding sand, and when we compact it, the projections outside the projections, also the mould sand is rammed and when we withdraw the pattern, even the projections will create some hole, some space. In that space the cores will be resting.

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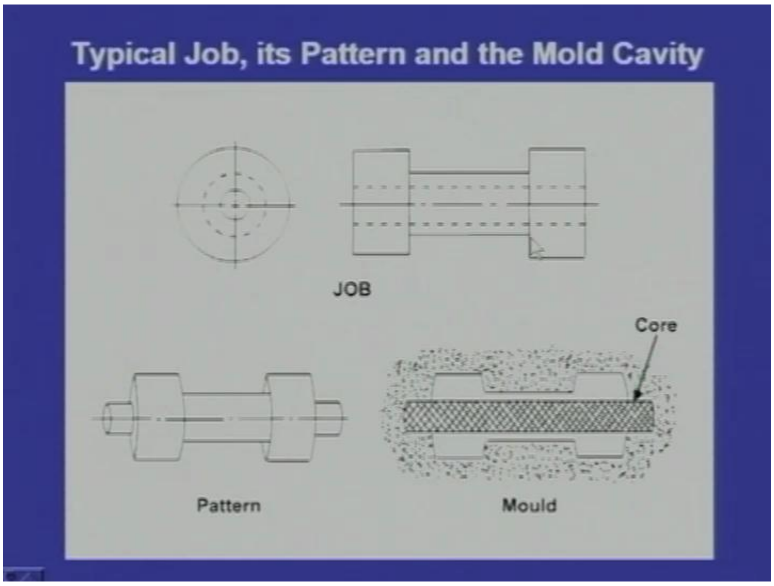

Let us see this is the component to be manufactured and this is the pattern. So, the pattern will have this shape and this is the core print. Actually to make this kind of shape, this portion is not required, this projection is not required even, right, but why we have kept this projection. With this projection, we are creating a place where the core will be resting. So, this is the core made up of sand after cavity is created. We are inserting this core into the mould cavity and to place this core, there is a place here where we are supporting the core here, and here. How that place is created that seat? How that seat is created? It is because of these projections. If these projections are not there, this place would not have been there. Then, it is impossible to support the core. So, by using core prints which are the extra projections, we create the seat where the core can rest. So, that is the purpose of core and core prints.

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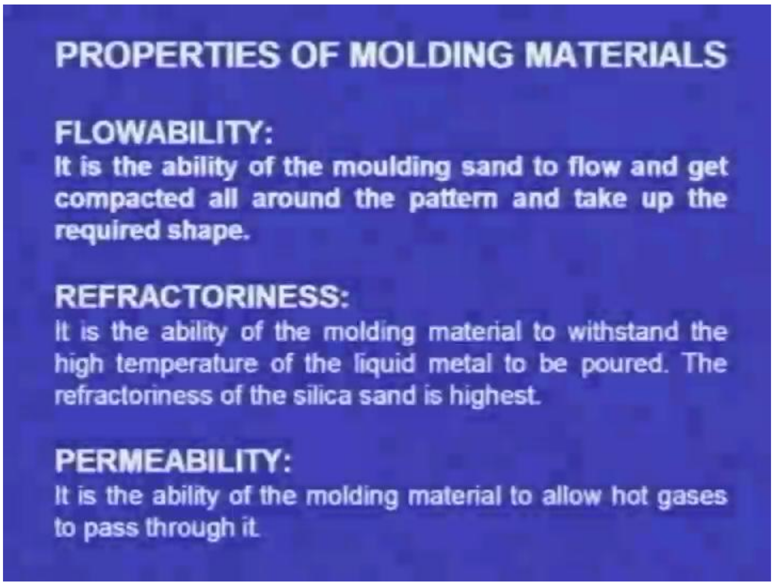

Now, let us see properties of molding materials. We have seen the different allowances, different types of patterns. Now, let us see the properties of molding materials. Molding materials means the molding sand and we add clay and moisture. What kind of properties it should posses? There are certain properties which the molding sand is expected to posses. One is flow ability. What does it mean? It is the ability of the molding sand to flow and get all the details of the pattern exactly occupied, and get all the details of the pattern, so that when we pour the molten metal into the cavity, it gives the exact dimensions, exact details.

There may be some sands, which if you compact it would not take all the details. Only it will be stick outside, but it would not be sticking to the interior details. At such times, it is difficult to get the shape of the casting, but good molding sand should have the flow ability. It is the ability of the molding sand to flow and get compacted all around the pattern and to take up the required shape.

Next one is refractoriness. What is this refractoriness? It is the ability of the molding sand to withstand high temperature when we make the mould. After making the mould, after withdrawing the pattern, we pour the molten metal. The molten metal is at very high temperature. If we are making an aluminum casting, it is heated about 700 degree centigrade. If we are making a casting of cast iron, it is heated about 1400 degree centigrade. At such high temperatures, there is every chance the sand may fail the molding. It may no longer retain the shape, but good molding sand should retain the shape and retain its strength, and it should resist the high temperature. That is the refractoriness. It is the ability of the molding material to withstand the high temperature of the liquid metal to pour. The refractoriness of the silica sand is highest.

Next one is permeability. This is another important property. When we pour the molten metal into the mould, it is going and keeping in touch with the molding sand. The molding sand contains moisture. When the molding sand goes on in contact with the molding sand, the moisture turn into vapor and some other hot gases are produced. This vapor and hot gases have to be sent out. They should escape out of the mould. If they stay inside the mould cavity, they will result in blow holes or pin porosity or other defects. Good molding sand should have the good permeability. It means though it is compacted tightly, still when the molten metal is poured, it should allow the hot gases to pass through it even in the compacted stage, even in the compacted condition. That is the permeability. It is the ability of the molding material to allow hot gases to pass through it.

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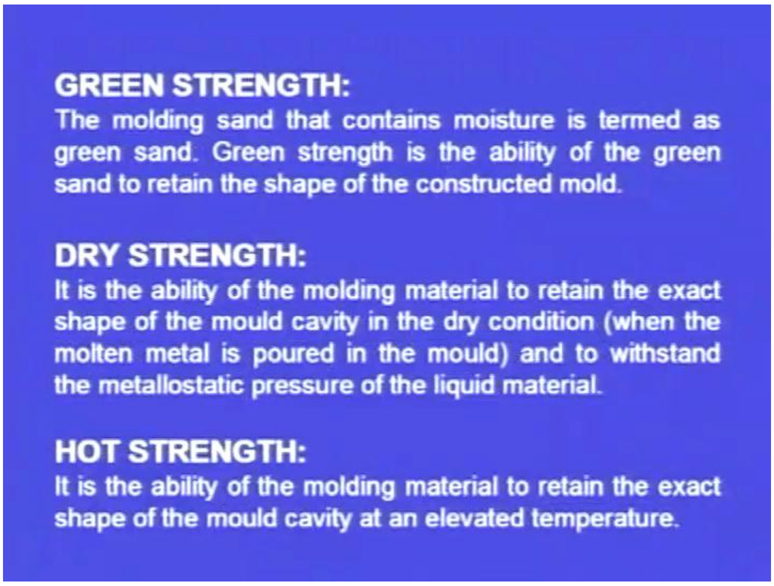

Next is green strength. Green strength means, green means the presence of moisture. Yes good molding sand should have green strength. It means it should have strength when the moisture is present. The molding sand that contains moisture is termed as green sand.

Green strength is the ability of the green sand to retain the shape of the constructed mould because moisture is present. It should not lose its strength.

So, good molding sand should have good green strength. Let us see the dry strength. Dry strength means in the absence of moisture, yes when immediately when we pour the molten metal, the moisture will be evaporating. It is possible some sands may have good green strength, but the moment the moisture is evaporated, they may lose the strength, but good molding sand should have good dry strength means even in the absence of the moisture, even when the moisture is evaporated due to the pouring of the molten metal, it should have good strength. It should retain the shape of the cavity; it should retain the force created due to the pouring of the molten metal. That is the strength. That is the dry strength.

Next one is hot strength. It is ability of the molding material to retain the exact shape of the mould cavity at an elevated temperature. Dry strength is the strength just in the absence of moisture whereas, hot strength is that strength where it posses the strength when the mould is heated to an elevated temperature. Now, initially the mould is in green state. There is moisture in it. It has strength and then, we pour the molten metal. The moisture is evaporated.

So, it has got dry strength, but that is not enough. It should posses hot strength means after drying of the moisture as we keep pouring the molten metal, the mould is heated to much higher temperature because the molten metal temperature is about 1500 degree centigrade. If we are making a cast, iron casting, the mould is heated to much high temperature. At much high temperature, the mould should not lose its strength. It should retain the shape. So, that is the hot strength. It is the ability of the molding material to retain the exact shape of the mould cavity at an elevated temperature.

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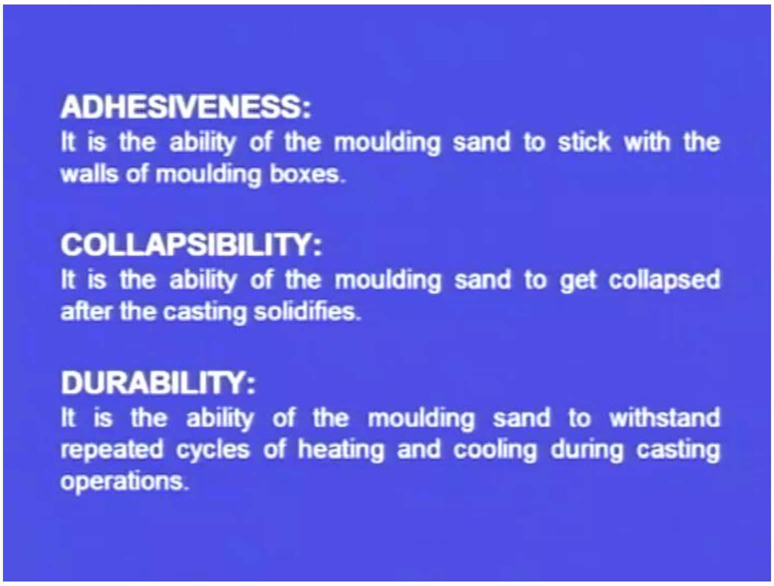

Next is adhesiveness. It is the ability of the molding sand to stick with the walls of molding boxes. It is important that the molding sand should be sticking to the molding boxes, otherwise when the mould is ready, we will be carrying the molded boxes. It is possible that the mould may slip out of the molding box and it may fall down, but that should not happen. After compaction is over, the molding sand should be sticking to the walls of the molding box. It is the property of the adhesiveness. Good molding sand should have good adhesiveness. It means it should be sticking to the walls of the molding box.

Next one is collapsibility. It is the ability of the molding sand to get collapsed after the casting solidifies. Yes, we pour the molten metal and after sometime, the molten metal solidifies. After solidification is over, we have to take the casting out. Then, we start breaking the molding sand at that time it should allow us, so that we can break the molding sand easily and if it is resisting us to break the molding sand, then we have to put more efforts. Then, if we have to put more efforts, we have to use more labor. We have to spend more money that increases the cost of the process. Yes good molding sand should be easily collapsible after solidification is over. That is the collapsibility.

Next one is the durability. So, when we pour the molten metal after solidification, we withdraw we break the molding sand, and we take the casting outside. Then, the sand which we have broken, we cannot discard. We have to reuse it. This sand again and again we will be using for making several moulds and making for several castings. So, good molding sand should be in a position so that we can use it again and again. So, that is the durability.

So, it is the ability of the molding sand to withstand repeated cycle of heating and cooling during casting operations. Yes, during the casting operations, it is subjected to heating and cooling. So, good molding sand should be able to withstand this repeated cycles of heating and cooling.

So, in this episode, we have seen different pattern allowances, shrinkage allowance, the machining allowance, draft allowance and camber allowance. We have also seen different types of patterns. Single piece pattern, sweep piece pattern, match plate pattern, gated pattern skeleton, pattern cope and drag pattern. We have also seen the different properties of the molding sand. What are the ideal properties which good molding sand should posses we have seen and in the next episode, we will be seeing the mould sand composition, that we will be seeing in the next episode.

Thank you.