Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 2

Module- 13

by
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Hello and welcome to this manufacturing process technology part 1, Module 13.

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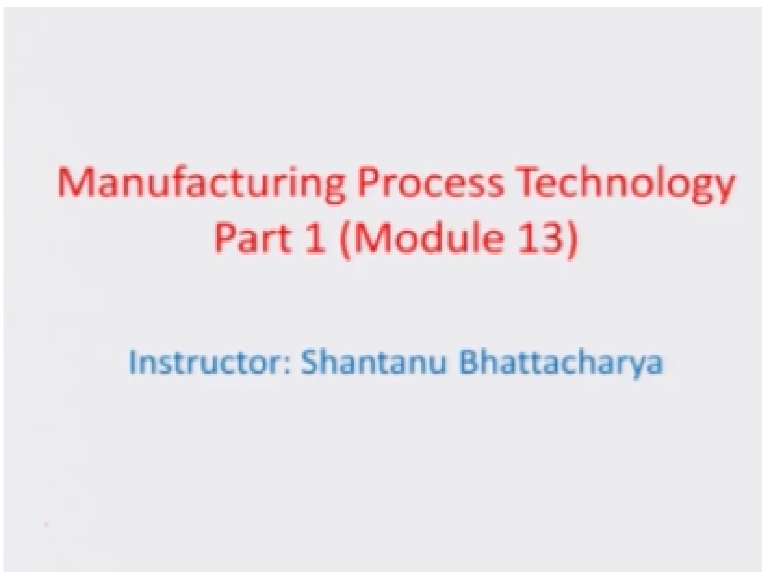

We have finished the engineering materials section and from today onwards we are going to discuss the first process which is one of the oldest process in the history of manufacturing which is called casting and so if we look at you know casting really it is one of the first steps of manufacturing.

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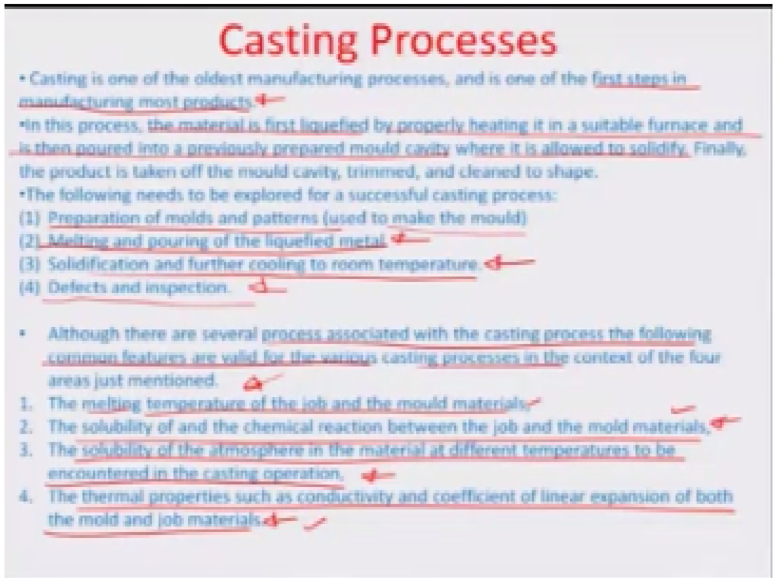

That can be followed in most of the products because the reason being that as I told you this is one of the primary process which will give the overall shape or size to the product beyond which you know you can do a lot of suiting of the products to engineering assemblies by many secondary process so this is one of the primary process of manufacturing so in this process the material is first liquefied as you know by properly heating it in a suitable furnace and then poured into a previous sleep prepared mold cavity.

Where it is allowed to solidified so therefore the important aspects of the liquid metal is first formulated and there is a question of liquid metal vis-à-vis the liquids alloying which happens because of the dissolution of a second phase in that and then it is a heated in a suitable Furness which actually takes a you know it is own or it sorry imposes it is own effects by the mode of heating so for example if the Furnace is induction based than the heating is completely homogenous throughout the material.

But if a Furnace is something where there is a you know wall based heating or the heating happens through the walls there is going to be always temperature gradients which are going to be there so when the product is finally taken off then you can further process it, trim it you know clean do the concern shape something you know which is more suitable for engineering some assemblies etc. And so the following needs to be explored for a successful casting process one is the preparation of molds and patterns.

Which are used to make the mold, mold basically is the housing which would hold the liquid metal till solidifications, so therefore you need to be able to prepare it with the refractive material normally sand molds greens and molds are very commonly available, because sand is refractive material which can withstand high temperature and still be strong you know so that is why sand is mostly, used and then also you have to melt and pore the liquid metal so there is an lot which sort of comes into ten way this.

Because you are essentially passing it through a channel which is also known as the metal and the metal runner and there is a gate which goes or which throws of the metal in to the cavity where the filling action starts taking place and so doing all this process there is always heat transfer because remember the mold is always at a lower temperature than the super hot liquid metal which is flowing through it and therefore there is always a possibility of solidification before entering.

And so the process should be defined or designed in the manner so that liquid metal really enters before the solidification happens and then you have to give heat to finally the solidification and for the cooling to room temperature and one of the reasons why this is important is that you know we assume that most of the metal goes into the mold from the gate region as liquid metal and so once the liquid is now station inside the mold and you have obtained a indication from the other side, which is also known as the riser side.

To the metal as fully full the cavity there is going to be heat transfer of this metal to the casting walls. casting where a metal mold is what is basically used for finding of the metal so there the heat transfer rate should really define how the crystal growth would take place and in fact that also define what is the surface hardness of the casting of vis-a-vis the hardness inside or even other many other properties, like strength ,overall ductility, yield point etc. So therefore it is very important aspect to be considered while dealing with casting.

Solidification, cooling so and then obviously once the casting is prepared then you have obviously it is not free of defect, so you have to have the method for defect inspection so you first understand some of the defects and the try to inspect and remove most of the time nondestructively so that the casting material can be used further processing, so although there are several process associated with casting, the following casting process in context of the four areas just mention one is the melting temperature of the job and the mold material.

This is very critical because it should not happen in the mold starts melting away and joins the liquid metal because of the super heat that the material is in, so you have to able to have a refractory in any event which does not have it is own contribution by melting into the cast okay that is how the mold would be, molds materials would be the solubility of an the chemical reaction between the job and the mold materials also is a very, very critical aspect because obviously there is going to be out gassing which happens from mold or even at sometimes you know if supposing there is some organic which cannot with stand this item pressure this can be entrapped is a vapor pocket within the casting material.

And so in some cases these may be very harmful because primarily it may react and make the casting very brittle like hydrogen solubility a major issue in castings because excess hydrogen made the casting very brittle, so these are some of the issues there should not be a chemical reaction which formulates a hydrate or nitrate or some kind of an oxide state which you know changes the property of the material obviously this solubility of the atmosphere in the material at different temperature to be encountered in the casting operation is also major issue to be consider because atmosphere itself has these gases and if there is possibility of solublising the gases within the liquid metal then it may mean a lot of property changes because of this solubility.

And the thermal property is such as conductivity and coefficient of linear expansion of both the mold and job materials which also are very important because you have to have engineering dimensional okay did to some material which is being cast and so therefore you must consider allowances which are because of these shrinkage phenomena obviously metal port in hot state is going to cool of which is going to make the volume smaller and then obviously it is also going to cool down further from this solidification point of the room temperature which is going to be linearly contracting the material further.

So therefore you have to have sufficient allowances so that what you are getting is the final dimension and the final dimension to be close to what the plan dimension is or the engineering dimension is of the particular castings so you always need to give these allowances in the casting or in the mold design process. So that ultimately what you get is what you are looking for okay. so that is how you can say that you know castings can be sort of defined.

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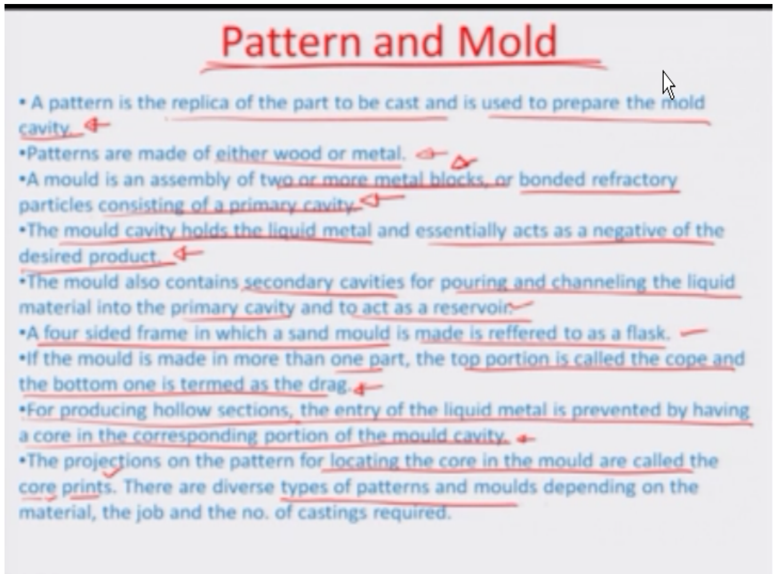

So let us talk about now patterns and molds these are most important pattern is something which is needed to formulate the mold okay. So a pattern is a replica of the part to be cast it is use to prepare the mold cavity. So obviously if we are talking about as let us say you know sphere of metal that we are going to roll out for casting process so the mold for that should be spherical cavity in to which the metal would go and then solidify and so be sphere.

So therefore the pattern is exactly the replica of the parts and the mold is exactly the negative of the part or the replica that we are talking about. So patterns can either be made of wood or metal a mold is an assembly of two or more metal blocks obviously the mold contains the material which is used for making the mold cavity and this materials is normally bonded refractory which consist of the primary cavity where the metal should be filled and the mold assemble typically is made in to two or more parts because you want to be able to pattern the mold and extract the pattern out.

So typically the practice that is followed is that make a for a spherical patterns for example or you know for a very large casting let us say casting of a wheel, you should have a half and half patterns you know, so therefore there is rapper half of the mold and lower half of the mold lower half is normally known as drag the upper half is the cope and then these two are actually having a parting line but the pattern is kept in a manner so that you have this split pattern particularly that we are talking about you have half inside the lower portion and half the upper portion.

So if we have let us say put this material inside the refractive material and before that you have put the mold inside and then you have compressed the refractive material like sand and then when you remove the upper half and the lower half you can extract the pattern away and once the pattern is extracted and you close the upper half back over the lower half you have a cavity there. So that is how you basically making the mold, so therefore it is an assembly of two or more metal blocks as been rightly indicated here.

The mold cavity holds the liquid metal and essentially acts a negative a desire product as I have already discussed mold also contains secondary cavities for pouring channeling etc of the liquid metal in to the primary cavity and this is and also sometimes there is a cavity which acts as a reservoir for flowing the metal. So therefore you have the whole you know pouring basin and then a runner and then the riser on the other side which are cavities which otherwise would not be needed if there was no requirement of pouring the metals.

So this is a sort of a metal channel you can say liquid metal channel, so this is also a secondary cavity obviously this would have solidified and as to be removed once the metal piece is extracted because the metal which is going to stay inside that cavity is also want to suffer heat law and get solidified. So there is a trimming action which has to be performed on the casting almost always after extraction so that these component so these parts that is the raiser side or the runner side as to be totally chopped off you know and that is how you recover the whole casting.

So it is obviously a wastage of material because you want to design the riser and the runner in manner so that the wastages very little but still there is going to be wastage of material during this pouring process. A four sided frame in which sand mold is made is refer to normally as a flask, so the mold is made off more than one part the top portion is call the cope and the bottom is termed as the drag as I think I had already entered told you.

And for production of hollow sections the entry of the liquid metal is prevented by having a core in the corresponding portion of the mold cavity. So supposing you wanted to make a hollow object so obviously you would like that the metal does not go in to that part of the mold where they needs to be hollow, so you have to have something called a core and for supporting them you may have to need something which are like legs where the core can be standing on which are known as core prints which are within the mold so you have a small central core and some legs to hold that core in place so that you know when the metal comes around it basically goes around and you know it is not able to go into that region which has the core so you can exactly you know make the design in the manner.

So that the core can be extracted later on . so that is how would this kind of hollow castings okay so core is very important the projection of the pattern for casting the core and the molder called core prints as I have just mentioned it is like legs which are holding the core and place there are diverse types of patterns and molds depending on the material the job and number of castings which are needed.

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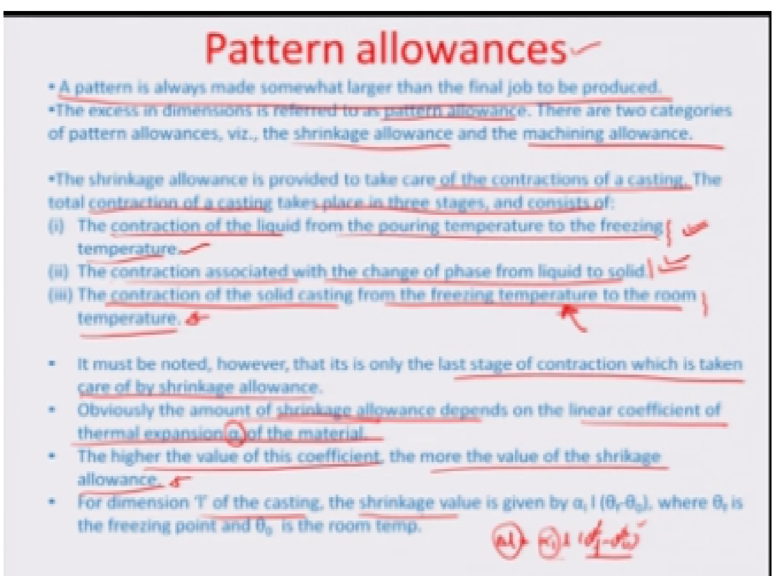

And the first important consideration which one has for designing these patterns are pattern allowances. the pattern is always made one what larger than the final job that is to be produced obviously because the excess in dimensions which are there because of this rapid cooling and shrinking action of the material is not an ideal you know in an ideal case obviously because of the thermal gradient or because of a let change in temperature that metal is going to be shrinking so these are referred to as pattern allowances.

So such excess dimensions are always called pattern allowances there are two categories of pattern allowances you have shrinkage allowances and then you have machining allowances so obviously a shrinkage allowances I told is more because of thermal issues associated with the sudden you know sudden decrease in the temperature of the metallic system.

But you know ultimately this casting or this primary shape has to be fitted into a general engineering assembly and it needs to be compatible with the tolerances or the overall you know a matching with that engineering assembly supposing you making a shaft for example it has to fit into a certain hole so there has to be some tolerances you know there has to be some fits of how the shaft would made with the particular hole in question. And so there are certain machining allowances which always need to be incorporated where such fine machining operations on the casting would ensure that it has to be exacted dimensions and the tolerances that are needed for that casting to participate into an assembly, an engineering assembly.

So there is a shrinkage allowance because of the metallic the property of metals to contract when temperature goes down and then there is a machining allowances which is useful because you want to fit these into assemblies so shrinkage allowances is provided to take care of contraction of casting as I told you the total contraction of casting takes place in three stages so one is the contraction of the liquid from the pouring temperature to the freezing temperature.

You have to understand the pouring temperature is way above the freezing temperature and so therefore there is going to be some kind of contraction of the liquid there is going to be a contraction associated with the change of phase from liquid to solid so obviously the solid would occupy lesser volume than the liquid because you have more into molecular forces binding the atomic system together.

And the contraction of solid casting from the freezing temperature to the room temperature is another aspect where we are talking about the solid face contraction this is the phase change contraction and this particular is the liquid contraction prior of pouring it may be possible that super heat the materials and the pouring temperature and freezing temperature is apart because of that and because of some reasons because you want the metal to be transported in longer runner or longer risers.

You do this intentionally that super heat the material above the liquid fraction point you know of the this is the freezing point so there is going to be a difference in temperature there so that when this temperature changes obviously there is going to be a change in the overall volume of the metal which is in question so it must be noted however there it is only the at stage of the contraction which is taken care by shrinkage allowances.

Because these two stages that is the liquid contraction and the change from liquid to solid the contraction is very, very minor you know and that need not be considered and probably some of this gets cleared off because of machining and the other process which follow the casting processes obviously the amount of shrinkage allowances would depend on the linear coefficient of the thermal expansion of the solid material that is αL once the freezing has happened.

The shrinkage always the major shrinkage always takes place after the freezing process so the higher the value of the coefficient so higher is α the more is the value of the shrinkage allowances and for dimensions L of the casting let say the shrinkage value is given by αL times of $L(\theta_f - \theta_0)$ where θf is a freezing temperature at which the material starts to solidified, θ_0 is the room temperature.

So obviously when the metal as just frozen to still hot and frozen to solid and from there slowly there is cooling to the room temperature. So the amount of the Δl when the change in the length, which happens is actually proportion to the original length and proportion to the difference of temperatures and obviously αl is the thermal coefficient which has to be plugged in. It is constant for a particular material system, so the shrinkage value normally which is given to the casting are.

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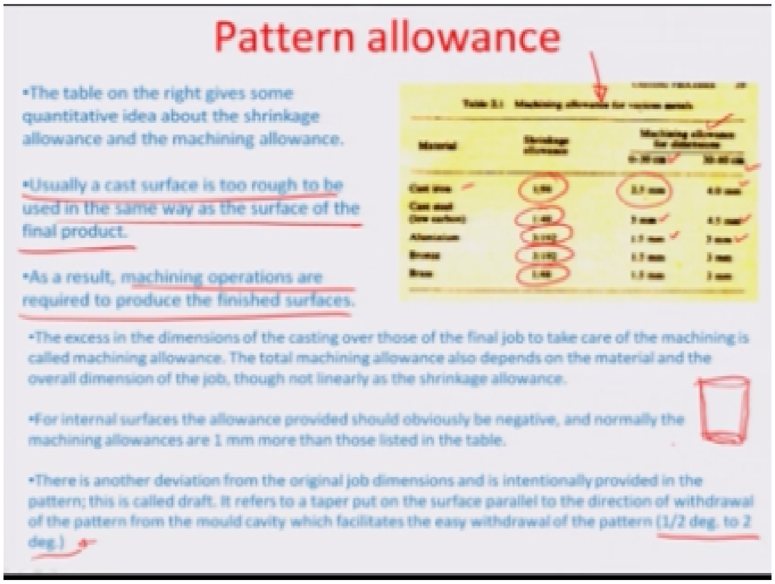

Are recorded here for example in cast iron, shrinkage allowances typically 1/196th and you know for, if you look at the machining allowances side, for the dimension 0 to 37, so these are thumb rules, which people are generated have been running these industries. If you have machine allowances 30m to 60 cm, the for dimension 30 to 60 the machine allowances will be about 4mm, so on so forth.

So similarly you have cast steel, low carbon which as the shrinkage allowances 148th of the actual dimension, which is in question? Bronze 3/192 again and brass 1/48 again and then machine allowances for the dimensions is 3mm, 1.5mm. Similarly 30 to 60 cm for cast iron so on so forth, so that is how some of the thumb rules are defined in terms of what shrinkage allowances and machine allowances will take for various material system in question.

Usually the cast surface is rough to be used in the same way, as surface of the final product, so as the result the machine operations and surface machine operations are needed. I think I have just mentioned about it here and the other more important factor that I want to consider is that, apart from these two allowances, there are other which needs to be provided to facilitate the easy withdraws of the pattern.

So it refers to some kind of taper because obviously if the pattern is straight and it has to be, it has to be removed from a refractive wall as reserves pattern is tapered, taper always gets removed quiet easily. So you must have some taper allowances, normally it is ½ degree to 2 degree which given, so for example fore casting a cylinder, you need not to have the pattern exactly straight but may be a little bit of ½ degree to 2 degree taper, so that is easy to remove this pattern out, while you are making the whole.

So these are the normally some of the thumb rules used for doing pattern designing. So we will talk about more in the next module about how further we designed the mould? how further we designed runner and riser which are two most important things to ensure that the metals flows well and flows into the cavity before it freezes and also risers at other side, to indicate that the cavity is full. So thank you as if now, thanks.

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