Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 1

Module- 14

by
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Hello and welcome to this manufacturing process technology part 1, Module 14.

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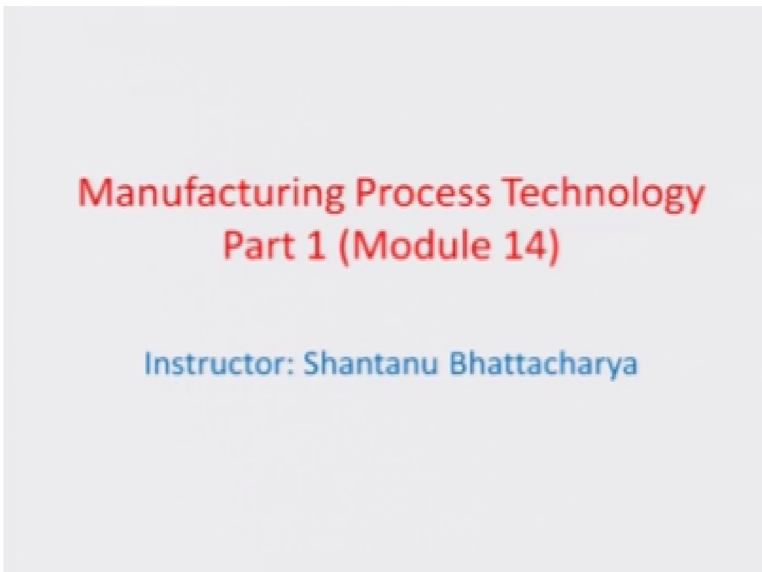

Just quick recap of the last module we were talking about shrinkage allowance and machining allowance and casting process and we saw that you know the shrinkage allowance primarily because the casting needs to lower its temperature from the freezing temperature at which it is just solidified all the way to the room temperature there is going to be coefficient of linear contraction because so it is a metal and so therefore normally an allowance is given to the pattern.

So that eventually after the contraction the casting can be of the size which is desirable and also I shared with table where we talked about the various materials the various shrinkage allowances and the more important machining allowance which is used because the casting as for now get into the assembly into a certain assembled machine and for that it needs to have the respective tolerance on the surface.

So today we will be looking into a slightly different aspect which is about what are the different kind classifications of the patterns which can be made in casting processes.

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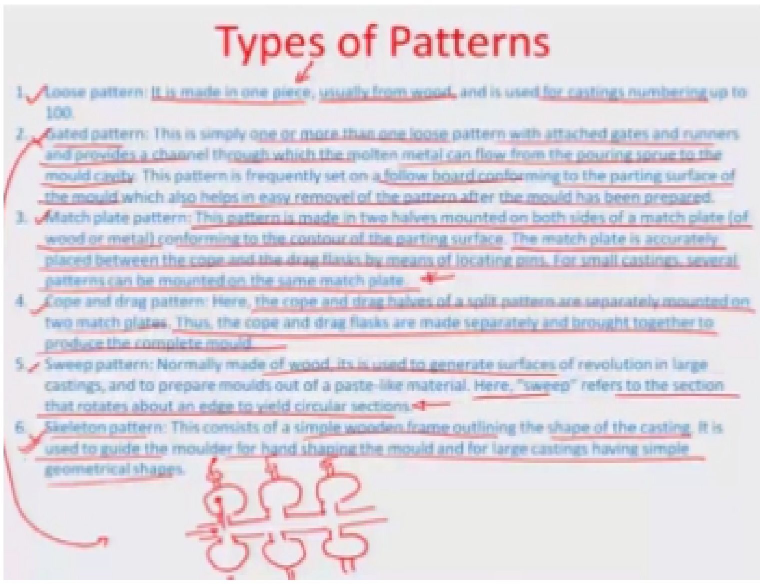

So principally there are about 6 different types of patterns which available one is call the loose piece pattern, the gated pattern, and the match plate pattern, the cope and drag pattern, sweep pattern and Skelton pattern, now these are only the kind of patterning techniques available for a variety of different shapes that you want to cast and some of the limitations are posted by the shapes itself because of which this varied number if patterns exits.

For example let us say when we talk about a loose piece pattern it is usually one piece out of the remaining part of the pattern which you know if you want to retrieve form the mold may create a mold damage, so you have to somehow bolt this piece to the main assembly and then remove the main pattern first and then before removing the main you unbolt the loose piece so that the loose piece stays into the sand mold and first extract the main pattern and then the unbolted loose piece separately.

So that this way the mold does not get damaged and therefore it is a very good technique to do single piece pattern so usually these are made of wood and you can use these for castings of large numbers then let us talk about gated pattern similarly to you know it is like concept of high production where let us say there are many mold which you want to fill with the single in let channel.

So what do you do is that you make this inlet channel behave like a gate with runners running form the gate in both the directions into different molds so that therefore you know you have the gates and runners all sort of you know or many runners attached to a gate which is feeding from the pouring basin and the raiser can be on the other side of that main runner so it is something like a network of runners.

Let me just show you hear what I mean by what I am saying actually let us say these are patters which you want to fill up all at go at one go with the metal so basically you make runners out of these patterns and connect all of them using a feeding channel or feeding runner and you can have a either a gate you know or either a riser in this direction you know or any other direction for example in the single pattern.

So basically the idea is that the fill of this cavity would be illustrated by the liquid metal flowing in this direction, all the way to this direction and coming up or hosing out from here which can give you an essence of the whole molding as been filled so these are gated patterns to typically one or more than one loose pattern with attached gates and runners provides a channel through which the mold metal can flow from the poring sprue to the mold cavity.

The pattern frequently set on a follow board so which can come from to the patterning surface of the mold which also helps an easy removal of the pattern after the mold as been prepared, then you have match plate patterns, in the match plate pattern the pattern is made into two half's mounted on both sides of a match plate of wood or metal conforming to the control of then pattering surface.

Now typically you can also use a core here so what happens is that there is you know one wooden pattern that you have made and split it up into a exactly two parts, if there is a core on it there as to be also a core built up separately which can also be done by this matching plate concept that there are two let us say wooden black blocks which you have developed the core separately using sand and sodium silicate, okay.

So you can actually use the core as well as the cast by realizing the two half's of the whole pattern one on the cope half another on the drag half and bolting them in a way so that they align to each other with a common board in-between or a common small sheet in between which is known as the match plate, so once these two upper half's and lower half's are separated the plate is removed obviously.

So you have the invert, inverted you know geometry or the negative geometry of pattern is there on the match board and you can place a core and then close on the cope half and the drag have together by removing the match plate, so then now you have a cavity with a core, so this is actually a match plate pattern it is a you know you can have a match plate in a typically for small castings where you have more than one components on the pattern.

So basically supposing there is a continued part where there are different features one of some of them are in the cope half some of them are in the drag half, even that kind of a realization can be done using the match plate patterns and then there are cope and drag patterns here the cope and drag half's of split patterns are separately mounted on the two match plates, so you are doing instead of one match plate two different match plates.

One match plate goes into the cope half another match plate goes into to the drag half and you have ensured that the match plate has been fabricated in a manner so that it has you know exact one to once energy of the components on the half of patterns on both sides of then matching plate so all it needs is to sort of match the upper half of the plate with the lower half of the plate and the cast and then remove you know the plates so that there is a cavity which is formulated.

So the difference between a match plate pattern and a cope and drag pattern typically is a that match plate has a single match plate and in a cope and drag there are two different match plates with different split patterns which are recombining together then there is a sweep pattern which are normally again made of wood to generate surfaces which typically induce revolution you know surface of revolution so basically there is let us say a radius and this there is a certain shape of this particular radius.

And as the molder moves the radius in a circle around a central point which is fixed you will actually have a pattern generated by the shape in a circular bases okay and so it is very easy for particularly large casting processes, so you can have you know the you can also sweep you know because you are sweeping the radius you can refer to as sweep pattern And it refers to the section that rotates about a edge to yield a circular section etc…

So it is normally preferred on sort of geometries which are very large then over skeletal pattern which consists of simple wooden frame outlining the shape of the casting it is used to guide the molder for hand shaping the mold for large castings having simple geometric shapes so you can actually go into the skeletal it is not once single pattern okay and the try to hand shape by putting the sand around the skeletal so that you can exactly have the you know skeletal replicated using casting process.

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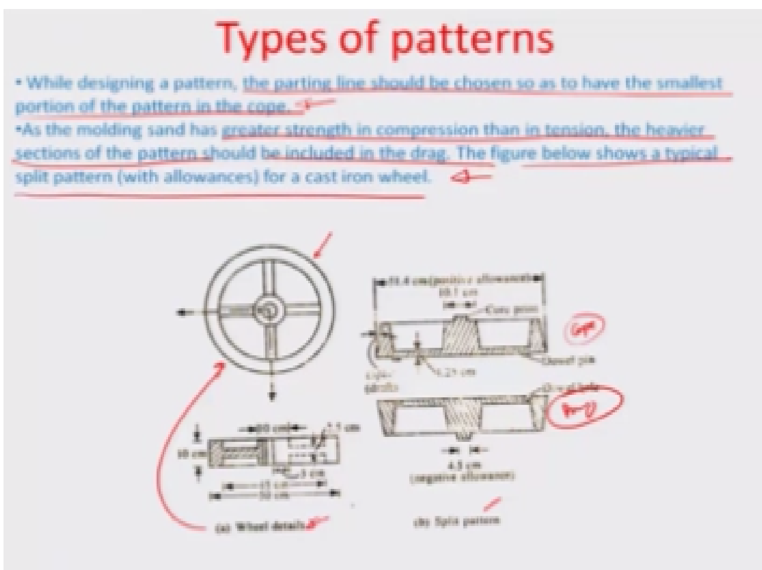

So these are generally the 6 different types of patterns and then coming to just look of you know what are the considerations so while designing a pattern the parting line should be chosen so has to have the smallest of the smallest portion of the pattern in the cope side obviously because when you are trying to put liquid metal inside the cast there is also going to be a factor of buoyancy and this buoyancy would ensure that if supposing a major portion of the metal goes into the cope half.

Which is the upper half there is a possibility of the mold to be damaged or distributed because of the huge movement forces which would result rather it is preferable that you have the drag half the lower half as most of the metal containing you know containment and remaining metal whatever is left over even a small part could be in the cope half so normally the patterns are not realized 50-50% in the cope and drag half but obviously the smaller part is the cope half and the large part is in the drag half.

So as the molding sand as greater strength in compression than in tension the heavier sections of the pattern should be included in drag obviously you are trying to keep the sand in tacked so that there is no damage and the casting can be formulated easily these are some of the details this is a wheel pattern, as you can see this is again a split pattern of this wheel that you wanted to cast so you can have a cope half and a drag half you know this is a cope half okay. This goes into the drag half and so this is how you typically make these as split patterns.

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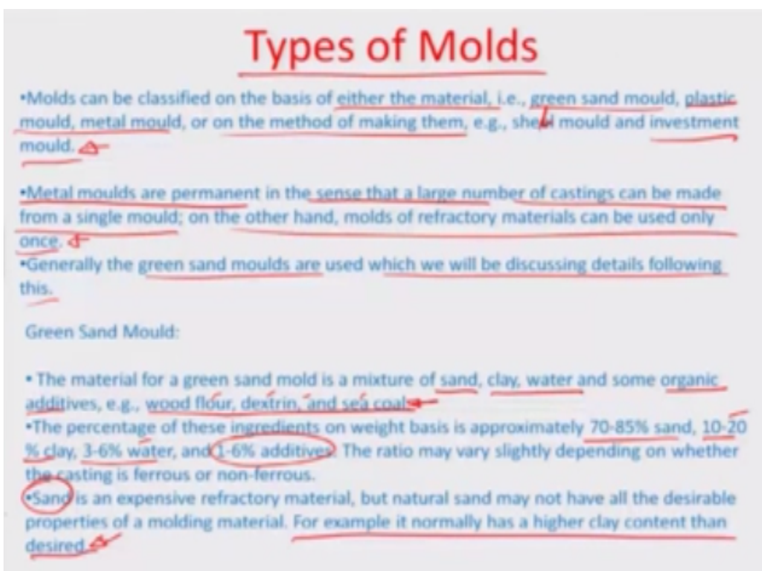

So let us now look at the type of molds just as the type of patterns so molds can be classified on the bases of the material that is being used for example there are greens sand molds there are plastic molds metal molds and also on the basis of the method for making them like for example you have the shell molding technique or the investment molding techniques so we will delve into some of these so metal molds are permanent in the scene that a large number of castings can be made from a single mold on the other hand the other hand the mold of refractive materials can be used on the once because you have to reclaim the sand once the casting process is over.

In fact I told you that there is a declamation process associated with all casting in the first few lecture so generally the greens sand molds are used which we will discuss in detail now so greens sand mold what it composes of material of greens and mold typically is a mixture of sand clay and water and some organic additives normally would flour dextrin or sea coal and the way that it goes is that organic additives get vaporized okay and it always creates a good porosity and always creates you know the refractory sand to have some scope for expansion with breakage. Because think of that the sand grains are part of sort of you know put together in the assembly like a bunch of different balls and there are these small organics inside which gets vaporized so there are going to cavity created where if the sand expands there is enough space for it to go so the mold will not be broken because of the expansion of the sand as such so that is reason why these organic additives are very important.

Percentage of these ingredients on the weight bases are approximately 70 to 85% sand about 10 to 20 % clay this is used mostly as a binder material and about 3 to 6 % water and about 1 to 6 % additive the ratio obviously may vary depending on weather the casting is ferrous casting or a non ferrous casting and typically you know that the most inexpensively available you know material is which is a refractory material in which can hold strength at a higher temperature stand.

But the problem with sand is that the sand is that stand a long cannot formulate the you know the desirable properties that the mold most have and therefore this has to be a sort of mixed with clay and water another ingredients as mentioned and this makes the whole mix which is used for casting process quite expensive okay so normally it is a higher clay contain than desired and so sand also as to be clean in away to make pure sand.

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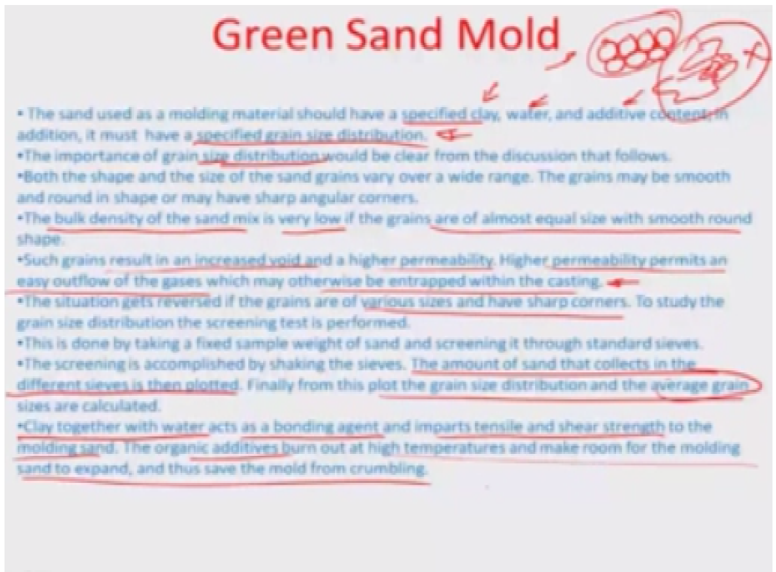

Okay so this includes the processing cast so let us talk about now what are the different aspects of the greens sand mold so I think I have already mentioned about the specified quantity of clay and the naturally available clay contain may be more but you have to somehow clean the sand of the clay by washing it then you have water additives content in addition it must have a specified green size distribution.

This is a another very challenging issues because obviously if it is a if it has a wide green size distribution it may result in a lower porosity in comparison to if it has a similar kind of green size so think about it that if supposing the sizes of the grains are almost equal and I am also further saying that they are spherical in shape and you are going to perk these greens together so obviously the bulk density would be quite low because these gaps would be very high because you are spherical claims like it is a pack of spherical balls put together in a an assembly.

So obviously there is going to be a huge amount porosity inside and the density would go down so the bulk density of the sand makes generally in that case is very low if the grains sort of almost equal size with smooth round shape on the other hand if the greens where angular you know and then it had different shapes then obviously there would be all these voids filled up and the overall bulk density would be very high in that event and the porosity would be low which is not a desirable condition for doing castings.

So our preference here would be that if the sand grains are all spherical and have uniform size the we will have a better situation obviously I no need to retain that at higher temperature the sand expands and it looks at those voids where it can get into without breaking the mold so your giving porosity just for that purpose and you will actually creating by using some kind of additives etc.Which vaporize and create this pores so that there is no problem of the sand expanding and breaking the mold as such so such grains you know result in an increased void and higher permeability obviously higher permeability permits a easy out flow of the gases which may otherwise be entrapped within the casting as well apart from the strength issue that I was mentioning and if you have various sizes and I have sharp corners of the greens.

So then the gas cannot come out so easily and also it cannot accommodate the expansion of the sand which makes it having a lesser strength overall. so how do you actually do the separations size based separation of the sand green so you pass it so sieving matrices of different you know dimensions and collect different grains so that you can actually categories a grain as some grate size okay or below some grit size and this you can plot by seeing that how much of these grains are you know.

So basically all grains of a higher size then the grit size would be retrained vis- a- vis all the grains of the lower grit size the lower size and the grid size would actually passes through the particular sieve. so it is lot of a sort of filtration system where actually plot what is the quantity of the you know grain size 1, grain size 2, grain size 3 so on forth.so the amount of sand that collects in the different sieves is plotted and finally this plot gives you the grain size distribution with grain size as well as a spread around which the grain size varies.

So as I already told you the clay together with water acts as a bonding agent imparts and tensile shear strength to the molding sand and the organic additives burn out at high temperatures and room, for the molding sand to expand and save the mold from crumbling. so these are some of the issue that I have already discussed and so in.

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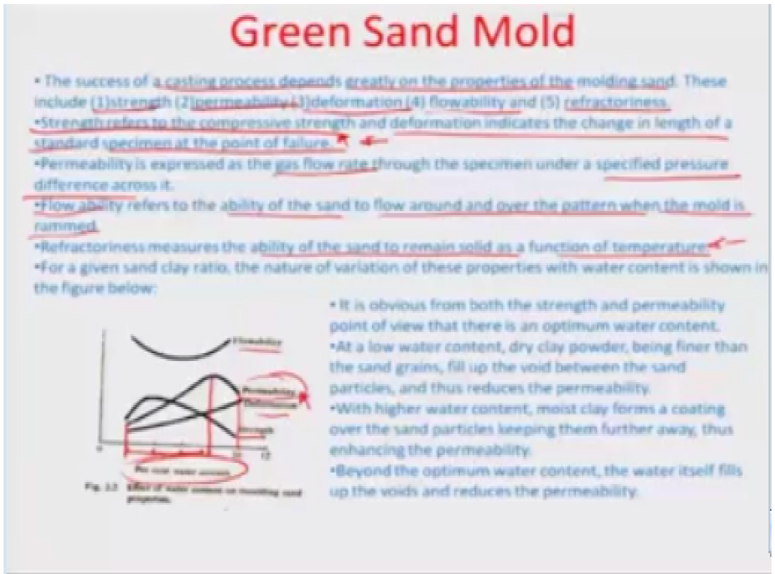

Regarding green sands again the success of the casting process would typically depend on the properties of the molding sand for example this must include high strength more permeability so that the gases can out flow from the casting more deformability and flow ability because obviously sand needs to get into indicate shapes and set etc particular in complex castings formulate the boundary and make the cavity so it has to be could you know it as to have good flow.

And then it should have a good refractoriness and should be able to hold strength at a higher temperature. so these are the 5 essential characteristics that would be there in a sand molding sand so the strength actually mostly refers to the compressive strength as well as the casting proceeds goes obviously the metal is going to formulate you know it is going to be on the top of the sand and size or weight on the sand which will make it more common even if it is a let us say if it is in side assign cavity.

It is a buoyancy forces would actually also make the sand compress on the other side of the wall so it is essentially compressive strength that we are talking about in all casting processes and the deformation indicates the change in length of the standard specimen at the point of failure okay so that is how strength can be gauged strength of a material can be gauged by looking at the maximum deformation that would be allowed without failure without the sand getting failed and so the other concept which is important is permeability, it is expressed as a gas out flow rate through the specimen under specified pressure difference.

So it definitely includes the quantity or density of voids and also the void sizes of the particular mold the other important abilities of flow ability obviously refers to the ability of a sand flow around and over the pattern and the mold is rammed and the refractoriness measures the ability of the sand to remain solid as a function of temperature so I think I have covered all these 4 parts as I mentioned earlier.

The most important part that I would like to illustrate is that this factor permeability and in fact as a matter of all the other factors strength, deformation, flow ability,. they are dependent on the percentage water content that the green sand mold would have and let us look at how the permeability would vary so obviously if the water content is quite low then there is a situation that the loose clay which is available you know it can actually it is a very small size particles and these can get into the it is like dry clay powder you can get into the voids and because the water is not there simply an adequate water is not there simply to formulate a bond and you know hold them together so there are loose particles so at a lower amount of water mixed into the particular sand there is a tendency that the dry powder may get into the voids etc…

Of the sand mold so obviously the void overall be filled up and the permeability would be lower because of that now as the water content is slowly increased that is a point of time when water is just about adequate for the clay particles to sort of go and coat all the sand particles together, so now there is a of a bond formulation between the silicate which is there and the you know the clay particles and so in that situation you can say that all the loose clay which was otherwise powder into the voids have been taken up and coated on to the sand particles most is spherical and so still it realizes a lot of voids which where otherwise filled with this loose powder now.
so the permeability would go quite high in that particular case as you can see from here to here as a percentage of water is increased between to an 8% now what happens after that is that essentially now all the clay is gone because it is coating the particles the sand particles but if you put water more in this situation then all the additional water comes back into the voids and fills the voids so that the permeability can go down so that is how you can see a depth or a decrease in the permeability with an increased content over and above 8% water into the sands mold.

So this is a very important aspect and similarly explanations are available in the literature all about flowability, deformation, strength you know as this concept of loose powder clay, coated powder clay and additional water into the different voids of the sand so with this I think I would like in the interest of time end up this particular module and in the next module I am going to again continue some of the issue that related to you know again how to prepare these molds what can be a high yield process for making mold at a faster rate like jolt ramming etc…

Some techniques and we will also talk about the basics of how there are challenges related to evolution of gases into these liquid melts and how that can down play the equality of the cast and also look into some aspects related to how you melt those melts and ensure that there is very less amount of undesirable gas evolution so with this I would like to close on thank you.

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