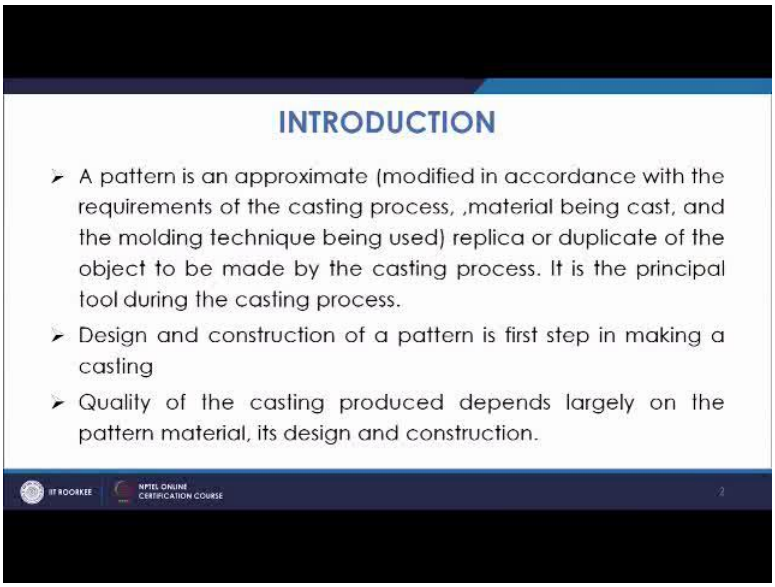
Principles of Casting Technology

Dr. Pradeep K. Jha
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 06
Technology of Patternmaking
Pattern Materials

Welcome to the lecture on Technology of Patternmaking. So, in this lecture we are going to discuss about the Pattern Materials.

(Refer Slide Time: 00:33)



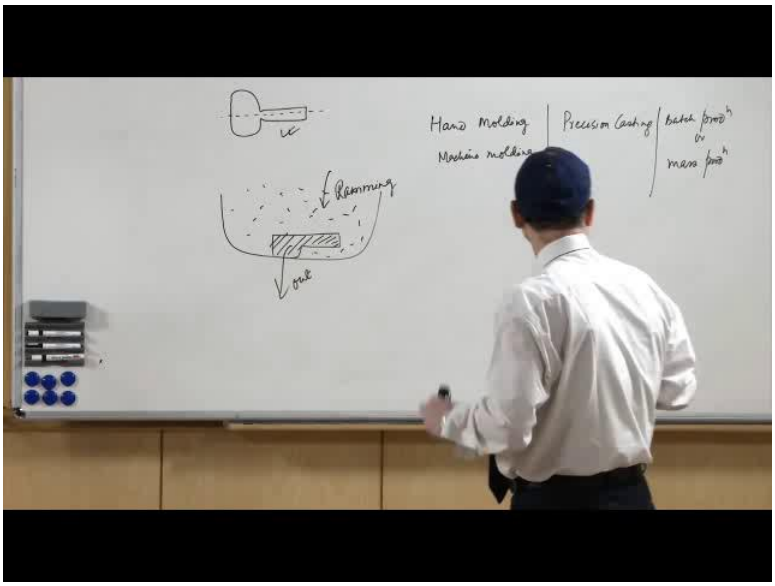
So, first of all let us know what is a pattern? In the casting process, the patternmaking is the first step. Pattern is nothing but the replica of the casting which we are going to make with certain modifications. So, it is defined as an approximate, because it is modified in accordance with requirement of the casting process, material cast, and the molding technique being used. So basically we have the similar shape of the cast and that is why pattern is required so that the same type of, same shape of, casting is produced. So, it is replica or duplicate of the object to be made by casting process.

Now, we know that in casting, basically we are using the molten metal, we have the solid state metal, which is converted to a liquid state and then it has to be poured in a cavity. Now, the cavity has to be made and certainly, the cavity shape will be same as the casting shape. Now the problem is, that how to make this cavity? If the cavity is simple,

then fine, but anyway there are certain methods to make that cavity. So, first of all you need the similar shape of something, which is put in a mold and then that particular item is removed, so that a cavity is formed.

So, what we put inside a mold and then further we remove, that is nothing but a pattern. Design and construction of a pattern is first step, in making a casting. So, basically first of all we have to see, what kind of pattern you have to make.

(Refer Slide Time: 02:44)



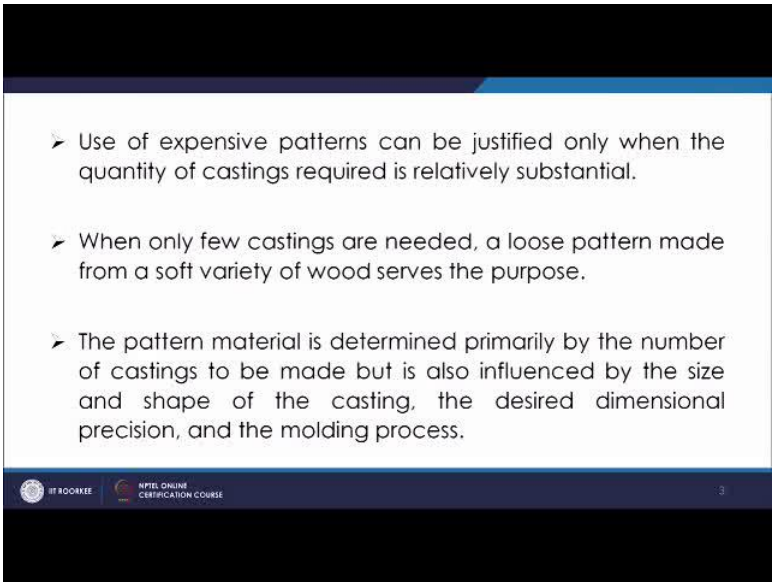
Suppose, you have a casting, which is required of this shape, now if you want to make a cavity for this, either you can put in the horizontal direction or you can put in the vertical direction. But the thing is that, you cannot make this cavity, without the use of certain you know piece, which is to be put in a molding material.

So, what we do is, we have a box in that you have, initially what you do is you put this half part. So, half part will be put here, and like that. This is being put, and this portion basically, and all other places will be sand. So, this way you will have, some cavity created, when you take this out. So, when you take this out, that basically gives you certain cavity, so for that initially you make with, some material and for that, we will discuss about different type of pattern materials. So, in that, what we do is once we remove this a cavity is formed in that cavity molten metal is to be poured. This molten metal once you poured and solidified it will give you similar shape.

Basically, but during that process, it is not the same. It is shape is not completely the same, but with certain modifications. That is why, the modification what we do, will depend upon what kind of process we use, what kind of materials we cast. The thing is that the quality of casting will depend, largely on the pattern material design, and construction. So basically, the accuracy of this pattern, will determine the accuracy of the casting produced, the material with which this pattern is made. If this if the surface of this, pattern is smooth, you are likely to get every smooth surface of the casting. So, basically you need to have, accurate good surface finish pattern, which can give you a good casting.

Use of expensive patterns can be justified, when the quantity of casting required is relatively substantial. The thing is that normally, we have to see what is the degree or level of production for our unit.

(Refer Slide Time: 05:40)



A pattern is used and then, we take it out, further we are using for the same the same pattern for another casting. Now, as we know, that the pattern can be used single time, it may be used many times. So, once you have to use only for single time, you can think of a pattern material, which should be cheap, because you are using it only for one time. But when you are going to use it for larger number of time, there is detoration in the quality of the pattern or there may be, the decreases in the accuracy of the dimensions ratherly wear and tear. But then at the same time, if you are using the pattern material in

such a way, that they are more durable, it will be more costly. So, in that case you have to justify that how long you are going to use it, for how many productions you are going to use it.

So, basically we can go for expensive patterns, which will be durable, but then we have to ensure that it should be used for longer runs, it is used for mass production. When only few castings are needed, a loose pattern made from a soft variety wood so of the purpose. That is, what we discussed, that when you need only one item or two item. You need not go for the pattern, which is very costly, only on the assumption that it will give a very accurate result. Because, we have to see the viability in terms of economics also, so, in that case, even the loose pieces, loose patterns from soft variety wood will serve the purpose.

Pattern material is determined primarily, by number of castings to be made, but also influenced by size and shape of casting desired dimensional precision and molding process. So, basically that is what we discussed, but we have to select the pattern based on what kind of molding process we are going to use, whether we are going to use hand molding, whether we are going to use machine molding, whether we are going to have a precision type of casting where the accuracy is very important, whether we are going to go for batch production, or mass production. So, all this parameters affect the selection of pattern material. Now selection category of our pattern materials that is, type and form of material to be used. So, basically we have to first of all see, what type of material we have to use whether we have to use, wood or metal in what form, method of molding, in molding process, what we do is here the ramming is done.

So, in hand molding, the ramming is done by hand whereas, in machine molding, this is put on a machine. So, this move ramming is done by machine, which requires the pattern to be strong. It will decide what kind of material, if you want to go for machine molding the pattern has to be stubbornned - it has to be strong.

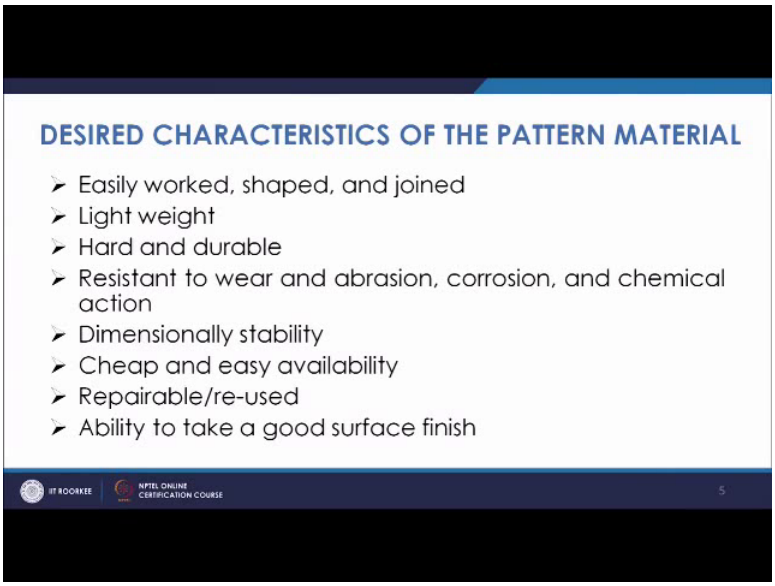
(Refer Slide Time: 09:46)

Construction details like provision of loose pieces core prints. So, when you take the, when you make the pattern, and if in the molding, you feel that molding cannot be possible, without the provision of loose pieces, in certain case you cannot make the pattern in a such a way that whole cavity is formed. So, sometimes you have to provide the loose pieces, this we will discuss when we talk about the type of pattern.

Also in the pattern itself you have to provision of providing core prints. So, basically when you are making any pattern, and if you have there is a core a core has to be supported. So, there will be a certain provision for the core printers. So, because core as to be rested on both the sides. So, these are the core prints which are required, and this provision also is given in the pattern itself. So, all these things are required to be considered, when you talk about the patternmaking. Method of gating and feeding to be followed, what kind of gating and feeding methods are there, that will also tell us or assist us in choosing the pattern, provision of various foundry aids, like you can say that chills or sometimes staplets, all this things these are the selection criteria for choosing the pattern material.

What should be the characteristic of a typical pattern material? First of all it should be easily worked Shaped and joined.

(Refer Slide Time: 11:30)



We know that the pattern, shape has to be same as that of casting, with certain modifications. So, you have to make the pattern, similar to the shape of the casting. It means there should be, no much of the problem, in shaping that material to a particular shape, it means it should be easily machined easily worked, so that is the first thing. If you take a very brittle material, and try to either machine it or form it or bring it to a shape it is very difficult. So, you have to have a material, which can easily be worked upon and given a desired shape, mostly by machining, cutting or so.

It should be light weight. So, this is the criteria because the pattern is to be handled many a times, when we talk about the manual molding or hand molding, and when it is a small scale foundry unit. The pattern is to be lifted or it is handled by the labors and they do it by hand. If it is very heavy one, it will create a lot of problem and it will decrease the productivity of the labour.

So, basically it should be light weight, hard and durable. It should have sufficient strength. So, that during the handling even if it, falls down or even if there is enough of the compressive strength, on it or if it is rammed even with larger forces it is able to sustain that, for that it need to be hard and durable, I mean it should last long. So, that the cost of making pattern is justified, because anyway this pattern is going too used for longer runs. So, that will certainly increase the productivity.

Resistance to wear and abrasion, corrosion, and chemical action, now the pattern basically is used, against the molding materials, and the molding materials are normally sand, using organic binders or inorganic binders, and they are also left in the atmosphere, so they are subjected to large amount of environmental reactions. So, they are and since they are in touch with the sand so, they are likely to have wear and abrasion, they are likely to have corrosion, because they are in the atmosphere, there may be corrosion effects, there may be chemical effects, because there are chemicals used with the sand, which is in context with the pattern material.

So, all this property a pattern material must possess, so that it is durable. If it is not so, the pattern material, will not behave in optimum manner, it is life will be less. So, more on the side we can think that, if the pattern material is degraded, not only that we have to replace so, replacement cause is there, but also it will basically reduce the quality of the cast so that will further hamper the productivity.

Dimensional stability, this is required because we are going to use the pattern, weather by weather. So, there may be dimensional variations, when we move from weather to weather or when, there is a change in temperature, or change in humidity, or environmental conditions. The pattern, as to have the dimensional stability, so that it can always produced, the casting of certain size, and proper shape.

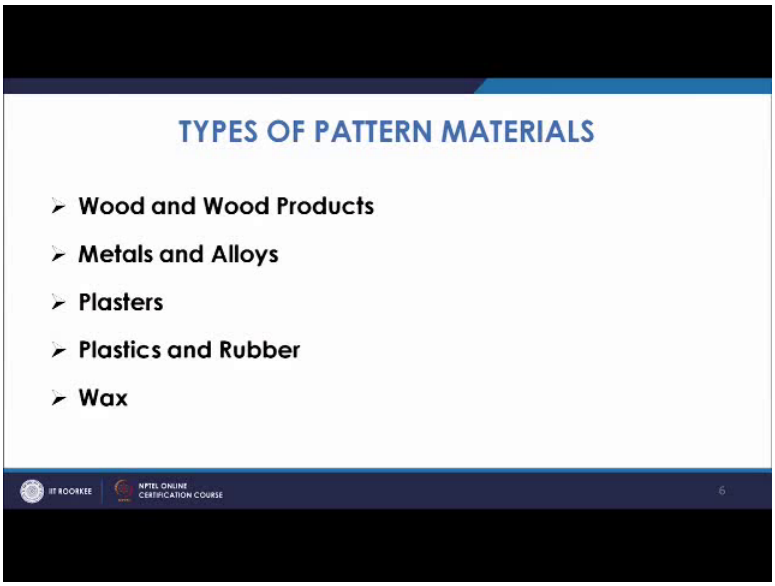
Cheap and easy availability, this is very important. Because this pattern it is initially used and it has to be used for long run. So, one of the requirement is that it should be cheap and easily available. It as to be cheap, because unless it is cheap, the casting process cannot be justified, if it is very costly it can only be justified based on the assumption that it will have the quality of finish, which cannot be produced by other pattern materials, or it is for a very long range of production units.

Repairable and re-used, many a times there may be some (Refer Time: 16:12) to the pattern. So, our pattern should be of such a material, so that we can do, minor modifications by repairing it and we can further reuse it, so that will basically decrease the cost of operation, otherwise you have to further replace it and there will, that will unnecessarily add cost to the production process.

Ability to take a good surface finish; so the pattern material, must be such that should provide a good surface finish, otherwise the cost of providing finishing will be more. So,

you must have a pattern material, which have a smooth surface, so that when you cast the material, you also get the surface smooth, and the cost associated with machining or giving proper surface finish will be minimum. So, these are the desired characteristics of a pattern material.

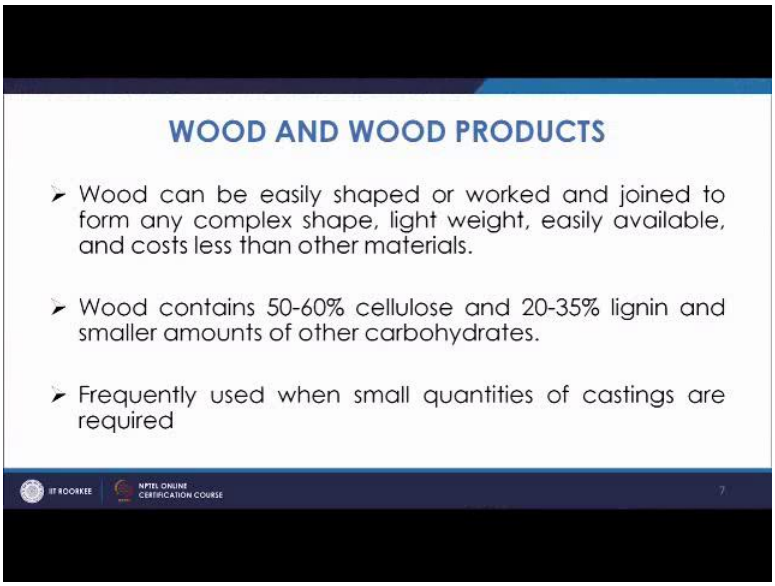
(Refer Slide Time: 17:18)



Types of pattern materials, now we will discuss what are the different types of materials, which are normally used as patterns. The first and foremost is Wood and Wood Products. So, among the wood and wood products, we have normal wood, and then variety of, so in that you have variety of wood, and also then you have plastic wood, and you have laminated, plastic laminated wood products they are coming under this wood and wood products. Then you have Metals and Alloys, you have Plasters, Plastic and Rubber and Wax. These are the commonly used pattern materials.

Let us go one by one, to these pattern materials. So, we will talk about Wood and Wood products. Now, wood and wood products are the most preferred pattern materials, because of many criteria. The criteria like it is light weight, it is easily available, it costs less than other materials, it can be easily shaped or worked and joined to form any complex shape, all this criteria makes wood to be selected as universally it is universally accepted, to be taken as the pattern materials.

(Refer Slide Time: 18:24)



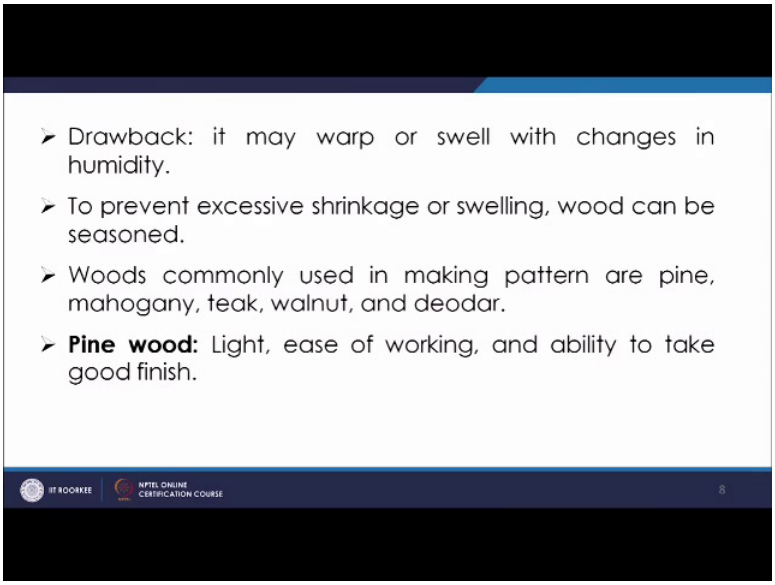
About the wood, you know wood contains 50 to 60 percent of cellulose, and 20 to 35 percent of lignin, apart from that you have some amount of carbohydrates so it is the structure of wood if you look at, you have cellulose and lignin. So, now, wood is frequently used when small quantities of castings are required. There is reason behind it because wood one used, if you are using it in the sand molding for, larger number of runs there may be abrasion on the wood. So, for that it is basically suitable, when you are going to use that pattern for long, not very large number of castings to be produced. It has a drawback, that it may warp or swell which changes in humidity.

Now, in the case of wood, what we should know, that it as certain moisture in it. Now this moisture, if it is more than that, more than (Refer Time :19:42) content of moisture, in that case due to the moisture, it may swell or if the moisture is less, and if it is dried more, then it may warp, or it may be dimensionally unstable. So, this is one of the drawback of wood, and for that there is certain treatment required for the wood, there are certain varieties of wood, which have a good dimensional stability, but in normal case, normal wood cannot be taken as the pattern materials, so that care as to be taken when we take wood as the pattern material.

To prevent excessive shrinkage or swelling wood as to be seasoned, so there is a process known as seasoning of wood. In that basically we are controlling, the moisture content of

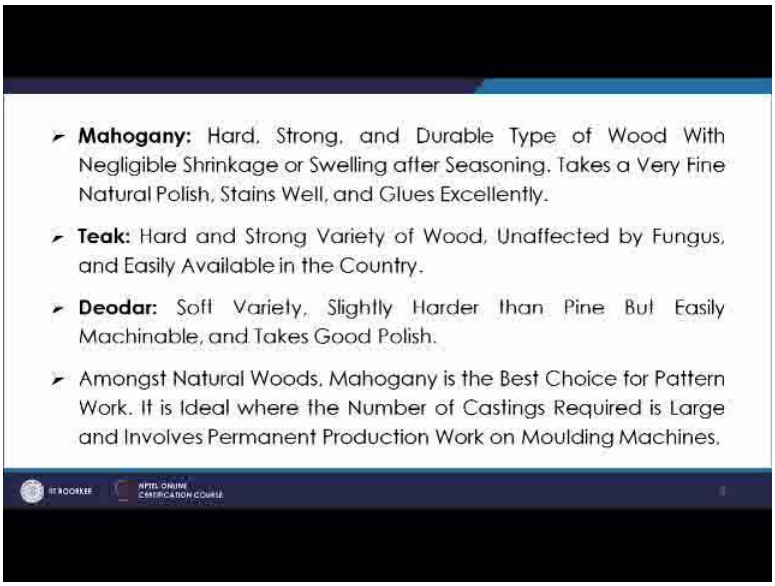
the wood. The wood, which is normally used for making pattern, is pined mahogany teak walnut and deodar.

(Refer Slide Time: 20:41)



So, these are the normally used wood, which are used for making patterns, which are having that characteristic, which are suitable for making pattern material. You have the characteristics of all this varieties of wood, like you have Pine wood; which is Light, ease of working, and ability to take good finish.

(Refer Slide Time: 021:04)



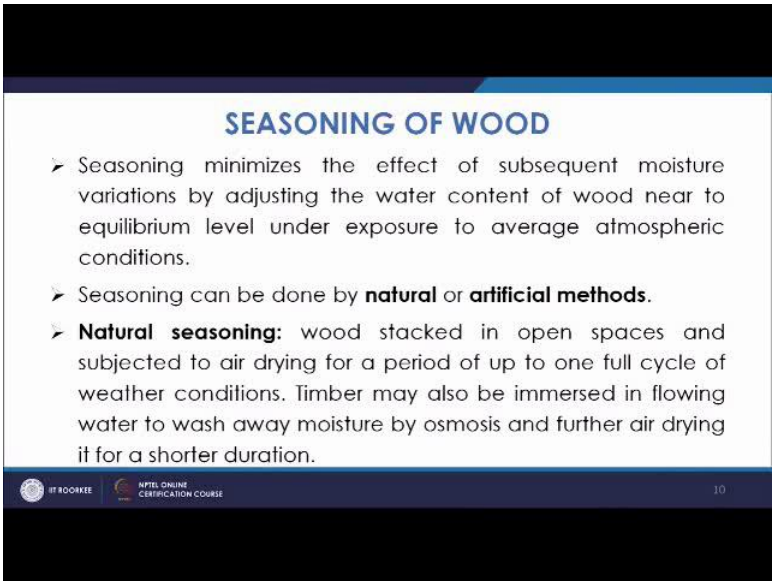
You have Mahogany, which is Hard, Strong and Durable Type of Wood with Negligible Shrinkage or Swelling after Seasoning, so once you do that mahoganies quite, takes a Very Fine Natural Polish, Stains Well, and Glues Excellently. So, basically join ability is there, good finish is there, all this qualities are there in mahogany.

You have variety of Teak. Teak is Hard and Strong Variety of Wood, Unaffected by Fungus, and Easily Available in the country. So, this is also positive point for teak, which is mostly available, even in this region of the country.

Deodar is Soft Variety, Slightly Harder than pine. But Easily Machinable, and Takes Good Polish. So, these are the normal type of wood, which is used for patternmaking. Among all the Natural Woods, Mahogany is the Best Choice for Patternmaking Work. It is Ideal where the Number of Casting Required is Large, and Involves Permanent Production Work on Molding Machines.

So, basically as we have seen it is quite durable hard and strong. So, it can even be used, when we go for machine molding, where it as to withstand large impact forces or large ramming forces, that time mahogany is better suited. So, mahogany is taken as the having the, more preferred choice among these woods. What we discussed was the seasoning of wood. There as to be, proper moisture in the wood and this is controlled by seasoning. You might have seen, the stacks of wood lying, on the road side, when you move, and when you come across certain wood shop. So, that is nothing but seasoning basically they are controlling the moisture content and seasonal variations are basically maintained.

(Refer Slide Time: 23:07)

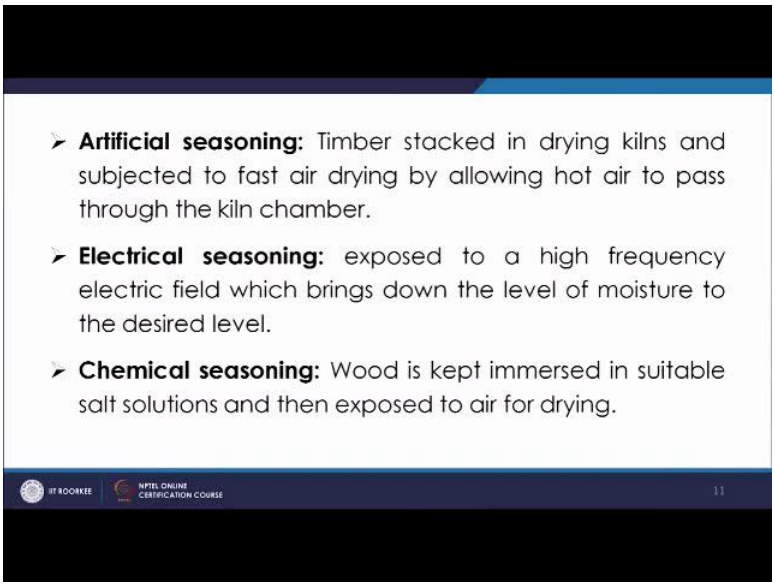


So, seasoning what it does, Seasoning is minimizing the effect of subsequent moisture variation by adjusting the water content of wood, near to equilibrium level under exposure to average atmospheric conditions. So, basically this is a process by, which we control this moisture content of water content. It can be done by natural or artificial methods. So, there are many methods by, which the seasoning is carried out.

Natural Seasoning, natural seasoning for that basically we are leaving the wood in air or in flowing water. So, basically wood is stacked in open spaces and subjected to air drying for a period of one, up to one full cycle of weather conditions. So, basically we are putting in the environment and we are exposing it, for one full cycle of weather condition you can also immersed in the flowing water, which will basically washed away the moisture, which is there in it by osmosis process and further we dried for shorter duration, so that this water level is maintained at the equilibrium level.

There are even artificial methods of seasoning, artificial methods in that basically Timber is stacked in drying kilns and subjected to fast air drying so, basically they are fast methods, which do this at a faster rate. So, hot air will be passed and it will be done quickly.

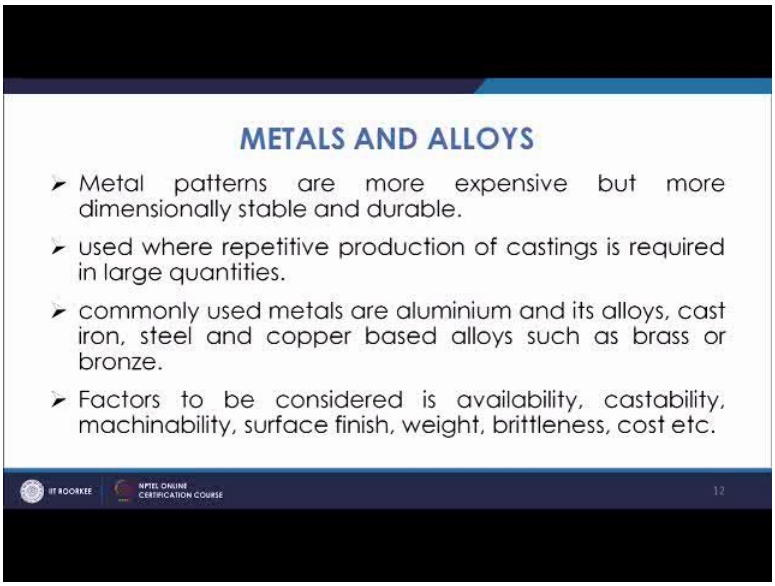
(Refer Slide Time: 24:27)



Electrical seasoning also is there, where it is exposed to high frequency electric field which brings down the moisture level quickly in no time. Chemical seasoning: where the wood is immersed in suitable salt solution and then exposed to air for drying, for drying so that the moisture content is kept under control.

Now, we will come to another variety of pattern materials that is metals and alloys. In case of, you know when we talked about wood, wood is universally accepted, but the drawback is that, it is not as hard, and durable as metals. When we have to use it for larger production runs, and when it has to be used against sand, and also chemicals the quality of finish, the quality of durability comes into picture. So, in that case the metals and alloys, they are a good choice they are expensive, but more dimensionally stable, and durable, because in metals in the case of metals, there is no problem related to the moisture variations as we face in case of wood. So, metallic patterns that way also they are hard and durable. So, they can be used for longer runs.

(Refer Slide Time: 26:10)

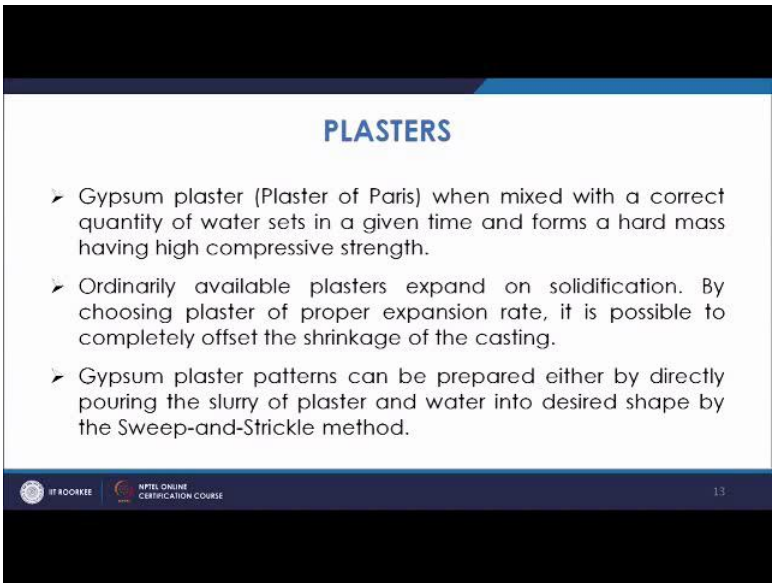


For repetitive production of casting in large quantities you can use them because they are, they are having larger strength, and the durability is more. Commonly used metals are aluminum and it is alloys, cast iron, steel and copper based alloys, such as brass, and bronze these are the normally used alloys, which are used for pattern materials. The factor to be considered is availability, castability, machinability, surface finish, weight, brittleness, cost etc like.

When we have to take any metal like, the normal metals, which we select is aluminum, cast iron, steel, or copper. So, if you look at that availability, you can say that it is for all the metals. Castability if you look at, for cast iron it is quite good. For steel it may be difficult, because it is an alloy. So, castability is not so good. If you look at the machinability, the cast iron has good machinability. Then copper also as good machinability and it is alloys, surface finish with most of the metals you will have better surface finish, especially with you can have like aluminum or you can have when with steel surface finish will be quite good or copper even. With, among in that we sense aluminum is preferred choice. So, because aluminum is light, brittleness is a problem, and cast iron may face, may fail in this aspect because cast iron is brittle. Then cost, certainly you have to see the cost and you have to go for that material, which is having less cost. So, that these are the factors, which will decide about, what kind of metals or alloys should be chosen.

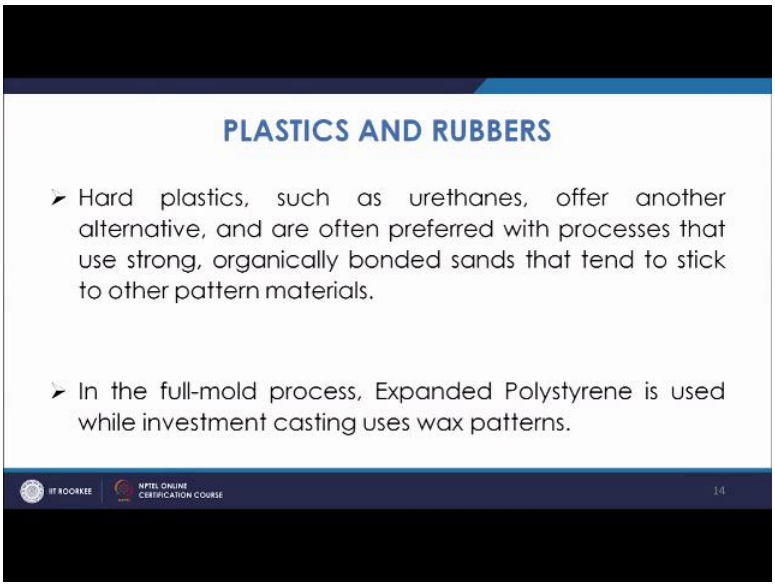
Next material is plasters. So, gypsum plaster that it plaster a (Refer Time: 28:02), basically it is a good pattern material in the sense, that it sets when it mixed with water, and allow to set for sometimes in the cavity, if you put the gypsum plaster of small of required amount and give the water mix them, and leave them, they will take that particular shape, and your pattern is made. So, this is a good material it has also certain expansion, coefficients it expands. So, basically it also takes care of that also, so when gypsum plaster is mixed with correct amount of water sets and gives you a hard mass, which as a good compressive strength and good pattern. Ordinarily they expand on certification so, basically shrinkage allowance can be offset, if the gypsum plaster of certain, particular expansion rate is taken, there can be prepared either by directly pouring the slurry of plaster and water into desired shape, or sweep and strickle method, by the sweep and strickle method, also you can make the pattern.

(Refer Slide Time: 29:00)



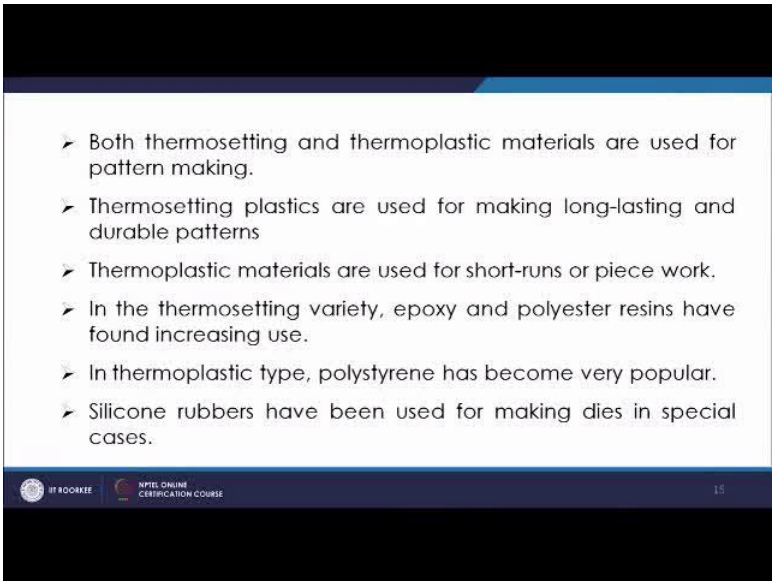
Then other varieties are plastics and rubbers. As we know, that we needs now a days the materials, should be light, and it should be chemically inert, in that case this plastics are very good choice, it has a very light weight, they can be handled very nicely. So, hard plastics of another alternative and preferred with posses that you strong, organically bound sense that tend to stick to other pattern materials.

(Refer Slide Time: 29:45)



So, this is another advantage of using plastics because when we use organic. Binders in that case other pattern materials are posing problem in the sense that they stick to the pattern. But in this case they are not posing any problem. Expanded polystyrene is used, in case of full mold, in say this is a kind of plastic, where beads are put in the cavity and expanded, so that they take the shape of the cavity. So, that is a good example of the plastic based material, pattern material, used in the patternmaking.

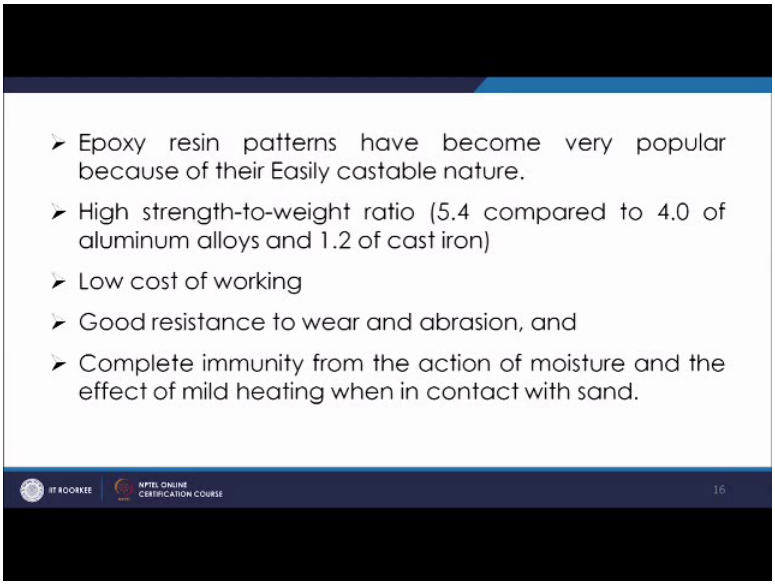
(Refer Slide Time: 30:21)



So, we have to use both kind of thermo setting and thermoplastic material. Thermosetting is certainly harder, then thermoplastics, and you have different varieties of thermoplastics and thermoplastics like in thermosetting variety you have epoxy, polyester resins, which are used in thermoplastics you have polystyrene which is mostly used we also use rubbers, silicone rubbers are also used, as pattern materials they are softer materials they are used for making even dice in this special cases.

Epoxy resins have become very popular in nowadays. Now, this advantage of these plastics is that, they have a good strength to weight ratio. So, that is why they are, preferred high strength to weight ratio like, 5.4 compared to 4 aluminum alloys, and 1.2 for cast iron. So, if you look at this point, you see that they are very light, and we have a very good strength to weight ratio as compared to other materials. Low cost of working, they are soft so they have you have low cost of working for it, even for furnaces also you required a low temperature furnace, which can melt them good resistance to wear abrasion and humidity from moisture and effect of mild heating. So, this is a very good quality for which the plastics are preferred.

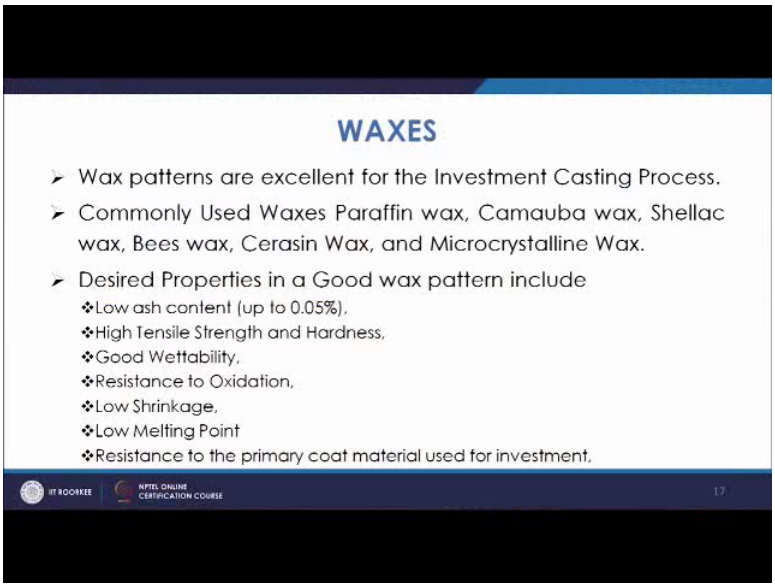
(Refer Slide Time: 31:32)



Then you have waxes, this is the another variety of pattern material, which are used for investment casting, waxes are used when you have interrogate shaped castings, these waxes are basically coated with certain materials and then further you are you are making another coat over it, and drying it. So, that it is a good thickness of coat is

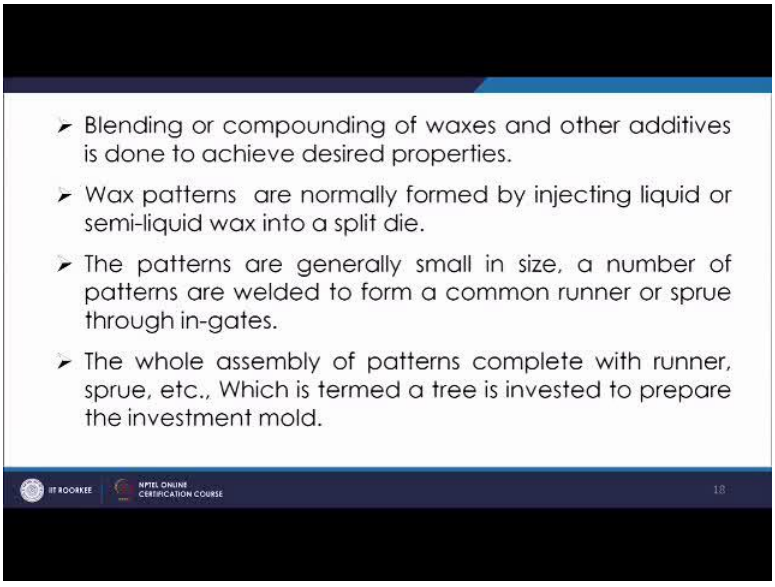
developed, then this whole unit is heated so that wax comes out, and a cavity is generated. So, these commonly used waxes are Paraffin, Camauba, Shellac, Cerasin, and Microcrystalline Wax, and these are properties like low.

(Refer Slide Time: 32:22)



And most of the important property is Low ash content tensile strength and hardness should be better, Good Wettability, Resistance to Oxidation, Low Shrinkage, Low Melting Point, and Resistance to primary coat material because we are going to further first of all go for primary coat.

(Refer Slide Time: 32:36)



Blending of waxes are done, by making the additives and give a special qualities to the wax, they this patterns can be made by injecting liquid or semi-liquid wax into split die, then patterns are smaller in size so they are added with the runner or a sprue by welding, and then whole assembly will be having that runner sprue, and it is like a investment tree in case of investment casting; investment casting is the one, which uses wax as the material. So, these are the normally used pattern materials, next we will discuss about, the types of patterns and pattern allowances.

Thank you.