Metal Casting
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Module - 06
Finishing, Design and Environment
Lecture – 03
Design Considerations and Economics

Good morning friends, in the previous classes, we have been learning about the special casting process. We have completed those special casting process and also we have come to the almost to the end of this course. So, today let us learn about design considerations and economics in the casting. First we will be learning about the design considerations of the product or the material or the mould then we will be learning about the economics. So, these are our contents in this lecture.

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First, we will be seeing the material selection and design. Next one design considerations related to product. Next one design considerations related to mould and finally the economics of casting. First we will see the Material Selection and Design.

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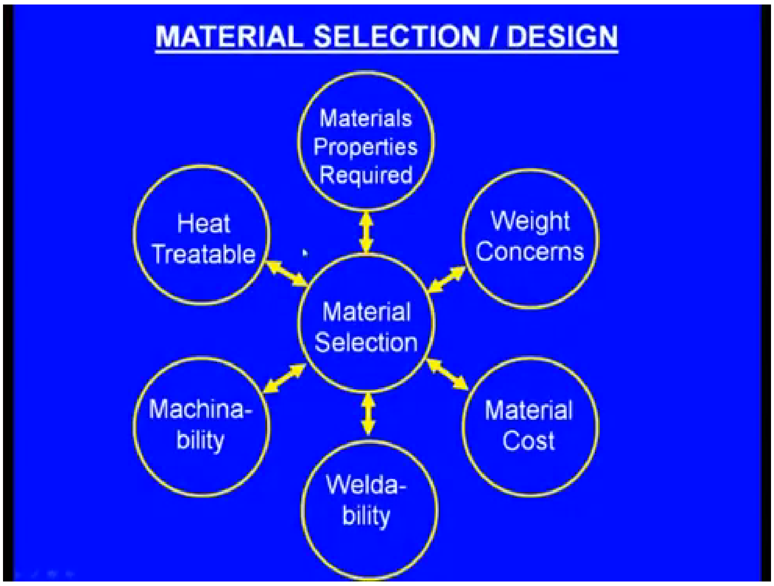

Now the material selection or the design depends upon several factors. How to select the material, if a customer comes and gives a you know what is a drawing and he asks us to make the casting. Now we have to select the what say casting, casting design we have to make, mould design we have to make. Then also material has to be properly chosen on what basis the material has to be chosen. The first factor is the materials properties required. What are the properties of the cast component or the material? Next one weight concerns what should be the weight of the casting should it be very light or it should possess moderate weight. So, this is another factor weight concerns.

Next one material cost, the material cost should be sometimes optimum, sometimes if the casting is a very precision what say casting the material may not be of higher concern. Next one weldability, sometimes it needs to be welded with another what say component. So, what is the weldability of the cast material? Sometimes it has to be machined. So, this is another factor machinability. What is the machinability of the material that we have chosen? Next one sometimes the material or the cast component should be heat treated. So, is that material heat treat bull or not so that is another concern.

Now if we consider the details.

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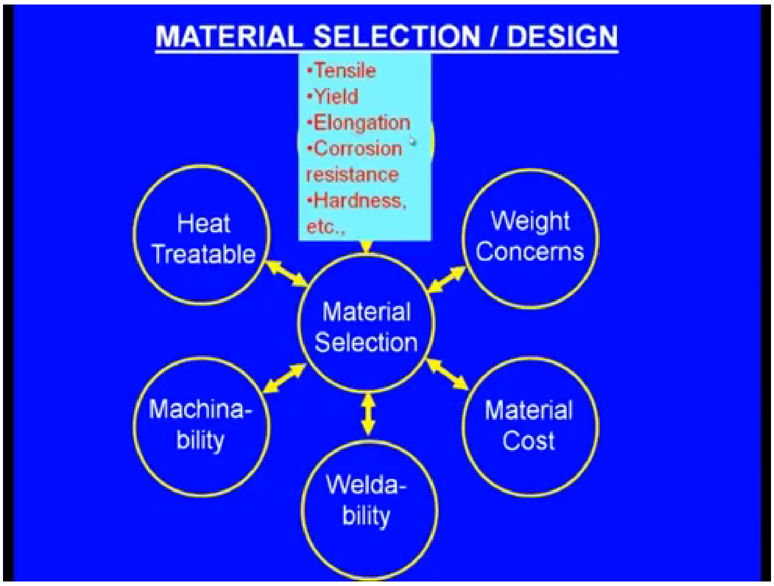

So, these are the material properties often considered Tensile strength, Yield strength, Elongation, Corrosion, Resistance, Hardness and so on. So sometimes depending upon the; what say application of the cast component, so these are the properties considered. Now does the material that we have chosen possess these properties or not so that is the first concern.

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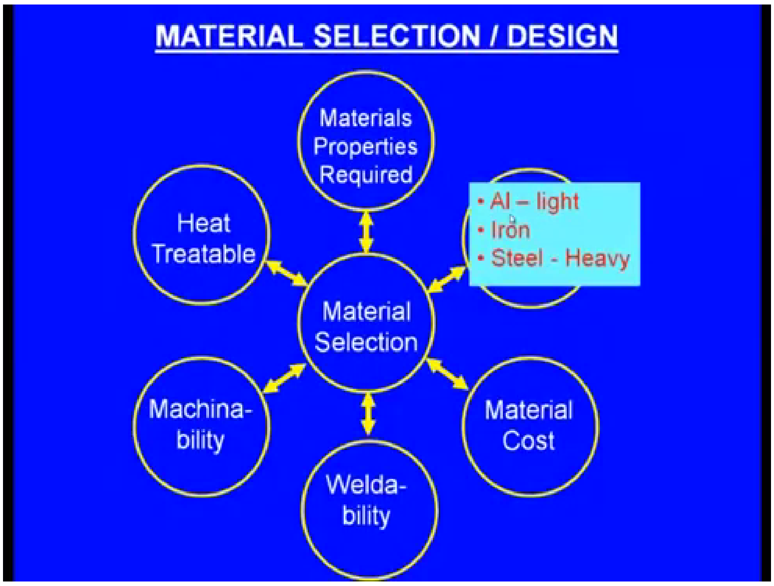

Coming to the weight concerns, so these are the common materials that are cast

Aluminium, Iron, Steel. Now aluminium is having lighter density, iron has moderate density whereas, steel it is very heavy. So, what is the requirement of the application. Accordingly we can choose the material.

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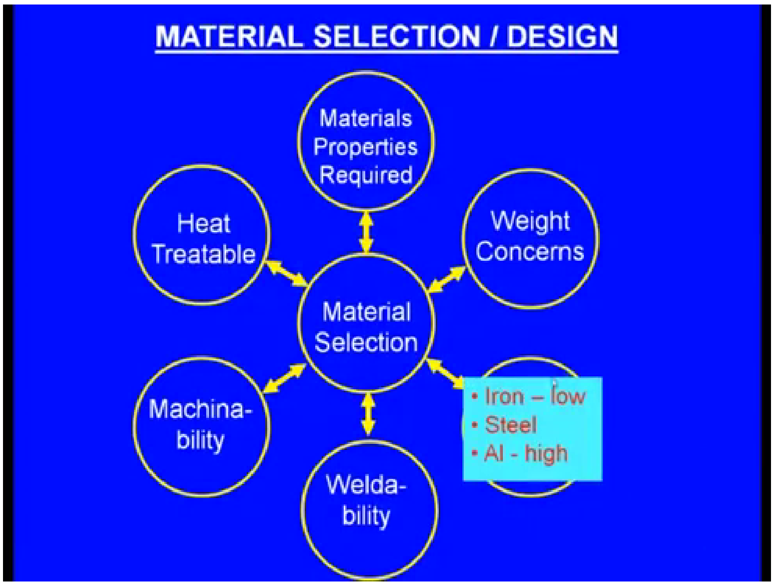

Coming to the material cost, iron its cost is very low, aluminium is very high, where as steel has a moderate cost. So, depending upon the requirement we can choose the material here.

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Coming to the weldability low or medium carbon steels have the best weldability. They have very good weldability, where as alloy steels are not weldable. In fact, they are worst in this regard, now low alloy steels and aluminium are next to the low or medium carbon steels. So, what is the degree of the weldability we require depending on that we can choose the material here. Next one let us see the machinability. So, you see here.

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So, these are all the materials which are arranged in the what say degree of their machinability, aluminium is having very good machinability.

Next comes the grey cast iron, next comes the low or medium carbon steel, next comes the ductile iron, next comes the alloy steels. Again alloy steels again it depends upon the hardness.

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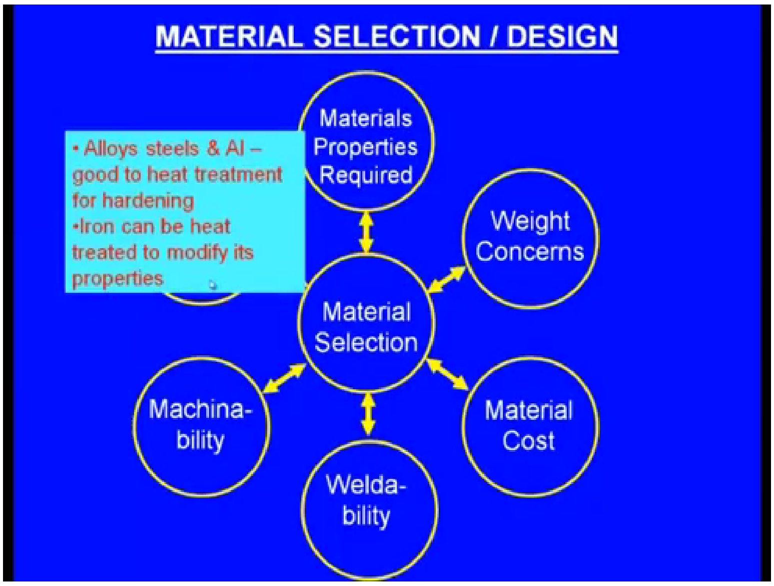

Coming to this coming to heat treatability alloy steels and aluminium have good heat treatment properties for hardening. Iron can be heat treated to modify its properties. So, these are the what say factors that are considered while choosing the material or while designing the what say material of the component which we are going to cast. Now let us see the design considerations related to product: First thing is geometric features incorporate to the part, the customer may give us a drawing. But as it is it is not possible for us to make the casting.

So, some features have to be modified which will enable us to cast the component successfully without any complications.

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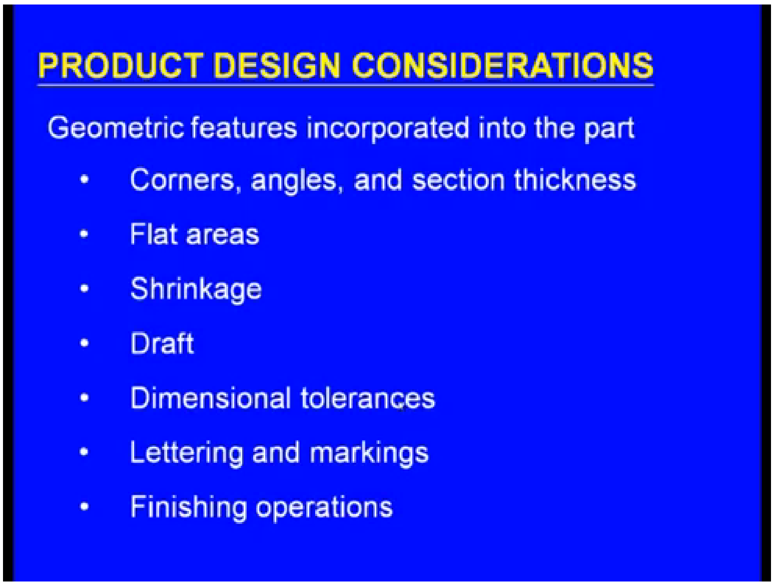

First thing is first aspect is corners, angles, and section thicknesses. Second one flat areas, third one shrinkage, fourth one draft, fifth one dimensional tolerances, sixth one lettering and markings, seventh one finishing operations. So, in all these stages we need to do some design or some modification to the design of the component. First let us see corners, angles, and section thickness.

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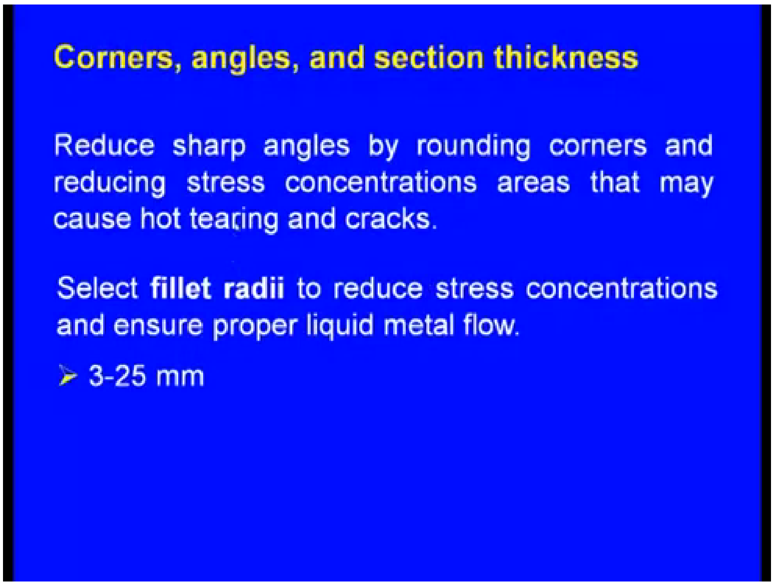

Now, what we have to do here reduce sharp angles by rounding corners and reducing stress concentration areas that may cause hot tearing and cracks. Select fillet radii to reduce the stress concentrations and ensure proper liquid metal flow. Now, let us see this one case study here.

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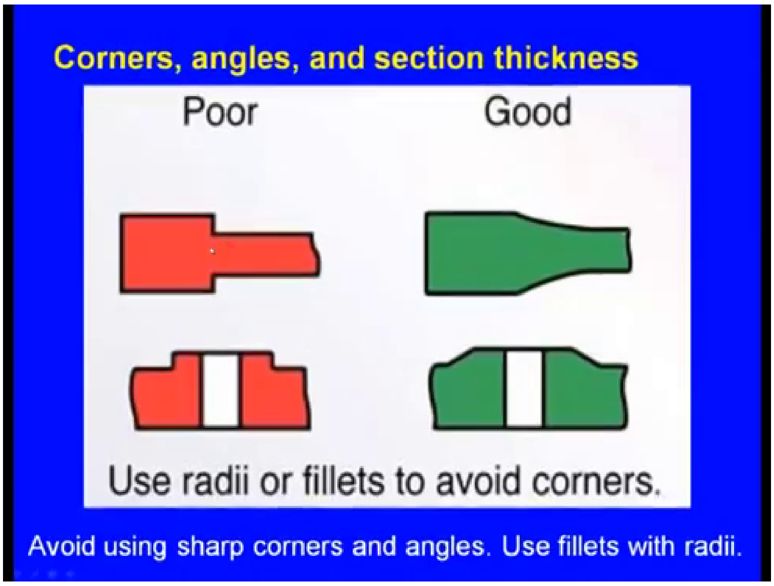

So, this is the what say components drawing as given by the customer. But as it is we should not what say cast the component we have to make some modifications means we have to avoid the sharp corner here. Here we can see there is sharp corner and here also this sharp corner, so it will lead to hot tearing.

So, we have to make a smooth what say corner, so like this we have to make. Similarly this is the drawing supplied by the customer, then as it is we should not what say cast the component and here we have to make modification like this. So use radii or fillets to avoid corners or sharp corners avoid using sharp corners and angles and use fillets with radii so this is regarding the corners, angles, and section thickness. Now, again let us see one more case study.

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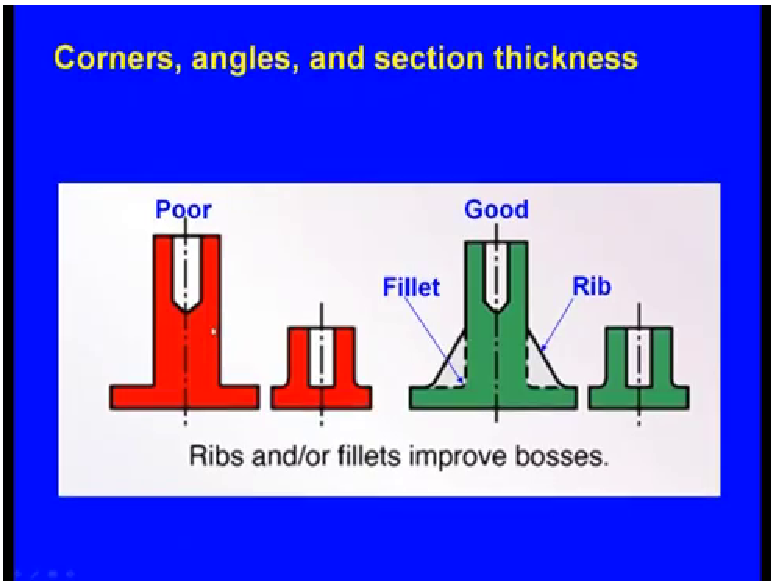

Here we can see this is the drawing supplied by the customer as it is, it is a poor design. Now how to improve its design and here we are making a rib that rib is not there in the customers drawing, but we the foundry man have to provide that rib. Next one here in the drawing supplied by the customer there is a sharp corner and here we are providing a fillet. So, this is the modification to the design and we are incorporating.

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And here we can see this is the drawing supplied by the customer and here we are modified like this means we are avoiding the sharp corners. Next one prevent planes of weakness.

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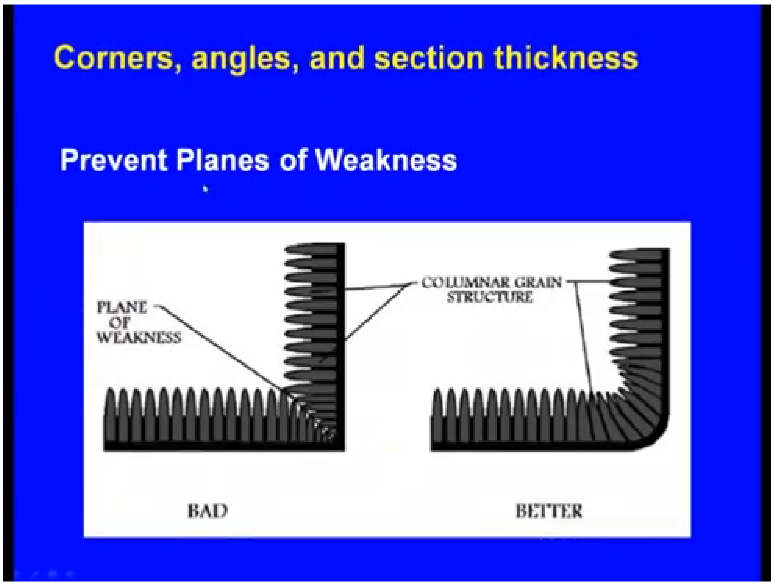

And here we can see this is the plane of weakness and here we are improving and here what say avoiding the sharp corners so this is better. Next one flat areas, let us see how to deal with the flat areas.

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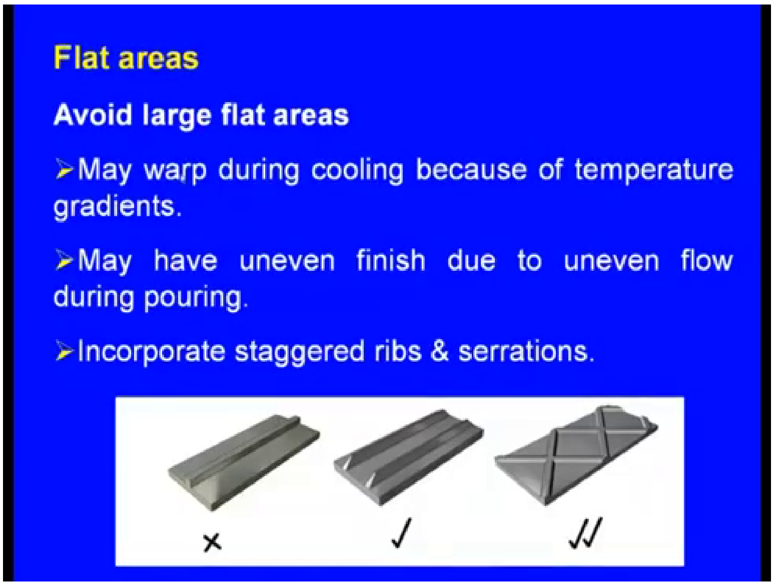

Avoid large flat areas if the drawing supplied by the customer possess what say large flat area it has to be modified why because it may warp during cooling because of temperature gradients. It may have uneven finish due to uneven flow during pouring that is why we need to incorporate staggered ribs and serrations. So, this is the flat area that is existing on the original drawing.

You see here so instead we have to modify like this. So, this is better the still better one would be like this. So always if the drawing possess a large flat area that has to be modified so that we can prevent the complications involved with that. Next one, shrinkage now sometimes the drawings supplied by the customer may not be what say help us adequate to prevent the shrinkage defect for example, you consider this drawing.

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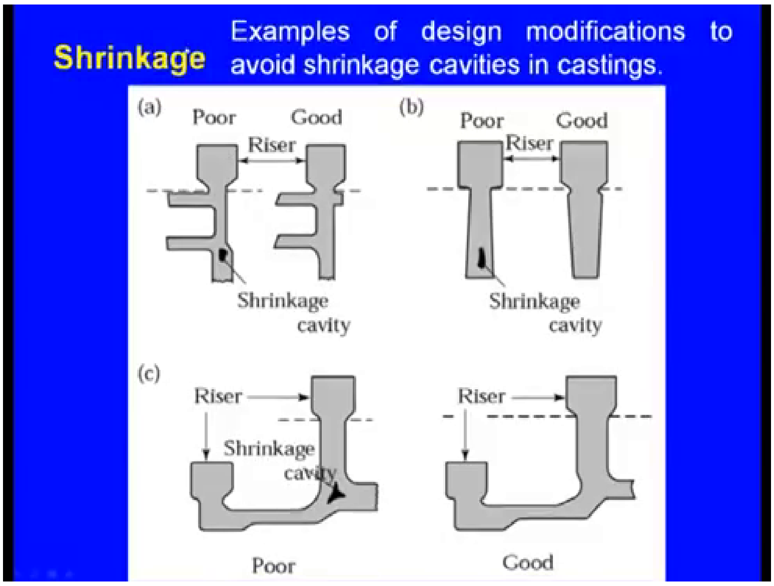

So, this is the drawing of the casting which is supplied by the customer. Now as it is if we make this casting and here we see there is the thickness of this section is very larger compared to this one. Now what will happen the riser will be somewhere here this is the riser. So, initially the riser will be feeding the bottom portion and slowly the solidification will be propagating upwards.

Now what will happen this section takes lesser time and this section will be taking more time, so this section will be solidifying first before this section freezes. Now what will happen because it has already frozen the liquid metal in the riser cannot flow to this lower section. So, ultimately there will be a shrinkage defect in that section.

So, we being the foundry man we have to modify the design. Now this is the way it should be modified you see here, here there was a larger section supplied by the customer and here we are modifying that means we are reducing the thickness of that section here and here there is a almost a sharp corner here we are improving and here we are providing a radii here. Now in this case there won't be shrinkage defect.

Next one you see here this is what say a drawing supplied by the customer and here the thickness is very large the same problem will happen. Here the shrinkage defect will arise now we have to modify the drawing. So, we are modifying the drawing and we are modifying the design you see here the thickness at the bottom is reduced, contrary to the drawing supplied by the customer. Now the shrinkage defect won't arise.

Now another case we see here. So, here also the thickness is very large here in this section. Now this is the riser, now because the thickness is very large here again there will be a shrinkage defect. Now we being the foundry man we have to modify the design. Now you see here the design is modified such that the thickness is not too much in this region so that there won't be any shrinkage defect. So, that is how we can supply the she what say we can prevent the shrinkage defects in the castings.

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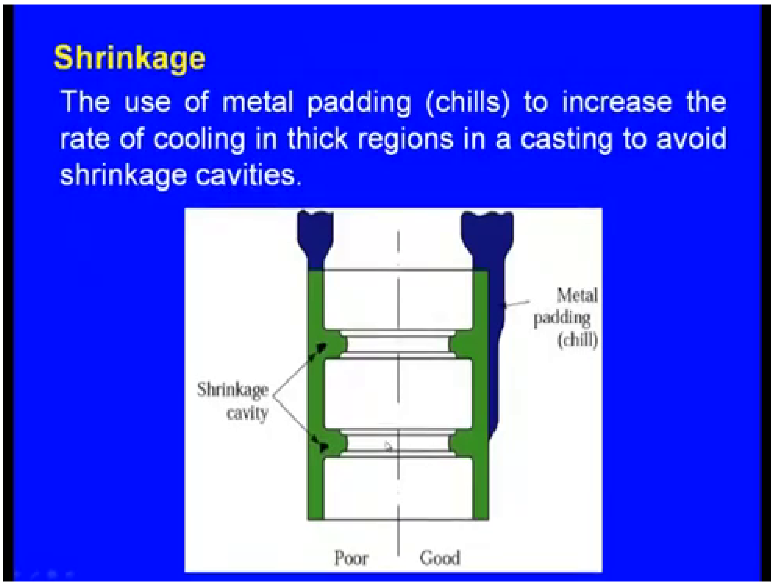

Now the use of metal padding or chills to increase the rate of cooling in thick regions in a casting to avoid shrinkage cavities. Now let us consider another case study. So this is the what say a drawing supplied by the customer. Now what is happening here somewhere here there will be riser. Now what is this region in this region there is excess of molten metal. Now this section will be solidifying first and this section will be solidifying,, but once this section solidifies the molten metal from the riser cannot come to this region for feeding purpose. Now ultimately there will be shrinkage defect in that region. Now how to handle this situation, now we have to use metal padding or chill to prevent shrinkage defect in that region means this is that metal padding means it is made up of steel, now this little padding is coming up to here.

Now, what is the specialty of this metal padding this metal trading or chill what say extract heat rapidly now it initially it may take maybe this section will take 1 hour and this section will take 1 and half hour that is how the upper section freezes first and the lower section does not freeze ultimately there will be shrinkage cavity. Now because we are incorporating metal padding it rapidly absorbs heat and even before the upper section solidifies even the lower section also that thicker section also solidifies. In fact, all those sections simultaneously will be solidifying.

So, the question of shrinkage does not arise, so that is how we have to prevent the shrinkage defect by using metal padding or chill. Now, you see here.

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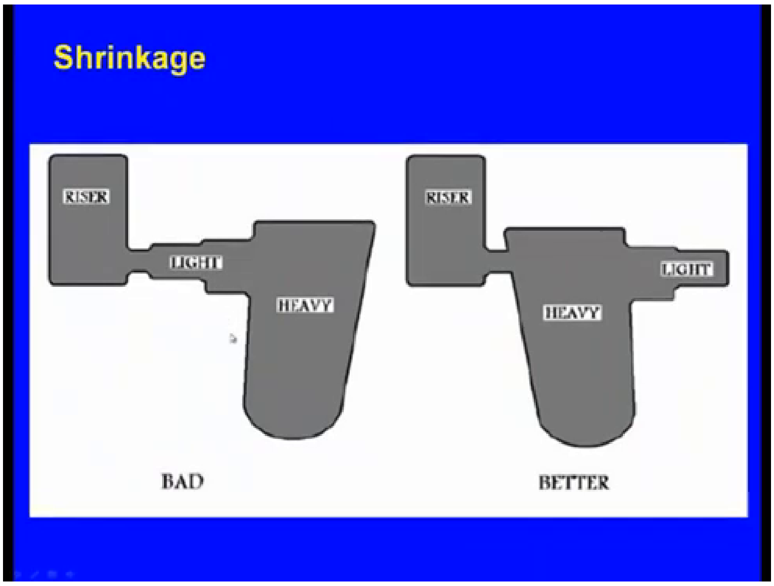

So, this is the what say regarding the location of the riser, now this is the casting and this is the heavy path of the casting and this is the light path or the thin section of the casting and this is the riser. Now what happens when you now the question is where to what say located the riser? Now the riser is located here now what will happen this takes more time may be let us say this section takes 2 hours for solidification where as this section takes 1 and half hour for solidification and this section takes only 1 hour for solidification.

Now, the molten metal from the riser will be coming to the casting for the purpose of feeding during shrinkage. Now what will happen as long as this what say thin section is not solidified no problem the molten metal will be going to the main what say the larger section. But once this what say section is solidified, the molten metal cannot feed to the, cannot to go to the casting, but this is still in liquid state where as this what say section is already solidified.

Now how the riser can feed the casting at this heavy section no it cannot feed ultimately there will be shrinkage defect. Now what to do now hear the position of the riser has to be changed now here we have placed the riser instead of placing the riser on the nearest section which has got very thin section instead keep the riser away from the thin section.

Now, the thin section is this side, now the raiser is on the other side. Now what will happen yes this may take 1 hour no problem let it solidify then after this section will solidify, next one the heavy section will be solidifying, till the heavy section is completely solidified the riser will be feeding liquid metal to the casting that is how by proper location of the raiser we can prevent the shrinkage defect.

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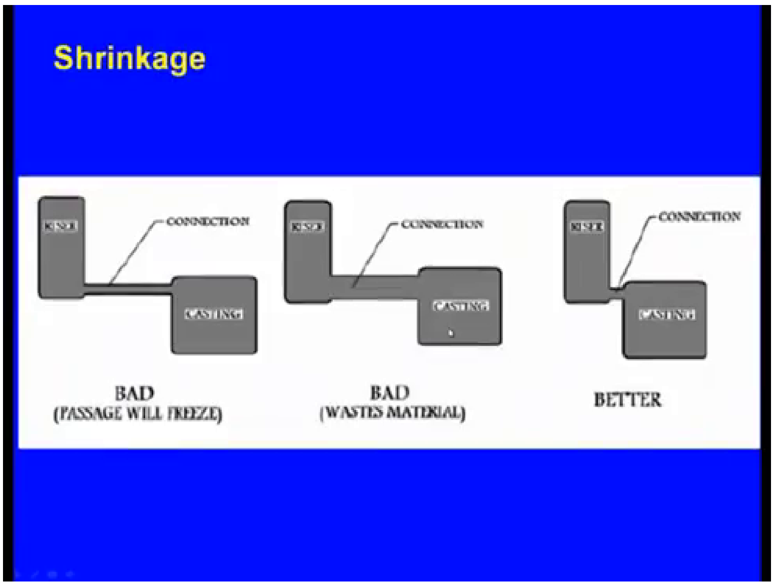

Now, you see here this is another case study here this is the channel through which it molten metal from the raiser is going to the casting. Now because this is a long channel, the molten metal may solidify as it is passing from the riser to the casting. On the other hand here it is very large, very large and also very thick this also not good why because it consumes more liquid metal on the other hand this kind of long sections should be avoided between riser and the casting see here it is a short what say connection, so this is better. So, this some more case studies we can see. So, this is the casting.

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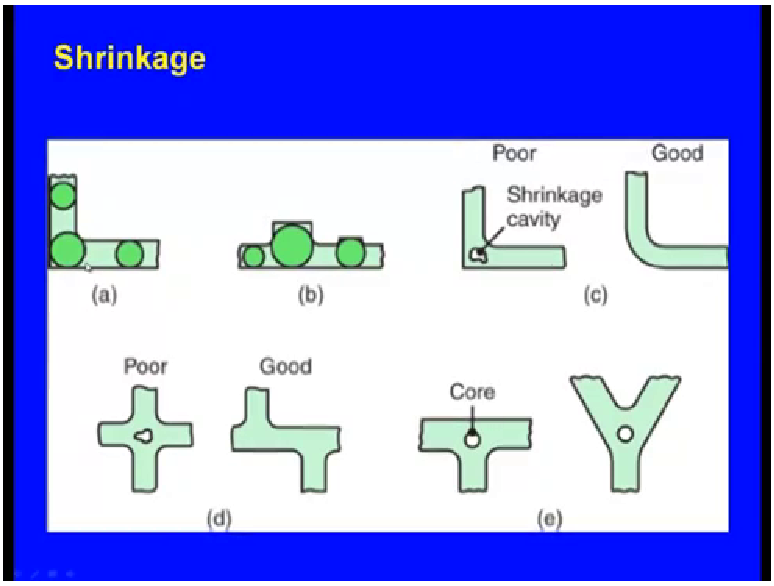

Next one here you can see this is another casting and here we can see a shrinkage defect. Now this has to be prevented by making a curve like this. Now you see here this is the what say drawing this is the what say casting, but as it is if we cast it and here there will be a shrinkage cavity. On the other hand we are modifying the design like this so this is good and this is poor. Next one you see here this is the casting and here there will be shrinkage defect, so we need to modify like this. So, this is better compared to this one. Next one draft.

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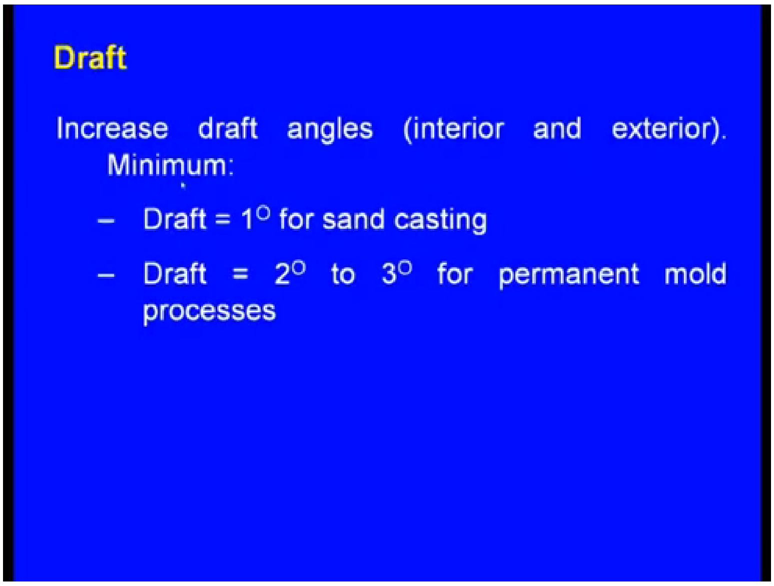

Increased draft angles, interior and exterior and draft angle should be 1 degree for sand casting and draft angle should be 2 degrees to 3 degrees for permanent mould process means dye casting.

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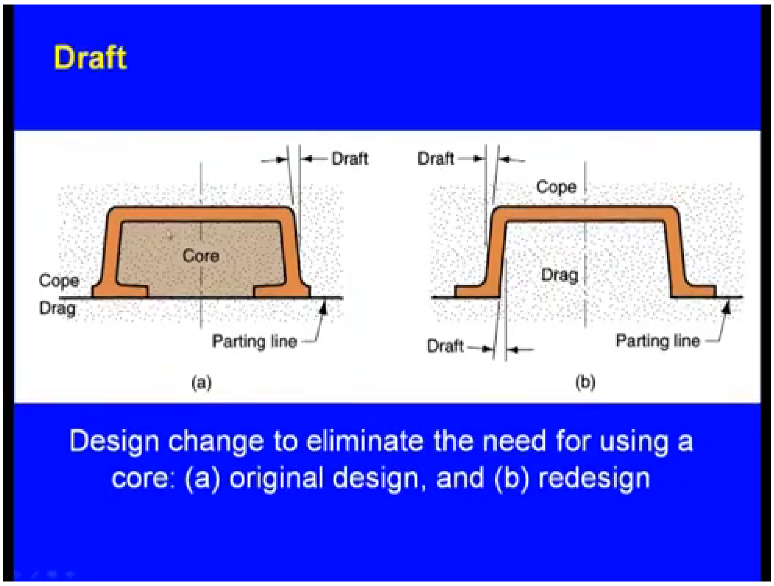

And you see here, here this is the cast component and this is the draft, design change to eliminate the need for using a core. So, this is the original what say drawing supplied by the customer where as we are redesigning like this. So, even the draft has to be redesigned and here the core cannot be removed very easily and here the core can be removed very easily. Next one dimensional tolerances.

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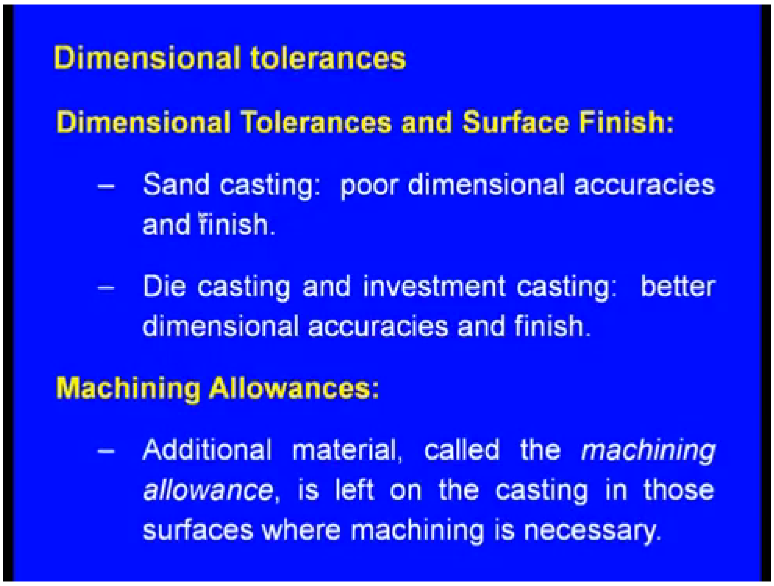

Dimensional tolerances and surface finish right for sand casting poor dimensional accuracies and finish will be there. Die casting and investment casting: better dimensional accuracies and finish will be there.

Next one Machining Allowances: Additional material, called the machining allowance, is left on the casting in those surfaces where machining is necessary. So, the castings especially the sand castings will have a poor surface finish, so we have to machine this so that there will be a better or a good surface finish.

So, we need to machine or we need to remove the material under the machines. So, for this purpose even the size of the casting should be little larger than what is required that is why there will be even the pattern will be designed such that its dimension is little larger than what is required. So, this excess dimension is known as the machining allowance. Next one dimensional tolerances it should be a wide as possible.

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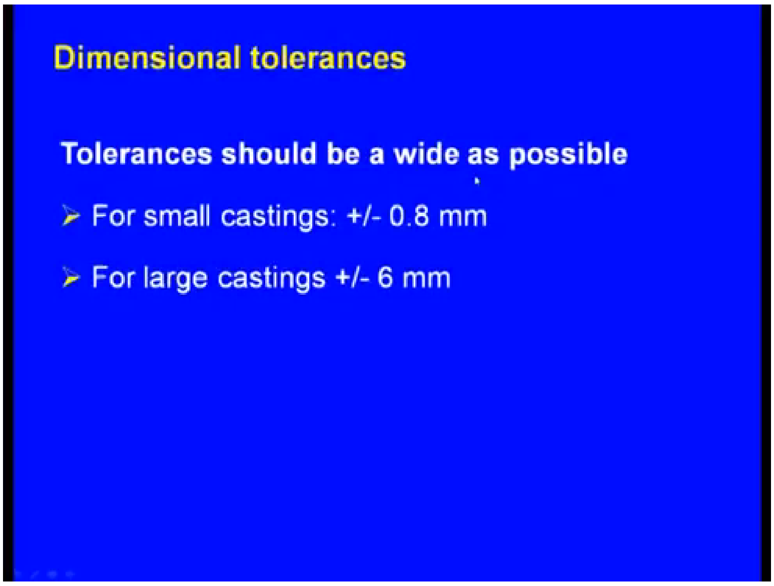

For small castings it should be plus or minus 0.8 millimeters. For large castings it should be plus or minus 6 millimeters. So, far we have seen the design considerations regarding the what say cast component how to modify the cast components geometry. Now let us see the design considerations related to mould.

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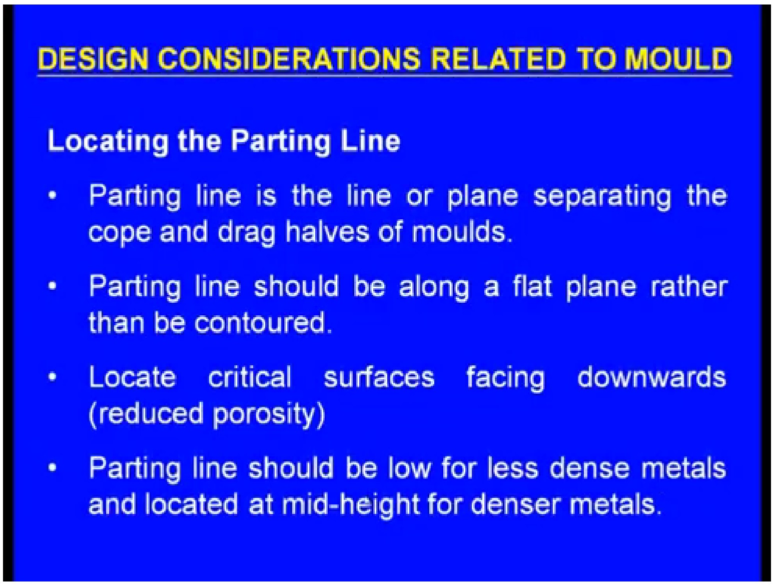

In the design considerations related to the mould, the first one is locate the parting line: Parting line is the line or plane separating the cope and drag halves of the moulds. Parting line should be along a flat plane rather than be contoured. Next one, locate critical surfaces facing upwards. Parting line should be low for less dense metals and located at mid height for denser metals. Now, you can see here.

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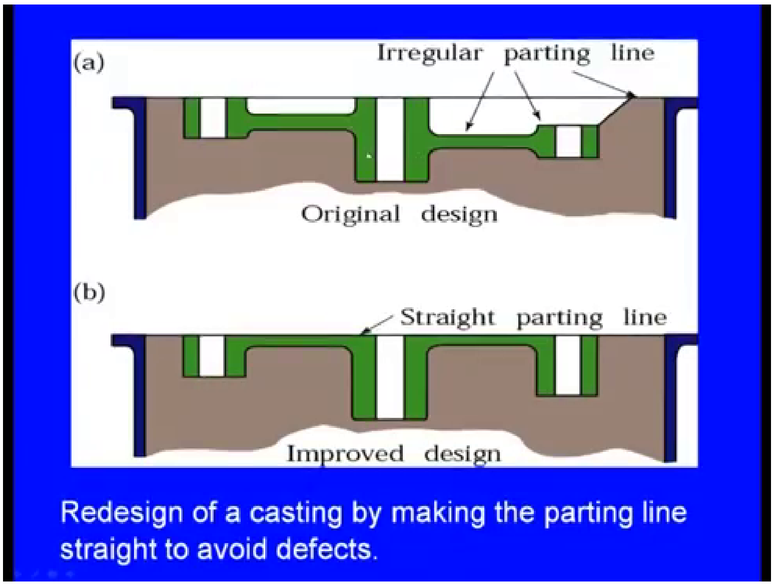

So this is the original design supplied by the customer. Now we need to modify the design so that the parting line will be comfortable for the foundry man. So, redesign of a casting by making the parting line straight to avoid defects. So, here the parting line is not straight and here this is part of the parting line and here this is again part of the parting line so that is not good and here we are making straight parting line you see here. So, this is the modification as far as the parting line is concerned.

Now design and location of the gates in the mould.

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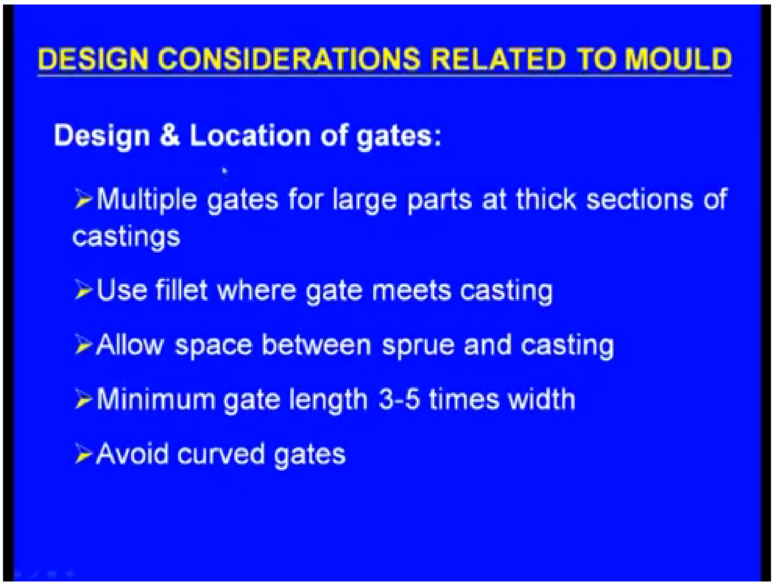

Multiple gates for larger parts at thick sections of the castings it should be incorporated. Next one use fillet where gate meets casting. Allow space between sprue and casting. Minimum gate length should be 3 to 5 times the width. Next one avoid curved gates. So, these are the simple rules that are related to the gates. Next one design of the runner, how to design the runner?

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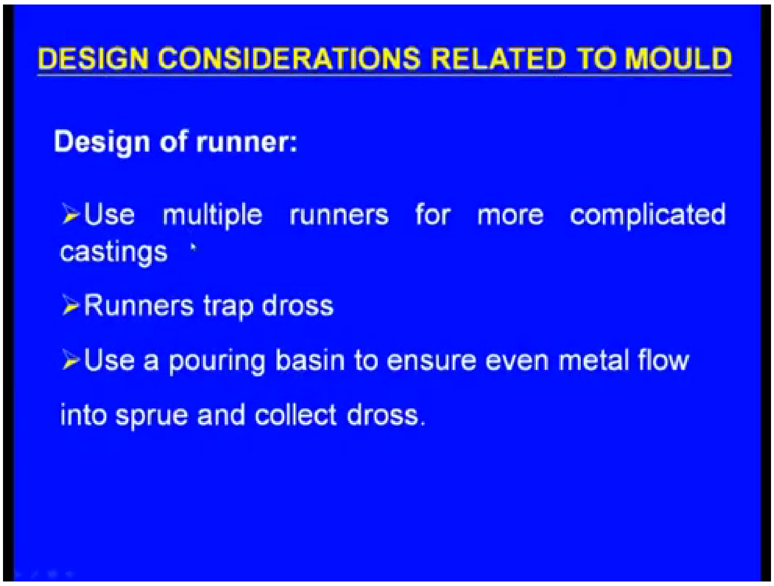

Use multiple runners for more complicated castings, multiple runners. Runners trap drosses remember that. Use a pouring basin to ensure even metal flow into sprue and collect dross.

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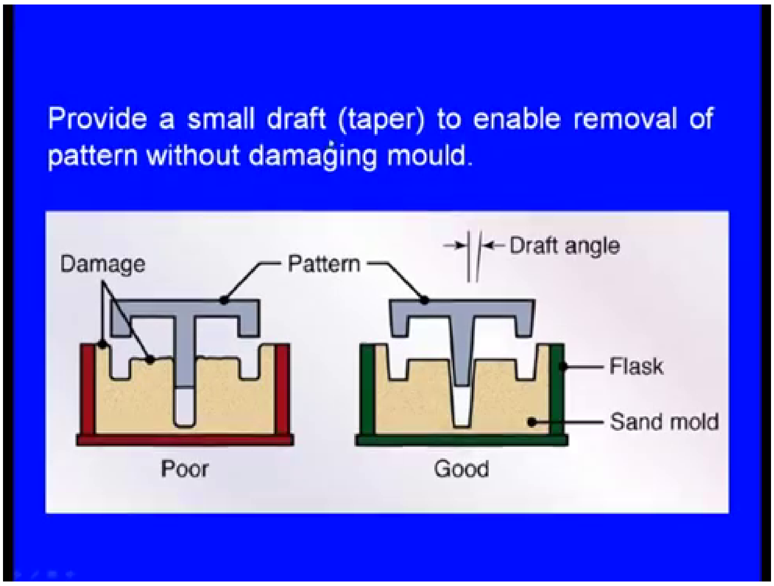

Provide a small draft of taper to enable removal of pattern without damaging the mould now this is the original pattern as it is you see it is a poor design why while after moulding while withdrawing the pattern you see till the pattern is completely withdrawn from the mould the pattern surface and the mould surface are in contact with each other. So, at any time the surface of the mould may break on the other hand we are making some modification to the pattern.

Now you the pattern is given a small tapper, so because of this tapper maybe in the beginning there may be a what say tight contact between the patterns surface and the mould surface. But once we withdraw a little there will be a separation between the patterns surface and the mould surface now that can be easily withdrawn. So, providing a draft or tapper to the pattern is very important. Next one design considerations for die casting. So, far we have seen the design considerations for the sand casting. Now let us see the design considerations for the die casting.

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Physical design considerations: sand coring is generally not possible in die castings, but in the sand castings we use only sand cores. Only straight steel core pulls can be used to define internal passages. Next one feeding of shrinkage is via the gates alone; parts should be designed with as uniform thickness as possible and here the shrinkage is carried out through the gates. Inserts can frequently be cast into the part. Hollow tubes, threaded inserts to fill out the bosses, engine bore liners and wear resistant inserts are common.

Guidelines for sizing:-

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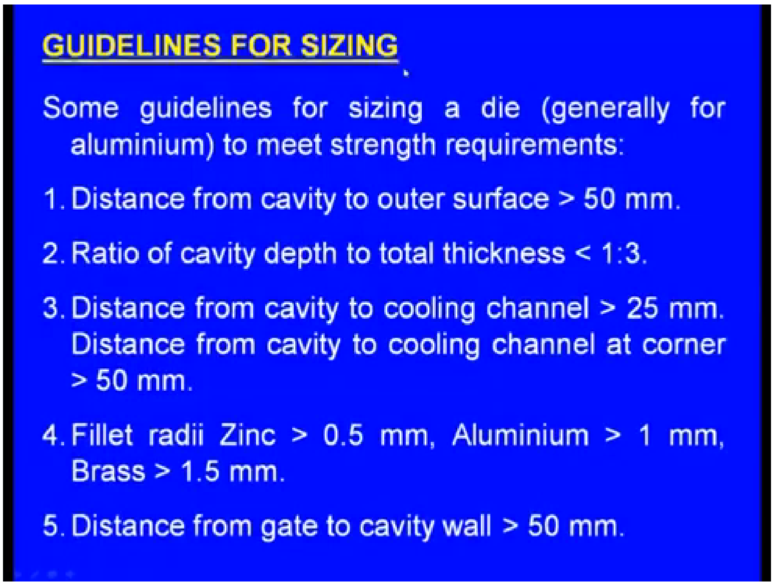

Now, some guidelines for sizing a die generally for aluminium to meet straight requirements: Distance from cavity to outer surface should be greater than 50 mm. Ratio of cavity depth to total thickness should be less than it should be 1 is to 3. Next one distance from cavity to cooling channel should be greater than 25 millimeters. Distance from cavity to cooling channel at corner should be greater than 50 mm. Fillet radii for zinc should be greater than 0.5 mm, for aluminium it should be greater than 1 mm and for brass it should be greater than 1.55 mm. Distance from gate to cavity walls should be greater than 50 mm.

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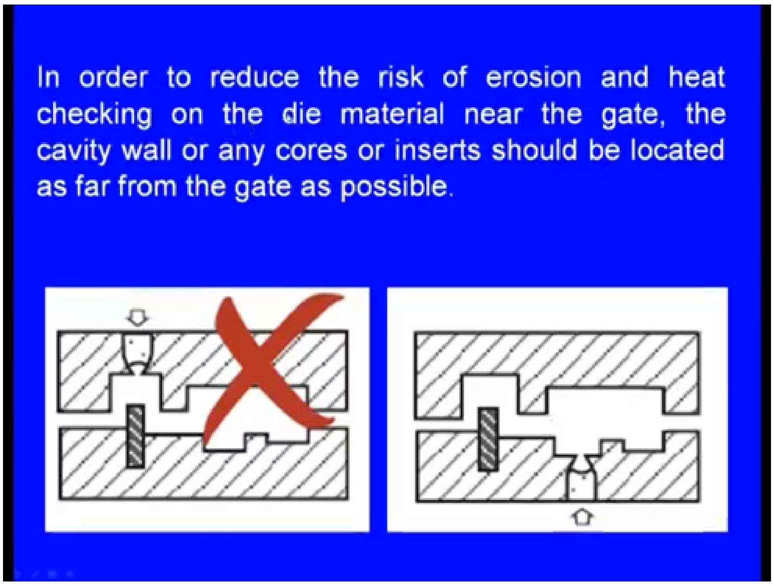

Now, in order to reduce the risk of erosion and die checking on the die material near the gate that cavity wall or any cores or inserts should be located as far from the gate as possible. Now this is the gate through which the molten metal will be injected into the die cavity. So, these are the 2 dies of the what says mould which are used in the die casting. So, this is the gate so through this gate the molten metal will be injected.

Now what will happen this is the core, now if the molten metal is coming and falling on the core what will happen there will be erosion of the material so this is the poor design. Now what is the correct design the core should be away from the what say the from the place where the molten metal is injected. So, this is the place where the molten metal will be entering into the mould cavity at a very high pressure. Now we are modifying such that the core is away from the what say a place where it will be entering. So, this is a better design.

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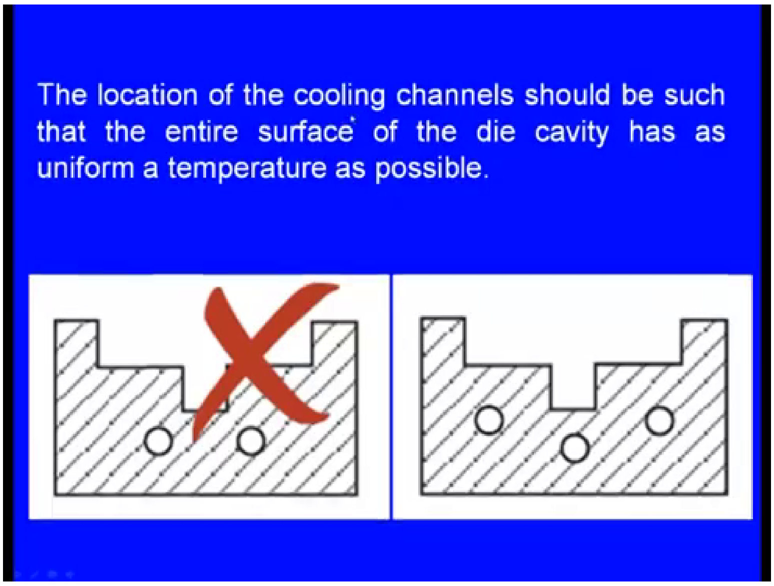

Next one the location of the cooling channels should be such that the entire surface of the die cavity has as uniform a temperature as possible. Now you see here so this is the these are the cooling channels through which the cooling what say coolants will be circulating to cool the beds. Now here we can see only 2 channels are there and they are not what say distributed properly, so that is a poor design. On the other hand the cooling channels are increased and they are placed uniformly around the cavity. So, this is a better design.

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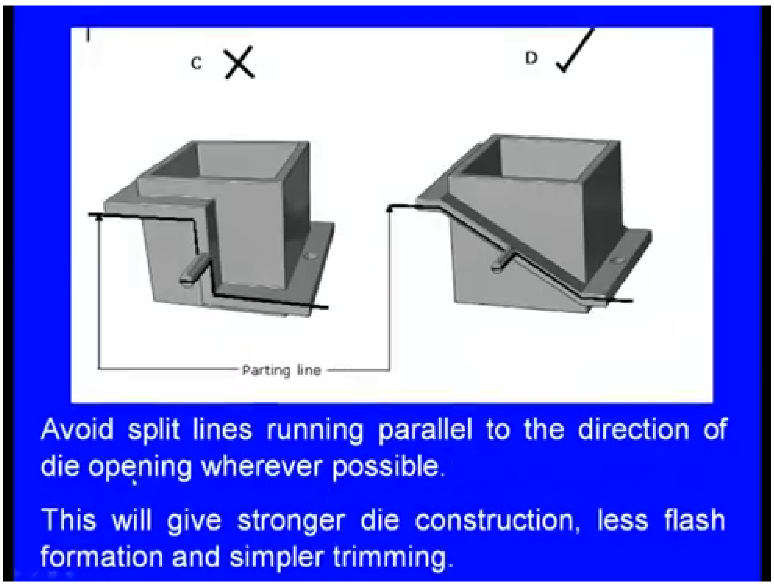

Next one avoid split lines running parallel to the direction of die opening wherever possible and this will give stronger die construction less flash formation and simpler trimming. So, this is a poor design where as this is a better design.

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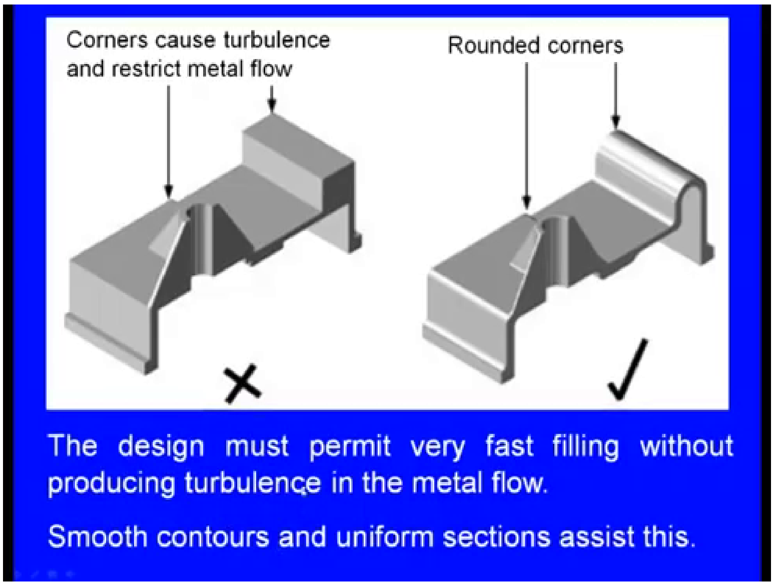

Next one the design must permit very fast filling without producing turbulence in the metal flow. Smooth contours and uniform sections assist this. Now here you can see so corners cause turbulence and restrict metal flow here.

So, here we can see sharp corners are there. So, this cause turbulence and they restrict the metal flow and here also we can see sharp corners. So, this is an improved design here we are a making rounded corners here we can see these are the rounded corners. So, this will minimize the turbulence and also enable easy filling of the molten metal.

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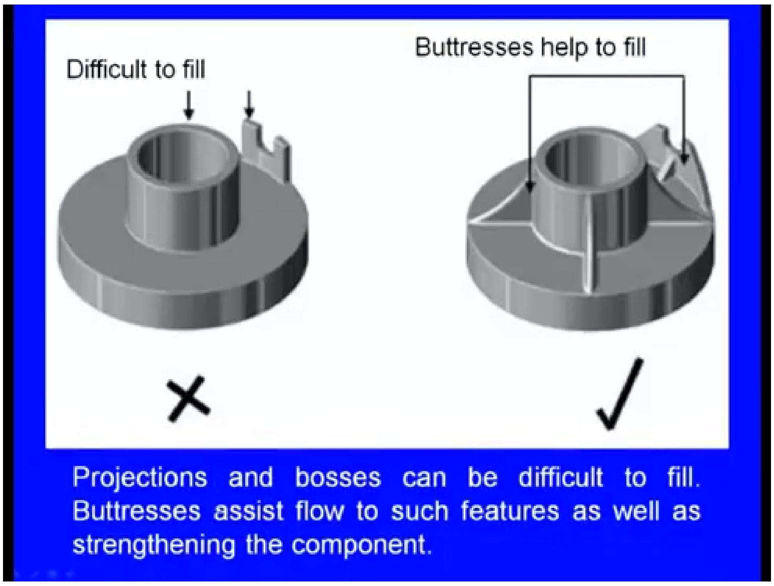

Next one projections and bosses can be difficult to fill buttresses assist flow to such features as well as strengthening the component. And here we can see so these are the buttresses to help the fill and this buttresses are not in the original design given by the customer, but we being the foundry man we have to modify the design and we have to incorporate the buttresses.

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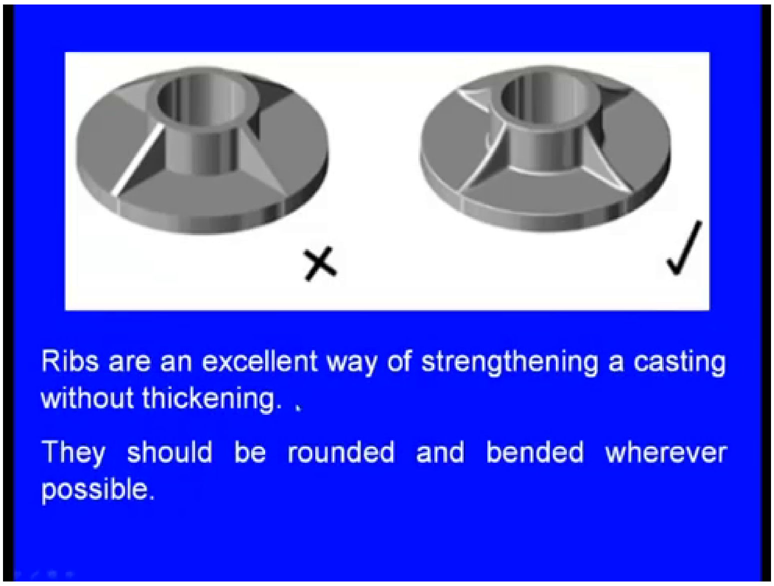

Next one ribs are an excellent way of strengthening a casting without thickening. They should be a rounded and bended wherever possible. And here we can see these are the ribs no doubt the customer has provided ribs in his drawing, but these ribs do not have the correct design. These ribs should be bent as far as possible and they should be rounded also there here they are rounded, but in this original design they are very sharp.

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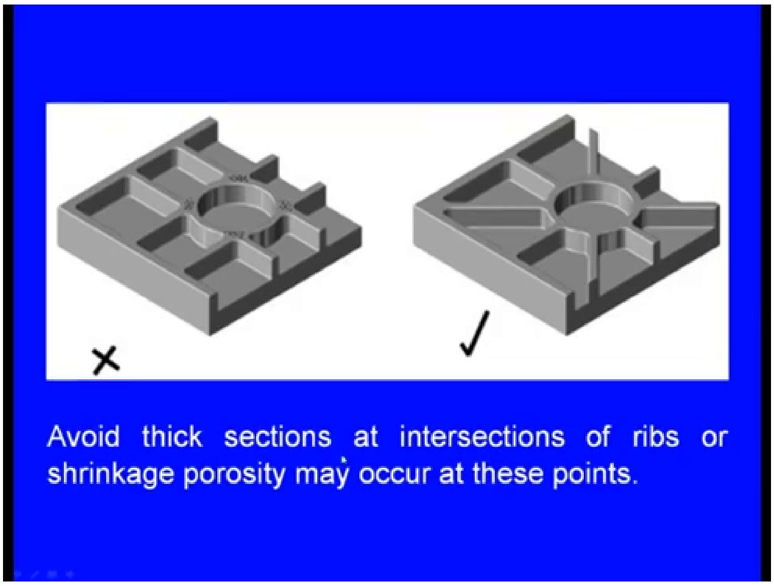

So, this is a better design compared to the original design: Avoid thick sections at intersections of ribs or shrinkage porosity may occur at these points. Avoid thick sections at intersections and here we can see these are the intersections and here we can see thick sections. So, here there will be shrinkage porosity will be there, now instead we are modifying the design such that this kind of thick section won't be here. So, this is the modified design or a better design.

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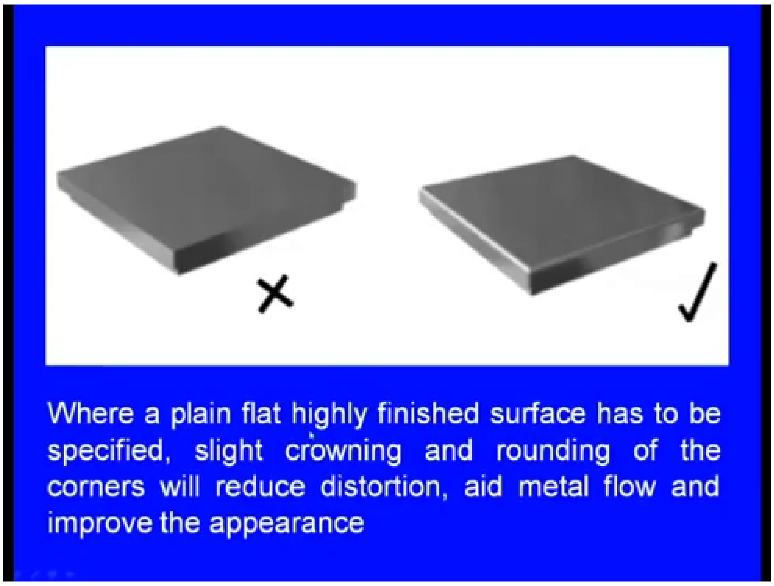

Next one where a plain flat highly finished surface has to be specified slight crowning and rounding of the corners will reduce distortion, aid metal flow and improve appearance. So, this is the original design, so this is not recommended and the what say edges should be rounded and there should be what say slight crowning will be there. So, this is a better design.

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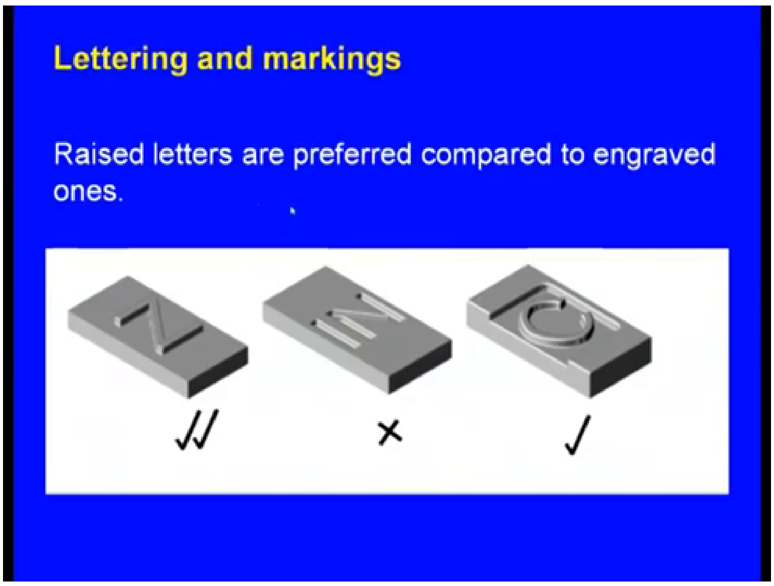

Next one lettering and markings: Raised letters are preferred compared to engraved ones. So, here we can see these are the letters, so these are the raised letters these are the engraved letters, engraved letters are not good, raised letters are preferred compared to the engraved letters and here we can see here also we can see a raised letter, but it is what say available inside a pocket. So, compared to this one this is a better design.

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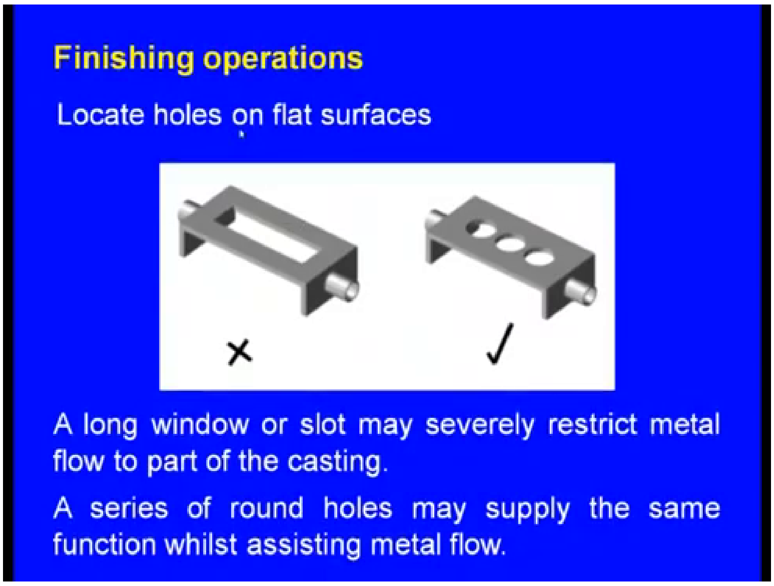

Next one finishing operations locate holes on flat surfaces. So, a flat surface has a hole like this, so this is not a good design a long window or a slot may severely restrict metal flow to part of the casting. A series of round holes may supply the same function while assisting the metal flow instead of having a long hole like this several holes small holes like this it will be useful and they will be evenly distributing the molten metal.

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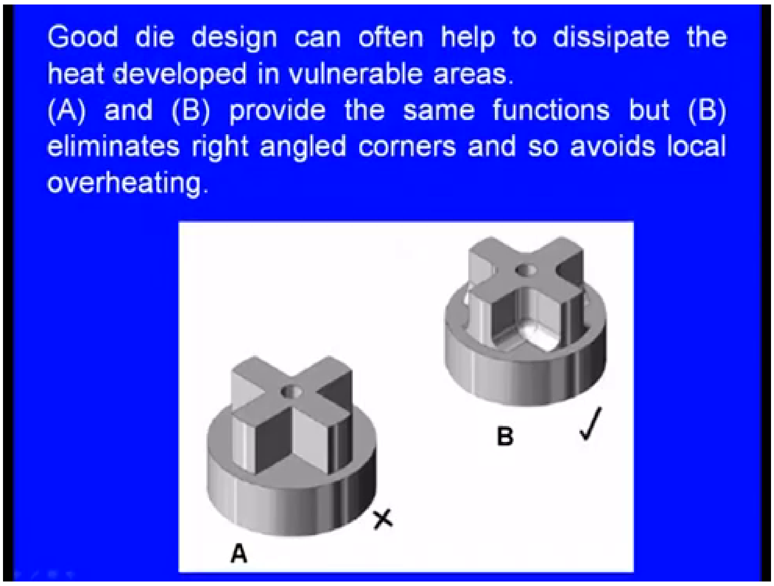

Next one Good die design can often help to dissipate the heat developed in vulnerable areas. Now A and B provide the same functions but B eliminates right angled corners and so avoids local overheating. And here we can see there is corners are there here sharp corners are not there so this is a better design, so it avoids local overheating.

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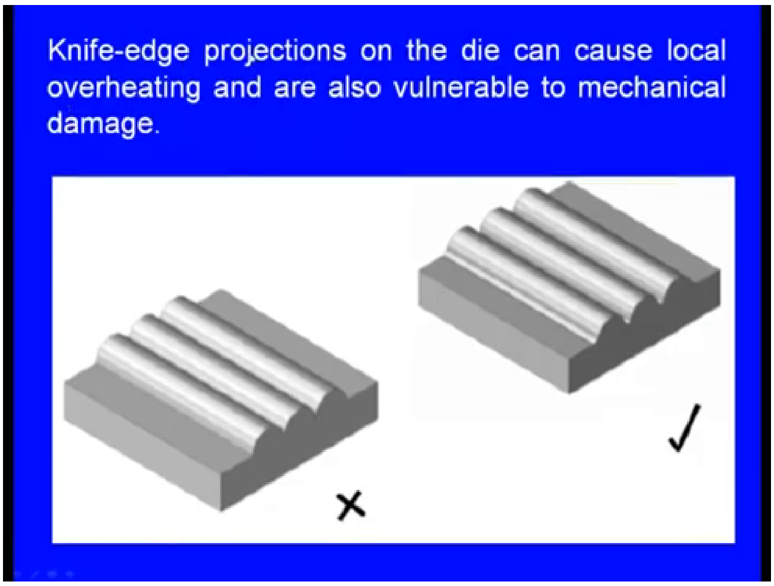

Next one Knife-edge projections on the die can cause local overheating and are also vulnerable to mechanical damage.

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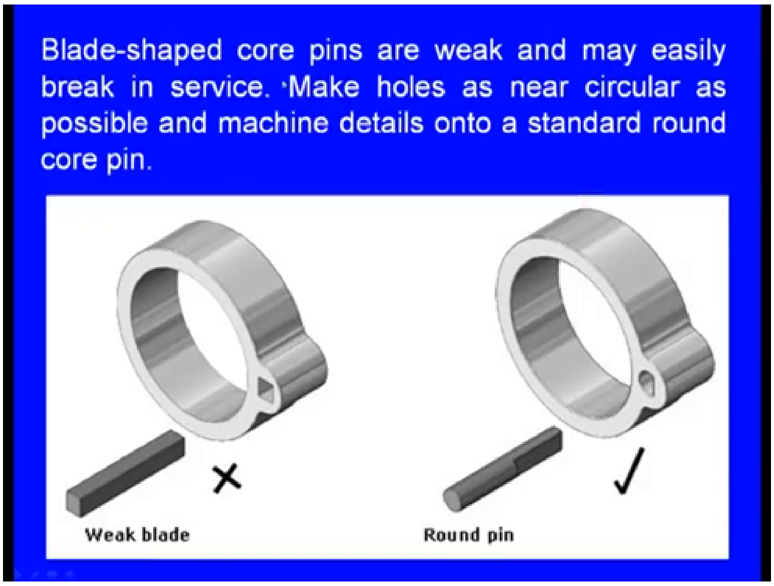

Blade-shaped core pins are weak and may easily break in service. Make holes as near circular as possible and machine details on to a standard round core pin. So, this is a blade it has got the sharp corners, so this is not a good design. On the other hand this is a round design, even the corners are rounded. So, this is a better design.

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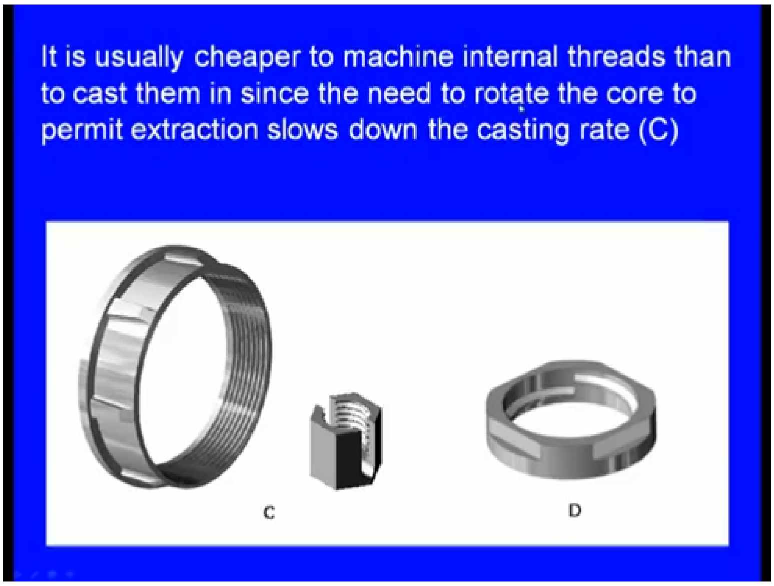

It is usually cheaper to machine internal threads then to cast them cast them. Since it they need to locate the core to permit extraction slows down the testing rate. So, is it is usually easier to machine the threading rather than to cast the threaded component. Now metallurgical design considerations.

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Die castings are not to be designed for bad bearing load bearing and safety critical applications. Next one die casting, are not heat treatable. Next one die castings possess limited ductility. So, these are the metallurgical design considerations. Now this so far we have seen how to what say modify the design of the cast component, how to modify the mould. So, why because to prevent certain defects like what say shrinkage defect what say hot tearing cracking and so on. So, this can be what say done using the computer aided design also several software's have been developed so in which we can even predict weather that design is good design or a bad design. So, among the software's so these are the important ones.

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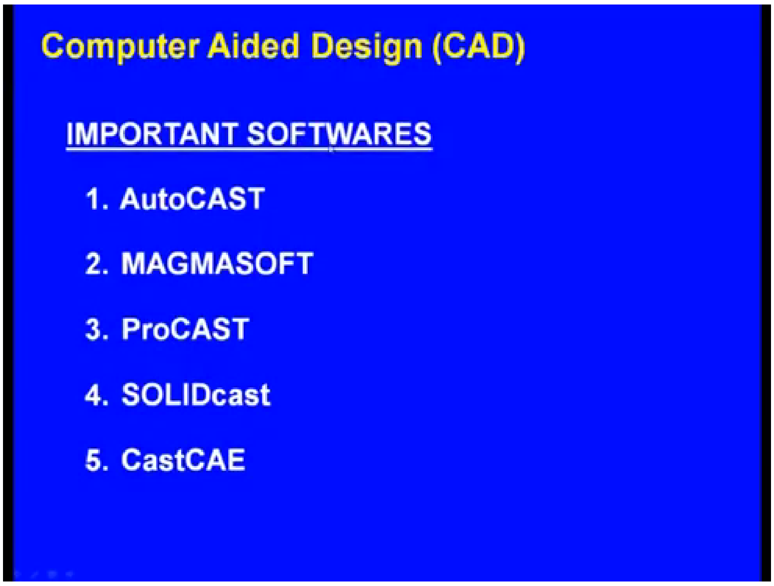

One is the AutoCast, second one MAGMA SOFT, ProCast, Solid Cast and Cast CAE. So, in this software's we can what say design the mould initially and we can test weather that design would be a sound one or a defective one. If it is any problem is arising if any defect is arising we can modify the design in the cad itself in the computer itself and this iteration continuous till there we get a casting without any defect. And here we can see a case study method design and model using autocast software.

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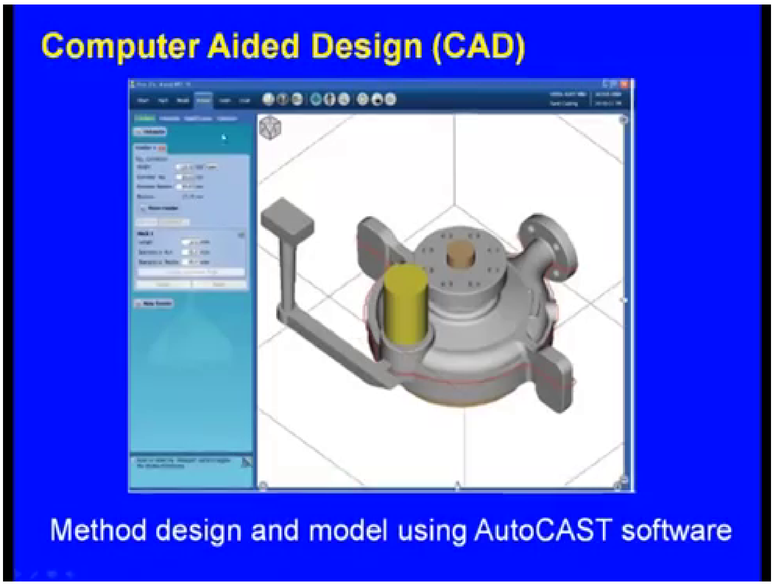

So, this is auto cast software was developed by Indian companies and it is very useful for predicting the what say defects that are commonly arising during casting process. Now the what say design of the cast component can be simulated the poring and solidification also can be simulated in this software. Now if any defect is there like shrinkage defect hafting defect, so this can be predicted and if this what say defects are persisting the model has to be what say modified till there won't be any defect.

So, whatever we have seen modification of the cast to design, components design, modification of the what say material, modification of the mold design can be simulated using the computer aided design using these software's. Next one finally the economics of casting:-

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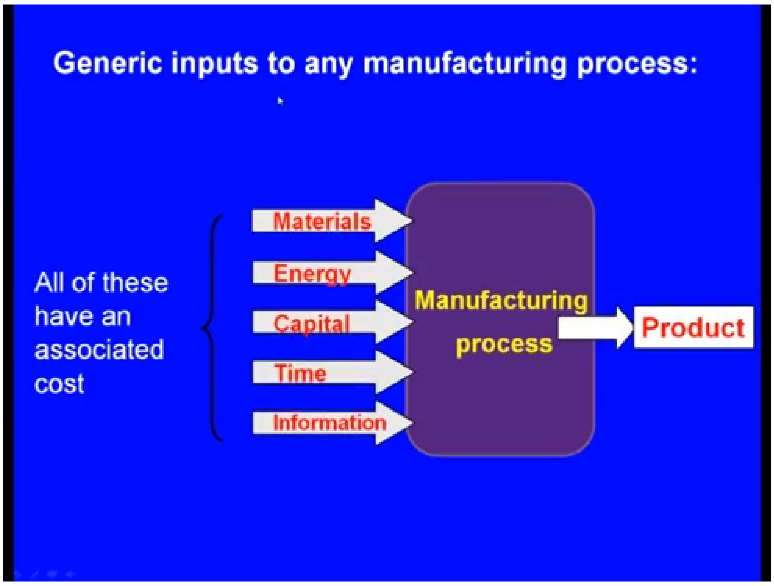

Now, generic inputs to any manufacturing process will be like this: One is the material cost, second one is the energy cost. Next one is the capital cost, next one time involved, next one information means we might have what say brought this technology from someone else. So, we might have been what say the pain to those people. So, that cost also comes here. So, all of this have an associated cost on the manufacturing what say cost. So finally, all these parameters will be what say useful and they will be playing an important role in the manufacturing process finally, we are getting the product. So, what is the material that we are using is it a costly material or a material of moderate cost. So, that determines the cost of the product.

Next one how much energy is consumed? Now what is the capital cost? If it is a sand casting process means capital cost will be less on the other hand if it is a die casting process means the initial capital cost will be very high. Now what is the time required for a sand casting the time required is very less on the other hand for an investment casting process the time involved is very high and information, so all this factors will be influencing the cost of the product remember whenever we are making a what say component the cost should be reasonable.

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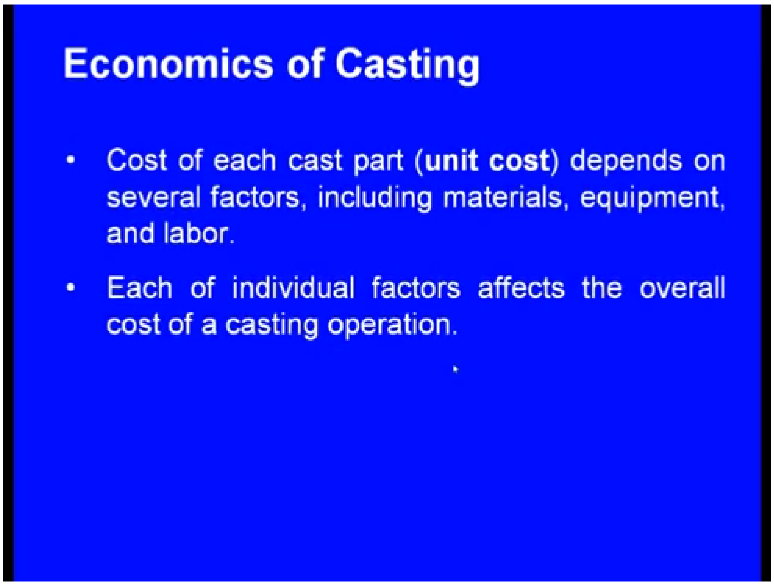

Now, cost of each cast part or unit cost depends upon several factors including materials equipments and labor each of individual factors affects the overall cost of a casting operation.

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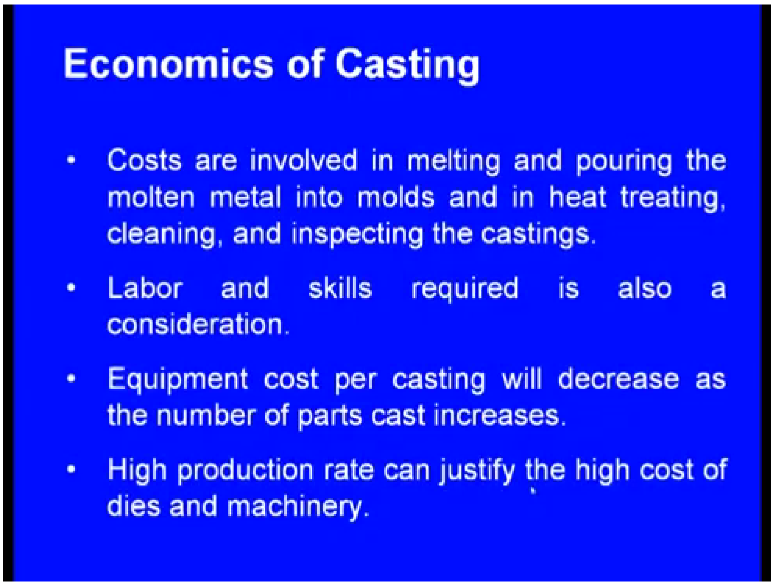

Next one costs are involved in melting and pouring the molten metal in to molts and in heat treating, cleaning, and inspecting the castings all this will be influencing the cost of the product. Next one labor and skills required is also a consideration. Next one equipment cost per casting will decrease as the number of parts cast increases. May be for example, if we consider the die casting the equipment is very costly and if you purchase that equipment and make only a few castings may be 10 castings or 20 castings the cost per each what say component would be very high. On the other hand if you produce say 5000 components the cost will be drastically reducing. Next one high production rate can justify the high cost of the dies and machinery that is what just now we have seen. Now cast what say cost component?

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Moulds, extremes we can see sand is very low and die casting it is very high, next one melting and pouring, next one heat treatment, cleaning inspection and labor charges. So, these are the what say cost component of a product or of a cast product.

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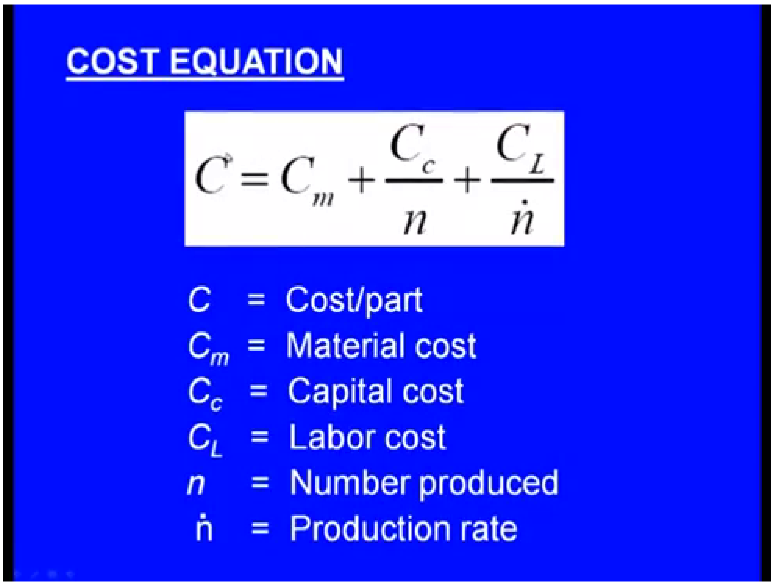

Now, this is a cost equation C is equal to C m plus C c divided by n plus C l divided by n where C is the cost per part, C m is the material cost, C c is the capital cost, C L is the labor cost, n is the number produced and n is the production rate.

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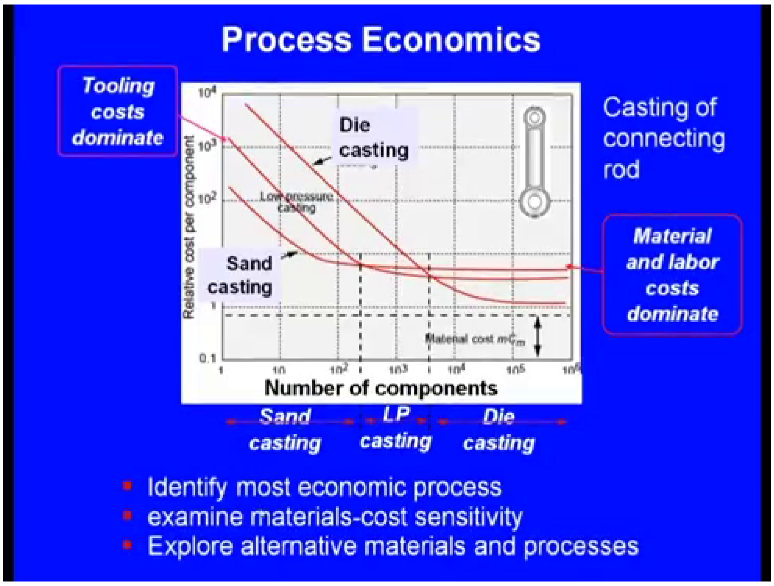

Now, this is the process economics and here we can see the what say economics of different casting process. So, here we can see the what say process economics of die casting. What we can understand from here so this is the number of components and this is the relative cost per component.

Now if we purchase a die casting machine and produce only 10 components cost is very high, but as we are increasing the number of components the cost per product is drastically coming down. On the other hand you see this is the curve for the sand casting, for the sand casting even if we produce few pieces the cost is not very high, but as the number of pieces will be increasing the cost will be decreasing, but still the cost of the sand casting per product is more than the cost of the die casting per piece and this is die casting and this is the low pressure die casting. So tooling, costs, dominate in the case of the die casting where as in the case of sand casting material and labor costs dominate.

Now, for low volume sand castings are better and for middle volume intermediate volume, low pressure casting, die casting are better and for high production volume die casting high pressure die casting will be better. So, now what you need to do identify the most economic process from this graph. Next one examine materials-cost sensitivity. Next one explore alternative materials and process.

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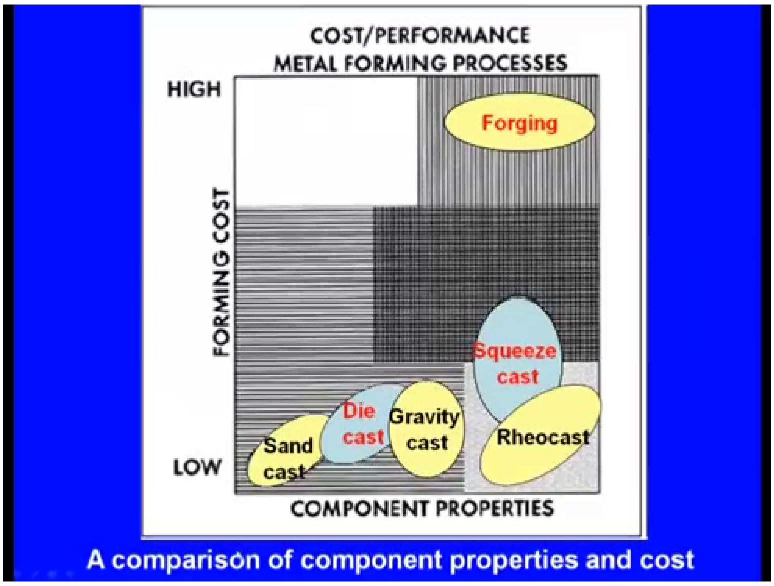

Now, here we can see a comparison of the component properties and cost and this is the sand costing process even if the number of components is very less the cost of the production is very low. And the die casting is little high than the sand casting and this is the gravity casting as the component what say cost of production we can see here and this is the Rheocasting and this is the squeeze casting. Now this is the forging and in the case of forging we can see properties are very good, but cost is very high, but on the other hand we can see squeeze casting squeeze casting is having same properties as that of the forging, but its cost of production is almost one-third of the forging. So, that is how we can analyze the what say cost of different process and we have to what say choose the right one or the most appropriate one.

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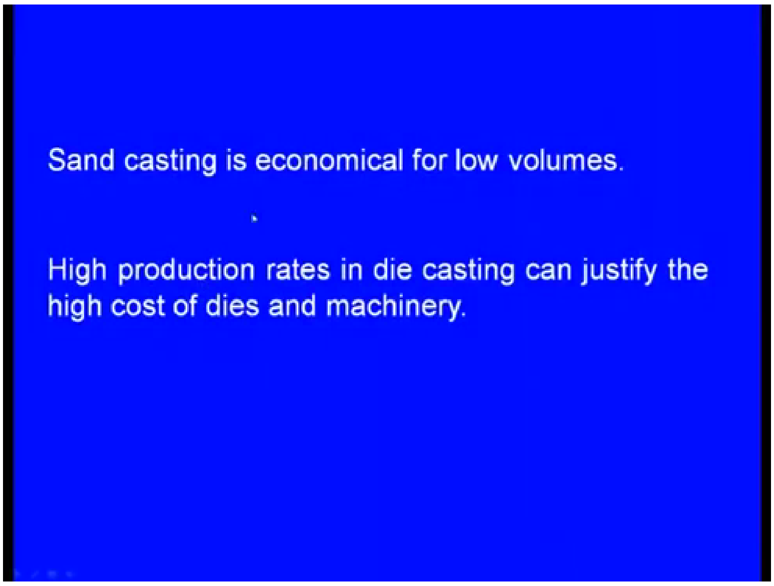

Sand casting is economical for low volumes. And high production rates in die casting can justify the high cost of dies and machinery; the profits, as a function of the amount of the scrap.

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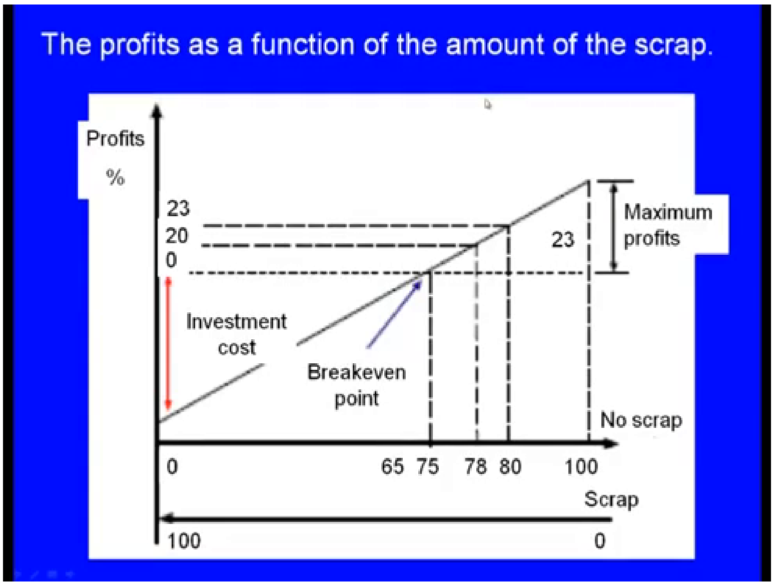

Now, here we can see the scrap curve is here this is the scrap. So, here when the scrap is about 75 percent we can see a breakeven point the profit is 0, as this scrap is increasing we can see the profit is increasing. So, we get the maximum profit in this reason when the scrap is between 75 to 100 percent now this is the scrap. So when the scrap is very less; we get the maximum profits. So, here we can see the scrap is very high and here the scrap is very high scrap is increasing.

So, this is the scrap what say position when the scrap is between 0 to what say 25 percent, 0 to 25 percent we will get the maximum profits.

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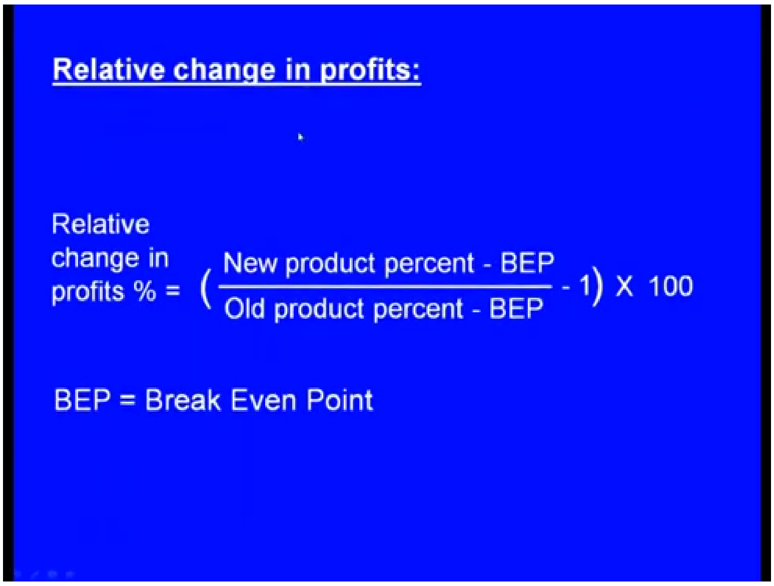

Now, relative change in profits, relative change in profits percentage is equal to new product percentage minus BEP divided by old product percentage minus BEP minus 1 multiplied by 100. What is this BEP, it is the breakeven point. Now, let us take a small problem.

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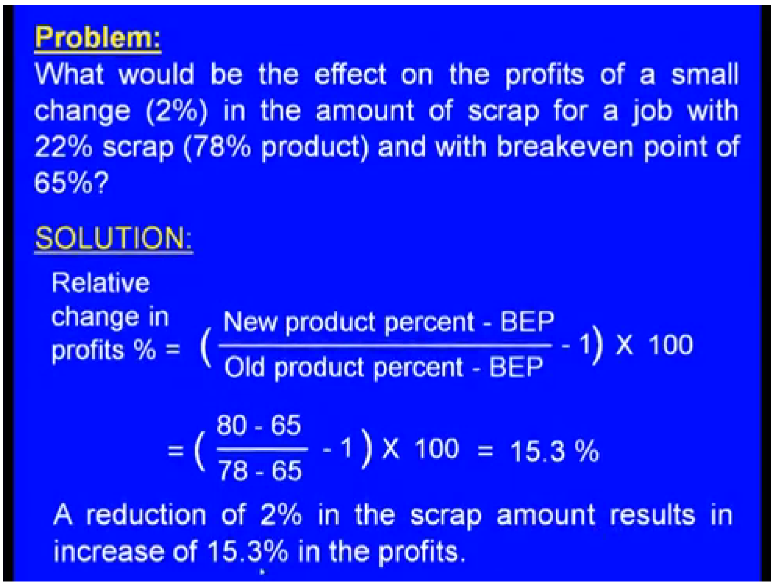

What would be the effect on the profits of a small change 2 percent in the amount of scrap for a job with 22 percent scrap or 78 percent product and with breakeven point of 65 percent relative change in the profit percentage just now we have seen new product percentage minus BEP divided by old product percentage minus BEP minus 1 multiplied by 100, so that is equal to 80 minus 65 divided by 78 minus 65 minus 1 multiply it by 100 that is equal to 15.3.

So, a reduction of 2 percent in the scrap amount results in increase of 15.3 percent in the profits.

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So, in this lecture we have seen design of the material selection. Next one design considerations related to the product. Design considerations related to mould and economics of the casting. So, with this we are completing this lecture and we will see in the next lecture.

Thank you.