Metal Casting
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Module – 02
Sand Casting Process
Lecture – 15
Design Of Gating System-II

Welcome back friends. In the previous lecture we have seen the gating system the meaning of the Gating System. We have seen that Gating System refers to all the sections through which the molten metal passes while entering into the mould cavity. We have also seen that these are the elements of the gating system; one is the Pouring cup, Sprue, next the Sprue well, next the Runner, Runner extension, Ingates these are also known as the gates and finally, the riser. So, we have seen the significance of different elements of the gating system.

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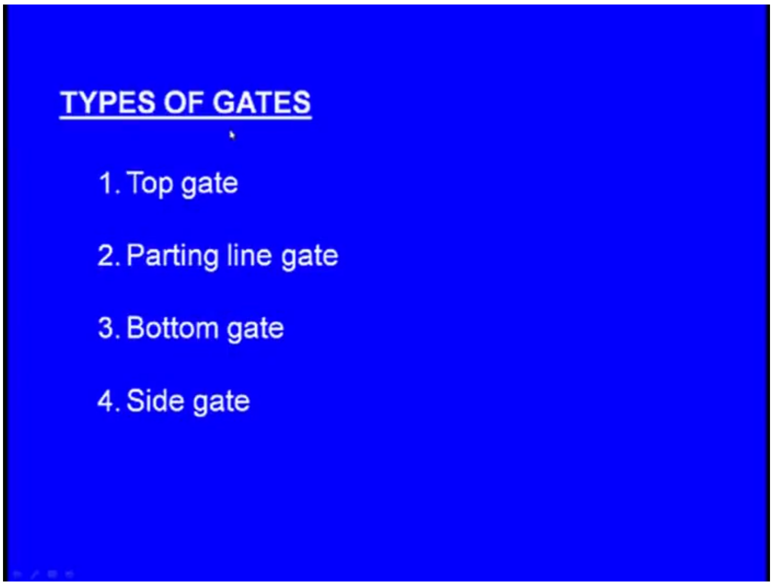

TYPES OF GATES

1. Top gate
2. Parting line gate
3. Bottom gate
4. Side gate

Now, let us see further there are different types of the gates are there one is the top gate, second one is the parting line gate, third one bottom gate, and fourth one the side gate.

Now let us see what these gates are let us first see the top gate, now this is the top gate, now you can see here this is the mould cavity and this is the pouring basin and this is the sprue.

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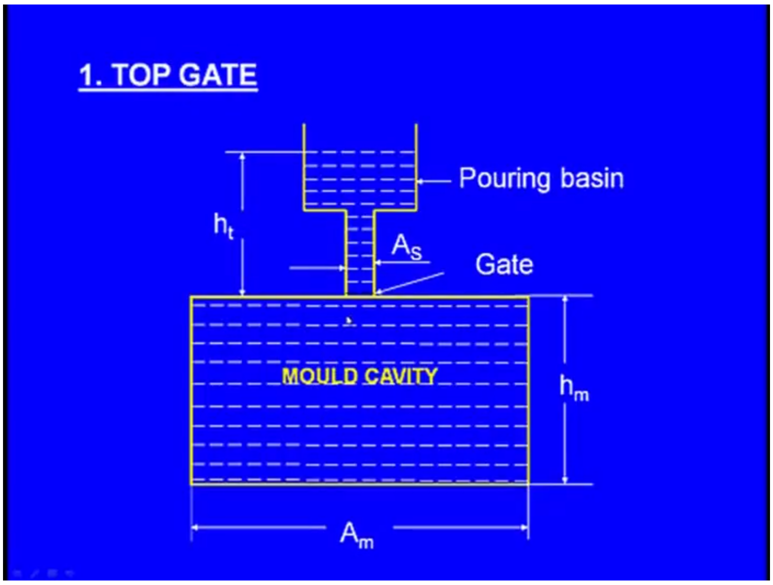

1. TOP GATE

Now here we pour the molten metal through this way, initially the molten metal fills the pouring basin and it passes through this sprue and this is the choke and this is the also the gate then it enters into the mould cavity.

Now how the molten metal is entering into the mould cavity from the top surface of the mould cavity that is why it is known as the top gate.

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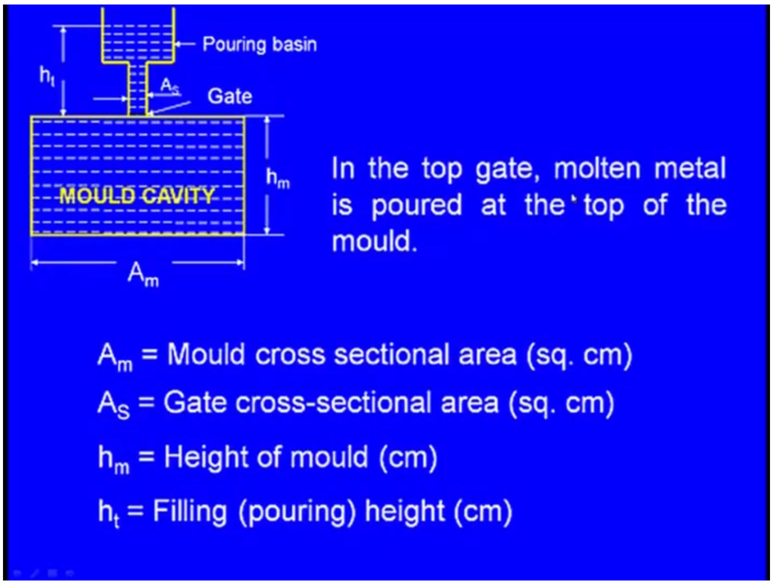

In the top gate, molten metal is poured at the top of the mould.

A_m = Mould cross sectional area (sq. cm)

A_S = Gate cross-sectional area (sq. cm)

h_m = Height of mould (cm)

h_t = Filling (pouring) height (cm)

Now, in the top gate the molten metal is poured at the top of the mould, now here we can see a m means mould cross sectional area, this is the mould cross sectional area usually we express this in square centimeters. Next one a s is the gate cross sectional area this also is expressed in square centimeters, next one h m is the height of the mould and it is usually expressed in centimeters, next one h t this is the h t and this is the filling height are the pouring height and it is usually expressed in centimeters.

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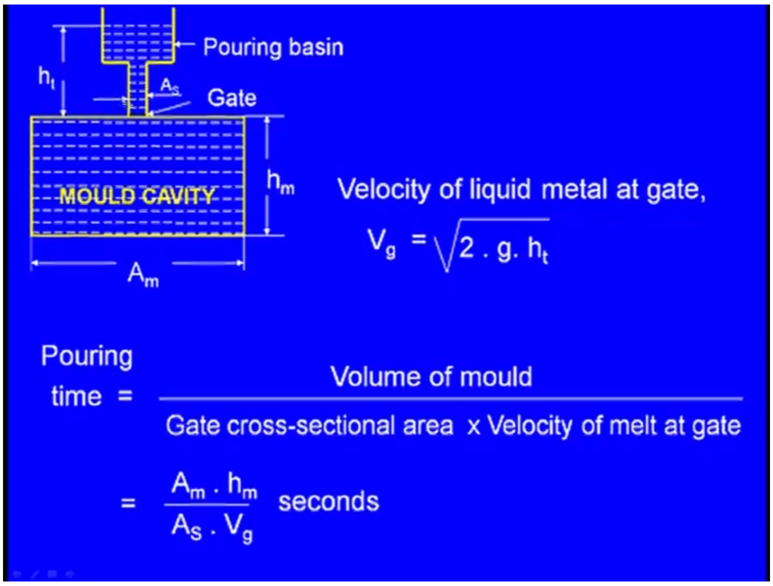

Velocity of liquid metal at gate,

$$V_g = \sqrt{2 . g . h_t}$$

$$\text{Pouring time} = \frac{\text{Volume of mould}}{\text{Gate cross-sectional area x Velocity of melt at gate}}$$

$$= \frac{A_m . h_m}{A_S . V_g} \text{ seconds}$$

Now, velocity of liquid metal that in gate what is the velocity of the liquid metal at this point what is that V g is equal to root of 2 g h t where h t is the pouring height this is the pouring height usually it is the 2 g h t. Now pouring time what is the pouring time? Pouring time is equal to volume of the mould divided by gate cross sectional area multiplied by velocity of melt at gate, that is equal to a m into h m divided by A s into V g and this is expressed in seconds.

So, this is the formula for pouring time in the case of the top gate.

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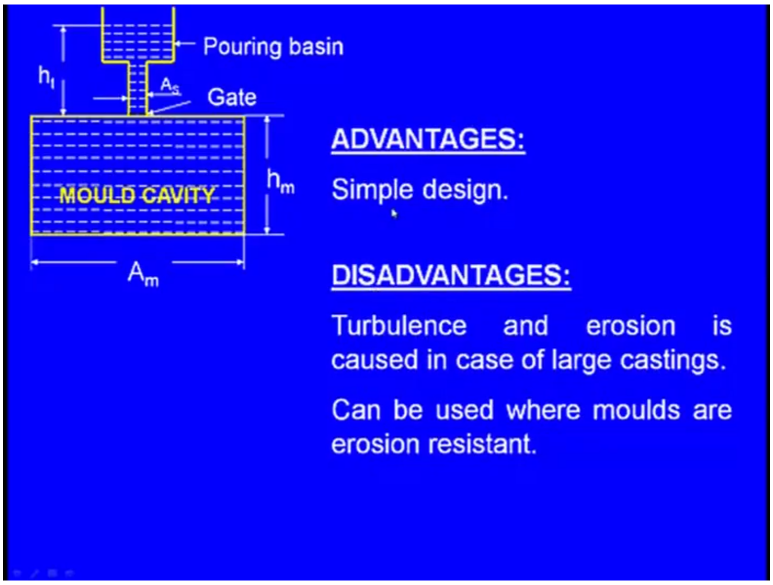

ADVANTAGES:

Simple design.

DISADVANTAGES:

Turbulence and erosion is caused in case of large castings.

Can be used where moulds are erosion resistant.

Now what are the advantages of the top gating system simple design, what then what are the disadvantages turbulence and erosion is caused in case of the large castings, if the casting is a small casting or if the mould cavity is the small one then we pour the molten metal from the top it does not matter, but if it is a large casting and the mould cavity is a large one then we pour the large quantity of the molten metal from the top gate, then what will happen from the choke the molten metal falls at a very high speed and it heats at the bottom surface of the mould cavity because of that erosion takes place and because of that turbulence takes place.

So, this is not useful for the large castings, this will be useful only for the small castings and this can be used where moulds are erosion resistance, where we think that the erosion cannot take place in such a case we can use the top gating system.

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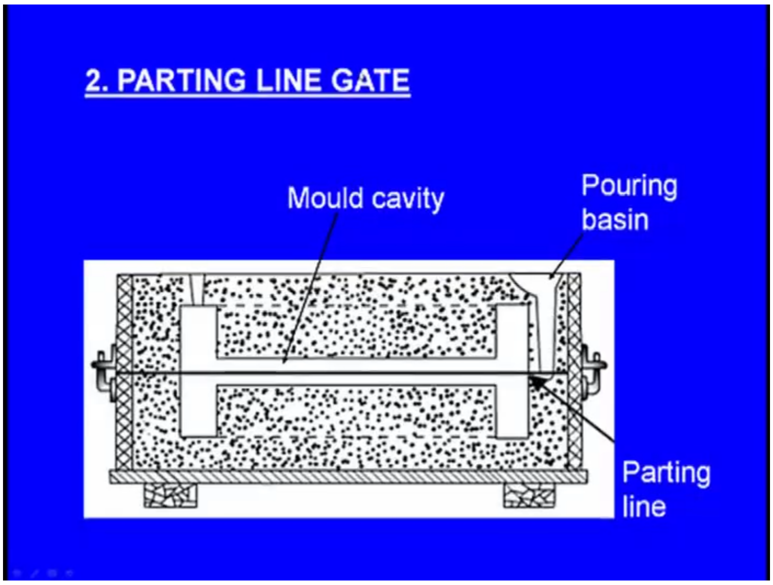

2. PARTING LINE GATE

Next one the parting line gate; now in the case of the top gating system the molten metal enters into the mould cavity from the top of the mould cavity whereas, in the case of the parting line gate the molten metal enters into the cavity along the parting lines. Now you can see here this is the drag box this whole thing is the mould this is the drag and this is the cope and this is the parting line this is the parting line, now this is the pouring basin and this is these sprue and this is the choke. Now the modern metal is poured at the pouring basin and it enters into the what say sprue then it enters into the runner choke finally, this is the mould cavity and here we can see the raiser.

So, here the molten metal enters into the mould cavity along the parting line, the gate is located along the parting line that is why it is known as the parting line gate.

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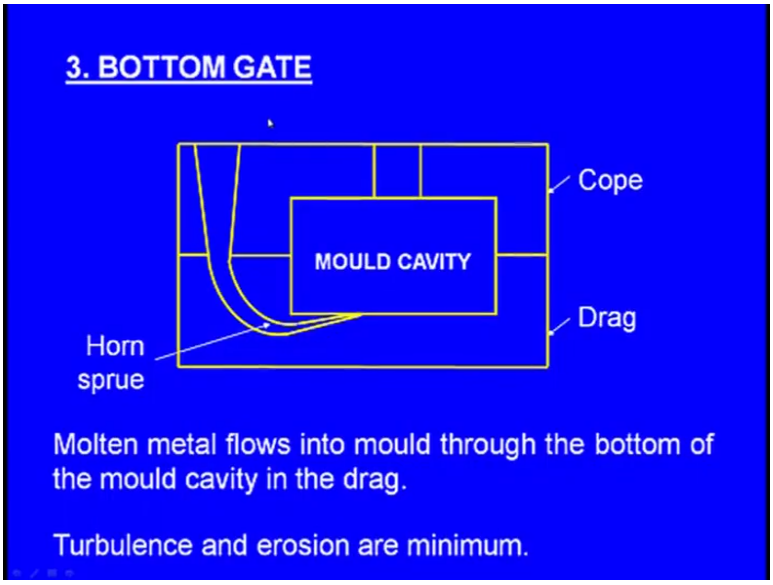

3. BOTTOM GATE

Molten metal flows into mould through the bottom of the mould cavity in the drag.

Turbulence and erosion are minimum.

The third one is the bottom gate; first one is the top gate where the molten metal enters into the mould cavity from the top surface of the mould cavity. And the second one the parting line the moulding what say the molten metal enters along the parting line, now in the case of the bottom gate the molten metal flows into the mould through the bottom of the mould cavity in the drag box you see. So, this is the mould cavity and this is the cope and this is the drag, this is this sprue, the molten metal is poured along this sprue, now the molten metal comes this way, now there is a kind of horn sprue means a curve or sprue is there, now the molten metal comes like this and it passes through the curved path finally, it enters into the mould cavity and it fills the mould cavity.

Now here because of this the turbulence and erosion are minimum. Now, what are the disadvantages of the bottom gate, metal at the top of the cavity will be at a lower temperature is it not the metal that is filled initially it will be going up and the new metal will be occupying at the bottom. Now what happens at the top there will be a lower temperature metal and at the bottom the temperature of the metal will be higher. Now the raiser is here you can see here the raiser is here, now what is the principle in the solidification the raiser should be the one which has to solidify at the end then only it can supply the molten metal to the casting which is undergoing the shrinkage.

Now, in this case what will happen the upper portion of the liquid metal will be at a lower temperature naturally even the liquid metal in the raiser will be at a lower temperature whereas, the liquid metal at the bottom of the mould cavity will be at a higher temperature, then what will happen the upper portion will solidify earlier, the lower portion of the casting will solidify later, that be the case raiser may solidify before the casting the raiser may not supply the liquid metal to the casting during freezing. So, this is the drawback of the bottom gate.

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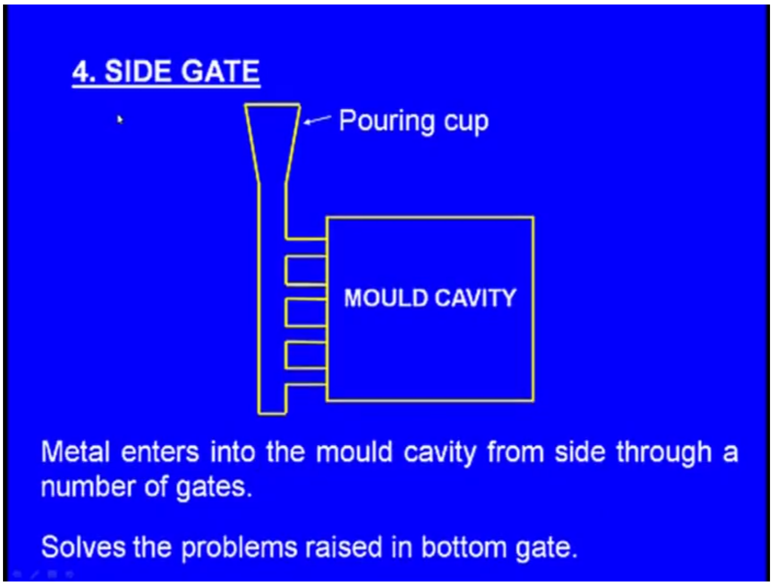

4. SIDE GATE

Metal enters into the mould cavity from side through a number of gates.

Solves the problems raised in bottom gate.

Next one the side gate, now you can see here this is the mould cavity and here the molten metal enters into the mould cavity along the sides on one side of the mould cavity we can see several in gates are there. Now this is the pouring cup and this is the sprue now the molten metal is poured here and the molten metal enters this way, it enters this way, enters this way, enters this way finally, the whole cavity is filled with the molten metal.

Now, this solves the problems raised in the bottom gate. Now there is another classification of the gating systems, now the first classification is based on how the molten metal enters into the mould cavity whether it is through the top or throughthe sides or through the bottom. So, that is the criteria for the earlier classification now there is another type that is the it is based on the pressure of the gating system right. So, here we can see another classification.

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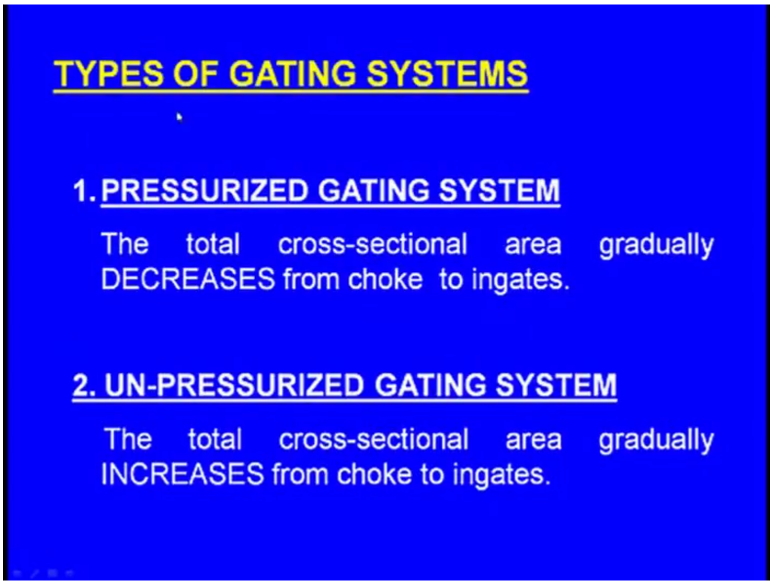

TYPES OF GATING SYSTEMS

1. PRESSURIZED GATING SYSTEM

The total cross-sectional area gradually DECREASES from choke to ingates.

2. UN-PRESSURIZED GATING SYSTEM

The total cross-sectional area gradually INCREASES from choke to ingates.

Now, one type is pressurized gating system and the second type is unpressurized gating system. In the pressurized gating system the total cross sectional area gradually decreases from choke to in gates now when we are pouring the molten metal. So, the molten metal enters into this sprue and it enters into the cavity at the choke sorry not at the cavity at the end the end of this sprue it passes through the choke.

Now at this sprue choke the pressure will be more as it enters into the runner, as it enters into the mould cavity the pressure will be decreasing whereas, in the case of the unpressurized gating system the total cross sectional area gradually increases from choke to ingates. So, naturally the pressure of the molten metal will be what will happen will be decreasing as it passes from this sprue to the runner and ingates the pressure will be decreasing. That is why it is the unpressurized gating system whereas; the first one is the pressurized gating system.

Now, let us see what are the differences of these 2 systems and what are the advantages and limitations of these 2 systems. Now these are the typical gating ratios again different gating ratios have been recommended for different casting alloys.

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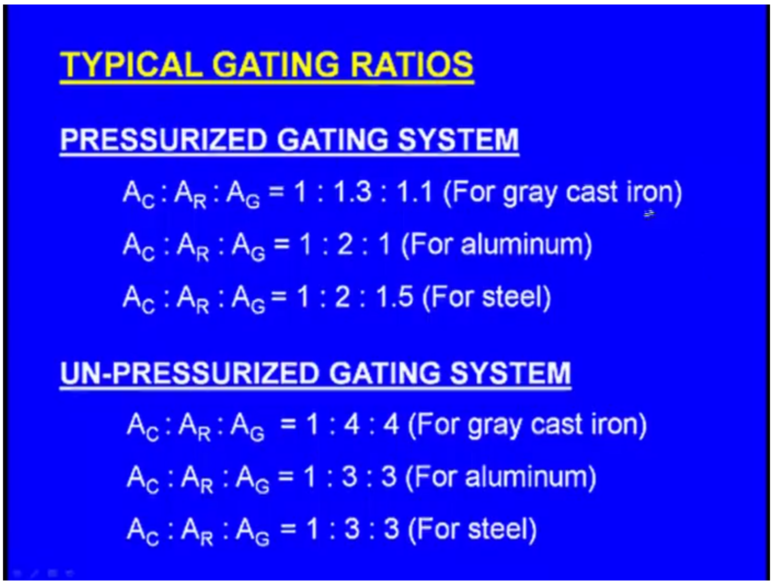

TYPICAL GATING RATIOS

PRESSURIZED GATING SYSTEM

$A_C : A_R : A_G = 1 : 1.3 : 1.1$ (For gray cast iron)

$A_C : A_R : A_G = 1 : 2 : 1$ (For aluminum)

$A_C : A_R : A_G = 1 : 2 : 1.5$ (For steel)

UN-PRESSURIZED GATING SYSTEM

$A_C : A_R : A_G = 1 : 4 : 4$ (For gray cast iron)

$A_C : A_R : A_G = 1 : 3 : 3$ (For aluminum)

$A_C : A_R : A_G = 1 : 3 : 3$ (For steel)

Now for gray cast iron this is the gating system under the pressurized gating system now here we can see under pressurized gating system, for gray cast iron A C A R A G is equal to 1 is to 1.3 is to 1.1 what does it mean this 1 corresponds to choke area, 1.3 corresponds to runner cross sectional area and 1.1 corresponds to the total cross sectional area of the all the ingates. Similarly for aluminum alloys this is the gating ratio, 1 is to 2 is to 1 and for steel the gating ratio A C is to A R is to A G is equal to 1 is to 2 is to 1. 5. So, these are the gating ratios for important cast alloys under the pressurized gating system.

Now, let us see the unpressurized gating system under this again for the same important cast alloys the gating ratios have been recommended after extensive experimentation. Now for gray cast iron A C is to A R is to A G is equal to one is to 4 is to 4, similarly for aluminum alloys A C is to A R is to A G is equal to 1 is to 3 is to 3 and for steel A C is to A R is to A A G is equal to 1 is to 3 is to 3. So, these are the typical gating ratios under pressurized gating system and unpressurized gating system for important cast alloys.

Now, comparison of the gating systems so here we see the comparison and the differences of these 2 systems, now here let us see the what is say merits and demerits of the pressurized gating system and here we see the merits and demerits of the unpressurized gating system. Now in the case of the pressurized gating system the total cross sectional area decreases towards the mould cavity that is why the pressure will be increasing as the molten metal is entering into the mould cavity.

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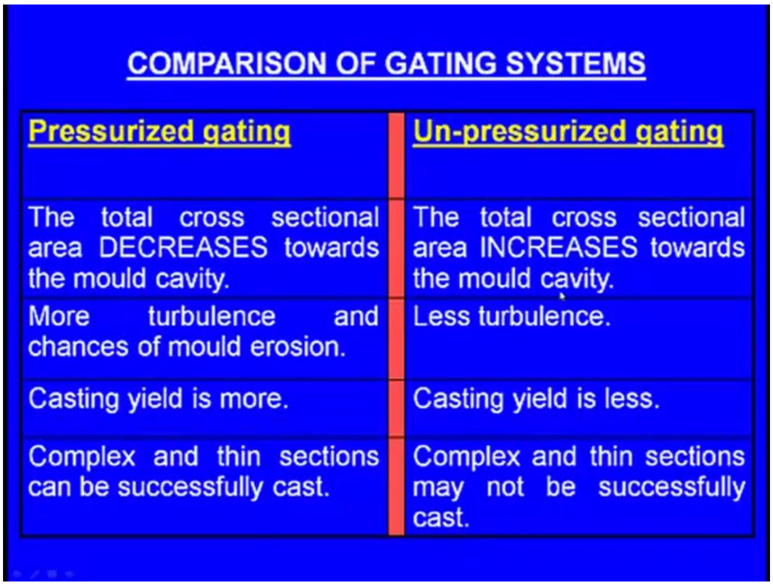

COMPARISON OF GATING SYSTEMS

Pressurized gating	Un-pressurized gating
The total cross sectional area DECREASES towards the mould cavity.	The total cross sectional area INCREASES towards the mould cavity.
More turbulence and chances of mould erosion.	Less turbulence.
Casting yield is more.	Casting yield is less.
Complex and thin sections can be successfully cast.	Complex and thin sections may not be successfully cast.

Whereas, in the case of the unpressurized gating system the total cross sectional area increases towards the mould cavity; that is why it is the unpressurized gating system.

Next one what happens in the case of the pressurized gating system as the cross sectional area is decreasing from choke to the ingates, then what will happen the pressure will be intensifying for the liquid metal. Because of that more turbulence and chances of mould erosion naturally, but here because the what say cross sectional area is increasing the pressure will be decreasing that is why there will be less turbulence.

Now, in the case of the pressurized gating system casting yield is more, what is casting yield suppose if we are making a casting of 10 kgs do you think that we pour only 10 cases of the metal no. If we are making a casting of 10 kgs we may pour about 13 kgs; 13 kgs means say we say we have to fill the what say sprue with the liquid metal we have to fill the raiser with the liquid metal and the runner and the ingates these are not the part of the casting only the casting which solidifies in the mould cavity is the final casting. So, the weight of the poured metal is always greater than the weight of the casting.

Now, what is this casting yield weight of the casting divided by weight of the poured metal multiplied by 100 usually this is between 70 percent to 80 percent in the industries.

Now in the case of the pressurized gating system what happens as we go inside the gating system the cross sectional area is gradually decreasing? So, the less metal is required for filling the whole mould cavity and also the gating system then what happens less metal is required then that be case casting yield will be more. Then what happens in the case of the unpressurized gating system as we go from choke to inside the mould cross sectional area sorry the gating gate cross sectional area it will be increasing. Then what happens it requires more metal for filling the gating system and the mould cavity then the total consumption of the liquid metal will be increasing, then what happens finally, the casting yield is less. So, this increases the cost of the production for the foundry.

Next one now what happens in the case of the pressurized gating system complex and thin sections can be successfully cast. Sometimes the casting may have a complex and very thin sections, now if we chose the unpressurized gating system then what happens because of the lesser pressure of the liquid metal these thin sections may not be filled with the liquid metal. In such a case to fill such what say complex and thin what say sections we need the pressurized gating system. Only when we choose the pressurized gating systems the molten metal will be forced to inject into those thin sections and we can successfully cast such a thin and complex sections whereas, on the other hand if you choose the unpressurized gating system these thin and complex sections are very difficult to be cast.

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LOGICAL APPROACH FOR A PROPER
DESIGN OF GATING SYSTEM

Now, let us see the logical approach for a proper design of the gating system.

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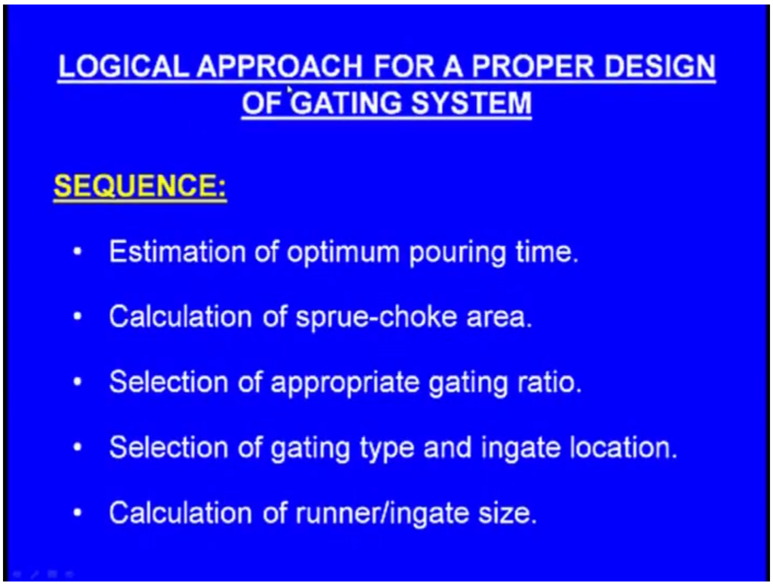

LOGICAL APPROACH FOR A PROPER DESIGN OF GATING SYSTEM

SEQUENCE:

- Estimation of optimum pouring time.
- Calculation of sprue-choke area.
- Selection of appropriate gating ratio.
- Selection of gating type and ingate location.
- Calculation of runner/ingate size.

Now this is the logical approach what is this first one estimation of the optimum pouring time, second one calculation of the sprue choke area, next one selection of appropriate gating ratio, next one selection of gating type and ingate location, next one calculation of runner or ingate size. So, this is the sequence in the logical approach for a proper design of gating system.

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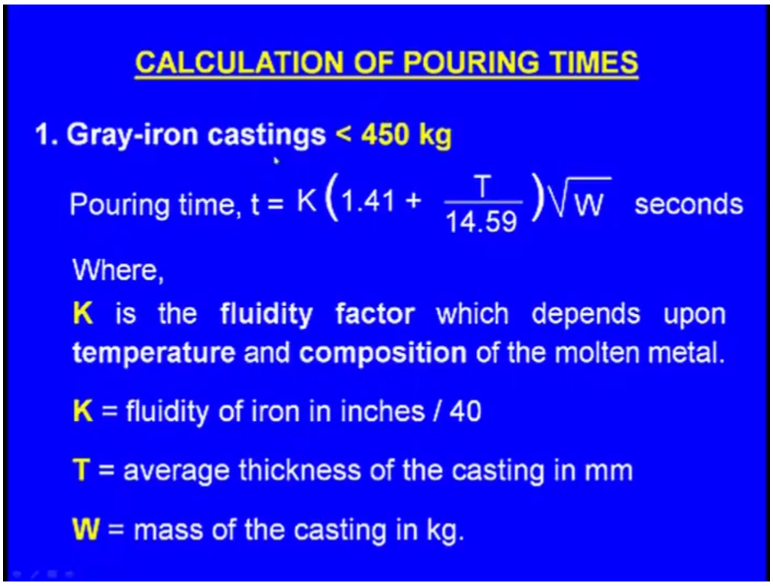

CALCULATION OF POURING TIMES

1. Gray-iron castings < 450 kg

Pouring time, $t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$ seconds

Where,

K is the **fluidity factor** which depends upon **temperature** and **composition** of the molten metal.

K = fluidity of iron in inches / 40

T = average thickness of the casting in mm

W = mass of the casting in kg.

Now, calculation of the pouring times for grey iron castings and if the weight of the casting is less than 450 kgs pouring time which is indicated by T is equal to K multiplied by 1.41 plus T by 14.59, multiplied by root of W seconds, where K is the fluidity factor which depends upon the temperature and composition of the molten metal. K that is equal to fluidity of the iron in inches divided by 40 what is this there will be a spiral will be there so a spiral casting. So, the if we stretch it will be equal to 40 inches.

Now, in this spiral mould we pour the liquid metal then what happens depending upon the fluidity of the melt some metals what say some alloys may flow up to maybe 39 inches or some metals may go up to 35 like that different alloys will flow to different what say lengths again it depends upon the temperature of the melt.

Now, this fluidity of right is equal to right K is equal to fluidity of iron in inches divided by 40 T is the average thickness of the casting in millimeters. W is the mass of the casting in kgs kilograms. So, this is the what say pouring of the what say pouring time for the gray iron castings when the weight of the casting is less than 400 and 50 kgs.

Now, let us see the second case now what happens if the weight of the casting is more than 450 kgs. Again from the exponents it has been recommended that pouring times T is equal to K multiplied by 1.236 plus T by 16.6 5 multiplied by cubed root of W seconds.

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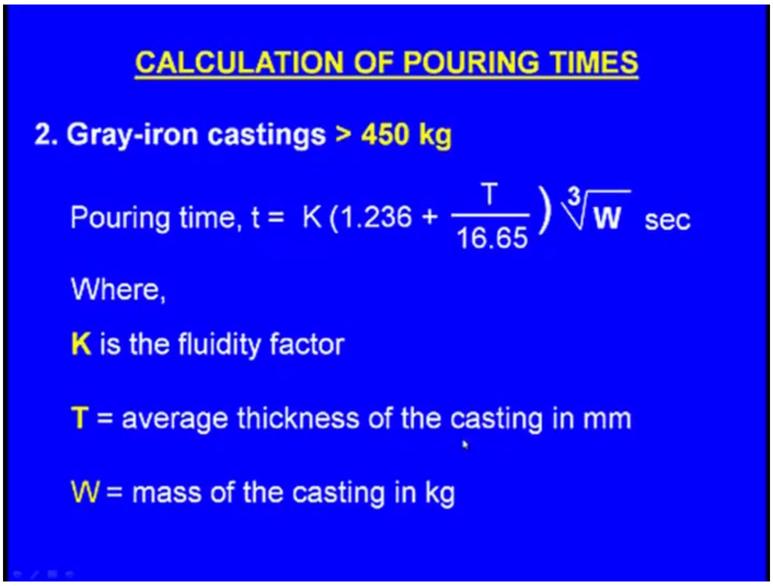

CALCULATION OF POURING TIMES

2. Gray-iron castings > 450 kg

Pouring time, $t = K\left(1.236 + \frac{T}{16.65}\right)\sqrt[3]{W}$ sec

Where,

K is the fluidity factor

T = average thickness of the casting in mm

W = mass of the casting in kg

Where K is the fluidity factor the same way we have to calculate as we have discussed before, T is the average thickness of the casting in millimeters W is the mass of the casting in kilograms.

Next one shell moulded ductile iron.

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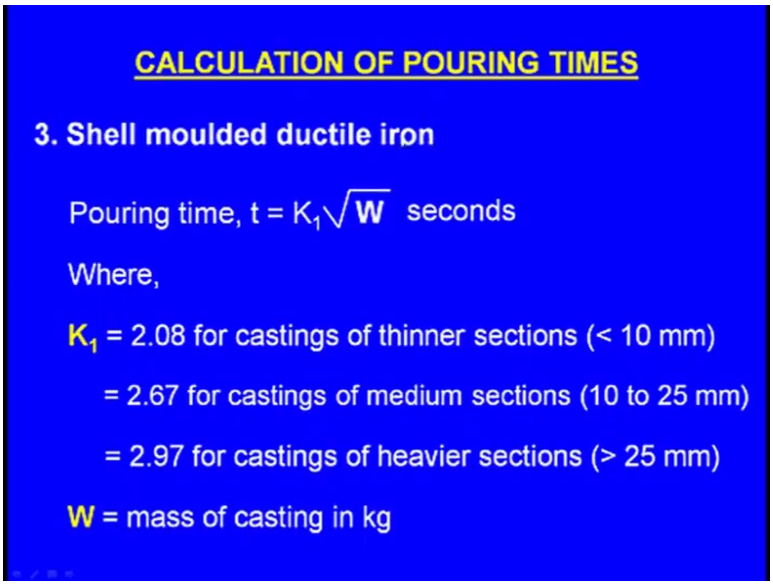

CALCULATION OF POURING TIMES

3. Shell moulded ductile iron

Pouring time, $t = K_1\sqrt{W}$ seconds

Where,

K_1 = 2.08 for castings of thinner sections (< 10 mm)

= 2.67 for castings of medium sections (10 to 25 mm)

= 2.97 for castings of heavier sections (> 25 mm)

W = mass of casting in kg

Now, how to calculate the pouring time; pouring times T is equal to K 1 root of W seconds, where K 1 is equal to 2.0 8 for castings of thinner sections or when the thickness is less than 10 millimeters. That is equal to 2.6 7 for castings of medium sections when the thickness is between 10 to 25 mm that is equal to 2.9 7 for castings of heavier sections when the thickness is more than 25 millimeters and W is the mass of the casting in kilograms.

Next one the fourth case steel castings how to calculate the pouring time for the steel castings.

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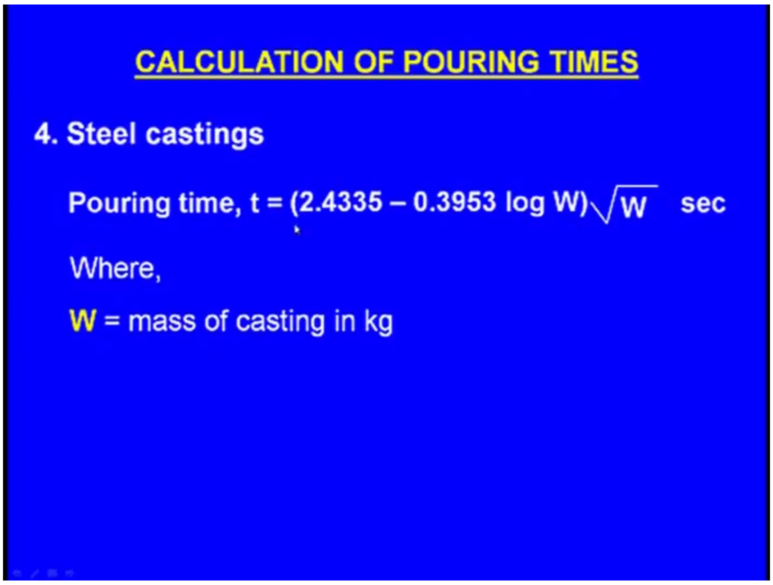

CALCULATION OF POURING TIMES

4. Steel castings

Pouring time, $t = (2.4335 - 0.3953 \log W)\sqrt{W}$ sec

Where,

W = mass of casting in kg

Pouring time T is equal to 2. 4335 minus 0.3953 log W multiplied by root W seconds where, W is mass of the casting in kilograms.

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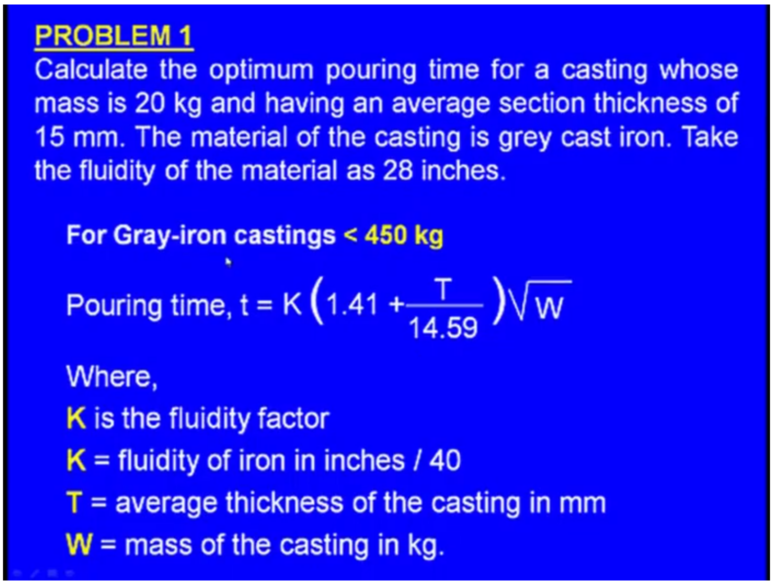

PROBLEM 1

Calculate the optimum pouring time for a casting whose mass is 20 kg and having an average section thickness of 15 mm. The material of the casting is grey cast iron. Take the fluidity of the material as 28 inches.

For Gray-iron castings < 450 kg

Pouring time, $t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$

Where,

K is the fluidity factor

K = fluidity of iron in inches / 40

T = average thickness of the casting in mm

W = mass of the casting in kg.

Now, let us see some problems let us solve some problems. Now problem one calculate the optimum pouring time for a casting whose mass is 20 kilograms and having an average section thickness of 15 millimeters, the material of the casting is gray cast iron take the fluidity of the material as 28 inches

Now, for grey iron castings when the weight of the casting is less than 400 and 50 kilograms pouring times T is equal to K multiplied by 1.4 1 plus T by T by 14.59 multiplied by W, where K is the fluidity factor that is the fluidity of the iron in inches divided by 40 T is the average thickness of the section in millimeters w is the mass of the casting in kilograms.

Now, just let us substitute in the formula pouring time is this is the for formula for the gray area castings for less than 400 and 50 grams K is that is equal to 28 by 40, T is the 15 mm you can see here this is the thickness is 15 millimeters, now W mass of the casting is 20 kgs 20 kgs just we will substitute in this formula.

Now, pouring times T is equal to when we substitute, we get T is equal to 7.632 seconds. So, this is the way to calculate the pouring time.

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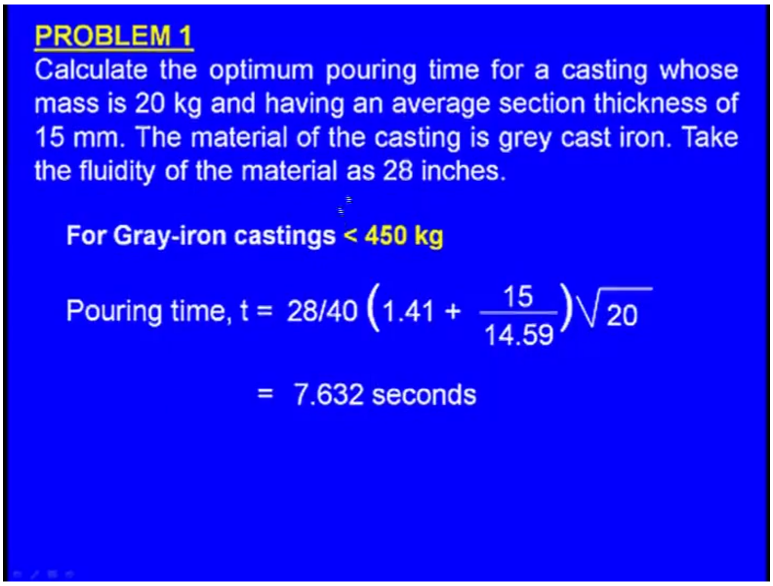

PROBLEM 1

Calculate the optimum pouring time for a casting whose mass is 20 kg and having an average section thickness of 15 mm. The material of the casting is grey cast iron. Take the fluidity of the material as 28 inches.

For Gray-iron castings < 450 kg

$$\text{Pouring time, } t = 28/40\left(1.41 + \frac{15}{14.59}\right)\sqrt{20}$$

$$= 7.632 \text{ seconds}$$

For gray iron castings when we what say pouring what say weight of the casting is less than 400 and 50 kilograms now problem 2 solve the previous problem if the material is steel.

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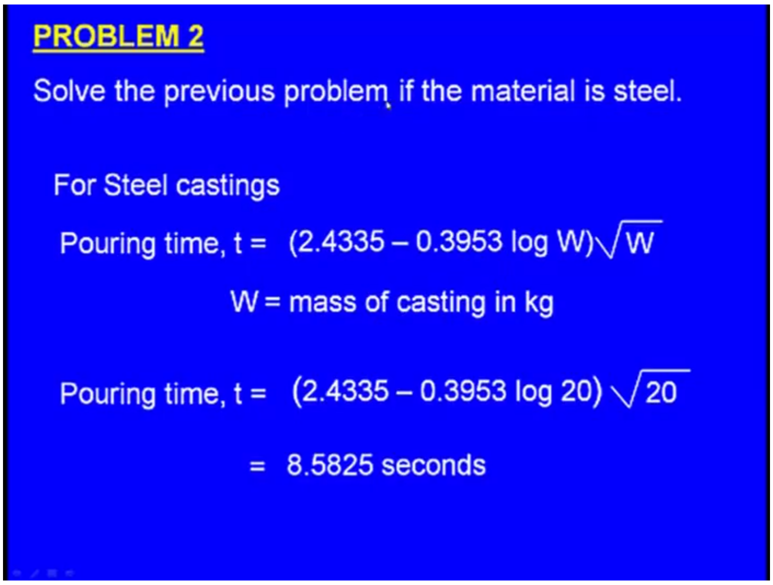

PROBLEM 2

Solve the previous problem if the material is steel.

For Steel castings

Pouring time, $t = (2.4335 - 0.3953 \log W)\sqrt{W}$

W = mass of casting in kg

Pouring time, $t = (2.4335 - 0.3953 \log 20)\sqrt{20}$

$= 8.5825$ seconds

For steel castings pouring time T is equal to 2.4335 minus 0.3953 log W multiplied by root of W and here W is the weight of the casting.

Now, just to let us substitute the W in this formula then we will get pouring time is equal to 8.5825 seconds. So, this is the way to calculate the pouring time when the material is steel.

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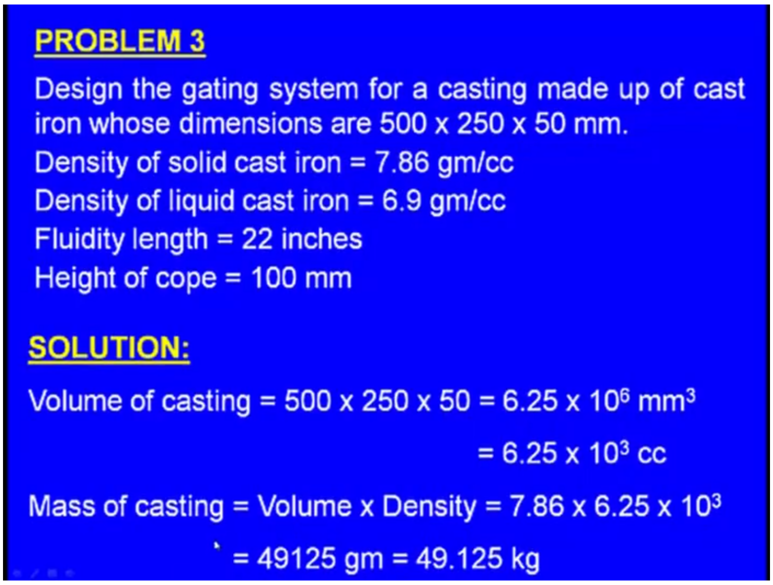

PROBLEM 3

Design the gating system for a casting made up of cast iron whose dimensions are 500 x 250 x 50 mm.

Density of solid cast iron = 7.86 gm/cc

Density of liquid cast iron = 6.9 gm/cc

Fluidity length = 22 inches

Height of cope = 100 mm

SOLUTION:

Volume of casting $= 500 \times 250 \times 50 = 6.25 \times 10^6\ \text{mm}^3$

$= 6.25 \times 10^3$ cc

Mass of casting = Volume x Density $= 7.86 \times 6.25 \times 10^3$

$= 49125$ gm $= 49.125$ kg

Now, let us take another problem design the gating system for a casting made up of cast iron whose dimensions are 500 into 250 into 50 millimeters, density of the solid cast iron is equal to 7.86 grams per cubic centimeters density of liquid cast iron is equal to 6.9 grams per cubic centimeters fluidity length is equal to 22 inches height of the cope is equal to 100 millimeters.

Now, here the dimensions of a casting are given simple dimensions the length is 500 mm width is 200 and 50 mm and the thickness is 50 mm, how to what say design the gating system means initially we have to design the choke what is the diameter of the sprue at the choke we have to design.

Next one what is the cross sectional area of the runner after that we have to design the ingates how many ingates should be there and what should be the cross sectional area of each ingate. So, this is the meaning of the design of the gating system. Now solution initially we need to find out the volume of the casting that is equal to 500 into 250 into 50 that is equal to 6.25 into 10 to the power of 3 cubic centimeters.

Now, mass of the casting is equal to volume into density it is a well known formula that is equal to now this is the density 7.86 into 6.25 into 10.3 that is equal to 49.125 kilograms. So, this is the mass of the casting. Assuming casting yield as the 70 percent again we need to recollect what is the meaning of the casting yield, now here what is the weight of the casting or the mass of the casting it is 49.125 kilograms if this is the mass of the casting what should be the mass of the poured metal, poured metal do not think that the weight of the poured metal also will be 49.125 kilograms. So, this much will be occupied in the mould cavity, what about the sprue, what about the pouring cup, what about the runner, what about the ingates, what about the riser here also liquid metal will be filled.

So, this requires extra metal then the weight of the casting that is why the mass of the poured metal is always greater than the mass of the casting

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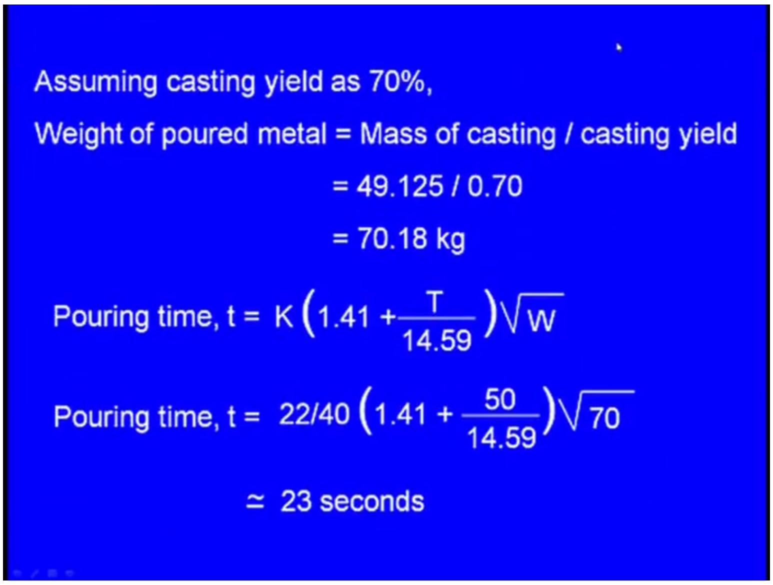

Assuming casting yield as 70%,

Weight of poured metal = Mass of casting / casting yield

= 49.125 / 0.70

= 70.18 kg

$$\text{Pouring time, } t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$$

$$\text{Pouring time, } t = 22/40\left(1.41 + \frac{50}{14.59}\right)\sqrt{70}$$

$$\simeq 23 \text{ seconds}$$

So, now, what is the casting yield casting yield means mass of the casting divided by mass of the poured metal multiplied by 100 usually we have seen that it varies from 70 to 80 percent

Now, let us assume the casting yield as the 70 percent, now weight of the poured metal it is not the casting you see weight of the poured metal is equal to mass of the casting divided by casting yield. Now casting yield is we assumed 70 percent means here it is 0.7 now it becomes weight of the poured metal is equal to 70.18 kilograms.

Now, pouring time T is equal to this is the formula K multiplied by 1.41 plus T by 14.59 multiplied by root of W that is equal to where K is 22 by 40. Now here we are substituting for T that is this thickness of the casting that is the 50 mm and here we can see this is W is this 70 we have rounded it to 17, now pouring time is almost equal to 23 seconds now we need to calculate the choke area.

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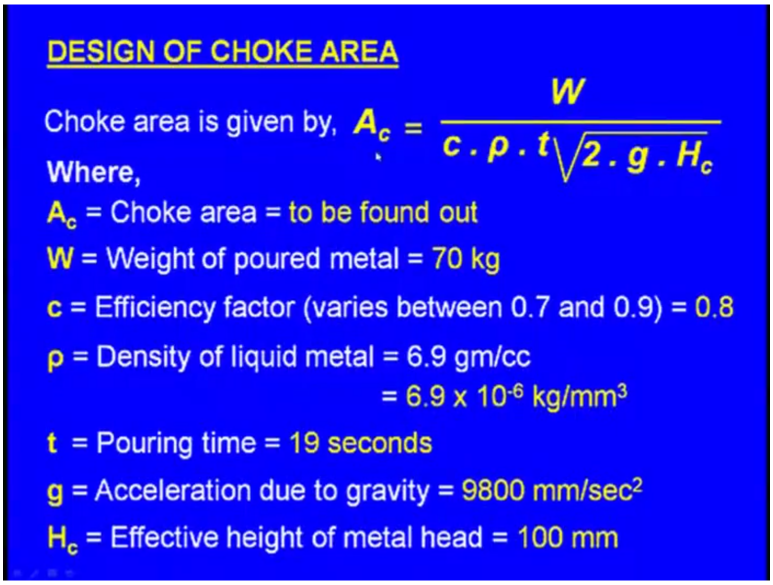

DESIGN OF CHOKE AREA

Choke area is given by, $A_c = \dfrac{W}{c \cdot \rho \cdot t\sqrt{2 \cdot g \cdot H_c}}$

Where,

A_c = Choke area = to be found out

W = Weight of poured metal = 70 kg

c = Efficiency factor (varies between 0.7 and 0.9) = 0.8

ρ = Density of liquid metal = 6.9 gm/cc

= 6.9×10^{-6} kg/mm^3

t = Pouring time = 19 seconds

g = Acceleration due to gravity = 9800 mm/sec^2

H_c = Effective height of metal head = 100 mm

Now, in the previous lecture we have derived this expression for the choke area; choke area a c is equal to W divided by c rho t root of 2 g H c with A c is the choke area and in this case we have to find out W is weight of the poured metal, that is in this case it is equal to 70 kilograms c is the efficiency factor what is what is that because of the friction involved in the flow of the liquid metal.

So, this efficiency factor comes into picture whereas, for an ideal fluid this will be 1, but here generally it varies between 0.7 to 0.9 and here we are taking 80 as 0.8 rho is the density of the liquid metal that is equal to 6.9 grams per cubic centimeters that is also equal to 6.9 into 10 to the power of minus 6 kilograms per cubic millimeters, t is equal to pouring time just now we have calculated that is the 19 seconds, g is the acceleration due to gravity that is 9800 millimeters per second square, H c is the effective height of the metal head usually it is height of the mould box that is 100 mm.

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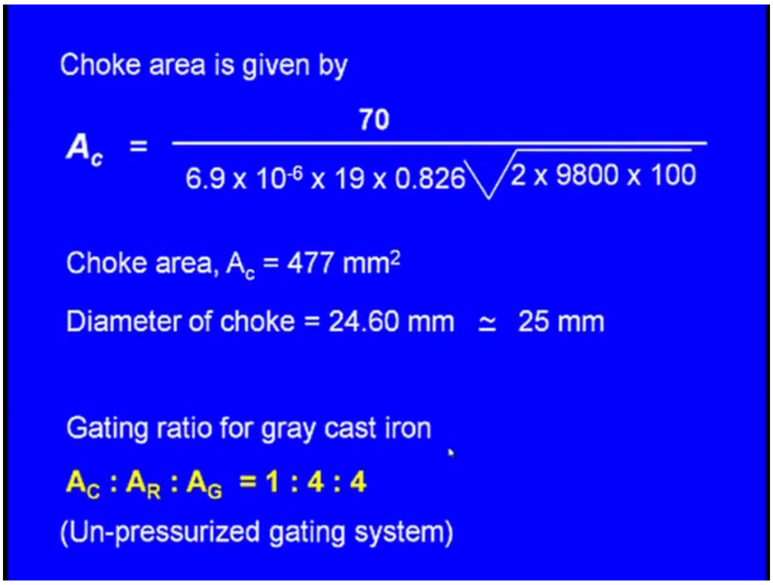

Choke area is given by

$$A_c = \frac{70}{6.9 \times 10^{-6} \times 19 \times 0.826\sqrt{2 \times 9800 \times 100}}$$

Choke area, $A_c = 477\ \text{mm}^2$

Diameter of choke = 24.60 mm $\simeq$ 25 mm

Gating ratio for gray cast iron

$$\mathbf{A_C : A_R : A_G = 1 : 4 : 4}$$

(Un-pressurized gating system)

Now, choke area is given by A c is equal to 70 that is the weight of the poured metal 6.9 into 10 to the power of minus 6 into 19 this is the pouring time right and here, we have taken say 0.8 to 6 whole multiplied by 2 into 9800 into 100, choke area is equal to 400 and 77 square millimeters this is the what say choker area generally the choke area will be a circle that be the case what should be it is diameter.

Now, if we simplify this the diameter of the choke will be 24.60 millimeters or that is almost equal to 25 millimeters. Now what is the gating ratio for grey cast iron for grey cast iron the gating ratio is A C is to A R is to A G is equal to 1 is to 4 is to 4 and we are taking here unpressurized gating system, why because the casting is a simple 1 is a simple what say rectangular cross sectional one no complex shapes are there no intricate shapes are there that is why we are choosing the unpressurized gating system. So, this is the unpressurized gating system ratio 1 is to 4 is to 4. Now we have already found out the ac the choke area.

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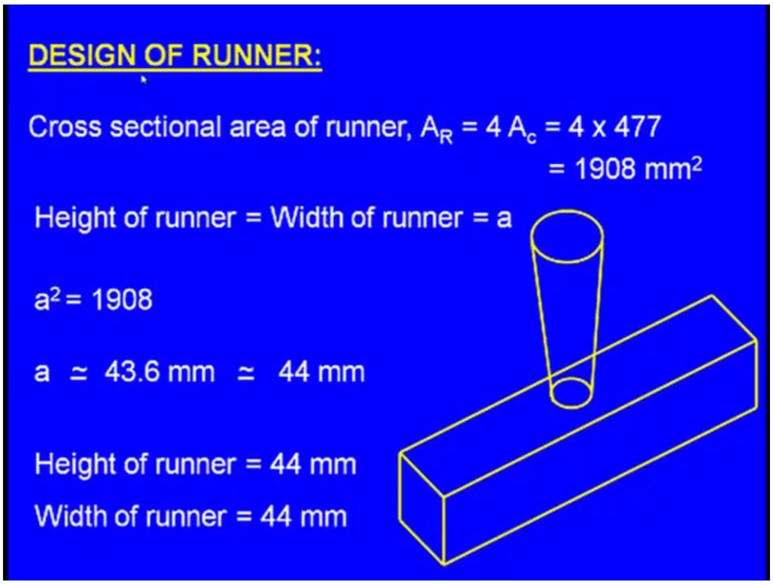

DESIGN OF RUNNER:

Cross sectional area of runner, $A_R = 4\,A_c = 4 \times 477$
$= 1908\ mm^2$

Height of runner = Width of runner = a

$a^2 = 1908$

$a \simeq 43.6\ mm \simeq 44\ mm$

Height of runner = 44 mm

Width of runner = 44 mm

Now, next we need to find out the run design the runner what does it mean what is the cross sectional area of the runner, cross sectional area of the runner in the case of the unpressurized gating system A R is equal to 4 into A C that is equal to 4 into 400 and 77 that is equal to 1900 and 8 square millimeters.

Now, usually the runner will be of square cross section that be the case height will be equal to runner let us assume that is equal to a. Now what is the cross section of the runner what say height multiplied by width that is equal to s square s square is equal to 1900 and 8, then if we simplify this a g is equal to 43.6 that is almost equal to 44 millimeters. Now let us what say specifies the dimensions of the runner, height of the runner is equal to 44 millimeters, width of the runner is equal to 44 mm same then the question is what is the length? Length we have not specified length it all what say always it depends upon the length of the casting. So, we need not specify

Now, we need to design the inagtes.

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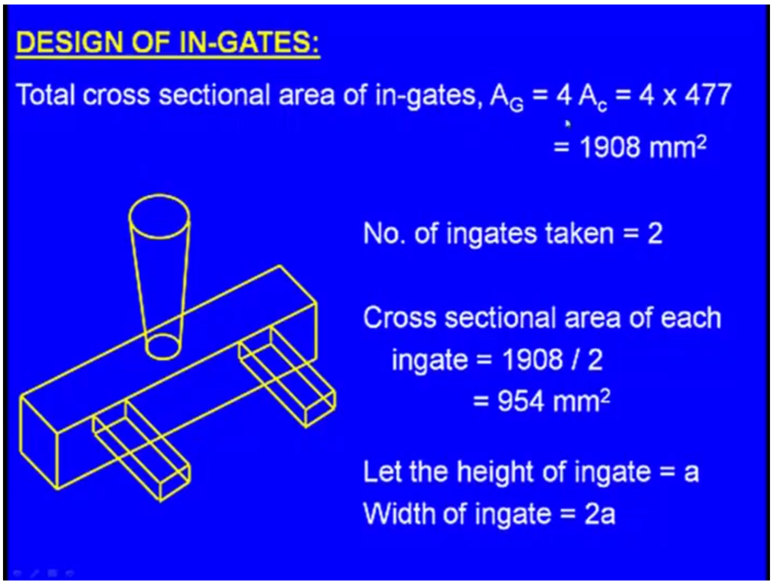

DESIGN OF IN-GATES:

Total cross sectional area of in-gates, $A_G = 4\,A_c = 4 \times 477$

$= 1908\ \text{mm}^2$

No. of ingates taken = 2

Cross sectional area of each ingate = 1908 / 2

$= 954\ \text{mm}^2$

Let the height of ingate = a

Width of ingate = 2a

The total cross sectional area of ingates A G is equal to 4 into A C that is equal to 4 into 400 and 77 that is equal to 1900 and 8 square millimeters. Now in this case we are taking 2 ingates the cross sectional area of each ingate is equal to total cross sectional area divided by 2 that is equal to 900 and 54 square millimeters. Now usually the cross section of an ingate will be a rectangle and the width of the rectangle will be double than height of the rectangle. So, if the height of the ingate is a then the width of the ingate will be 2 a.

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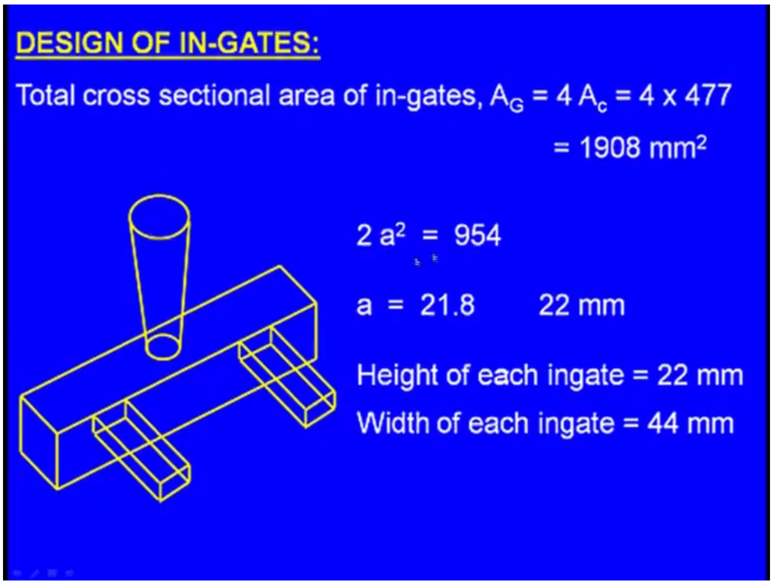

DESIGN OF IN-GATES:

Total cross sectional area of in-gates, $A_G = 4\,A_c = 4 \times 477$

$= 1908\ \text{mm}^2$

$2\,a^2 = 954$

$a = 21.8 \quad 22\ \text{mm}$

Height of each ingate = 22 mm

Width of each ingate = 44 mm

Now, this is the cross section of the ingate 2 a square is equal to 900 and 54 and if we simplify this a is equal to 21.8 that is almost equal to 22 millimeters.Now let us specify the dimensions of the cross section of the in each ingate, height of each ingate is equal to 22 millimeters width of each ingate will be equal to 44 millimeters.

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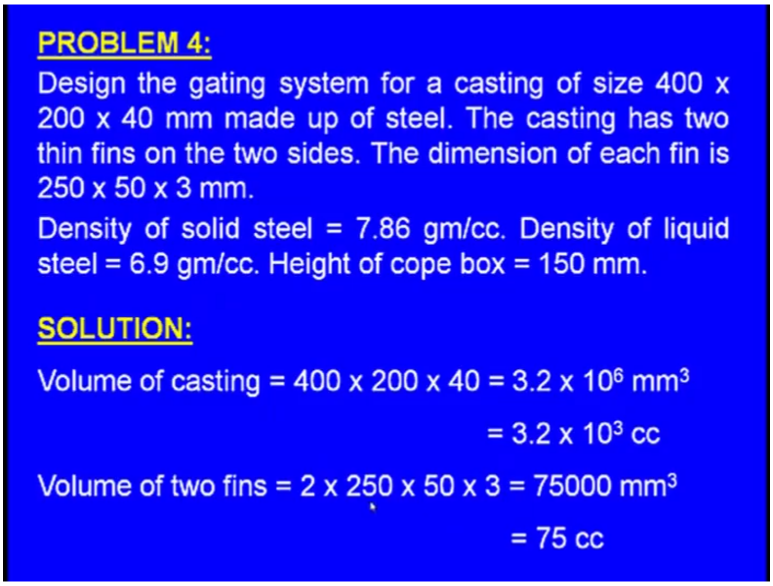

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Volume of casting = $400 \times 200 \times 40 = 3.2 \times 10^6\ \text{mm}^3$

$= 3.2 \times 10^3\ \text{cc}$

Volume of two fins = $2 \times 250 \times 50 \times 3 = 75000\ \text{mm}^3$

$= 75\ \text{cc}$

Now, let us take another problem. Design the gating system for a casting of size 400 into 200 into 40 millimeter made up of steel the casting has 2 thin fins on the 2 sides. The dimension of each fin is 250 into 50 into 3 millimeters, density of the solid steel is equal to 7.86 grams per cubic centimeter, density of liquid steel is equal to 6.9 grams per cubic centimeter, next one height of the cope box is equal to 100 and 50 millimeters.

Now we need to design the gating system means what is the cross sectional area of the choke, what is the cross sectional area of the runner what is the cross sectional area of the ingates. So, that is our task, now initially we need to find out the volume of the casting that is equal to this much that is 3.2 into 10 to the power of 3 cubic centimeters.

Next one volume of the 2 fins there are 2 fins are there on 2 sides, volume of 2 fins is equal to each fin dimension is 250 into 50 into 3. So, 2 multiplied by 250 into 50 into 3 that is equal to 75 cc.

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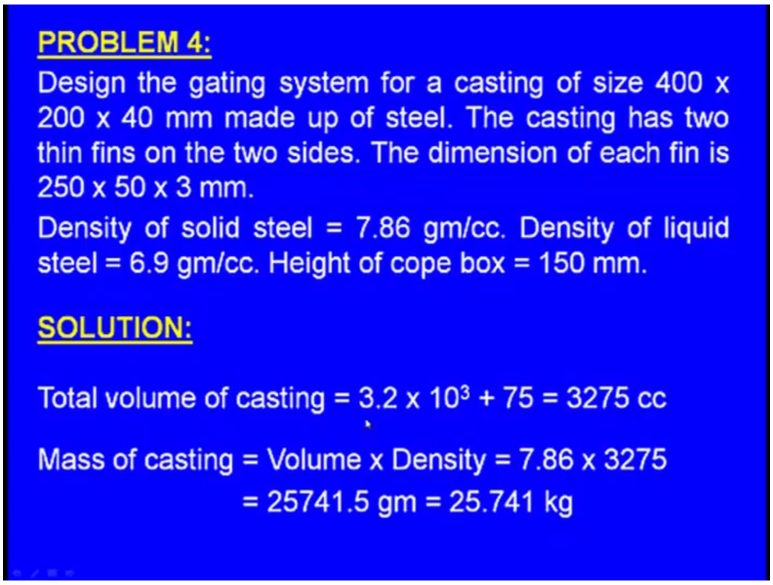

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Total volume of casting = $3.2 \times 10^3 + 75 = 3275$ cc

Mass of casting = Volume x Density = 7.86 x 3275
= 25741.5 gm = 25.741 kg

Total volume of the casting is equal to 3.2 into 10 to the power of 3 plus 75 the 75 is the volume of the thin fins. So, total volume of the casting is equal to 3200 and 75 cc.

Now, mass of the casting is equal to volume into density, now the density of the solid casting solid steel 7.86. 7.86 into 3275 that is equal to 25.741 kilograms. Now again we will assume casting yield is 70 percent.

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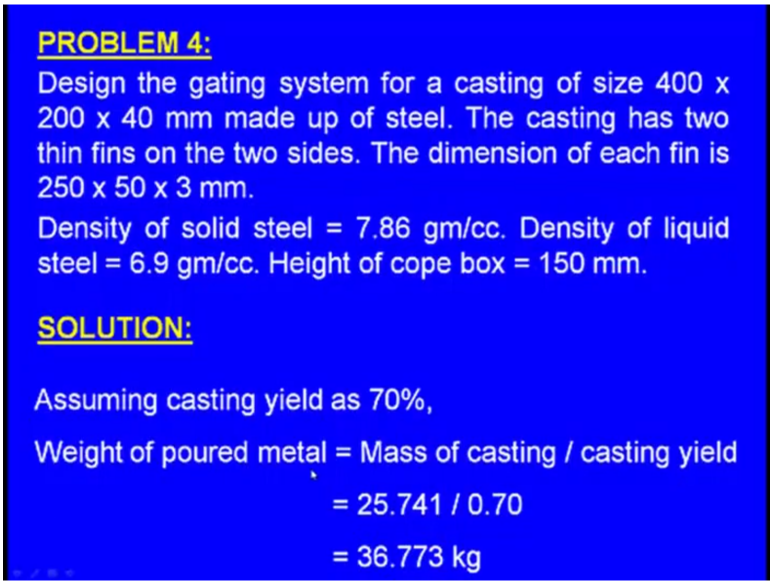

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Assuming casting yield as 70%,

Weight of poured metal = Mass of casting / casting yield
= 25.741 / 0.70
= 36.773 kg

That be the case weight of the poured metal is equal to mass of casting divided by casting yield that is equal to 25.741 divided by 0.7 that is equal to 36.773 kilograms. Now we need to find out the pouring time.

Now, what is the material of the casting here it is the steel you can see here it is steel.

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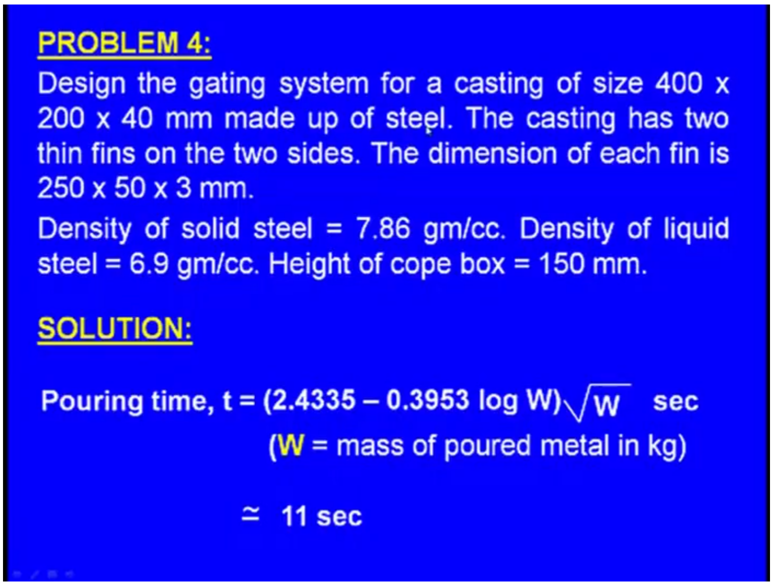

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Pouring time, $t = (2.4335 - 0.3953 \log W)\sqrt{W}$ sec

(W = mass of poured metal in kg)

$\simeq$ 11 sec

So, for steel the pouring time t is equal to 2.4335 minus 0.3953 log W multiplied by root of W and where W is the mass of the poured metal in kilograms and if we substitute the mass of the poured metal in this formula we will get the pouring time as 11 seconds. Now we are going to design the choke area choke area.

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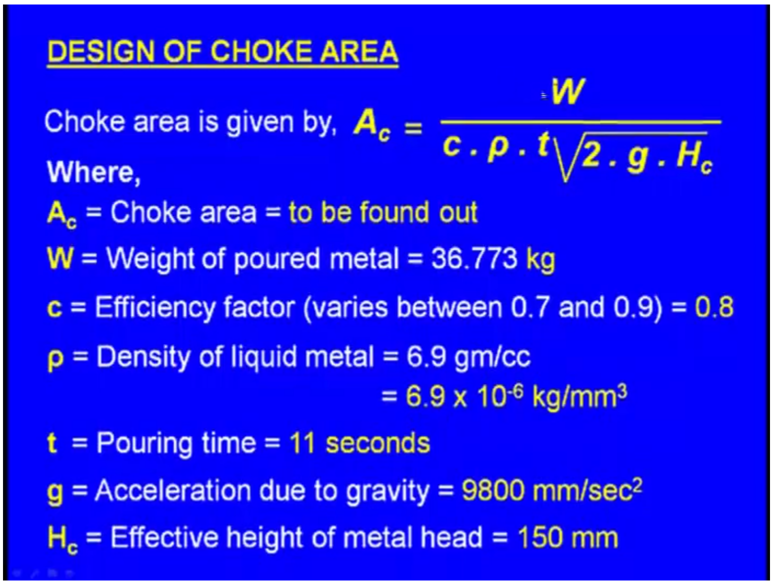

DESIGN OF CHOKE AREA

Choke area is given by, $A_c = \dfrac{W}{c \cdot \rho \cdot t\sqrt{2 \cdot g \cdot H_c}}$

Where,

A_c = Choke area = to be found out

W = Weight of poured metal = 36.773 kg

c = Efficiency factor (varies between 0.7 and 0.9) = 0.8

ρ = Density of liquid metal = 6.9 gm/cc

= 6.9×10^{-6} kg/mm^3

t = Pouring time = 11 seconds

g = Acceleration due to gravity = 9800 mm/sec^2

H_c = Effective height of metal head = 150 mm

A c is equal to W divided by c rho t root of 2 g H c and a c is the choke area and we need to find out that W is the weight of the poured metal that is equal to 36.773 kilograms, c is the efficiency factor that varies between 0.72.9 and here we have taken 0.8 and density of the liquid metal that is equal to 6.9 into 10 to the power of minus 6 kilo grams per cubic millimeter, pouring times is equal to 11 seconds g is the acceleration due to gravity 9800 millimeters per second square, H c is the effective height of metal head that is equal to 100 and 50 millimeters.

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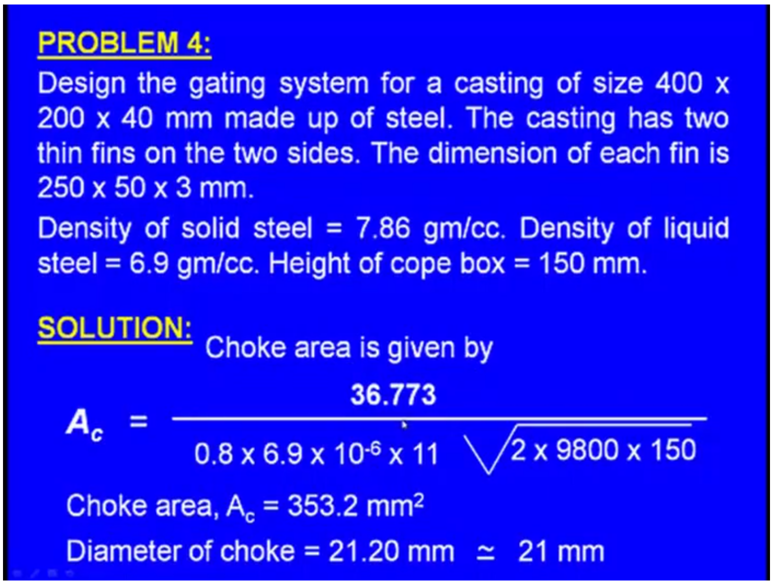

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION: Choke area is given by

$$A_c = \frac{36.773}{0.8 \times 6.9 \times 10^{-6} \times 11 \sqrt{2 \times 9800 \times 150}}$$

Choke area, A_c = 353.2 mm^2

Diameter of choke = 21.20 mm $\simeq$ 21 mm

Now this is the choked area we are substituting different terms in the formula this is the weight of the poured metal and this is the what say c now this is the weight of the liquid density of the liquid metal and this is the pouring time.

Now, choke area a c is equal to 353.2 square millimeters, now the choke area is usually a A circle, now from this if we simplify this the diameter of the choke is equal to 21.2 millimeters or that is almost equal to 21 millimeters. So, we have designed the choke area, next one we need to design the runner before that we need to specify the gating ratio.

Since the casting has got 2 fins on the 2 sides, now if we want the molten metal to successfully fill those what say tin sections we must what say adopt the pressurized gating system.

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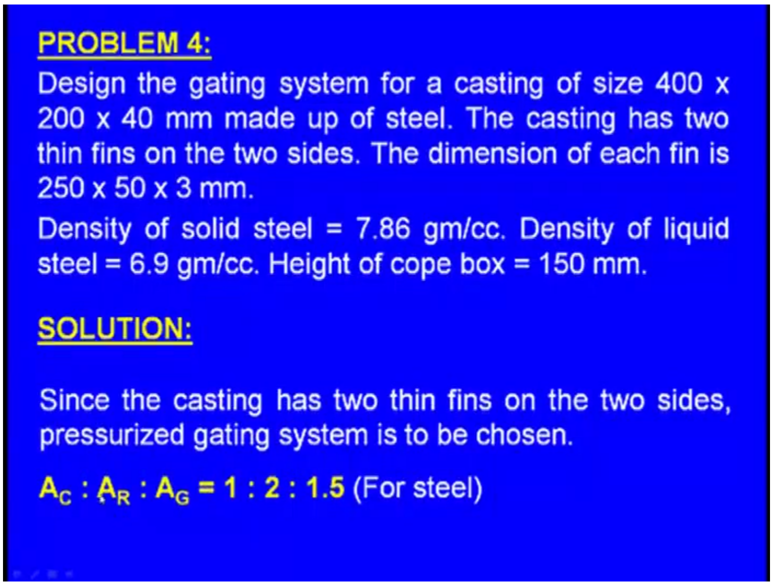

PROBLEM 4:

Design the gating system for a casting of size 400 x 200 x 40 mm made up of steel. The casting has two thin fins on the two sides. The dimension of each fin is 250 x 50 x 3 mm.

Density of solid steel = 7.86 gm/cc. Density of liquid steel = 6.9 gm/cc. Height of cope box = 150 mm.

SOLUTION:

Since the casting has two thin fins on the two sides, pressurized gating system is to be chosen.

$A_C : A_R : A_G = 1 : 2 : 1.5$ (For steel)

So, in the pressurized gating system A C is to A R is to A G is equal to 1 is to 2 is to 1.5 when we are doing with the steel when the material of the casting is steel.

Now, we will design the runner.

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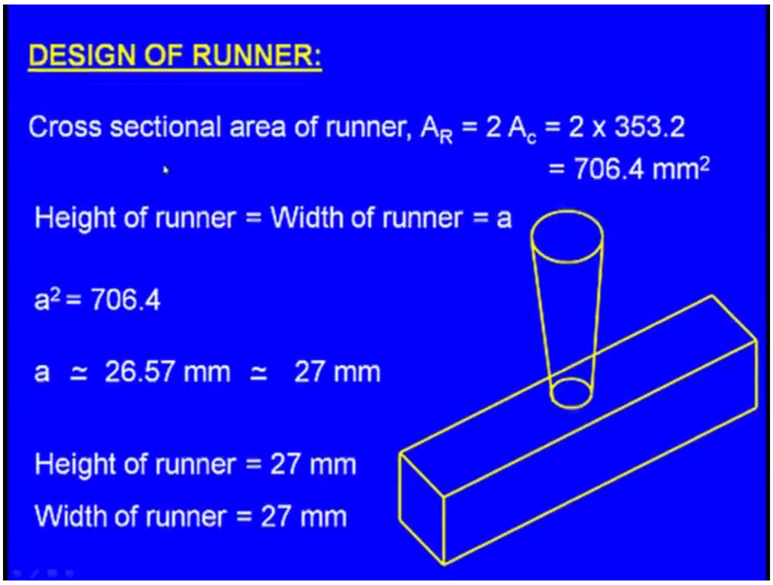

DESIGN OF RUNNER:

Cross sectional area of runner, $A_R = 2\,A_c = 2 \times 353.2$

$= 706.4\ \text{mm}^2$

Height of runner = Width of runner = a

$a^2 = 706.4$

$a \simeq 26.57\ \text{mm} \simeq 27\ \text{mm}$

Height of runner = 27 mm

Width of runner = 27 mm

Design of the runner, now the cross sectional area of runner A R is equal to 2 into A C that is equal to 2 into 353.2 that is equal to 700 and 6.4 square millimeters. Now for your runner the cross section is a square, height of the runner will be equal to width of the runner let us assume that is equal to a, then a square that is the cross sectional area of the runner is equal to 700 and 6.4 and if we simplify this a is equal to 26.57 or it is 27 mm.

Now, let us specify the dimensions of the cross section of the runner height of the runner is equal to 27 millimeters, width of the runner is equal to 27 millimeters next we need to design the ingates.

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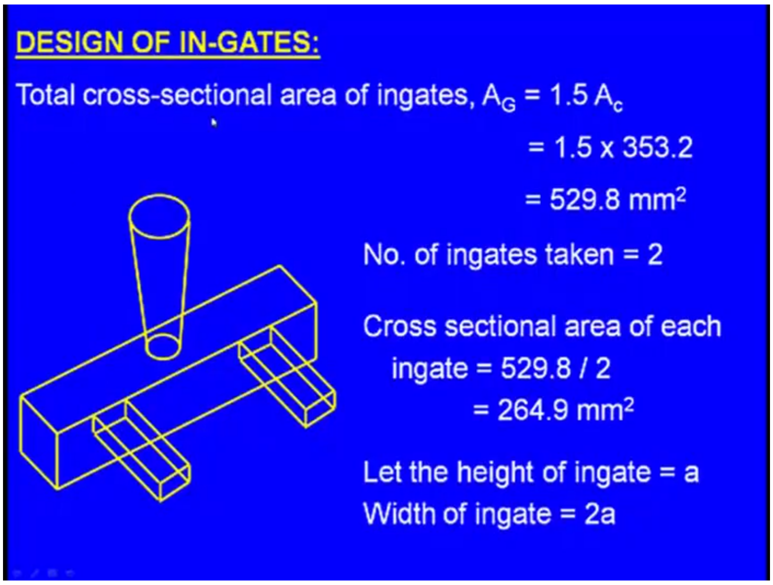

DESIGN OF IN-GATES:

Total cross-sectional area of ingates, $A_G = 1.5\ A_c$

$= 1.5 \times 353.2$

$= 529.8\ mm^2$

No. of ingates taken = 2

Cross sectional area of each ingate = 529.8 / 2

$= 264.9\ mm^2$

Let the height of ingate = a

Width of ingate = 2a

Now, the tot total cross sectional area of ingates A G is equal to 1.5 A C that is equal to 1.5 into 353.2 that is equal to 529 500and 29.8 square millimeters. Number of ingates here we are taking 2 now the cross sectional area of each ingate is equal to 500 and 29.2, they were 500 and 29.8 divided by 2 that is equal to 200 and 64.9 square millimeters and again the cross section of an ingate is a rectangle and the width of the cross section will be double then it is height.

Now, the height of the ingate is equal 2 a then the width of the ingate will be 2 a.

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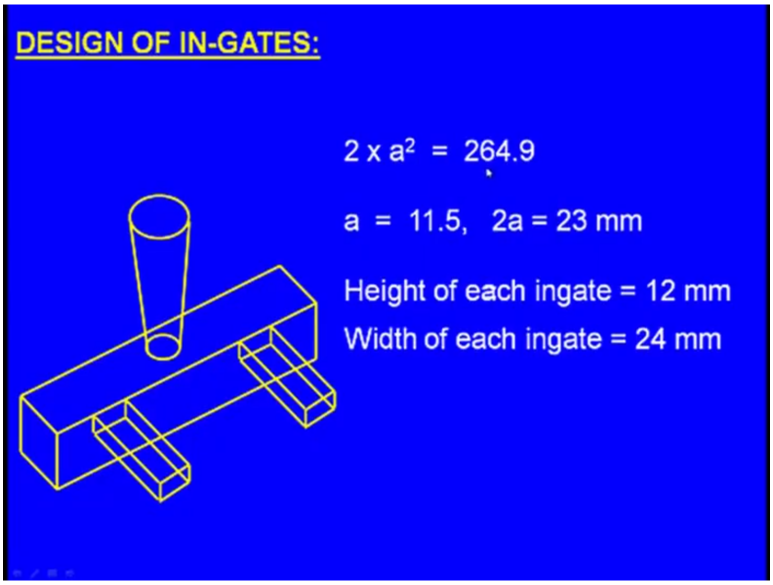

DESIGN OF IN-GATES:

$2 \times a^2 = 264.9$

$a = 11.5, \quad 2a = 23\ mm$

Height of each ingate = 12 mm

Width of each ingate = 24 mm

Now this is the cross sectional area 2 a square is equal to 200 and 64.9 then if we simplify this a is equal to 11.5 and 2 a is equal to 23 mm. Now let us specify the dimensions of the cross section of the ingate height of each ingate is equal to 12 mm this is almost 12 12 mm width of each ingate is equal to 24 mm. So, we have designed the ingates also.

Now, let us consider some Case Studies.

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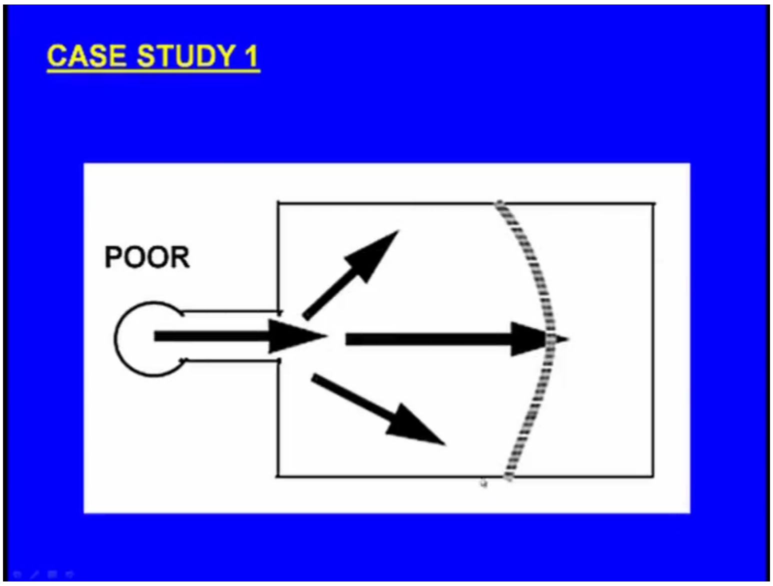

CASE STUDY 1

Now you see this one this is the casting, now the here is the what say sprue means here the sprue is perpendicular to this spot, now and this is the what say runner and here we can see the gate and the molten metal flows and here and it fills the cavity the molten metal stream it flows like this and it flows like this and it flows like this. This is the poor design this is a poor design, then what should be the a the better 1 or what is the alternative you see here, this is the sprue and this is the casting mould cavity this is the mould cavity.

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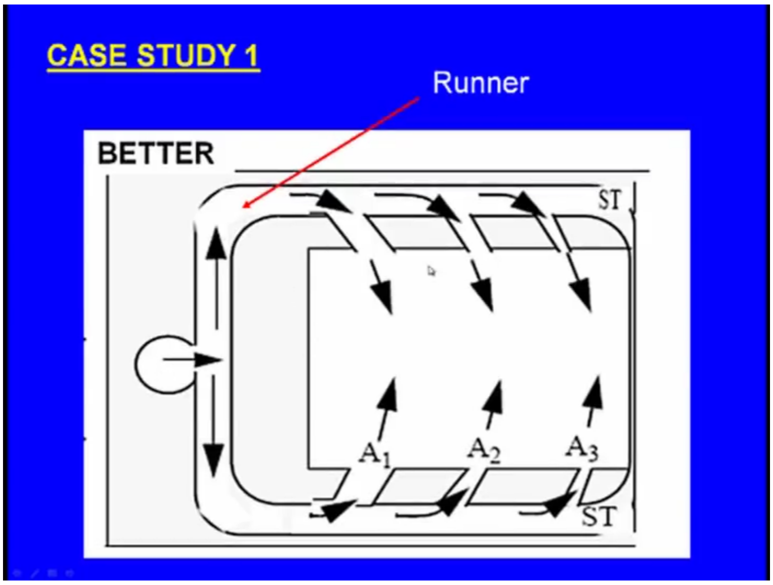

CASE STUDY 1

Now, the runner is like this the runner is surrounding the mould cavity you see this whole thing this is the what say sprue and this is the runner. The runner starts from here and it goes like this and it goes like this and up to here this is the runner again the runner is this side also it is like this. And here you can see this side there are 3 ingates here is one ingate, second ingate, and forth ingate and this side also one ingate second ingate and third ingates.

So, the runner is surrounding the mould cavity. So, this the better runner compare to the previous one. So, this is a case study this is better, next one let us take another case.

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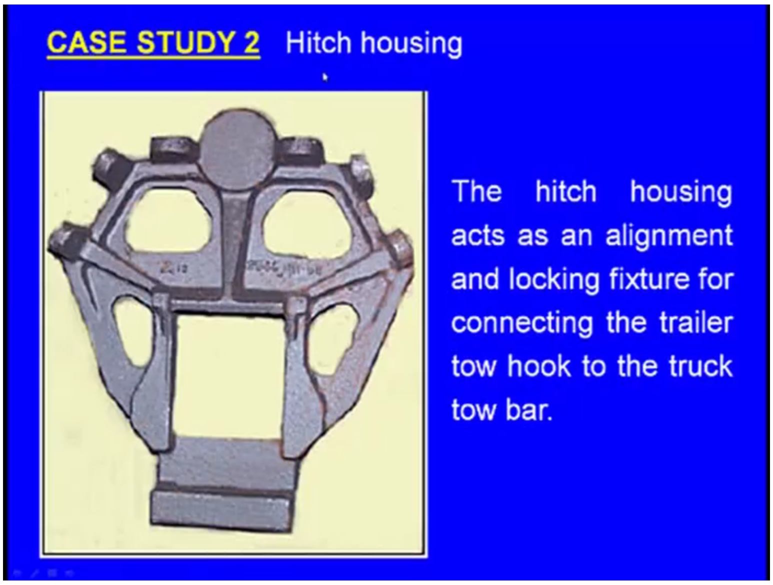

CASE STUDY 2 Hitch housing

The hitch housing acts as an alignment and locking fixture for connecting the trailer tow hook to the truck tow bar.

Let us consider a hitch housing the hitch housing acts as an alignment and locking fixture for connecting the trailer tow hook to the truck tau bar. So, this is the shape of the casting and how should be the what say pattern oriented inside the mould box how this runner should be designed. So, this is a again a case study let us analyze.

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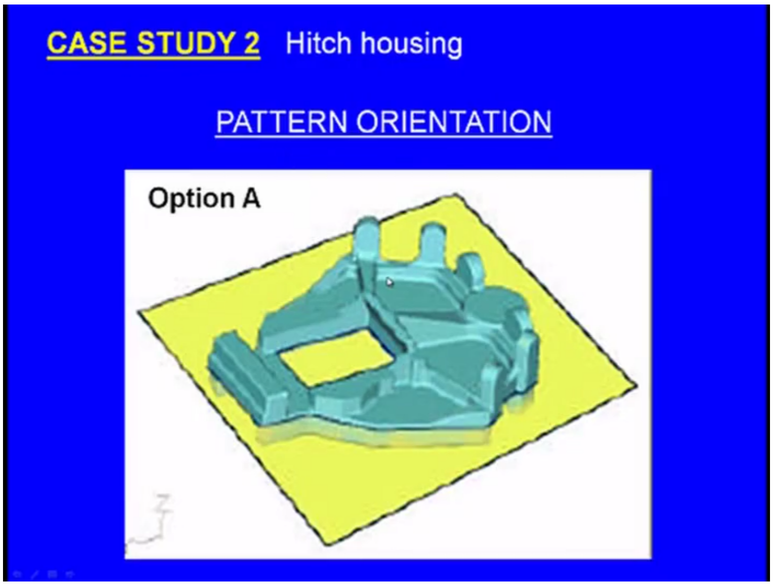

CASE STUDY 2 Hitch housing

PATTERN ORIENTATION

Option A

Now, how should be the pattern orientations now option A, now the thing is the pattern has got some complex and intricate features, you see these are all the complex and intricate features. Now in this option a first option these complex features are facing upwards and the flat portion is facing downwards. So, that is the first option.

Let us takes a second option in the second option the what say complex and intricate shapes are facing bottom and the flat portion is facing upwards. So, this is the second option.

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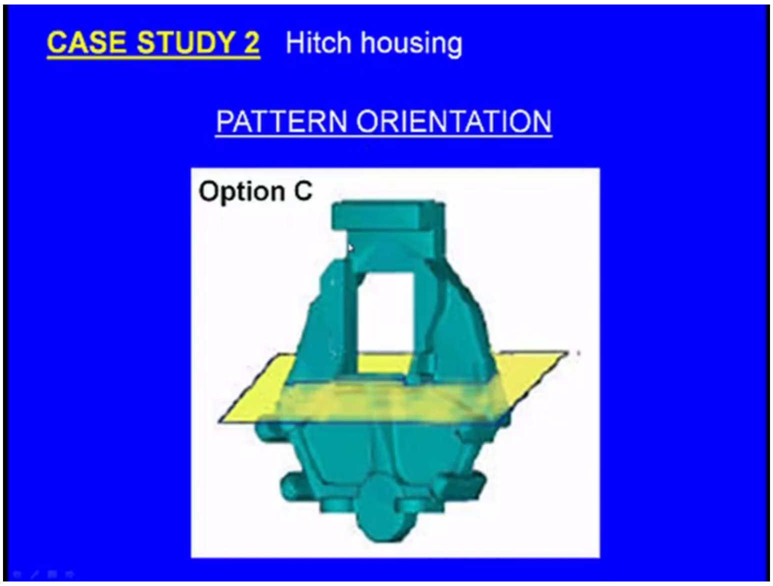

CASE STUDY 2 Hitch housing

PATTERN ORIENTATION

Third option the pattern is like this now we have seen 3 options which is better for this casting.

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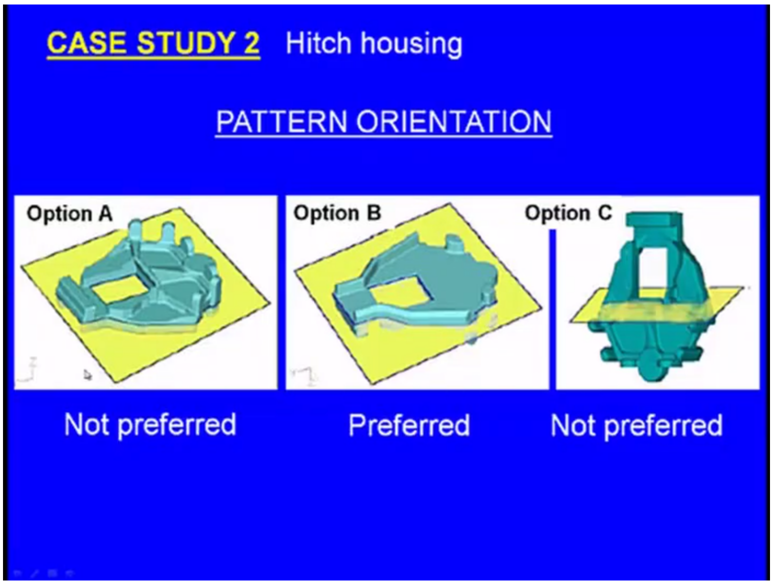

CASE STUDY 2 Hitch housing

PATTERN ORIENTATION

Not preferred Preferred Not preferred

Now you see this option A the intricate shapes are facing upwards that be the case the molten metal may not exactly fill these shapes these intricate shapes that is why this is not preferred.

Next one let us option 3 it is what say almost perpendicular to the moulding bone this is also not good, what happens the again the problem comes with the complex shapes again the these complex shapes may not retain the molten metal, but you see the option B the complex shapes are facing downwards. So, definitely the molten metal will go inside these shapes and the they retain the molten metal. So, the option B is preferred for this casting.

Now, let us analyze further how to design the runners for this casting gating and a runner option.

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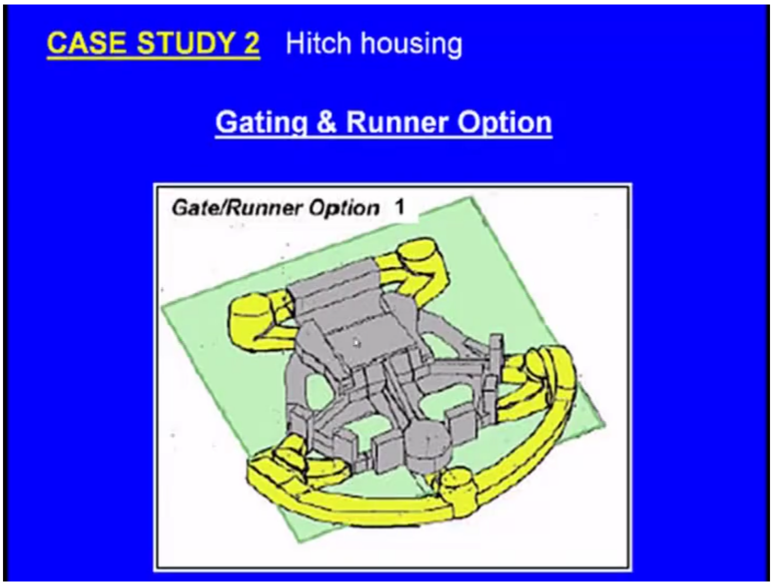

CASE STUDY 2 Hitch housing

Gating & Runner Option

Now you see this is the what say pattern, now this is the runner you can see here and this is the sprue the molten metal goes like this and it fills and here is one ingate and here is one ingate, and it fills like this again this is the again part of the runner the molten metal goes inside like this and it goes like this then finally, the molten metal fills the cavity. So, this is the option 1.

Let us say take another option now this is the sprue here is the sprue, now here is the sprue the runner is surrounding the casting like this again this side also it is surrounding the casting.

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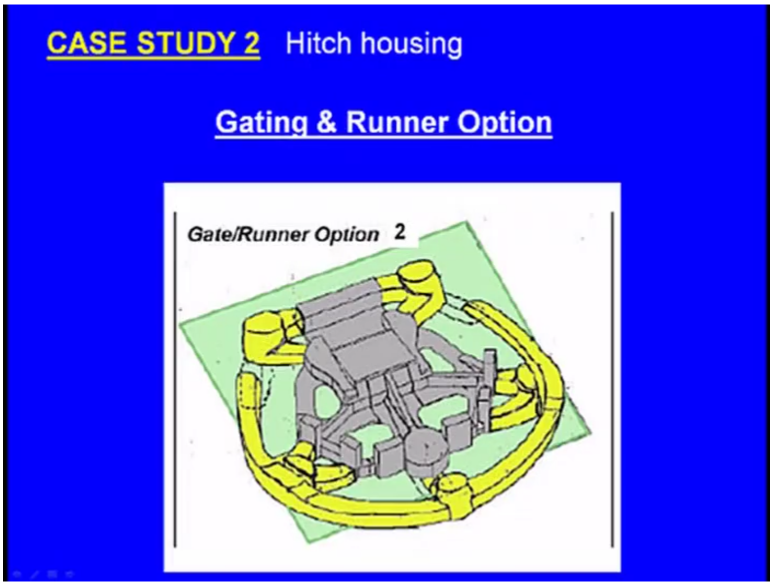

CASE STUDY 2 Hitch housing

Gating & Runner Option

Now here is one ingate and here is one ingate and here is one ingate and here is one ingate and here is one ingate and here is one ingate likewise there are several ingates and the runner is surrounding the casting.

Now, we have studied 2 cases 2 options for the runner design which one is better.

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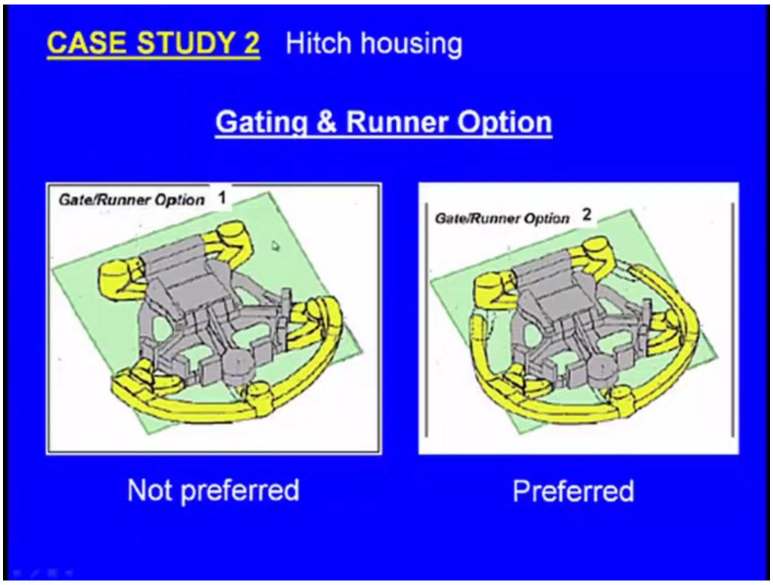

CASE STUDY 2 Hitch housing

Gating & Runner Option

Not preferred

Preferred

This is not preferred because the molten metal may be it may not what say fill uniformly, the molten metal initial it fills then slowly it progresses or it flows to the extreme what say said in which case it may not be good by the time it will travels from this portion to that portion the there will be a temperature drop will be there.

On the other hand this is preferred why because the runner is surrounding the casting from all directions the molten metal is parallely entering into the mould cavity. Then the filling of the mould cavity will be uniform. So, the second option is preferred in this case.

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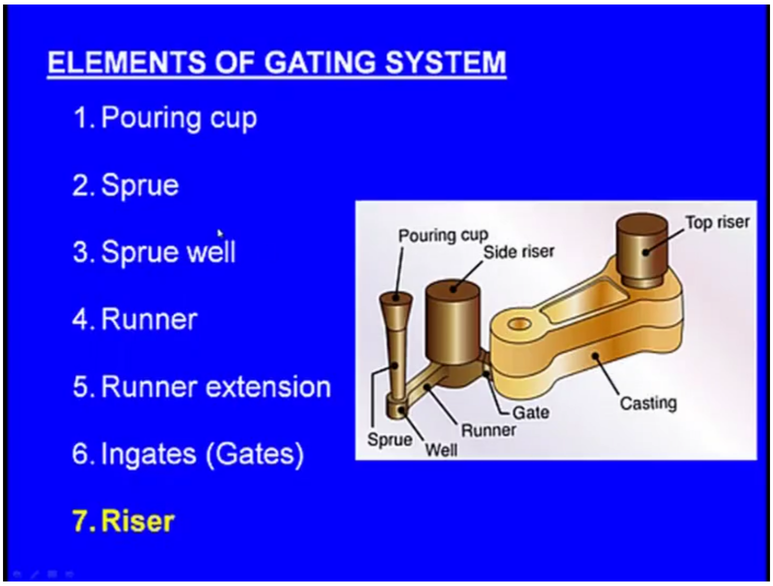

ELEMENTS OF GATING SYSTEM

1. Pouring cup
2. Sprue
3. Sprue well
4. Runner
5. Runner extension
6. Ingates (Gates)
7. **Riser**

Friends in these 2 lectures we have seen that the elements of the gating system are pouring cup sprue sprue well, runner runner extension, ingates and the riser and we have seen the significance is of different elements of this gating system. Now the primary question is when to design the riser, first question is whether to design all these elements first and finally, to design the riser or to design the riser first that is the most important question. First one has to design the riser though in this list risers appears in the last, but riser should be designed at first, then only one should design the choke area the runner cross sectional area and the ingates. So, this is very important again I am telling the riser must be designed first, then only all other elements must be designed. So, with this we are completing the design of the gating system. In the next class we will see the casting defects.

Thank you.