Iron Making
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Lecture – 30
Iron Making

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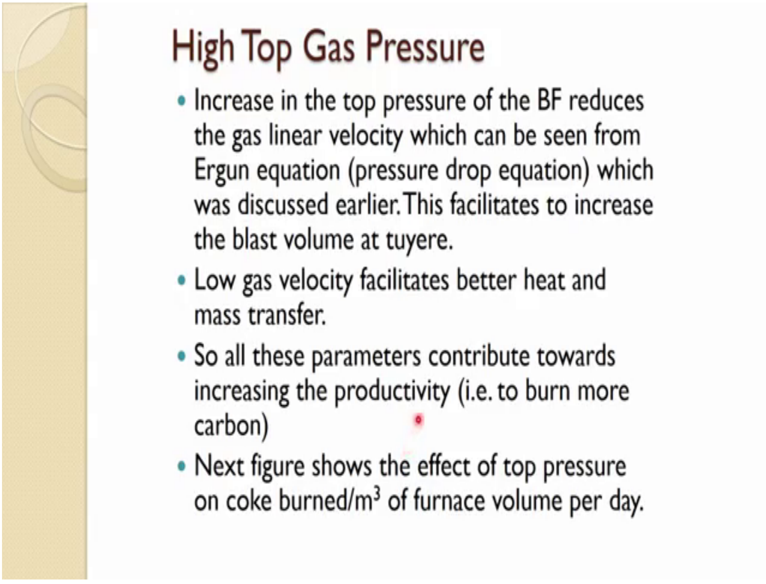

Another parameter is about the high top gas pressure. So, increase in the top pressure of the blast furnace is reduces the gas linear velocity, which can be seen from the a Ergun equation, if you look at our previous lectures, where we talked about the aerodynamics of the blast furnace. As you can see from that the gas, if you increase the top pressure of; then the gas linear velocity will decrease and so this facilitate to increase the blast volume.

So, to maintain the same gas linear velocity as in the conventional way; what one is to do; one is to increase the blast volume. So, in one way there the and that is the one of the requirement to increase the productivity. So, that is the key factor. So, blast volume is can be; so the you have a high top pressure them blast volume more blast volume can be put into the blast furnace.

So, low gas velocity facilitates better heat and mass transfer. Now, another advantage if the gas velocity is low the residence time of the velocity is higher in the blast furnace, which means when residence time is higher, so it has more chance to react.

So, mass transfer would be better, similarly it has more time to give up the heat to the charge. So, heat transfer is also better. So, low gas velocity facilitates better heat and mass transfer.

So, all these parameter contribute towards increasing the productivity that is to burn more carbon. So, next figure shows the effect of top pressure on coke burden per meter cube of furnace volume per day.

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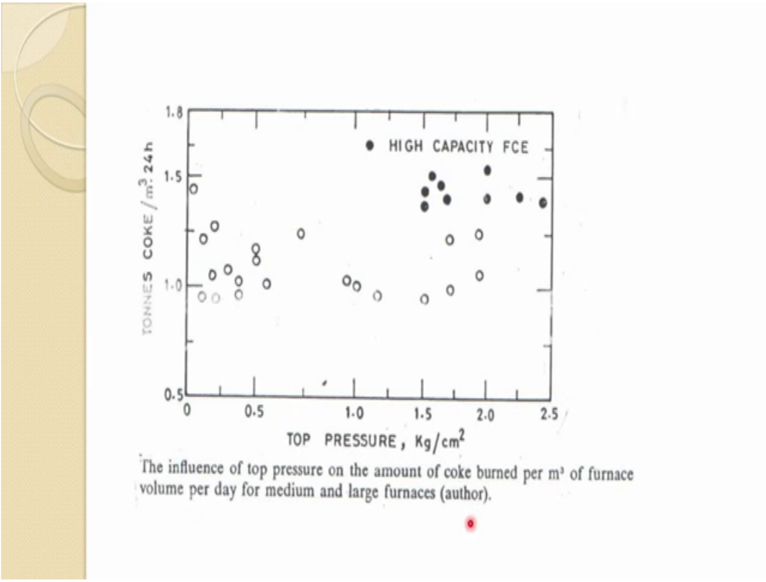

So, you can see that, if the top pressure increases these are really high capacity furnace, which are being do it nowadays this is somewhere in act is or like that. So, quite old, but this is the one which are being used nowadays.

So, one can see the and most of this modern furnace; now they there are it could be the high top pressure somewhere 2 to 3 kg per centimetre square of the trend.

So, one can see certainly that coke rate as increase with the increase of the top the top pressure. So, that is going to increase the productivity of the furnace.

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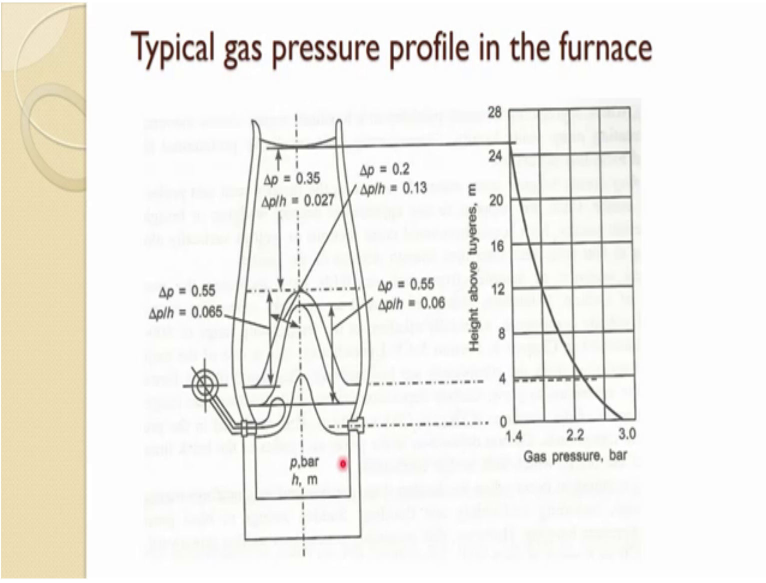

And this figure gives a typical gas pressure profile in the furnace. So, you can see that; pressure drop in this region is very high. This is between sort of a dripping zone and the upper one can say about the cohesive zone. And if you take the upper boundary of the cohesive zone at, which it is starts softening the charge and from there we take; so it is again almost same.

So, this is a quite high pressure drop in comparison to in the stock region; see stock region height is very high. So, this and that is why also the gradient of this pressure drop is quite low, here height is low, but is still the pressure drop is very high.

So, very high pressure drop exist in the lower part of the blast furnace. And across the cohesive zone; in fact the height is very low, pressure drop is quite high you can see that pressure drop is quite high and which is also indicated by this pressure gradient very high gradient one order magnitude almost.

So, this is the importance of the cohesive zone or cohesive region, because this is the one which of our maximum resistance to the flow; and that is why lots of chart preparation is needed to control that and to narrow it down, so this can be reduced.

And to look at the normal gas pressure from the injection point, so this is a tuyere a level about 2.5 or close to 3 and you can see just within almost 12 meter or so first 12 meter the pressure drop goes almost a drop to 50 percent.

And remaining almost 14-15 meter, it is a stroke about point 2 bar; hardly 10 percent. So, it is a big drop in that region, 50 percent and after that it is very little pressure drop about 10 percent or so, in the upper part of the furnace.

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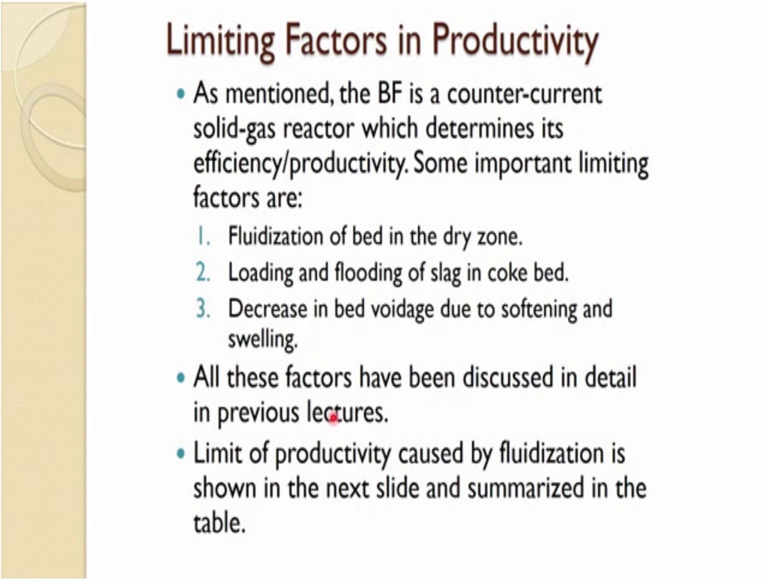

So, this lower part of the furnace is very critical and has to be maintained to have a good productivity of the blast furnace. This is the one which dictate all qualities of the raw material, and even the blowing of the air and other thing it dictates it is controls and thus it controls the productivity of the blast furnace.

So, there are some of the limiting factors in the productivity; so as mentioned before this is a counter current reactor blast furnace, solid case reactor which determines; it is efficiency in productivity. So, some important limiting factors are fluidization of bed in the dry zone, loading and flooding of slag in coke bed, decrease in bed voidage due to softening and swelling.

So, all these factors have been discussed in details in previous lectures. So, limit of productivity caused by fluidization is shown in the next slide and summarize in the table. So, again I will emphasize about this fluidization, loading flooding and decrease in voidage.

So, with respect to that, because the slag and liquid is flowing down, voidage is a reducing and; so that will carry away more liquid and it can deteriorate, if this is not maintained. Velocity is high more fluidization, because the you have a smaller particle size here also. So, fluidization may occur localized one.

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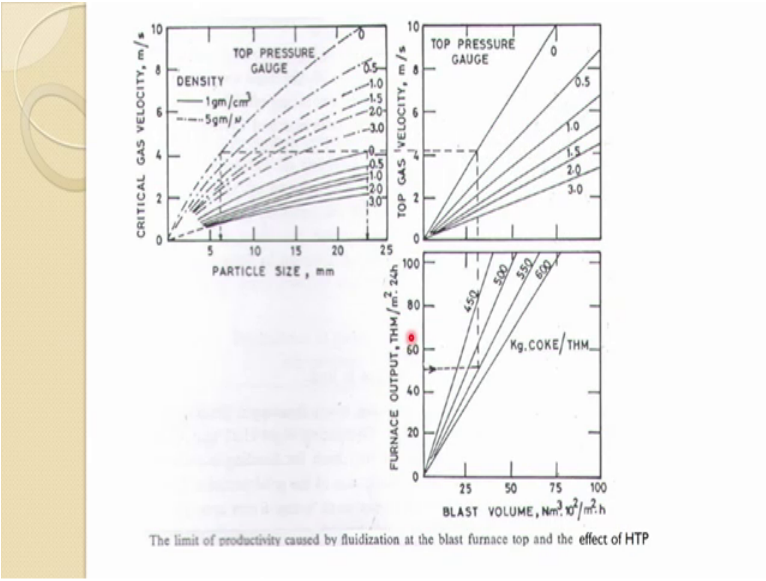

The limit of productivity caused by fluidization at the blast furnace top and the effect of HTP

So, this is the thing which actually it is talking about. So, this gives one idea that the limit of productivity caused by fluidization at the blast furnace top and the effect of high top pressure. So, if you have a see this because it is quite complex and it is a very good figure to judge, what sort of productivity one can have it; so furnace output at some 550 coke rate. So, that is a blast volume also is there and at what height of top pressure you are operating?

You can choose one of those line; and then you can decide based on that; what sort of particle size you should have in the blast furnace to achieve that sort of harness output depending of course, on the gas density. So, gas density curve is here for the 0 and this is actually the your material charge material density or ore density.

So, 5 gram per centimetre cube. So, it depending on that one can actually and these are shown in the top pressure height in the furnace. So, these are called the top pressure in the furnace.

This is the gas density, these are the ore density. So, based on your top gas pressure, which means you are choosing; accordingly you can take the graph of that one and accordingly also you can plot the line.

And similarly for the gas density and charge density and you can select the graph at a particular top height of pressure and based on that you can select what sort of size it is should have.

So, this really showing sort of; probably the minimum size and this because the gas density they also important with respect to that the fluidization should not occur. So, that shows that sort what sort of size is needed to should get fluidization should not occur.

So, based on that one can calculate a size distribution also about the charge, depending on the all this parameter gas density, charge density, that high top pressure, the coke rate and the blast volume.

So, these are typical values, these are shown in one can really get the fair idea about various parameter from this graph. So, it is a very useful graph for the from productivity viewpoint and selecting approximate parameter for the optimum productivity.

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Table 11.7.[3] Dependence of productivity per m² hearth area per 24h on particle size of ore of density 5 gm/cm³ and HTP

Assumptions: Fluidization in the throat to be limiting. Coke rate 500 kg/THM, coke = 87.5% C

HTP, atm. gauge	minimum ore size mm	highest productivity THM/m².24h
0	6	50
0	8	60
3	6	95
3	8	116

So, these figures shows there also dependence of productivity per meter square of hearth area per 24 hours on particle size of ore of density 5 gram per centimetre cube, and high top pressure. So, fluidization in the throat to be limiting, coke rate is 500 kg per ton of hot metal, and coke as 87.5 percent carbon.

So, when a high top pressure is 0, so it is the same as means vary, then the minimum ore size which is required; if 6 millimetre without fluidization. So, and that is how this is calculated below that one fluidization will occur. So, we cannot have it. So, it should be sort of a that is range.

So, mostly let us we said 10 plus millimetre size is a good one and. So, high production that 50, but if you have thus ore size 8 millimetres, you see the productivity is increased which of course, you can even go in a reverse way and you can check it and you can see your furnace output will increase.

And if your high top pressure is 3, and minimum ore size 6, you can say the see the productivity is almost 95 ton hot metal per meter square ton per day. And when they minimum ore size is 8 millimetre, it further increases the productivity.

So, this keeps you an idea that one thing is about the height of presser; how it is beneficial in increasing the production. So, for the same one from 50 to 95 almost double it had become. And one can also from these figures choose the appropriate parameter for the higher production.

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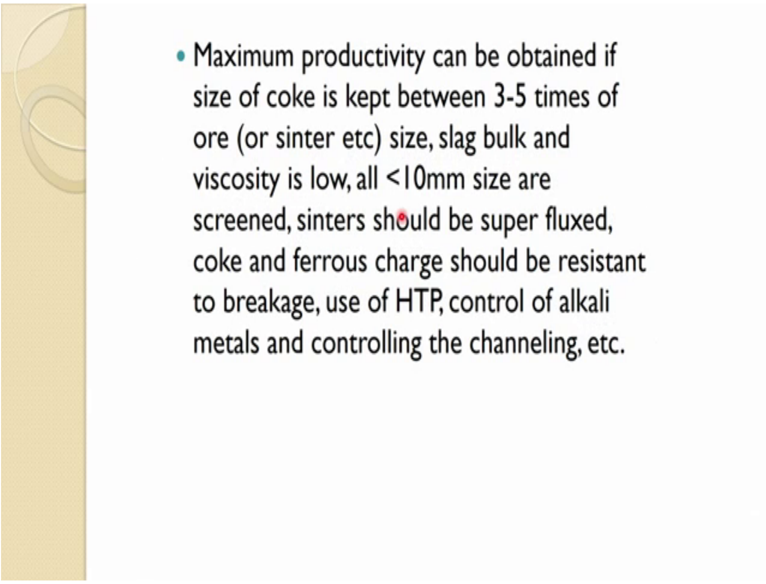

So, maximum productivity can be obtained if size of coke is kept between 3 to 5 times of ore size. So, usually sinter can do that thing and many of the modern flash furnaces, if they operate almost 80, 90 or sometimes when 100 percent sinter or palate.

Slag bulk and viscosity is low all less than 10 millimetre size are screened, sinter is should be super fluxed, so less slag volume; coke and ferrous charge should be in the super flux also it is a it is actually this is this cohesive zone and melting temperature delay. So, it is increase.

So, that is a one could think coke and ferrous charge should be resistant to breakage, use of high top pressure, control of alkali metal and controlling the channelling etcetera. These are the factors, which by controlling that you can achieve the maximum productivity in the blast furnace.

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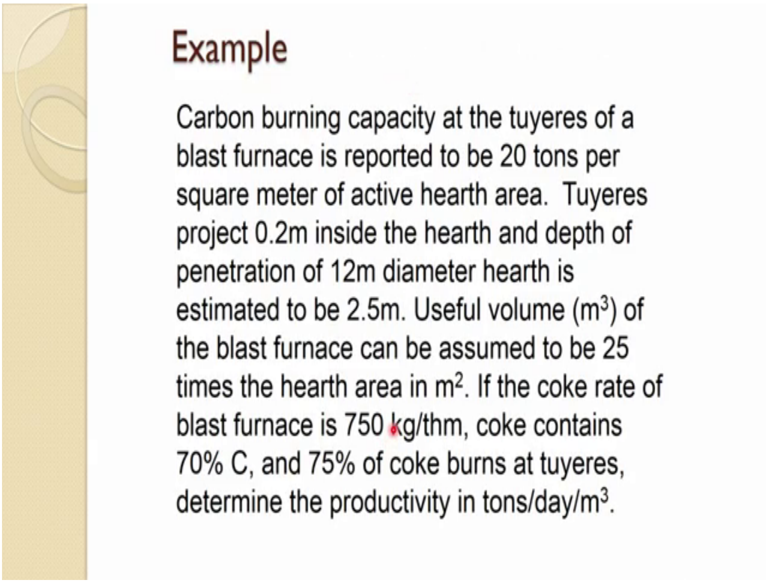

So, there is one example based on this, which we will take now. So, you can understand how you can calculate also the productivity beside of course, having a this diagram our figure, which get the approximate idea.

So, carbon burning capacity at the tuyeres of a blast furnace is reported to with 20 tons per square meter of active hearth area. Tuyeres project or tuyeres projection actually in 0.2 meter inside the hearth and depth of penetration of 12 millimetre diameter hearth is estimated to be 2.5 meter.

So, so this is actually depth of penetration means the raceway death in a 12, 12 meter diameter hearth is about 2.5 meter. Useful volume of the blast furnace can be assumed to be 25 times of the hearth area meter square.

If the coke rate of blast furnace is 750 kg per ton of hot metal, coke contains 70 percent carbon, and 75 percent of coke burns at the tuyeres, determine the productivity in tons per day per meter cube. So, here you have to calculate the productivity of the furnace.

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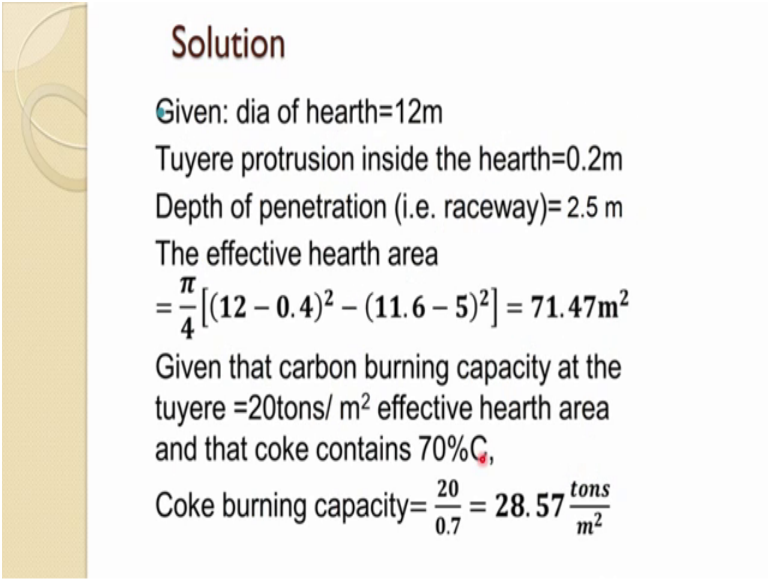

Most of the parameters are given; so what we have to do? We know the diameter of the hearth 12 meter, tuyere protrusion inside the hearth is 0.2 meter. So, that is not acting as a active area. So, we have to decrease remove that.

So, depth of penetration raceway is about 2.5 meter as we mention. So, that is a if quite active area, what we say. So, that effective hearth area would be is 12 meter minus 0.4. So, 0.2 meter each side of the tuyere protrusion, so it will become 0.4, so 12 minus 0.4 and then minus; so if we take a 12 minus 0.4 essentially it is 11.6.

So, 11.6; now we know the raceway is 2.5. So, that is also extending so both the sides so into 2 5; so 5 meter. So, this minus this is going to give us the effective hearth area; So, that this is being used for the raceway, this is in active by the tuyere protrusion, so what is remaining would be the effective hearth area.

So, when we calculate this effective hearth area it comes from this 71.5 meter square. So, given that the carbon burning capacity at the tuyere equal to 20 ton per meter square of effective hearth area and that coke contains 70 percent carbon.

So, really coke contains 70 percent 70 percent carbon; which means we can calculate the coke burning capacity from this 20 tons and 70 percent; so it keeps about 28.57 tons per meter square. So, effectively coke burning capacity is about this much 28.6 tons per meter square.

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Now, 75% of coke burns at tuyere level. Thus, actual coke burning capacity

$$= 28.57 * 0.75 = 21.43\,\frac{tons}{m^2}$$

Coke consumption=actual coke burning capacity x effective hearth area

$$= 21.43 * 71.47 = 1531.5\,\frac{tons}{day}$$

Coke rate=750kg/THM=0.750 tons/THM

Productivity of BF= $\frac{1531.5}{0.75} = 2042\,\frac{THM}{day}$

Useful volume= $25 * \textit{total hearth area}$

$$= 25 * \left(\frac{\pi}{4}\right) * 12^2 = 2827.43\,m^2$$

Hence, productivity= $\frac{2042}{2827.43} = 0.722\,\frac{THM}{day\text{-}m^3}$

And now, we have to find out the coke rate actually; so now, 75 percent of coke, once at the tuyere level, which is given again. So, the actual coke burning capacity; so total burning what we got the burning capacity of this much 75 percent only it once so actual coke burning capacity is 21.4 tons per meter square.

So, coke consumption actual coke burning capacity into effective hearth area. So, actual one we have calculated this and the effective hearth area we have already calculated 71.5. So, we multiplied this one that is going to give you 1531.5 tons per day.

So, this is the coke consumption, which is required and coke rate is given 750 kg the coke rate of blast furnace 750 kg per ton of hot metal. So,, but 75 ah; so it is a 0.75 tons per ton of hot metal.

So, coke rate we have coke consumption, actual we have; then we can get the productivity P by Q by K, if you look at over the first definition of the productivity, which says Q is the coke one in tons per day and coke consumed in tons per ton of hot metal.

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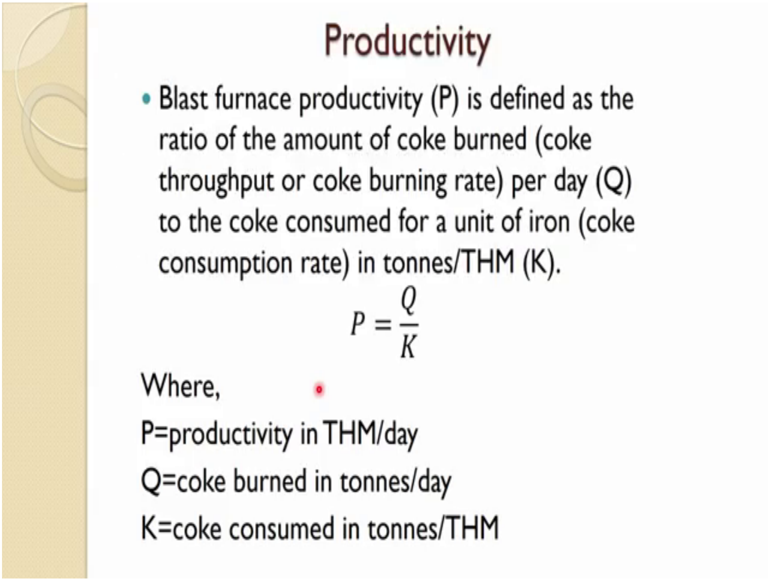

So, coke one we calculated and it consumed; that it is coke rate per ton of hot metals. So, that is really gives bring us to this to divide such a productivity of the blast furnace is 2042 per ton of hot metal, but what is in which I determine the productivity in tons per day per meter cube.

So, this is in ton hot metal per day. So, useful volume now this actually with a volume, if we if divide it we can get that one. So, useful volume is is mentioned 25 times of total earth hearth area.

So, total hearth area is; so you can see this is given here useful volume of the blast furnace can be assumed to be 25 times of the hearth area in meter square. So, this is actually; so that should be meter cube because of the volume.

So, productivity would be this 2042 divided by the useful volume, that is going to give you 0.722 ton of hot metals per day per meter cube.

So, this is the; productivity in ton hot metal per day per meter cube. So, this gives you or this example tells you at least, how you can calculate the productivity of the furnace; and that would be useful to know.