Iron Making
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Lecture – 01
Iron Making

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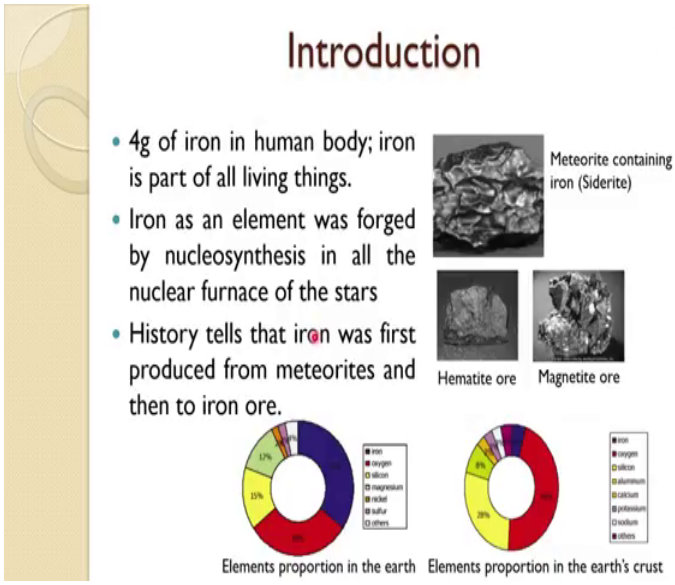

So, let us come to the introduction of Iron Making. I am not sure how many of you are aware of it, but in a human body we have about 4 gram of iron which means iron essentially is a part of all living things. So, it is very important in our life and s iron as an element was forced by nucleosynthesis in all the nuclear furnaces of the stars. So, if you read about the evolution of the stars will come to know iron is formed by nuclear synthesis process.

And, history tells that iron was first produced from meteorites and then to iron ore and in fact, the name of iron comes some say says it is like a holy metal and it is also in the old days they say the metal fall from the sky. So, the first evidence is iron came in the form of meteorites so, fell from the sky and that is how they gave the name iron. If we look at the percentage of iron in our earths, so, it is about 35 percent which a very big amount and, but most of it is concentrated at the core of the earth at the center and it is unaccessible. So, we cannot reach due to very high temperature at the center. So, whatever is available belong to the earths crust and that is the iron which we are using at

present and this is about 5 percent of earth crust and some of the iron ore is the hematite, magnetite which is which are shown here.

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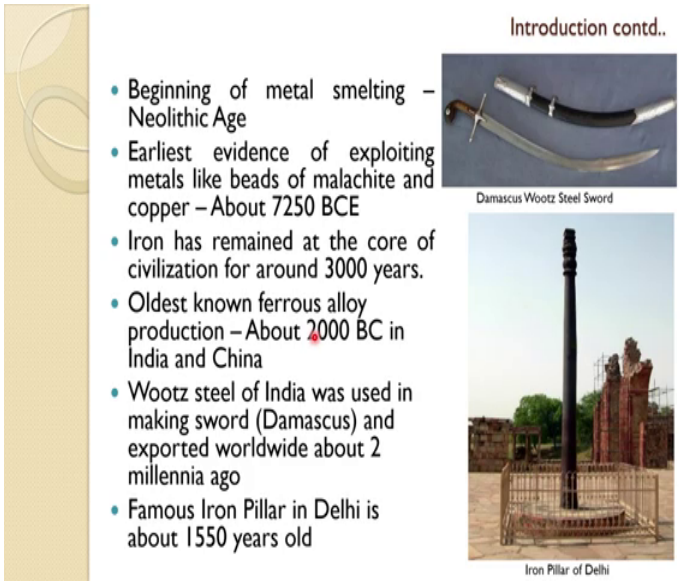

So, beginning of the metal is melting as you know it is started in Neolithic age and earlier evidence of exploiting metals like beads of malachite and copper about 7250 BCE. So, in fact, the Iron Age came quite late first the Stone Age, then copper age bronze and then the Iron Age. So, Iron Age remained at the core of the civilization for around 3000 years. The oldest known ferrous alloy production was about 2000 BCE and probably it is say may be more than sometime 2000 it is about 3000 actually in India it is a written one. So, that definitely we can say in India it was about 3000 BCE and the Wootz steel one of the main important iron process known is Wootz steel of India which was used in making Damascus sword and exported worldwide about 2 millennia ago.

And, this is the are Damascus Wootz steel sword which went all over the world and then another one we have around 1550 years old the known is iron pillar in Delhi which is not rusted dirt and quite heavy this is another marvelous of Indian metallurgist.

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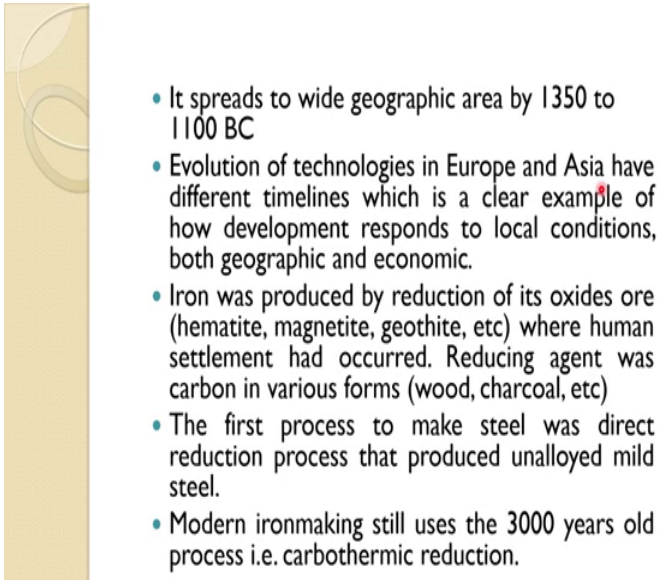

So, once this slowly after getting into this iron age it spread wide to wide geography area by 1350 to 1100 BCE and evolution of technology in Europe and Asia have different time line which is a clear example of how development response to local condition both geographic and economic. Ah, if you look at the history more closely you will find these are very different time line for Europe and Asia. So, is difficult to say what has happened in Europe is true all over the world and same thing is about the Asia. So, it said human settlement where it has occurred this technology developed.

So, iron was produce by reduction of it is oxides or hematite, magnetite, goethite, siderite etcetera and where human settlement it had occurred as I said in the previous one and reducing agent was carbon and various form of wood or charcoal. Ah, the feeling is when the human was settled somewhere and they were probably burning the fires and they are thought that place was iron rich they found sort of a nugget or some hard material and that is how this iron was discovered and this it started used.

So, the first process to make steel was direct reduction process that produced unalloyed mild steel and modern iron making steel uses this 3000 year old process known is the carbothermic reduction, because carbon is the main reductant here and that is how it is known as carbothermic reduction.

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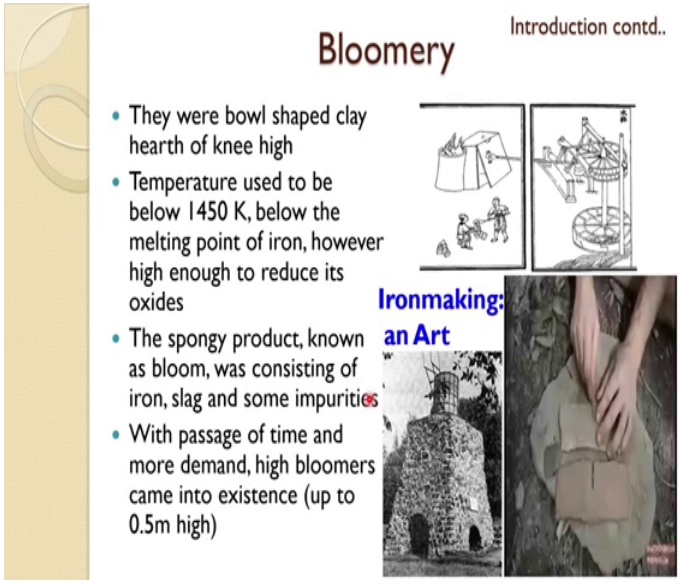

The way it is started what we know it is a in sort of a bloom just to produce and that place used to call bloomery. So, in that one just to have a bowl shaped clay hearth of knee high and that one temperatures ah, so, it is something like that and they are blowing the air through this into this part which is temperature is about 14 below 1450 Kelvin. So, that is below the melting point of iron.

But, it was a high enough to reduce it is oxide. However, this is spongy product which you get after reduction of oxide is not pure and that is why it is known as bloom, consisting of iron slag and some impurities, but they actually this video could show you a little can gives you a little idea about can we stop. So, this spongy product known as bloom was consisting of iron slag and some impurities. The following movie gives you an idea about how the blooms are produced.

So, with the process of, so, you saw this movie features show about the a spongy product kind of bloom in the old age, but you know at the time first demand of this metal increases due to it is hardness and other properties. So, with the process of time and more demand high bloomers came into existence up to 0. 5 meter high as you can see in the then this figure of course, this is a higher than that. So, more and more higher bloomer came.

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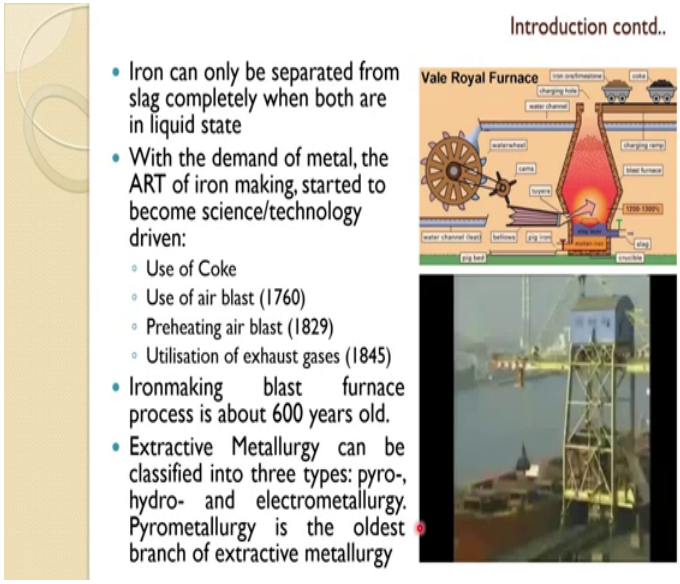

So, iron can only be separated from slag completely when both are in liquid state. So, as we were saying when the demand is mores then products also get increased the mechanization of the thing came as you can see in this one the blowing is through the water and. So, this is mostly what you are seeing is about the art of iron making as the people wanted more and more thing. So, the tries little innovative idea and started increasing the size of the bloomers and mores production of the bloom, but with the increase of the demand I think this art was not sufficient to fulfill it. So, slowly science and technology came into picture and the first use of coke was happen which because as you go high coal or charcoal or (Refer Time: 12:11) does not have that sort of strength which can be withstand the pressure of the material. So, they were restricted to it. So, invention of the coke came through the coal.

Then, use of air blast because the bloom becomes high you need more and more air and with the invention of steam engine high power below were available and that is how the air blast came into picture in iron making and to increase the efficiencies and preheating of the air blast started somewhere in 1829 and it is found that lots of heat is going wet in the form of exhaust gases. So, utilization of that also started somewhere in 1845.

So, essentially iron making what we have today is about 600 year old process and it is a part of the extractive metallurgy which is classified into 3 types pyro, hydro and electrometallurgy and pyrometallurgy is related to the heat and this is the oldest branch

of extractive metallurgy and iron making actually comes falls under this branch pyrometallurgy.

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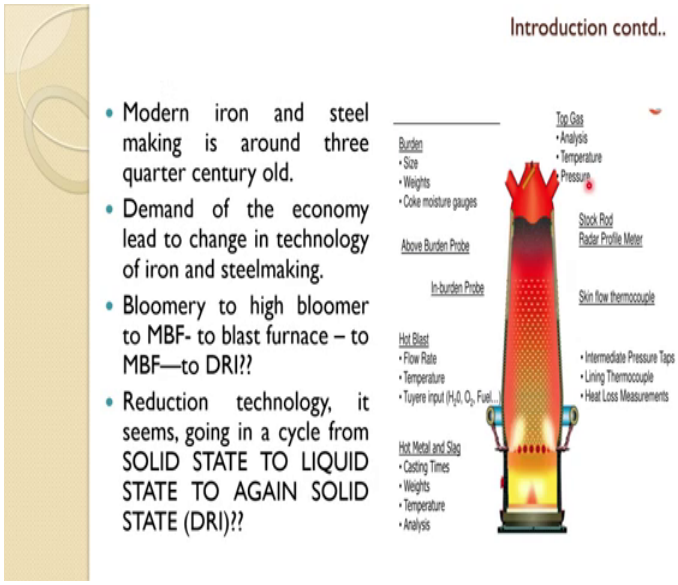

Now, coming to the modern iron making not exactly, but we see the development of modern iron in steelmaking, then this is around only 3 quarter century old, so, about 7 or 8 decade. Ah, so, pyro metallurgy is the oldest branch of extractive metallurgy and iron making falls under pyro metallurgy. Now, the modern iron making I will show you one video, a small clip which will tell you about how the iron is produced now. This is the video.

So, this clips or dual some idea about the modern iron making and this is around 7 to 8 decade old and as the demand is increasing or the this one new and new technologies coming into this and due to the economy many of the technology had changed and now, economy not the only thing environmental problems are there. So, many changes have occurred and as you can see from this slide that you have now burden it has to be size, weight, moisture control, all top gas analysis or skin flow thermocouple many types of probe and injection of the hot blast with fuel like pulverized coal injection, plastic, oil and there are. So, many things in the blast furnace which is shown in this figures.

So, nowadays blast furnace quite sophisticated. So, essentially if you look at the whole history of it, what we see it is going from bloomery to high bloomers to mini blast furnace to the blast furnace and as you know due to the environmental problem and

scarcity of the high quality coal people are going back to mini blast furnace and even to DRI, which is like source blooms sponge iron and then using this one into the electric arc furnace to make the steel, so, bypassing the blast furnace.

So, do not know after that what it would be, but it looks we are going in a cycle and if you look at in another way the reduction technology also seem to going in a cycle from solid state as the bloom then to liquid state we are coming to the blast furnace liquid iron in slag and again is going to the solid state to DRI and then using electric arc furnaces or other devices to make the steel.

So, it seems again it is going in a cycle.

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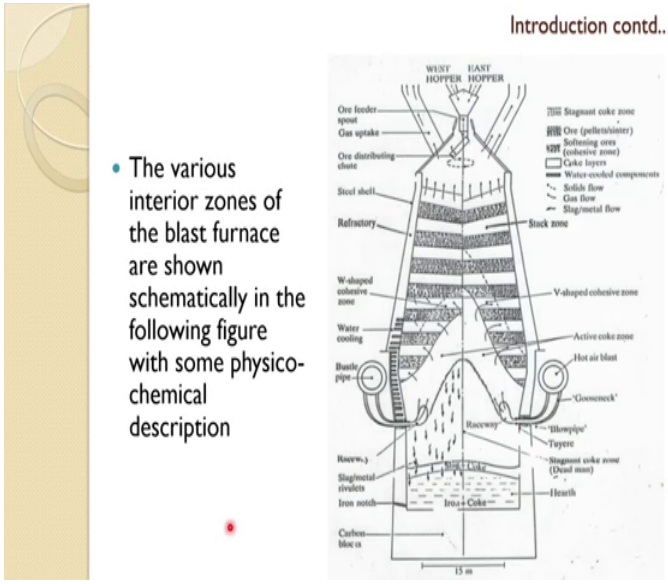

And, I will give you a little idea about the modern blast furnace various zones what is happening in it. So, this figure shows about the physical chemical description of the blast furnace. So, from the top we introduced raw material where iron ore and coke is charged. Now, iron ore depends if (Refer Time: 19:15) iron ore and it is followed with flux otherwise it could be only sinter or pellet us followed by coke and this is a chute which distribute this material the cross sectional of this blast furnace and where you have a layer of iron ore and coke.

Ah side of this is protected by refractory bricks and then the steel cell and cooling is done all around this and the hot air is goes through these nozzle pipes called tuyere and a

big kept is form called a raceway, because the coke is racing around here and this that produce CO which is highly reducing gas and that case goes up and reduced this charged especially the iron ore which is coming down from the top. So, slowly slowly this hematite to magnetite to iron ore it get reduces and when it comes somewhere over here it becomes semi molten in states.

So, sometime you call this zone as a cohesive zone. So, either it is a V shaped zone or a W; so, this one is a W and this one is a inverted V shaped zone and after that the of whatever metal and slag is there it is in the liquid form and only solid coke is there and so, this is a very hot zone. So, water cooling and other is required in across all of these around the furnace and this is known at bustle pipe, hot air is blown through this and your liquid iron and select trickle down through this and there is a sort of a lump of the coke, I would say what we call it dead men because as such it does not take any part in the reaction or any other thing, but it supplies mechanically strength to the burden and from the bottom you take out this liquid slag and iron from the respective nodes.

So, this is a brief description of the blast modern blast furnace.

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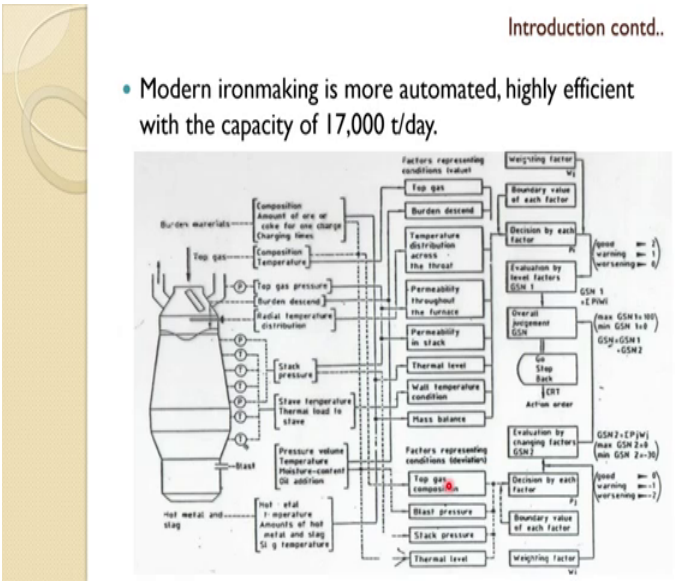

And, nowadays it they are quite automated and you would be surprised that the maximum capacity at the moment is 17000 ton per day this very high capacity. And, I am not sure when I am talking to you at this time another blast furnace might have come with probably 18000 ton per day or something. So, imagine it started with only few ton

per day to 500 to 1000 and now, to the 17000 ton per day, so, how much progress has been made in iron making and the below picture shows all automation and control of the blast furnace.

So, mostly do major various parameter top gas composition temperature at various places in the blast furnace, cooling system permeability of the bed and all these are fed and if there is any discrepancies or not falling under a certain range the value corrective measure is taken and that is how the whole blast furnace is controlled now through computers very few people work at the work so, at the plant. So, this is sort of a automation of this.

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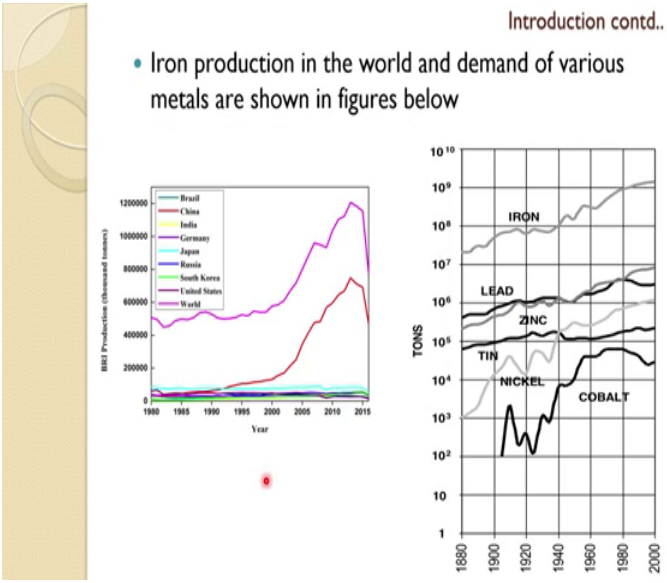

And, just to give you an idea about the demand of liquid metal as you can see in 2015 actually this liquid word production went up to almost 1200 million ton and after 2013 or 14. It is decreased a little bit and now it is almost constant the this downward trend is due to because the all data are not available, but if you go to 2016 it is something somewhere here so, which is almost becoming a constant. And, but if you look at this is the word production the China; it is due to the China which is produce so much hot metal due to their infrastructure development and now, they are reducing their capacity and India is coming up and India might be in another 5 years it would be going up to 300 million or another 10 years actually up to 300 million ton.

So, India need more infrastructure now. So, India is going up, China is becoming steady and other countries are ok. So, it seems the production would be steady if not decreasing. And, second figure shows how the on demand of iron has increased over a couple of century. So, you can see there are three metal which the demand of which has increased quite dramatically one is nickel, you can see almost 3 magnitude order it has increased in last century, iron of course, about 2 magnitude order it has increased cobalt at the same time almost 3 magnitude, but now it is a becoming steady or little bit at the decline side, but iron is still continuing. So, it still it has a demand and lots of infrastructure in various countries are getting built. So, this demand of iron will not decrease in near future.