Non-ferrous Extractive Metallurgy

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Lecture No. #30

Extraction of Precious Metals

Friends, we have so far discussed extraction of various metals in eight modules that I have covered so far. I now come to module number nine.

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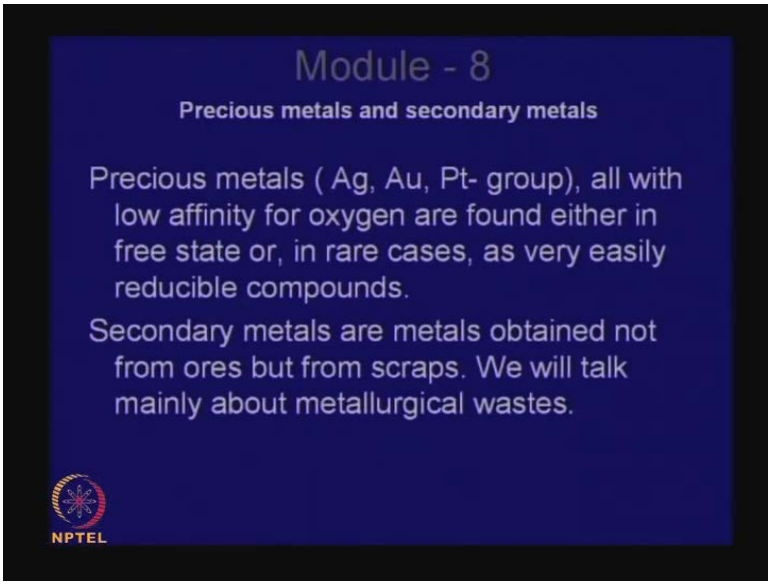

You will recall that earlier we have talked about extraction of a very large number of nonferrous metals from their minerals and ores whether they were in sulfides, they were as oxides or chlorides, the metals were in minerals. And in ores they were these minerals were found associated with lots of other things, the unwanted ones we called gangue materials, very often many minerals were mixed together. So from one ore one could get not only one element, but many other elements. Now, we are coming to discuss ores where metals are not present as minerals, but they are present in elemental form mostly.

And we will also discuss recovery of metallic values from metallic scrap, that is rejected after the consumer has found the use over certain period of time, and then the consumer has discarded. When we come to metallurgical wastes which are not scrap that can also be a source of recovery of metallic values, but let me now put emphasis on only these 2, metals which are mostly found in elemental form in nature, and metallic scrap which is also in elemental form of course, it may have undergone some weathering, some re oxidation, or it may be there in not exactly in the elemental form, but definitely they are not as minerals. There could be one or two exceptions for example, silver does form some compounds but, they are very weak compounds, very easily the metals can be recovered from that that is an exception.

So, in this module which is about precious metals and secondary metals, our learning objectives will be to first talk about extraction of precious metals, and then talk about production of secondary metals from scrap. Now, again I repeat that precious metals like silver, gold, platinum, group metals all with low affinity for oxygen are found either in free state or in rare cases as in the case of silver as very easily reducible compounds. When we say free state it does not mean there are chunks of platinum or gold lying around, no they have to be found amidst rocks or they are found as some waste that come out of processing of say sulfides, where you remember during electrolytic refinery of refining of copper under the anode there would be slime that slime contains precious metals.

The metals have gone through all the metallurgical process steps without reaction, to start with they were in elemental form, but mixed with so many other things that you cannot very easily get them. You have all heard about rivers where gold particles are found with the flowing stream Subarnarekha for example, and there are rivers where even today many people do panning, they take clothes and put it in the against the flow of water wait for hours to see if 1 or 2 particles of gold that are coming with the stream will get trapped.

But there was a time when gold could be found in plenty in nature, I have heard stories of plentiful gold in Latin America, you may have heard about emperor Montezuma who was captured by the Spanish, and then they said they would release the emperor if his subjects could fill up a room with gold objects, and they were astounded that day after day the subjects came with huge artifacts of gold and they finally, did fill up the room,

but that Montezuma was not released is another matter, but Latin America had so much of gold that they there were stories of cities which were paved with gold bricks, then lot of gold was found in America, and there was gold rush in the gold mines were from the rocks they found huge quantities of gold.

Now, India has always been very highly attracted towards gold, and that that attraction continues, every household in India likes to have a private hoard of gold. We did not produce that gold in the country however, because India used to import gold, from all kinds of countries Middle East even from Rome from Tibet, and India today has a huge deposit of gold, lot of them in temples in private hands some of our temples like in Thirupathi, they estimated to have some 15 or 20 tons of gold in their walls. Why were Indians so attracted towards gold much more than other people, where the Indians were fond of jewelry for adornment, their kings and Nawab's and emperors love jewels and gold, so they kept on collecting gold. So, gold has what we say ornamental value.

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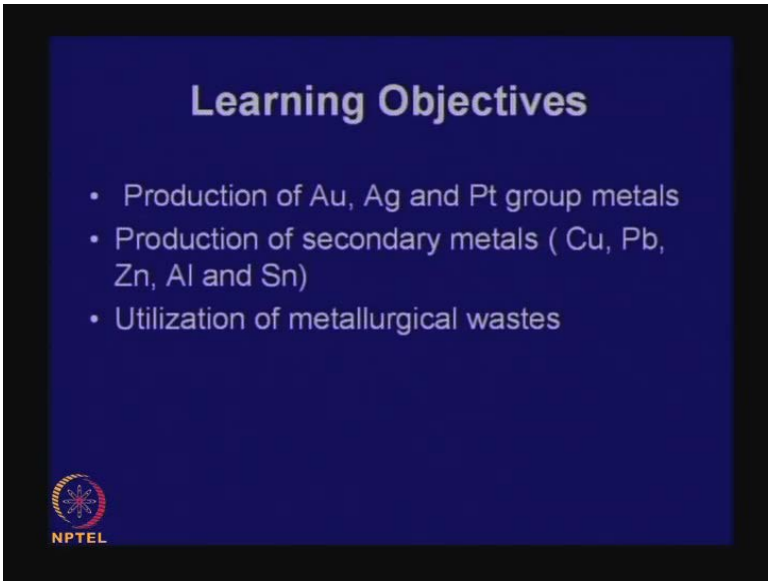

Now, when I mention this word ornamental value, let me discuss what we mean by the word value. Now, before that let me quickly go through what is written in this slide, the learning objectives of those this course will be production of gold, silver, platinum group metals, production of secondary metals like, copper, lead, zinc, aluminum, tin etcetera. And if time permits I will discuss utilization of some metallurgical wastes, which are not which do not have metallic values in elemental form, but they are source of metals. Now,

let me go back to this question of what we mean by value, when we talk of a metal as a precious metal, why do we call it precious? The word precious means that it is distinguished by rarity and very high priced.

Now, is it very highly priced, because it is rare it is not necessarily so, there can be something which is very rare but in may not be highly valued, this word value can actually have many meanings, and we can think of at least 4 kinds of values utility value, ornamental value, exchange value, prestige value let us see the differences, I need to say this because it has much to do with the valuation of precious metals. Consider a currency note of say rupees 500, now the currency note has value in India, Indian currency suppose you take it to another country, if you take it to an European country it has no value there, there is nothing that can be obtained in exchange, unless you go to a designated bank counter where they can exchange that Indian currency note with a local currency note.

But suppose you go to just a country side, or go to any country among the population and show them a 500 rupee note, or a 1000 rupee note it does not have any value there, because the value of that piece of paper is a designated exchange value as guaranteed by the reserve bank of India, and that exchange value is valid only in India, it has a exchange value elsewhere in those banks wherein exchange of that Indian currency they will give you the local currency note. Now, think of India; that piece of paper which says rupees 500 now can fetch you goods worth 500 rupees, because it is a standard the government has settled and the population and by and large accepted.

During the time of wars when things go out of order many currency have gone completely haywire, like what was available for 1rupee perhaps after a week would have been priced at 100 rupee, this happened during second world war in many countries. That is why if you go to the currency of Italy, it is always a million leader not 1 leader 2 leader it is always in millions, because that inflation devalued the currency so much during second world war, that what was available for 10s or 100s became available only for millions. So, this exchange value is an arbitrary value fixed by the government of India and accepted by the society, and it is it gives a standard of exchange.

Before we had this currencies things had to be on the form of a barter, that you give me a goat then I will give you 10 kilos of rice, this kind of bartering even takes place in

remote centers of the country even today, in say in the rural remote rural areas, they may not be using the currency so much they might actually go for barter. And there the goat has an exchange value of this much, or 10 kilos of rice has an exchange value of this, but as of today that what we know is a currency note has a value which is an exchange value. Now more basic value is what we called utility value, that it has an utility and it is more universal, like if you have a chair it is it has an utility value people can use it to sit, you take the chair to any part of the world it has a value called utility value, this value may not be the same everywhere.

For example in our country wood is very expensive, say wooden furniture costs lot more where if you go to a country like Canada, where wood may not be so expensive it may not cost so much of course, it could cost more because everything cost more there that is a different matter. But you understand there is a basic value called utility value depending on the utility, so when it comes to metals and alloys they all have utility values, because they can be used in various applications. So, it is a commodity with utility value incidentally commodity is something we can buy or sell that can be traded.

Now, all this precious metals are also commodities, but their utility value is not as high as the price indicates, they have a exchange value of a very high order, because it has been fixed like that. They also have two other kinds of values 1 is prestige value, because only the rich and the affluent they can afford gold, gold goes, gold, platinum, silver they are associated with prestige, that prestige is not directly linked to utility, nor linked with exchange it is value is prestige value, it also has an ornamental value, because it is used in adornment.

Just to give an example and close this discussion suppose you have a painting of M F Husain, those who do not know the painting may not understand the value of that painting, again you go to a remote place somewhere where they have not seen M F Husain’s painting, if you ask them how much would you pay for it people may not like to pay anything for it, or if somebody who likes art he might say I will pay you 10 rupees or 20 rupees, but if you tell them it is selling in the international market for crores of rupees they would not believe it, because that painting is not costing that much, because of our utility value not because of an exchange value it has a prestige value, because it enhances the prestige of the owner, and you know it appreciates, there are other reasons why garments and paintings are they cost so much.

Because it is a way of the wealthy to keep their wealth at one place, if they buy Husain's painting now, after 10 years they can sell it for 10 times more, so in a small space they can keep a lot of wealth. Now coming back to this precious metals their price also relates to prestige, relates to tradition, relates to acceptance by population, gold from time immemorial has been accepted as a standard basis of wealth, the more gold an emperor has the more respect he commanded, diamonds of course, also.

Today every country therefore, has to keep a stock of gold in the vaults to establish its financial status, and gold is the international basis of financial exchange, so gold has an exchange value, gold has a prestige value, it is the value is much more than what we say an utility value, its value is fixed on different criteria.

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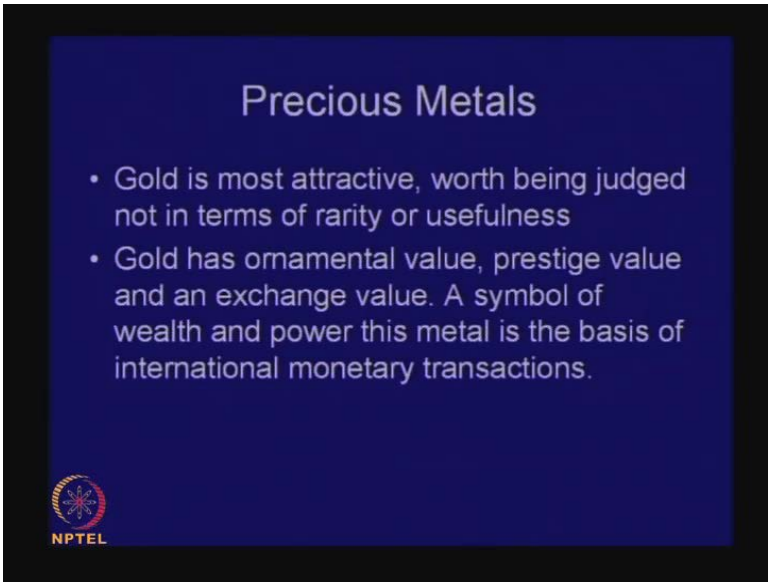

Now, I would say the gold is most attractive, of all the precious metals it is best known all though platinum is more expensive, but gold is most attractive its worth being judged not in terms of rarity or usefulness no, it has ornamental value, it has prestige value, and it has exchange value, you give this much of gold you can buy a lot of things with that kind of gold. It is a symbol of wealth and power, and this metal is the basis of international monetary transactions, these is not true for platinum or silver a bit for silver but, not for platinum its gold which is the basis.

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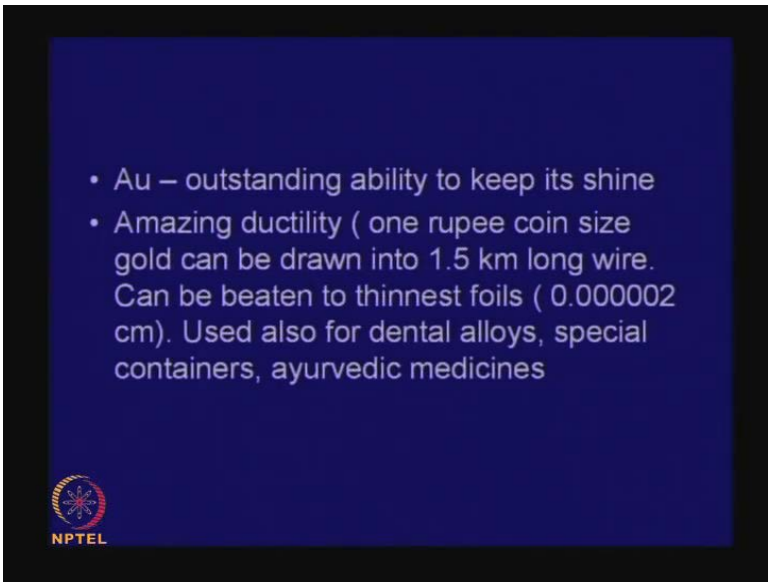

Of course it has utility not that it has no utility, it has outstanding ability to keep its shine, this is what attracted mankind to gold, that if piece of gold remains shining forever it is a symbol of eternity, and when it shines on a body you know the body looks so much more handsome and beautiful. As regards its properties it has an amazing ductility, and a 1 rupee coin can actually be drawn into 1.5 kilometer long wire, and because it has ductility it can be beaten to the thinnest foils, .000002 centimeter thick, and that is why even today some very expensive sweets or pans can have a gold foil, there are also Ayurvedic medicines covered with gold foil.

There is tinniest fraction of gold in that, had gold not been so ductile I do not think not many people would have ever been able to afford the Ayurvedic medicine, or the pan, or the sweet, but it does give a shine makes it look good. And you have seen the gold foil on so many temples Gurdwara's, the golden temple of Amritsar is covered with gold sheet, this sheet is not very thick, it because it is beaten into a thin sheet I do not exactly remembered its thickness, but had it not been so ducktail it will be much more difficult to cover the entire Gurdwara with gold sheet.

Similarly, the other temple; the temple in Banaras is also covered with gold sheet, incidentally this was donated by none another than Ranjit Singh the lion king of Punjab, he had given that gold for covering the Vishwanath temple, it is all because the gold can be beaten to a very thin sheet, but then gold has other uses, it is used in dental alloys in

very special containers, Ayurvedic medicines, in many electronic and other applications we can have gold for contact, because it will never get oxidized, it will always maintain good metallic contact, these are very special uses, but again the value of gold is not because of its utility, it is because of other reasons.

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Now, coming to silver this also has an ornamental value for slightly lower classes, like amongst us those who are very rich can afford to have diamonds and gold, those who are not so very rich very often would settle for silver. Silver also looks good as a matter of silver has a special appeal, because it has the whiteness, gold usually has the yellowish color, and that whiteness some time goes very well with diamonds it goes with some kind of a jewelry, it can be alloyed with gold as a matter of fact all gold, as some silver in it. Why it is? I will discuss that later, because different amounts of silver and copper gives better properties to gold in terms of fabrication, it also they also add different use you can have from white to green, hue can be imparted to gold by adding silver and copper, so silver and gold go together.

But silver has a utility value, it is a material which has the highest electrical conductivity, highest thermal conductivity, so silver can find applications in there, but silver has a problem. Silver tends to tarnish with time, tends to form lose its shine so it needs some maintenance from time to time. Now, because of its properties silver is used in electroplating, it is used in photography, you know silver alloyed is what was used in

photography plates, it is used in dental alloys, it is used in reflectors, silver solders are there.

So, silver has a lot of utility value, silver and copper additions as I mentioned little while ago hardened gold, pure gold is not good for making ornaments because it is too soft. So, some impurities in the form of copper and silver when added to gold makes gold more useful so that it can make ornaments. But additions of silver and copper impart a wide variety of colors that range from red through yellow to green, and this colors are very highly valued in jewelery. We will find this kinds of colors in many Rajasthan ornaments, gold ornaments but there are this colors, and it has come from alloying of copper and silver in different proportions.

Now, in nature wherever there is gold there is silver, these two go very often, and normally the ratio of gold to silver is 1 to 13, 1 gram of gold there will be some 13 gram of silver, and these two can be separated, there are very standard methods of separating gold and silver.

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Now, let us move on to the other precious metals more expensive, that will be the platinum group of metals, now if you see the television you know very often they show the what is the financial status of the world, you know sensex they will show nifty all kinds of things. They always show prices of metals, and to show the health of the

economy they always quote prices of gold and silver, they do not talk about platinum group metals which are more expensive, because gold is the standard and also silver, and you should see the price, and price of gold and silver are not according to their availability in nature it is all arbitrarily fixed.

Platinum group metals have a utility value, platinum group metal also have ornamental values, not so much does exchange value. As a matter of fact if you happen to have something made of platinum you can be in big trouble, because you cannot sell it anywhere, it does not have value sale value. Whereas if you have gold you can always sell it, or if you have silver you can always sell it, of course, at a slightly lower price because when you buy a gold ornament it has the price of the metal and also price for the craftsmanship. So, when you take it back to a jeweler you buy back the gold, and they would not give you the money you had paid for craftsmanship, so the price should be some 15 to 20 percent lower, but the gold metal has a value.

Supposing you had bought some gold 10 years or 20 years ago some ornaments, today the value would have appreciated so many times; so many people like to invest in gold and silver because the price will appreciate. But if somebody have given you a chunk of platinum you are in trouble, it cannot be sold, even the jewelry shops which make platinum jewelry will not buy the platinum from you, because there is some regulations about use of platinum. So, if you have platinum vessels, platinum wires, or platinum thermocouple, platinum rhodium things it has to only go back to 1 or 2 designated companies which make things out of platinum.

So, platinum rhodium and platinum group metals do not have this easy resell value as gold and silver have, although they are far more expensive. Now, platinum group metals have utility value, they have high temperature melting point, resistance to corrosion, and oxidation, and this make the metals suitable for special applications for example, you can melt salts and slags, in all our laboratory work if we want to melt glasses what kind of you have to go for platinum group of metals, it cannot melt them in gold or silver, because their melting point is too low, you will need temperatures of the order of 1500, 1600 which platinum group metals give us.

Of course pure platinum is soft, so it has to be alloyed with other metals in the group like rhodium or other metals, the platinum group metals also have other attractive properties,

some of them are high ductility, low vapor pressure, low coefficient of thermal expansion, high temperature coefficient of electrical resistivity. Now, all these properties are exploited in various applications, and you know that for temperature measurements platinum, platinum rhodium, thermocouples are so very commonly used, they can go to very high temperatures, and they are just the right materials for making thermocouples.

So, platinum group of metals have utility value, they also have prestige value, they do not have exchange value for commoners, may be at very high levels it can have an exchange value, but for between you and I, between you and me it would not have an exchange value.

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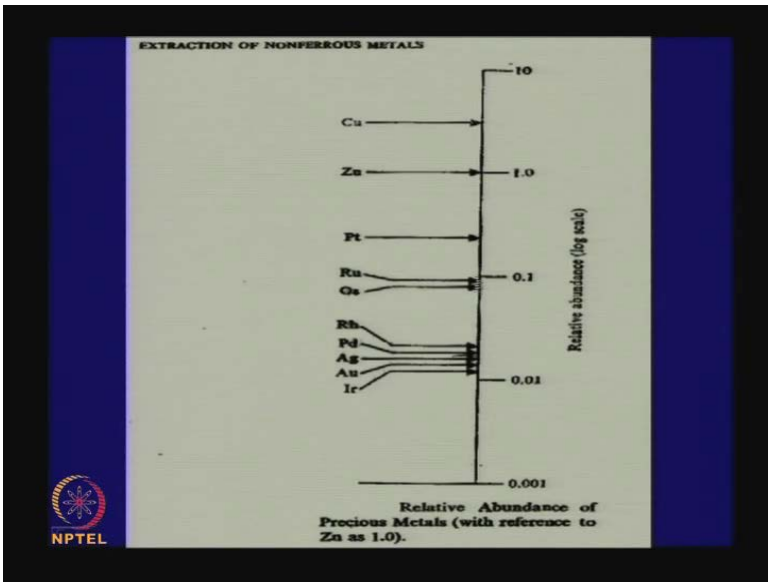

Now, let us look at the relative abundance of these precious metals, you will find that their price, that are set does not correspond with their availability. Now, the availability shown in a log scale, if copper is available in earth's crust zinc is quite below that not so much? Platinum is actually much more in abundance as compared to say gold and silver, it is lot more in abundance, in a log scale you see gold and silver are here, but platinum is here but, still it is much more expensive why it is so. Well there can be many reasons, one reason would have the difficulty of producing that metal, you know abundance is not the only criteria for the price of a metal, it depends on how difficult it is to produce that metal, it may be abundant but, it may be very difficult to produce the extraction process is difficult.

So, in the extraction process that makes the it more costly, and as I said there are also some arbitrary ways of fixing prices in the case of these metals, so those are also reasons. So, platinum is comparatively more abundant then comes ruthenium, osmium, rhodium, palladium, silver and gold are here. So, the point I want to make is though platinum is much more abundant it is priced at a higher level, all these are abundance so compared to zinc taken as a standard as 1.0, compared to zinc as one these are the relative values of the abundance.

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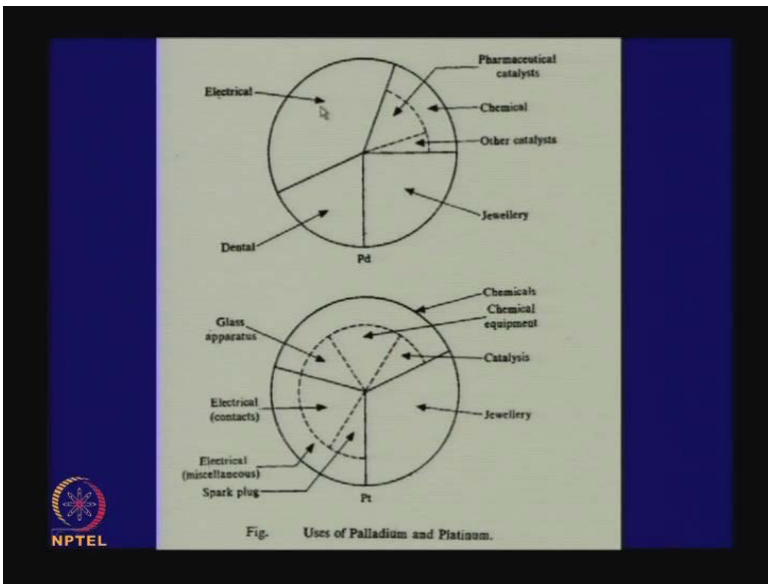

Now, coming to uses of palladium and platinum, I have already mentioned quite a few things let me repeat some of them. Coming to platinum first, platinum is also used in jewellery, unfortunately platinum as a metal is not that very attractive, sometimes it looks almost like aluminum. So, the designer has to depend a great deal on designing the right kind of jewellery, and it is invariably it is values enhanced by combination with diamonds, because diamonds go very well with platinum.

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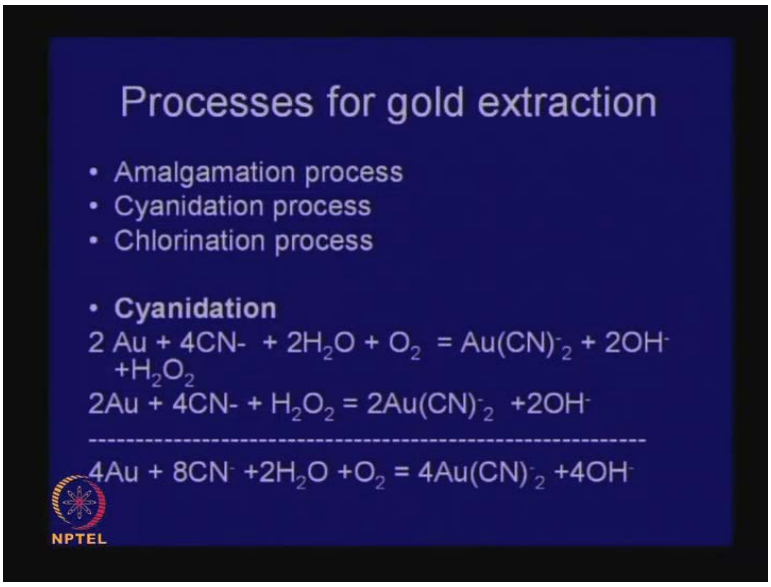

So, about 1 third of it or little more than little less than that is going into jewellery, it finds lot of application as chemicals and chemical equipment, in catalyses platinum servers as a very good catalyst in many reaction, we make chemical equipments and of course, glass apparatus, in many glass apparatus we will have platinum. Electrical contacts, miscellaneous electrical applications, power plugs, because platinum will not corrode, it has high electrical conductivity so these electrical applications are there.

Another metal with which we are normally not very familiar, but these metals are also there pressures metals is palladium, which has dentola application, some applications in jewellery also like platinum in chemicals as catalyst, in pharmaceutical catalyst, in electrical applications, platinum, palladium, rhodium, singly or in alloy form they find various applications. Now, I will quickly go through the various steps in the production of gold, silver, and platinum, again I will skip many details, I will not go into the details of the processes there available in books.

Something about gold extraction has been mentioned, quite some time ago when we are discussing application of kinetics in understanding extraction processes that was with reference to cyanidation, I will come to that again, cynidation happens to be only one of the several processes for gold exaction. The first process for gold extraction was invented by Egyptians 3000 years ago if not more, they had found they were also fond of gold and they had found particles small particles of gold embedded in rocks, that is how

gold is found very often in land masses, that there are rock surfaces where you see particles shining, the shining particles are gold particles, how do you take out this tiny particles of gold embedded in huge masses of rocks, extraction of gold from a mineral is not the topic now, gold is there as gold in elemental form, but it is embedded in whole lot of rocks which do not interest you, they are they can be considered gangue, so we need to have a beneficiation process some way to separate gold from the rest other things.

The Egyptians found a way of removing that gold by a cyanidation process, by a amalgamation process, by the word amalgam we mean solution of gold in mercury, what they would do I do not know how they found it is, break the rocks, crush them, grind them into very fine form you need to have crushing and grinding to release the gold particles which are embedded in rock surface, and then they made a slurry they put it in a suspension in the water, and the slurry was allowed to flow down a slope where they also poured mercury. So mercury and water slurry when they came down a slope the mercury dissolved the gold particles into itself, now if gold is brought in contact with mercury it very readily dissolves and forms an amalgam, it is like a solution of gold in mercury, it is not a compound it is almost a solution.

Now, there was various ways of making the process very efficient, but definitely 1 needed ground rocks, grinding of rocks for release of gold particles, then a slurry, and then slurry and the mercury, always tumble down a slope and in the process gold would go into the mercury to form an amalgam. And then it was very easy to separate the mercury, because after all the rocks and mercury they will separate very easily mercury is very heavy it will be at the bottom you just separate out the mercury.

Question now comes how do we get now gold out of the mercury? It was very simple mercury has a very low boiling point, you boil evaporate mercury out and gold is left behind. Now, Egyptians also came up with a very brilliant method of determining whether the removal of mercury was complete, what they would do they will weigh they will heat the amalgam, and after heating for a while they will wait and obviously they will find the weight has gone down because mercury has been distilled off, they will weigh periodically until the weight did not change any more, then they knew that the mercury has been evaporated.

Now, for weighing the needed very good balances at that time the Egyptians had invented the beam balances, and they had some very accurate beam balances, some of them are still there in the museum in Cairo, they can measure to may be one tenth of a gram, or even to a greater accuracy so beautifully they were made. So, they will take the amalgam heat it in a furnace to distil of mercury, cool it weigh it repeat the same weighing and when they found the weight was constant they knew all the mercury has been distilled out, that was the amalgamation process.

Now, this amalgamation process is not practiced any longer, because if you are heating an amalgam and releasing mercury vapor, we are doing something which is very dangerous for human health, the workers at that time perhaps did not know, but if many of them had premature death it will be from inhalation of mercury vapor. Today perhaps you could do it taking a lot of precautions etcetera, but handing huge amounts of mercury is never recommended as an acceptable thing in today's industry, so amalgamation process is no longer practiced. The other second method is cyanidation, this I have mentioned earlier discussing some kinetic principles, in cyanidation basically the reaction is this that we dissolve silver mercury in sodium cyanide solution.

Now, there is silver with gold so the gold will also undergo the same reaction, I am showing only the anion side, that cyanide anion reacts with gold to take form A U CN 2 minus so this is taken into solution. Some people write it slightly differently they said that somewhere a peroxide is formed that peroxide also takes part in the reaction, and the overall reaction is something like this, gold being taken into solution by cyanide ions and you have an anion containing gold. Now, this is also not a very safe reaction, because you know when your potassium cyanide of course, is a deadly poison, sodium cyanide is also a poison, it can also give rise to HCN gas under certain circumstances which is also a very dangerous gas.

So, this process also requires lot of precaution, unfortunately there are not many solvents for gold, if gold is you know one which does not react with different media, it cannot it will not be dissolved in say sulphuric acid or hydrochloric acid or sodium hydrocide, you cannot do leaching of gold particles, had that been possible it will be very simple bring crust rocks in contact with acids or alkalis. There is an acid which can dissolve almost everything that is aqua regia, but we are not talking about aqua regia we will talk about aqua regia later, but they have found that cyanides dissolve gold for some reason. So,

there is no other leaching reagent today than gold the cyanide, and once you have this it is quite easy to recover gold once it has been dissolved by a cyanide.

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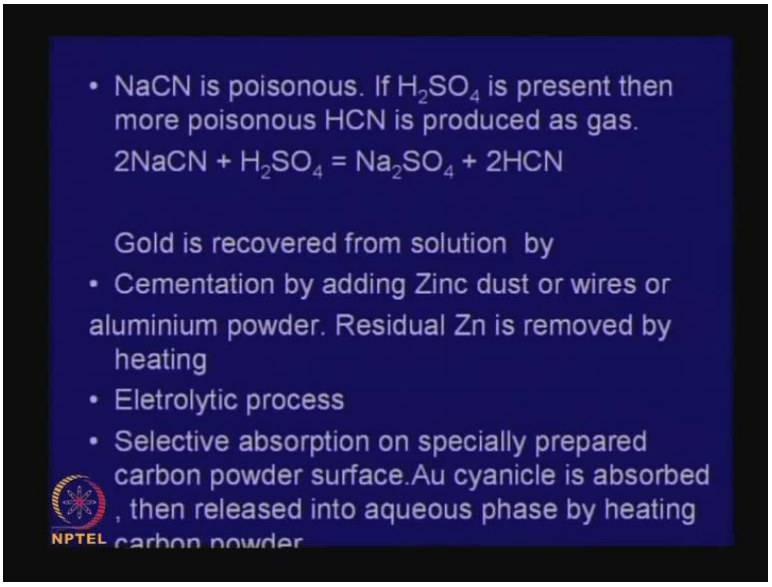

Before that again I will go back to the word of caution I mentioned NACN is poisonous, if there is any acid anywhere then poisonous HCN gas is produced and this is a dangerous gas. Now, once gold has been taken into cyanide solution it can be very gold can be easily taken out by cementation, you know about cementation now, if you have a copper sulphate solution and in that if you put a piece of iron which is more reactive copper precipitates in the surface of iron. Now, gold is even more noble it is even lower than copper, so if you put anything above that is placed above in electrochemical series in contact with cyanide solution then gold will get precipitate on that metal surface.

Now, there are many metals all the metals have gold actually in e m f series, so you have to choose what metal you want to use, generally we would like to use something which will not be expensive, which will go into solution and we should be find it easy to take it out of the solution and recover again, that metal very often is zinc dust, why dust? Because dust will have greater surface area so reaction will be faster, or it can be zinc wire which will gradually dissolved in cyanide solution, or we can use aluminum powder also. Once you they dissolve gold is precipitated out, if we are using zinc then the zinc can again be recovered by… if there is a residual zinc in the gold because the gold will entrap some zinc we can recover that by heating.

The other way of getting gold out of the cyanide solution will be electrolytic process, we can electrolyze, another very attractive process is selective absorption of specially prepared carbon powder surface gold cyanide it is not cyanicle it should be d this c should be d is absorbed and then released into aqueous phase by heating the carbon powder. So, we can have activated carbon powder thrown into the cyanide solution it will absorb gold cyanide on to the surface and we will we will later on gold can be released by heating, so this is the cyanide root.

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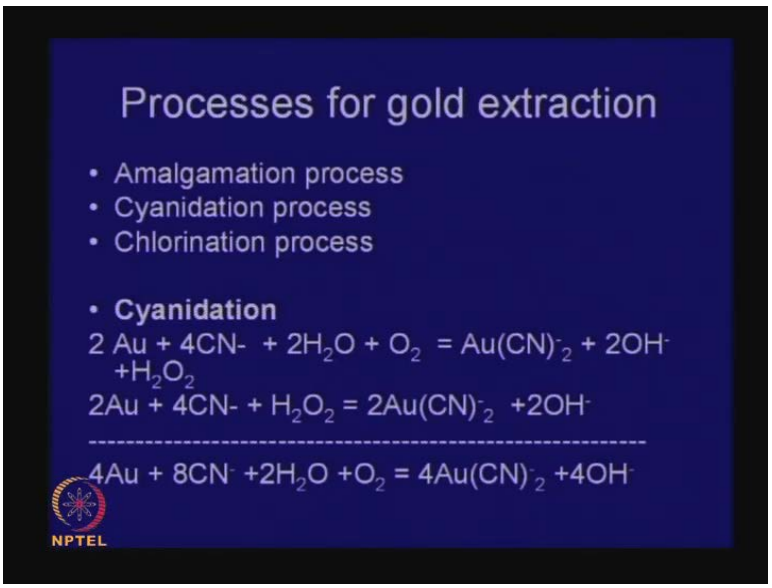

Previously I had also talked about the chlorination process, we can actually chlorinate and take out gold as a gold chloride, and that could be a very effective way of chemical beneficiation of the rocks and gold mixture. Gold is there in the elemental form, but to take it out we can chlorinate and remove gold as a chloride, where generally the technique followed is simply the cyanidation process.

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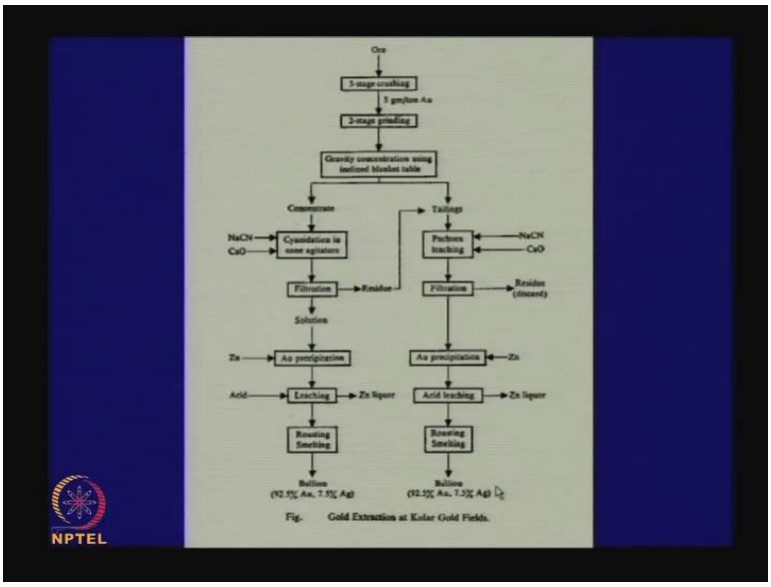

In India we have only one place where we extract gold; you have heard about it its Kolar gold mines. Now, unfortunately mining activity has been going on in Kolar for such a long time, that they are going deeper and deeper several kilometers deep they have gone digging rocks which contained gold particles, now they have gone so deep now the deeper you go the more difficult it becomes to continue mining operations, because you are going deeper down from there all the rocks have to be lifted for processing, labor has to go down and then go up all the communications have to be there from the surface, so the deeper the mine the more difficult the mining process becomes.

The Kolar gold mines have already become very difficult from economic point of view, also the gold content in the rocks is also going down, so I am not sure how long the operations in Kolar gold fields can continue, but we have not been able to find many other areas where we can do gold extraction, interestingly a lot of interesting work is going in the bio leaching of gold, which will make things lot more simpler that instead of very elaborate processing of gold rocks cyanidation to take gold into solution, there are now bioleaching processes where the bacteria will do the job for us, will bring gold into solution, but I will not discuss that now, I will discuss the conventional method of gold extraction as is followed in Kolar gold fields.

We used a word ore, here the word ore only means it is the source of gold it does not mean it contains any mineral of gold, it is rocks which contain gold particles and this

particles are in elemental form, it will need lot of crushing and grinding because unless we bring it to a very finer particle size we will not be able to release the gold particles, and please remember we use the word crushing to bring mean bringing on the particle size to some size and below that we talk about grinding, basically both crushing and grinding means size reduction or comminution.

Now, in the case of our Kolar gold field operation, one goes through three stage crushing operations of rocks which contain only 5 gram of gold per ton. So, in a ton of rocks there will be just about 5 grams of gold, but that is good enough for an economic operation, so it goes to three stage grinding, this three stage crushing and two stage grinding, why it is three stage, why it is two stage we need not discuss. You can never go to a very fine form in one stage you have to go stage wise, and there are also different stages and different ways because crushing and grinding needs a lot of energy, so there are ways of minimizing why having different steps and combining them in different ways.

Finally we will go for a gravity concentration using inclined blanket table, like once you have a fine crushed and ground rocks with gold particles, if we make a slurry and let it go along a slanted things, gold particles are heavier so they will segregate and we use the word concentrate which has more metallic value and tailings which have less metallic value, this concentrate goes for sodium cyanide leaching, calcium oxide is used for some reason I am not quite sure now, then we do filtration the residue will go into the tailings, we will see what is there in the tailings, from here we will precipitate gold by adding zinc, then there will be leaching step roasting smelting finally, we can produce a gold bullion 92 percent 92.5 percent gold 7.5 percent silver.

Now, here the tailings we can we are segregating here gold and silver, and there the tailings should go through again sodium cyanide leaching, we will precipitate gold by silver, acid leaching, and then there will be left with a bullion again 92.5 percent gold and silver which mean nothing is allowed to go waste, you go through the concentrate residue tailing should also be treated same manner, but eventually we do produce gold and silver, mostly gold and little bit of silver.

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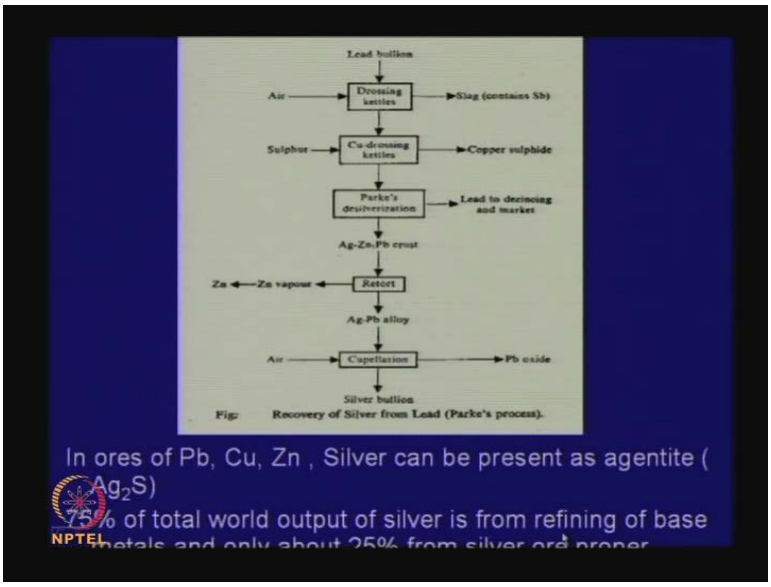

About the rest you can please read up, essentially what I have said is that although in theory there are different processes for gold extraction amalgamation process, chlorination, we are still use the conventional cyanidation process where sodium cyanide is leaching reagent a dangerous leaching reagent, it has to be used with lot of precaution, gold will be dissolved as a cyanide then it will be cemented up by using zinc or alumina. Zinc is easier because if zinc is trapped in the gold because normally it always will be it can be easily separated by heating zinc can be removed by heating, and then there are various steps of which are which are standard steps for chemical steps for to ensure that you get a purer product.

Next we will come to silver extraction, now you know silver and gold are always associated with sulphites, because sulphites are very good solvents for precious metals, but in ores of lead, copper and zinc the sulphide of silver can be present as a mineral called argentite a g 2 s, it is a very weak sulphide, and 75 percent of total gold output of silver is from refining of base metals and only about 25 percent silver ore proper. There are some silver ores, but most of it will come from the slimes that we obtain during electro refining in the case of this metals. So, I will discuss it in the next lecture, thank you very much.