Non-ferrous Extractive Metallurgy

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Module No. # 01
Lecture No. # 18
Extraction Aluminum (Contd.)

Friends, I have been discussing, aluminum extraction, for last four lectures or so. I will end the lectures, by discussing something very specific to Indian aluminum industries.

Now, there is a background to this and let me explain that. When I was in IIT, Kharagpur, as a professor, I joined in the year 1980. I floated a course called energy in metallurgical process and at that time many people did not realize why should there be a course of energy.

But now people know that this is a vital subject, that energy gives rise to environmental problems and so that is why eventually, I with some other friends of mine, I could write a book on energy in metallurgy and mineral industries.

Anyway, I have always been interested in the energy aspects and when you talk about aluminum, it is a vital thing; that energy requirement in aluminum industry, and when we use energy, you necessary create environmental problems.

So, after my retirement from Bhubaneswar, when I went to Calcutta, some of I got together with some people I knew, one of them was one Mr. R N Parboth, was the executive director of an aluminum company.

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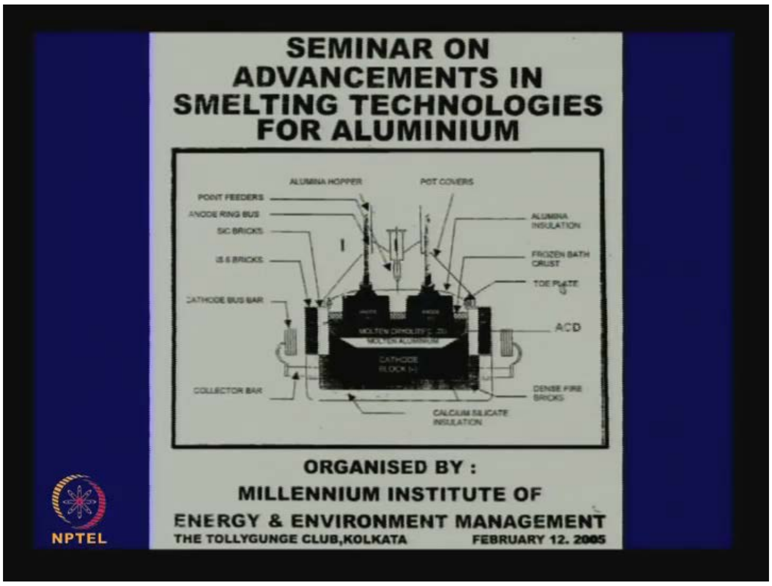

We formed a society, rather an institution, called the Millennium Institute of Energy and Environment Management. Mr. Parboth was the first president. I was the president, last year. Now, somebody else has taken over. Now, we organize many events, all in that energy and environmental related issues.

We happen to organize one in the year nineteen 2005, on, "Advancements in Smelting Technologies for Aluminum", because aluminum is an energy intensive industry. There were many speakers. I have picked up one paper, by somebody was very critical of what is happening, what is not happening, and I would present it without editing. I am not, I am keeping the name of the author, because I may comment, which he may or may not agree with this.

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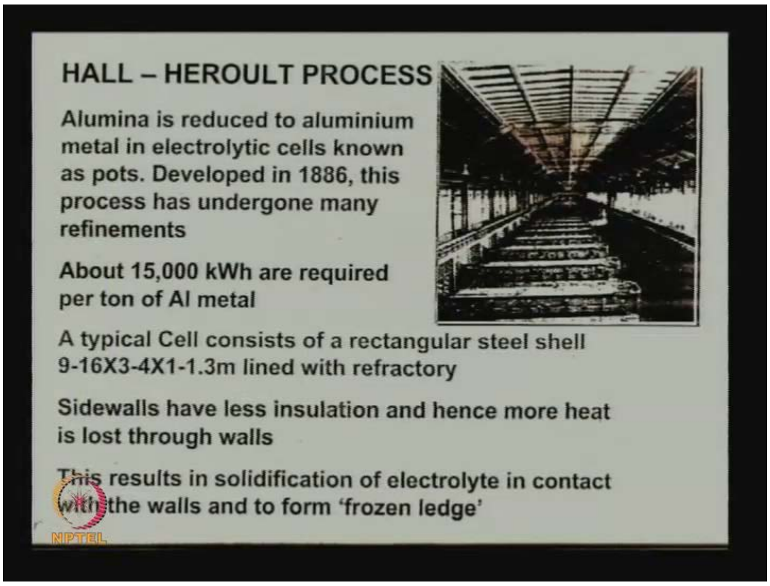

There are many things mentioned here, which I understand. Some, I do not understand. What I do not understand, I will tell you. What I understand, I will, and if there something I want to add, I would like to add, in this lecture.

Now, this is the picture of a typical aluminum plant. You see a series of pots, one after another, in a long house; pot house. These are the different electrolytic cells, one by one they come, and they are fed from two bus bars on top. They carry current from there. They all tap the current; they all operate under the same voltage, this is a typical view of aluminum electrolysis plant.

Now, I have mentioned it repeatedly that and let me read it out again here. This process is originated in 1886. In India today we are consuming something like 15000 kilowatt hour per ton of aluminum.

The best cells in the world operate, at about 13 kilowatt hour per ton. So, there are tends to bring down the figures, incidentally. Please remember this presentation is dated 2005. So, it is already four years, since then, not that many things have changed, but still I must mention that.

Is given typical cell dimension, rectangular steel shell, 9 point 16, 9 to 16 ,3 to 4, 1 to 1.3 meter high. These are the cell dimensions, these are lined with refractory, side walls have less insulation, and hence more heat is lost, and this result in solidification of electrolyte in contact with the walls to form ‘frozen ledge’.

Let me go back to the previous slide once more, because I want to mention something. Look at this figure, 15000 kilo watt hour per ton of aluminum metal, which means 1000 kg. So, for per kg of aluminum, you would need 15 kilowatt hour. Now, if one has to pay 3 rupees per kilowatt hour, then per kg of aluminum, you will need forty five rupees simply, as cost of power. If it is 4 rupees, it is sixty, if it is two rupees per unit, it will be thirty.

So, the cost of electricity that is supplied to the aluminum plant is vital. Now, most aluminum companies want to have their own power plant. So, that they can generate power very efficiently, but sometimes they have to buy from the government, from the grids and for which there has to be protracted discussion with the government.

Sometimes, government gives them a subsidy; they give them a special rate, which is lower than which some other industries can get, because the government realizes that aluminum industry has to consume power and if the power cost is more, the industry will become unviable. So, the entire aluminums industry centers around cost of power, and per kg of aluminum, if you are using 15 kilowatt hour, the price of electricity becomes vital.

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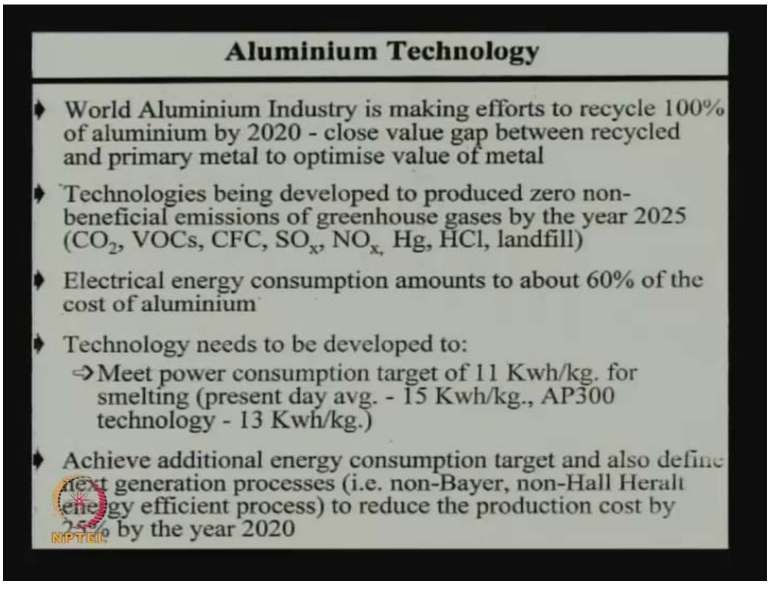

Now, the paper mentioned by saying that the world actually wants to see that 100 percent recycling of aluminum is done by 2020. Now, imagine what will happen to the world in a distant future, 50 years from now. You will produce all the metals you need, and then you need not go on producing more metal. Whatever is there, you have used, discard it, and recycle it. So, we can always think of a world, no more primary metal production is there, metals are recycling.

This happens to a very large degree for steel in advanced countries. You know steel goes; most of it goes for the automotive industry in America. If you ever go visit America, you see there are a huge stock yards of old vehicles. So, from there they take out of the electronic goods, the tires, and etcetera. Then the car body is a huge (( )) come and compact them.

Huge care becomes two feet by two feet by two feet or three feet by three feet by three feet cube, and these scrap goes in for melting. Some 40 percent or 50 percent of iron steel is produced in America by recirculation.

The advantage of aluminum in recirculation is, suppose you have an aluminum object or the aluminum utensils, you have used it, and then you have discarded, it does not get corroded it stays as it is.

Now, to produce a aluminum, you do not have to again have go for electrolysis, all you need is bit of cleaning, refining, and with much less energy consumption again you can produce aluminum. So, the aluminum industry is ideal for recirculation of scrap metal, but then 100 percent recirculation will not be possible now, because say in India, as we are advancing, we need more and more aluminum, and so we have to produce primary aluminum. The world would also grow, there is a population growth, and there is no need for aluminum. So, primary aluminum production will not come to zero, but as more aluminum we produce, more scrap will be available, more circulation should be possible.

So, the world aluminum industry wants 100 percent recirculation of aluminum by 2020, and then makes up the demand by producing some more aluminum. So, this will close a gap between recycled and primary metal to optimize the value of the metal, because the recycled aluminum, will cost much less, because the energy part will be minimum. Then there are technologies been developed to produce zero beneficial, nonzero beneficial emissions of green house gases. All kinds of gases, chlorine is one. There are many other things are mentioned, I did not go into detail.

In the (( )) electrical consumption amounts to about 60 percent of the cost of aluminum. This of course, depends upon where you are doing it. If you are working in Dubai, where the energy cost is very low this will not be valid. Under Indian conditions, it is a 60 some people say 50; some people say 40, because it all depends on the cost at which power is made available.

Then technology needs to be developed. So, that the power consumption target goes down to 11 kilowatt hour for smelting from the present average of 15 kilowatt hour and some of the best technologies are operating at 13 kilowatt hour, but the goal will be to bring it down to 11 or so.

Then the aluminum industry is also looking at to achieve additional energy consumption target, also defined next generation processes, that is non Bayer, non Hall Heralt process. Energy efficient process is to reduce the production cost by 25 percent by 2020.

Now, indicated, there is a process is called ALCAN process, there is a process called ALCOA process, unfortunately both depend on use of aluminum trichloride, which is a highly reactive solid, very difficult to handle industrially. So, one has to find some other method of producing aluminum or make the Hall Heralt process more efficient.

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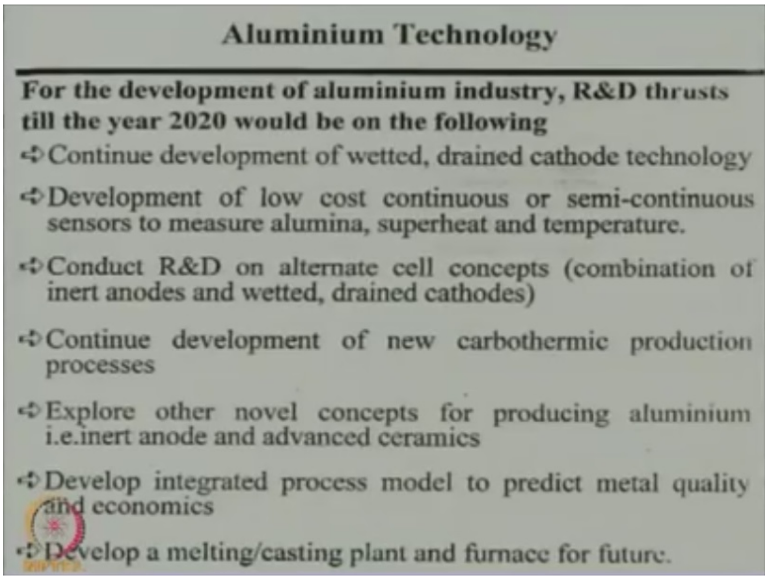

The R and D thrusts recommended, at least by the author, who has written this article says, continue development wetted and drained cathode technology. This, I do not understand very well. I guess it basically means that to have a cathode, the surface will be very efficient in discharge of aluminum ions to get aluminum metal, but I am not very clear.

Development of low cost continuous or semi-continuous sensors to measure alumina, superheat and temperature, this is very important. If you see what is happening in aluminum, from the top you are continuously feeding alumina, from the bottom you are continuously taking out aluminum metal. You want to maintain a constant electrode separation distance between anode and cathode and I have mentioned three to five centimeters of (( )).

So, there in an input, there is an output. How do you control? Now, in the industry, today all kinds of sensors are available to measure levels, and whenever the changes in the level there are automatic devices, which will control feeding rate here, discharge rate there. And as I mentioned little while ago that any industrial process is most efficient, one it operates under constant conditions; temperature, concentration, electrode separation distance, composition of electrolyte, for all these you need sensors.

Sensors, which will measure everything and sensors will be connected to automatic devices, which will immediately take a correcting action, if there is deviation from the level that we want.

We also need continuous development of new carbothermic production processes like ALCAN. Explore other novel concepts for producing aluminum that is inert anode, and advance ceramics. These I have made a mention. Conventional, you have a consumable graphite anode, which is getting consumed, taking oxygen anions reacting with them producing CO, CO 2. It has one advantage, it is bringing down the decomposition voltage, but it is leading to consumption of graphite, also generation of CO, CO 2.

If we could think of an electrode that we can afford aluminum platinum we cannot afford. So, as I said there are now inert electrodes under development, titanium dioxide where aluminum will get discharged, nothing will happen to the electrode, oxygen will be generated. So, instead of gases that we do not want, we will produce oxygen, which is an industrially, highly remunerative product.

Then develop integrated process module to predict metal quality and economic. Develop a melting/casting plant and furnace for the future. this I also I am not sure what it means.

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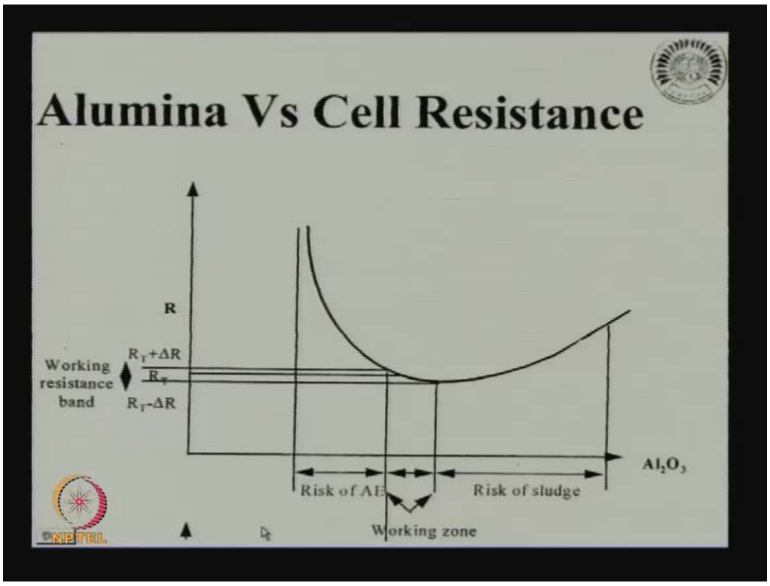

Now, he very rightly emphasizes something that I have discussed, that there are constraints the Hall Heralt process has to work under very strict boundary conditions, and one of them is the alumina content is plotting near alumina concentration, he hasn't given the figures, but I can tell you what they are. It is about to say five to eight, that is where the resistance of the cell is minimum.

He says there is a working resistance band; it must be between this and this. It should not go beyond. It cannot go below this because then you are entering the anode effect region, if you go beyond this then you have the risk of sludge formation that insoluble's will come on top. So, in a very narrow band, the narrow band is the working zone, say 5 to 8 percent or so. That is where you the minimum cell resistance and the operational conditions, an ideal.

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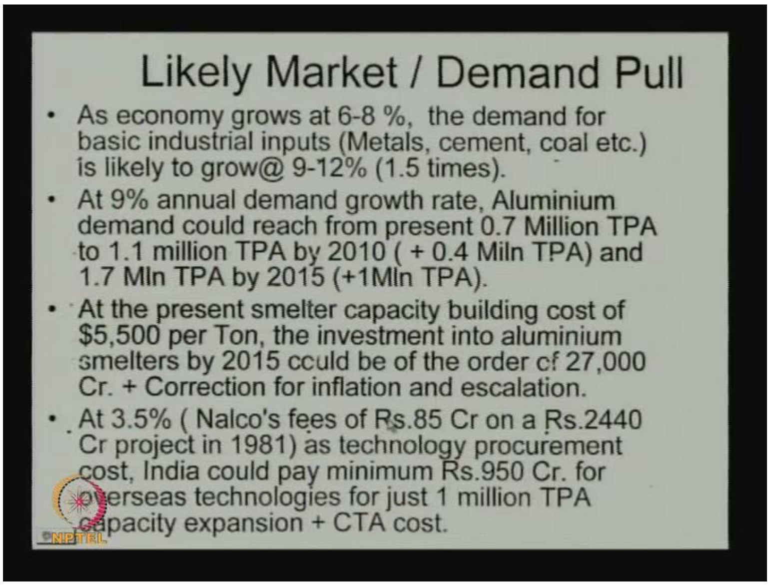

Now, here are some things that we do not normally discuss in a classroom, but I think you should have some idea, because after all, when you are talking about aluminum, it is more than what is written on the black board.

Then here are some data about likely market, demand pull. If the economy is going at 6 to 8 percent, the demand or basic industrials inputs, metals, cement, coal, etcetera likely to grow at 9 to 12 percent. At 9 percent, annual demand of growth rate of aluminum, the demand could reach from the present 0.7 million tons per annum to 1.1 million tons. In 2005 we predicted our demand will exceed 1.15 million tons, we do not produce that. We produce only a fraction of that, which is why you have depended on imports.

And by 2015, it may go up to 1.7 million tons that is the kind of development India is looking at. Now look at the financial aspects of that. At the present, smelter capacity building cost of 5500 dollar per ton. Now, if you want to bring in a smelter, this is how much it cost, in capital cost in 2005. So, the investment into aluminum smelter by 2015 could be order of 27000 crores.

So, the kind of investment required for expansion of the aluminum industry that we want to see, it may be 27000 cores plus correction for inflation, escalation, etcetera and the figure must have doubled by now because 5 years have gone passed.

And even today, we do not have an Indian technology. It is a National Aluminum Company of Bhubaneswar, they paid eighty five rupees 85 cores as fees for a 2440 core project in 1981, means, whenever they are getting a technology that is we call stub the shape, that will everything is compact, everything is defined, they give you the technology, this is how you do, we pay fees for it and for a 2550 core project they paid 85 cores.

He says in 2005 that India could pay a premium of rupees 950 core for overseas technologies for just one million ton per annum capacity expansion. So, for getting one million ton capacity expansion, you end up in 950 crore, suppose you make a rough figure of 1000. So, if we want increase of 10 million tons, you will pay 10000 crores. If you want 20 million tons expansion then 20000 crores, if you want 100 million tons, you will pay 100 million crores, and we are only producing about 350,000 tons. No, sorry, one point three million ton we want to increase it.

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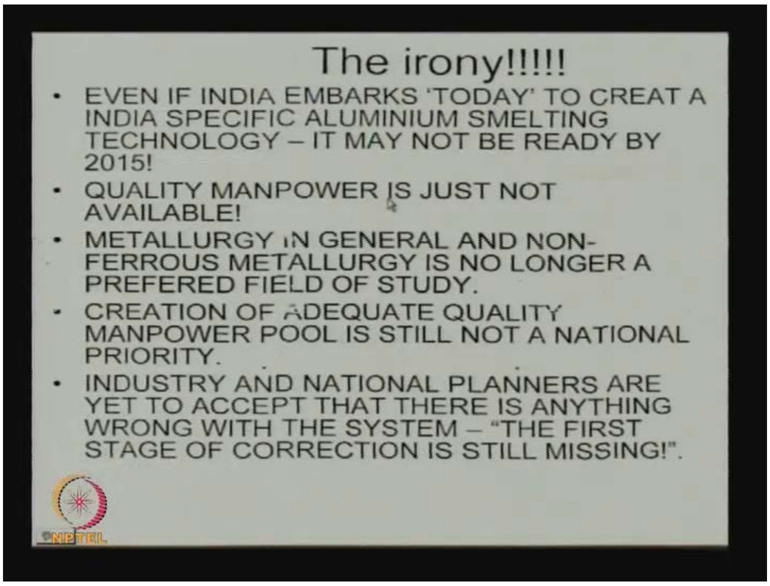

So, amount of the fees will have to pay for getting the technology and that is what it calls an irony, but even if India embarks today, to create an indies specific aluminum smelting technology, it may not be ready by 2015. He said that in 2005, it is 2009; we still have not started developing an India specific technology.

Still today, if you want to establish an aluminum plant, we have to go France or we have to go to USA, we might have to go to Canada. They supply the technology, they set up the plant, they take fees for it, and they take some royalties on the metal produced.

It is necessary that metallurgies of this country, engineers of this country come into this area, to develop our own technology. China does not do that, china will imports once or twice, then they go ahead and make their own things. All the blast furnaces, all the aluminums plant they set up is by their own design or their own engineers.

Why we cannot do it? First of all, we do not have quality man power. Why we do not have it? Because metallurgy, in general, non-ferrous metallurgy is no longer a preferred field of study, you all know it. We need to create an adequate quality man power pool, it still not a national priority. We do not have that kind of planning in our country. In countries like America, Russia, they plan centrally that we want so many engineers in this area; this is how we proceed.

It will interest to know that the steel ministry setup, about two years ago, a body to look at the needs in educational institutions that will guaranty man power for expanding steel industry. Steel industry had this problem, steel industry is expanding, and it is today 56, 57 million tons per year. They want to go to 100 million tons very soon.

Where are the engineers? Our metallurgical engineers, in other go for the IT sector, they go aboard, they go for research, they are not getting metallurgist, and in many metallurgy departments they hardly teach ferrous metallurgy. They are teaching material science, they are teaching other subject, which are important. I am not saying they are not important.

So, the committee finally recorded. They made an analysis and said that we need how many students; metallurgy graduates will be required, simply for to meet the demand of the steel plants, and then we found there are no teachers. So, now, steel ministry has given a directive and given funds that every metallurgy department will have a steel chair professor. There would be somebody in the area of ferrous metallurgy, to talk about steel production.

We do not have that in the area of non-ferrous metallurgy production yet, and in many metallurgy departments, if steel is taught; non-ferrous metallurgy still gets a secondary important. We need to bring metallurgy students, and they should not think that non-ferrous metallurgy, something which is dirty job, we are running around in mines or running around the plant, it can be as sophisticated as any, and there is tremendous need for metallurgies in non-ferrous sector.

He lamented that the industry and national planners are yet to accept that there is anything wrong with the system. The first stage of correction is still missing that we have not accepted the problem.

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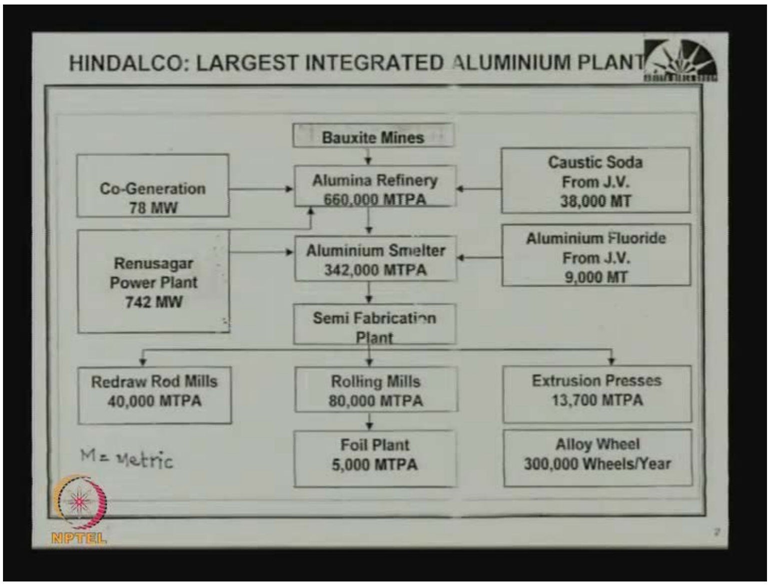

Now, he talked about HINDALCO, which is the largest integrated aluminums plant and you know in the right end corner, we have the HINDALCO's, Adithya Birla companies' logo. They own bauxite mines, refinery. There power comes from co-generation facilities, by the word co-generation, we means the thermal power plant generates power as well as steam, because steam goes for the leaching. So, its co-generation means electrical power as well as steam.

They have a joint venture caustic soda plant, they have an aluminums smelter, they have power plants which supplies power, there is an aluminums fluoride plant they own, it is again joint venture. Then after they are produced aluminums, they have a fabrication plant, rolling meals, foils they produce. They produce rods of various kinds, there extrusion processes, and they produce alloy wheels. So, the plant not only produces metal, but they also produce products and these are called Downstream processes, after you have produce the metal, when you the metal goes to produce various products for the industry, that is called Downstream processing.

Let the word, 'M' does not mean million, please remember, it is called metric. In the industry, the capital 'M' always means metric tons. It is not necessary any (( )) because at one time we had this problems with pound tons, 102240, 2000 etcetera, metric tons one thousand.

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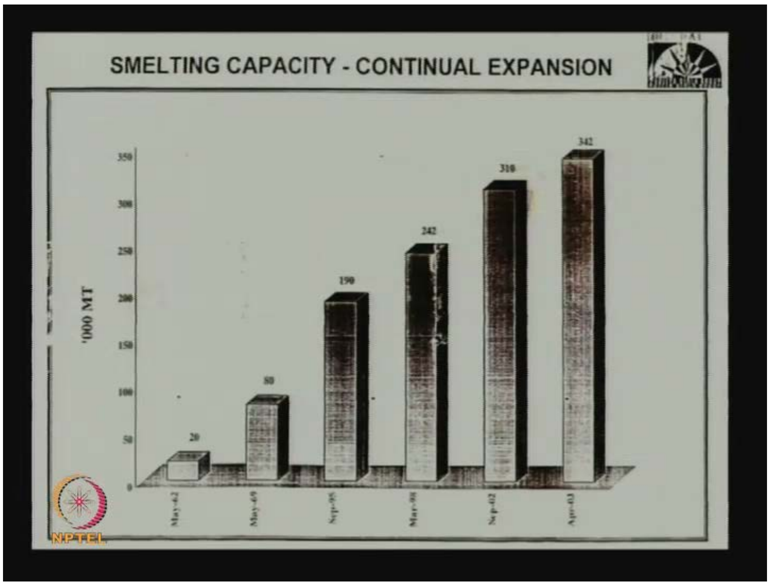

See, how the smelting capacity has gone up in our country, in Hindalco, it just keeps on going.

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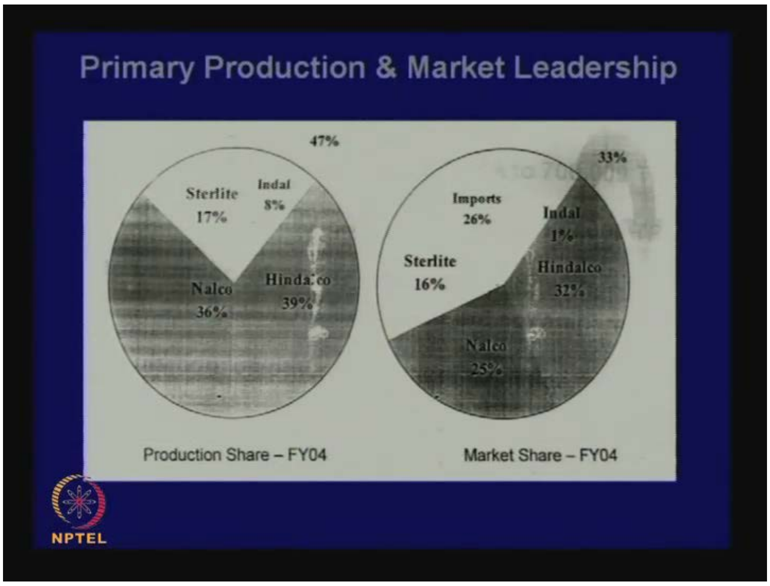

Production share of various Companies is shown here today. There is HINDALCO, I am sorry it is not very clear HINDALCO is 39 percent, NALCO is 36 percent, Sterlite is what BALCO is to be, now they have been taken out of Sterlite. Indal is 8 percent; Indal is near Calcutta.

So, these are the main companies there may be one or two small ones, and the market share, Sterlite is 16 percent, then NALCO 25 percent, HINDALCO is 25 percent, Indal is 1 percent, imports is 26 percent. We are importing to meet the marking line.

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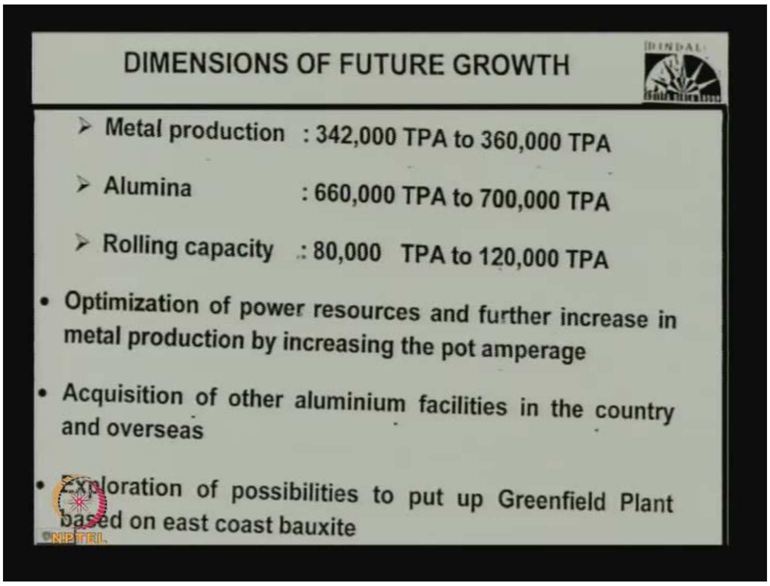

Now dimensions of the future growth; the dimension they say it has to go up to 360000 tons per annum, means 0.36 million tons. Alumina has to grow and the rolling capacity has to go, the optimization of power resources, acquisition of other aluminums facilities in the country and overseas, the exploration of possibilities put up Greenfield plant based on East Coast bauxite. This is what I discuss little while ago, in the east coast like Orissa and Andre Pradesh; there are lot of coastal bauxite. How do you put up Greenfield plant based there? That struggle is going on.

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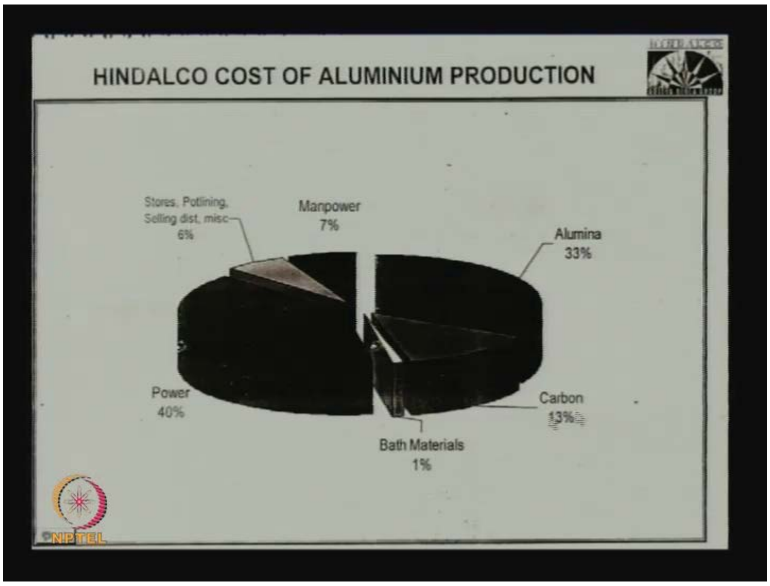

Now, the cost of aluminums production in HINDALCO, 7 percent man power, stores another thing 6 percent, power 40 percent, aluminums production is 40 percent, bath materials is 1 percent, carbon 13 percent, alumina 33 percent. So, both Bayer's process and the Hall Heroults process are consuming a lot of energy.

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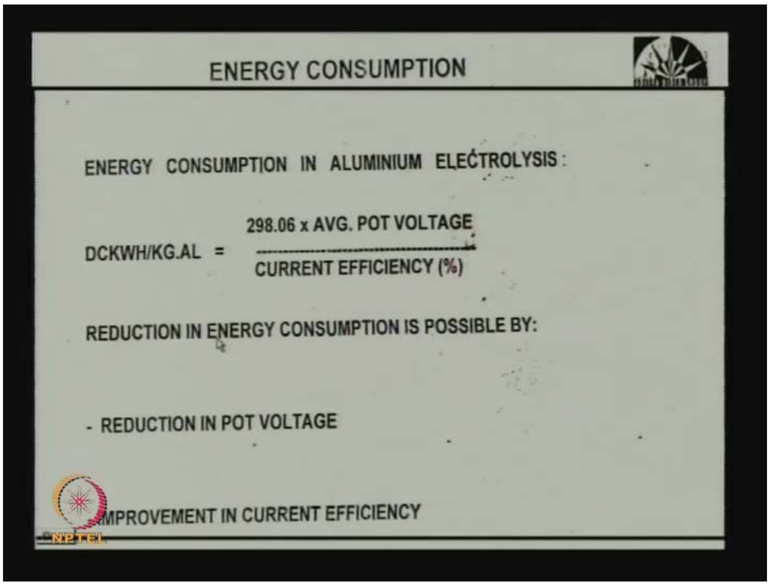

We gave an empirical equation for the energy consumption; that the current efficiency is high, if the pot voltage is low. Then the energy consumption will come down, it is understandable.

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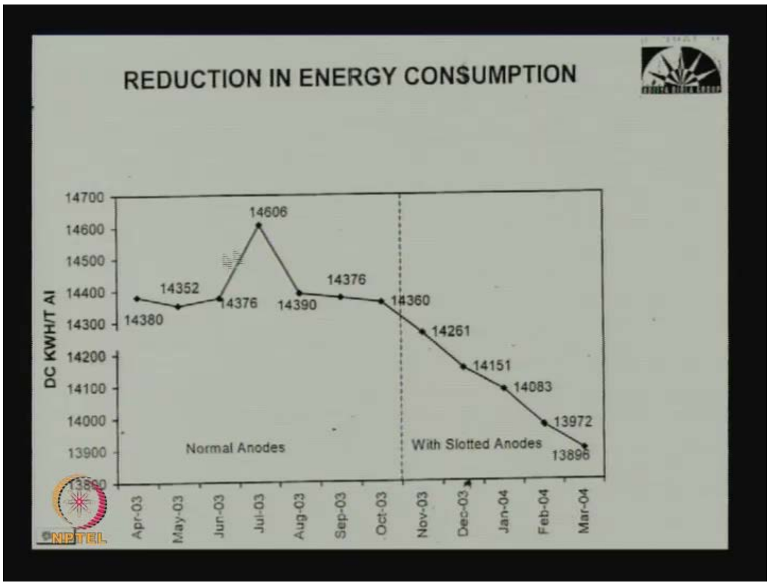

The energy consumption figures for HINDALCO are like this. From 2003 they were somewhere here, they have gradually manage to come down to this figure, 13.89 kilowatt hour per ton of aluminum, zero four it must have gone down further now.

There is also attempt to bring down pot voltage. You know this pot voltage, is a summation of decomposition of voltage, over potential, electronic circuit resistance that causes voltage drop, then the resistance of the electrodes themselves. So, there are and of course, the resistance of the bath.

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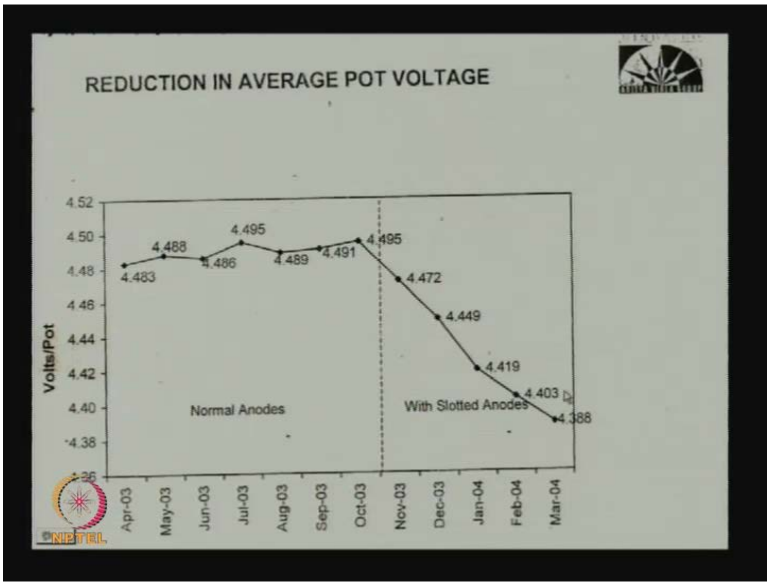

There is coke for reduction in voltage in all these and I have been discussing that. So, in the industry has been trying and they have been able to bring down the total pot voltage to 4.388. So, it is around 4.24 or 4.3 as of now.

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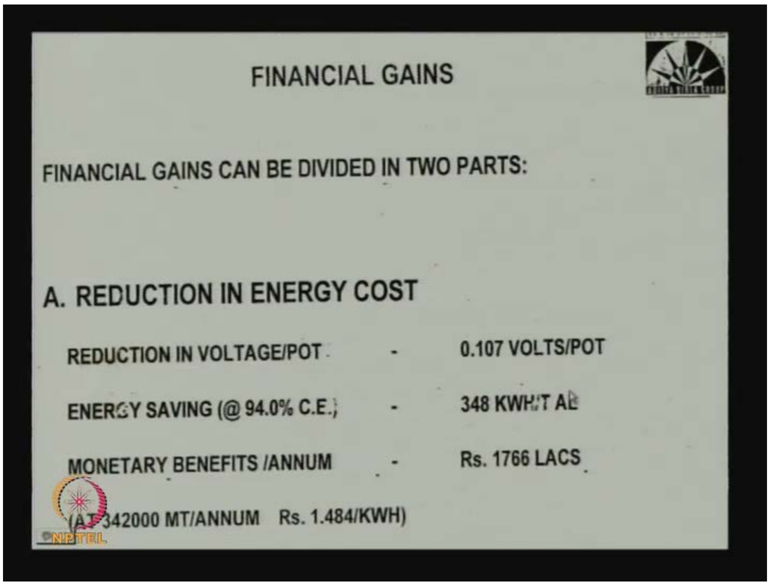

Industry is very sensitive about the financial implications of this, and there are some figures here, which you should note. If they can bring down the pot voltage per pot by only about 0.1 volt, they can save energy to the tune of 348 kilo watt hour per ton of aluminums; in monetary gains per annum would be point 1766 lacs. So, if even you know small amount of drop in the energy consumption, will bring them so much of financial benefits.

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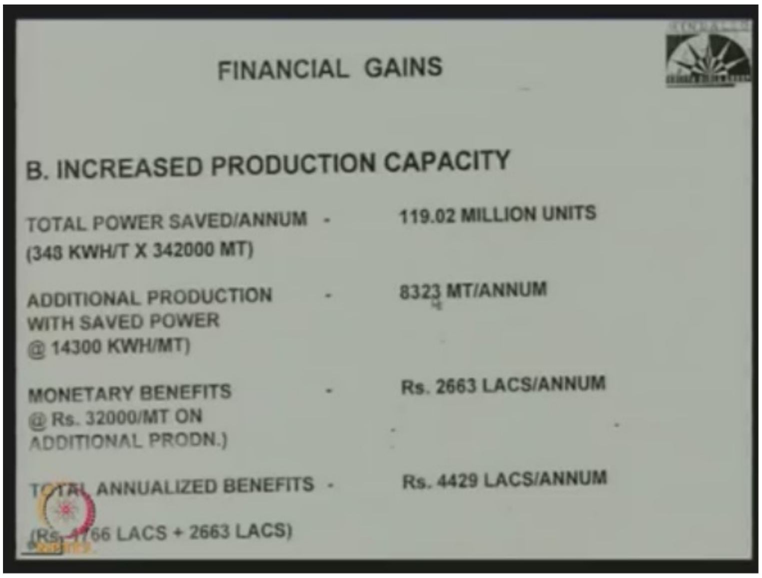

Other financial gains, total power saved per annum, so many units additional production. If you can, if you are using less energy, then you can say with the energy you are using earlier, you can have additional production. So, that also is taken into monitory benefit calculation. They say the total annualize benefits will be so much, 4425 lacs per annum simply by reduction of pot voltage by one point per one pot.

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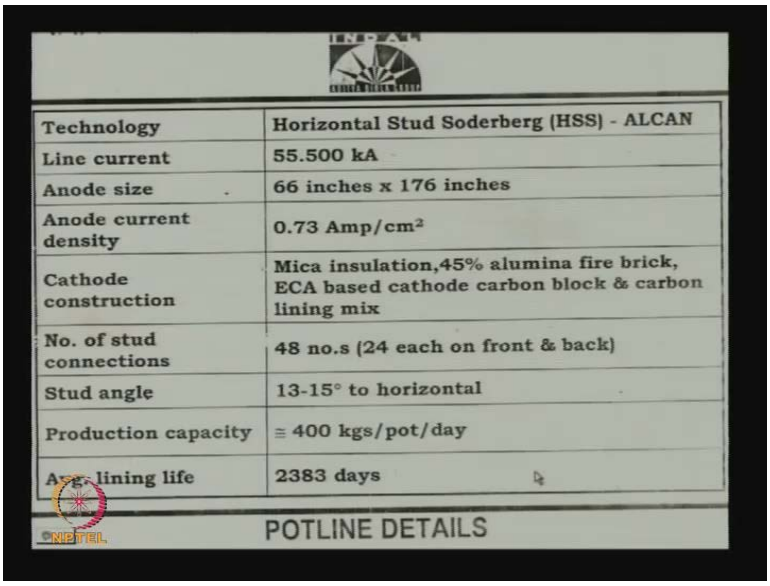

There technology is supplied by ALCAN, is a Horizontal Stud Soderberg (HSS). There the anode is not vertical, it comes horizontal stud, line current is this, these are the sizes of the anode, anode current density, the average life of the lining is 2383 days, means after every so many days, a pot has to be close down and the lining has to be changed.

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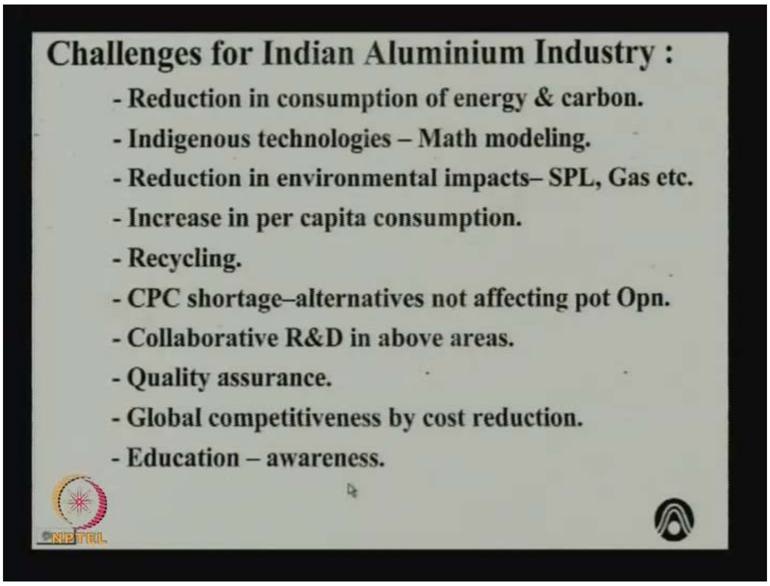

What are the challengers for the aluminums industry? A couple of challenges should become very obvious to you now, that first challenge is reduction in consumption of energy and carbon. Then we have indigenous technologies that we want and we want lot of mathematical modeling people to tell us how you optimize the entire process like voltage, current, cathode distance, cathode anode separation, the composition, of the electrolyte temperature.

So, in one does not do experiments anymore, and you cannot experiment with an aluminums electrolytic cell, to see what will happen if you do this, or if you do that. Now these are done in virtual cells in through mathematical modeling, people have developed equations to describe the cell behavior in terms of the process parameter using mathematical equations.

This is where maximum amount of R and D is going on. That is what you want to do in mathematical modeling and predict that if this happens then that happens. If you want to optimize this is what you should do, and at this by doing that, you can see by whether they are correct. So, in a cell you can do some mathematical modeling and then validate that.

When you are sure that ok what your predictions are, you have confidence, you can tell to an industry, please try this out and they see whether this is valid, but an industry will not do heat and trial experiments to study what happens if this goes up, what happens if this down. But they are willing to try something recommended to them, if they have confidence in the modelers.

And this work is done today extensively in Jawaharlal Nehru research development design center at Nagpur. There is a group which does mathematical modeling, they do things, they go with their package to Nalco and Nalco tries them out.

Reduction in environmental impacts, lot of work going on, increasing per capital consumption, now, this is a very interesting thing. The aluminums industry wants to increase demand in the country, because they say that if there is demand, then there will be pressure on the government to help the aluminums industry produce more. It is this question that suppose you produce a whole lot of cars, then you improve the roads, it is never like this that you first improve the roads because you know cars are coming. Things happen because of pressure, if there are lots of cars on the road, then the roads will be improved, then flyovers will be built.

So, the aluminums industry very typically also aims like that. They want to increase the demand among the public, bring him products, bring him, and show them possibilities of using aluminum. So, that people want more and more aluminums, then companies produce more and more aluminums, then government has to find how that they produce more and more aluminums.

One fantastic area in which that aluminum can be used in large quantities in silos in rural sectors, for storage of grain, or vegetables, or agriculture produce, perhaps you know in the rural sector, about 30 percent of agriculture produce are destroyed by pets, insects birds, rats, because we do not have storage facilities.

People can think of storage facility in terms of steel, but then they would be subject to corrosion. So, the aluminums industry and steel industry, they are trying to develop, for use storage facilities, means in all, for the rural sector, wherein every village, there will be, say 20 feet, 30 feet tall containers, from where you can feed that you want to store, will be fitted from the top. There will be a device to take out things from the bottom.

They can make double walled, so that the temperature fluctuations, in hot weather, it will not be so hot inside. There are all kinds of things are being thought off. This could be one way of creating big demand for aluminum.

Use of aluminums in the building industry, in transport industry, they are all coming up. For that we might have to develop new kind of aluminums alloys, which are attractive, but the industry is also working very consciously in developing avenues for increase in per capital consumption. Then the demand will increase; we want more and more of this, then there will be a case for more aluminums production, no matter about then the government has to support.

There is also emphasis on recycling. Whatever aluminums, we get that is clear discarded as a scrap, recycled and we need lot of R and D in all these areas. So, the aluminum industry actually is poised for a big growth. I have already indicated the contrary requirements that there are contradictions you want to do something, but there are other problems.

Now, the way the planners work is that when the plan, they visualize what are the problems that their plans can lead to, so they have to start working on those problems also; things must go in parallel. Say for example, you want to plan an aluminums industry in an area. You have to do couple of things together. First of all, not only survey the area, look for investors, you have to start talking to the people there that if land is to be taken and discussions to those people are necessary.

A settlement is necessary on social issues, this cannot happen in sequence, like first an industry comes, and the industry people will go there to survey, and the local people are up in arms, why are you here? They do not know. This project has not been discussed with them. So, then you run around to find out the solution. This will not work, they have to be done in sequence.

And when an industries plant, industry not only wants to produce aluminum and alumina, they have to find where alumina will go, where aluminum will go. They have to plan not only to produce the metal; they have to think of downstream processes. There are some intermediate products and there are some consumer applications.

Consumer applications of aluminum are infinite and even thinking of newer applications need research and development. People have found applications where nobody realize that there could be applications; foils for example, aluminums foils that are used in kitchen tray. You want to roast something chicken, you put aluminums foil, and do the baking, and do the roasting. These sorts of things were not thought of earlier, because people did not know that you can develop an alloy, which can be role to a thickness, the thinness of that kind.

People do not know that there are very special requirements of aluminum foils and many other things for the army, and the defense people, because of packages of food for all kinds of containers and vessels. So, the demand and the variety of aluminums products are infinite.

I think in India aluminum industry can have as bright a future as steel industry. There is a special reason why these things are coming more towards our side, if we go, to the developed world. You find extraction processes there are no longer what we use to do, because all metal extraction processes have an environmental problems.

Now, those countries, now want to pass of this environmental problem creating industries, to the developing world. They have gone to higher technologies, they have gone to sophisticated industry, sophisticated products electronics and so at one time America is to be a leader in steel production, is no longer a leader.

Now, steel production is mainly in China, South Korea, India, and Japan. It is no longer in UK or America. They have got rid of their processing industries of course; there is aluminum. Now as I said, aluminum is produced in Canada, in America, in large quantities. But, then slowly we will have to take over these things, but then there are against constraints, aluminums needs power, as I have discussed, we have to find solutions to that.

There is no alternative today than to use either high thermal power plants or the hydel powers we have. We cannot use, in the foreseeable future, any other source of energy to feed the aluminums industry.

Friends, that is all, I have to say for this module. So, for as aluminum is concerned, I still I am not done with extraction of metals from oxides. I will continue the subject, because there are many other metals, which come from oxides. I will go in to production of tin production of ferro alloys, which all come from oxide sources, and for every metal or every ferro alloy that we discuss there is a specific peculiarity. It can never be the same process applicable everywhere. It may look the same, but it may not be the same and when I discuss next the production of tin, this will become very clear to you.

I will take two more lectures to finish this module five, which is about extraction of metals from oxides and then I will move on to extraction of metals from sulfides that will also need several lectures, because under metals from sulfides will come many metals copper, lead, zinc, nickel also.

Then beyond that, I will come to metals from halides, not necessarily naturally occurring halides, where halides made from oxides. So, there is lot more in this course. I have been touching energy and environmental issues now and then, but these I will consolidate towards the end. I will take two or three lectures only to discuss energy and environmental related issues.

I have often trade into social issues. I have talked about social problems. One could discuss that in great detail but that I will not do. Accepting, I will mention something in the passing. There is today a word rather a phrase called, Corporate Social Responsibility; CSR, it is a buzz word and it is an internationally recognized term.

The word, ‘corporate social responsibility’, means that if there is an industry, then the industry can legitimately work for profit, financial gains, but there also morally and legally bound to look after the welfare of the people in their company and the people in the region, locally. So, united nations have discuss the subject and then given some eight or nine points. They are not mandatory, they are guidelines as to what should the industry do under this corporate social responsibility, and all big industries are now beginning to take it very seriously.

Like in one time, people use think, if you spend on environmental protection, then the company has to spend on ways of environmental protection and so though would be less profitable. But, now people have realized that is around concept.

If you take measures for environmental protections then eventually you gain. How do you gain? If you do things that are necessary for environmental protection, your image goes up. Your people, who work are happy; if they are happy, their efficiency goes up. Like if a laborer, if he is working under a polluting environment, not only he is not able to do function very well, he may fall ill, and then you have to require to look after him, take care of the medical expensive.

So, making the environment more human friendly, the company eventually gains and there has be a revolutionary changes in last 20 years or so. As a student, I remember, I use to go to Jamshedpur to take training in many of the companies. The place was filthy and dirty, even in the city you could see fumes, you could see dust and dirt, but now you go to Jamshedpur, they have planted thousands, may be millions of trees all around.

The whole city now begins to look like a garden inside factories. They have also taken environmental protection measures, they have spent huge amounts of money, but on the whole, they have come out more profitable.

Similarly, people use to think that corporate source and responsibility, which suggest certain measures that do for the welfare of the community would only mean expenditure.

But I will discuss that is not so, eventually, this time to gain. What will be the activities under corporate source of responsibility? That eight and nine of them and I have discuss them very systematically at the end, but just to hint there are from the United Nations, guide lines like this, education for the girl child, something about diseases like aids, this sort of thing should become a priority projects, with some industries. They have to work for the people all around.

So, an industry today is simply not a technology which churns out metals and churns outs something discarded. It is much more. We will discuss that. So, then let me rewind up what has been discuss so far under module five.

We started by discussion discussing extraction of magnesium, it was not a very completed thing. Magnesium oxide is obtained from magnetite by calcinations or Mg O CO can be obtained by calcination from dolomite, reduce by carbon, at temperature around 1000 degrees. It is not feasible thermodynamically, can be made feasible, the application of vacuum.

There is a very clean collection of magnesium, because magnesium vapors come out. You condense, you get magnesium, and it is simple. It is the mechanism of the reaction which is very important; it is not solid-solid reaction, because once you have, sorry, you are not reducing by carbon, you are reducing by ferro silicon, and once ferro silicon starts reacting, it reduces some calcium, we produce a turnery alloy, which permits the entire brigade and then the reaction is speeded up.

Then I have spend some five lectures on aluminum, and I have discussed in detail the useful properties of aluminum, I have discussed Bayer's process for production of pure alumina from bauxite, then I have discussed Hall Heroult's process for electrolysis of alumina dissolved in cryolite.

I mentioned that cryolite needs many additive source, many other additives, to modify the properties, melting point, density, surface tension, viscosity, solubility of Al 2 O 3 in it, this and that, and with all that, every company comes up with its own formula, as to what to add, what not to add. And then there are many process parameters that have to be optimized; temperature, distance between anode and cathode, composition of the electrolyte, etcetera.

Because we need to optimize things, and we need to control things to minimize energy consumption, graphite consumption in anode, increase current efficiency, and to keep things going, in the most efficient manner, we need vary accurate measurements and accurate control. These are done by sensors and feedback devices and to aid all these, today a tremendous use is made of mathematical modeling, which predicts as to what will happen, if things are change in a certain way. So, nobody does in the industry hit and trial experiments, in research laboratories, mathematical modules are developed to predict outcome of operation, under certain conditions.

In the industry if it accepts that as best tries to see whether that is valid. So, they validate the module. If they validate the module then they accept that module, I have talked about three layer processes for electro refining of aluminums and I have said that two processes have been tried out as alternate to Hall Heroult process.

One is electric furnace smelting of alumina to produce aluminum that contains iron, carbon, silicon, etcetera to get from that by reaction with aluminums trichloride, aluminums mono-chloride and decomposing that to get pure alumina or get pure alumina chlorinated to produce aluminum trichloride and then go for that ALCOA process which aimed that dissolving aluminum trichloride about 5 percent and sodium chloride, potassium chloride electrolyte. Electrolysis will take place at a lower temperature, no carbon consumption will be there and it will generate chlorine which you go for chlorination for Al 2 O 3.

Unfortunately, none of this processes worked out very well. Now, I had driven I present at you a nut shell, a paper that were presented by a man from the industry, and just to share, the way an industry person looks at thing, and which is not always the same the way an academic looks at it, of course, they are always looking at it from financial angle. So, that is why I mentioned some financial figures. Thank you very much.