Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 08
Life Cycle Assessment

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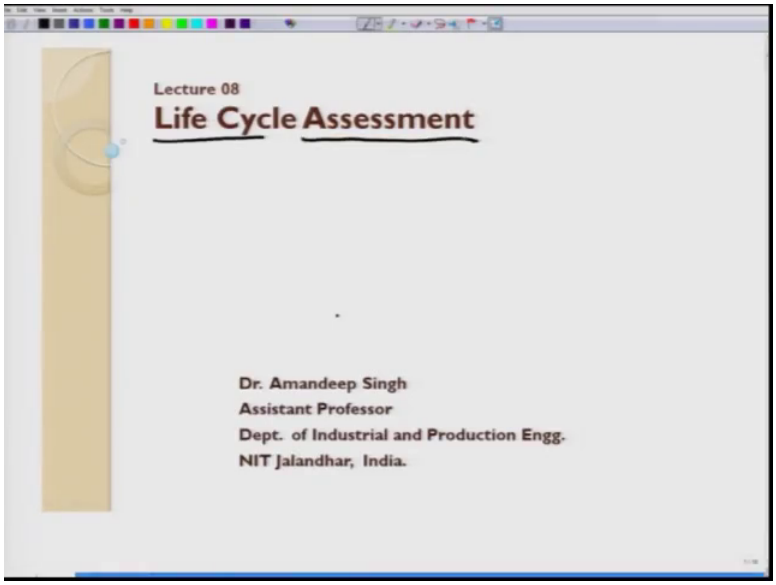

Good morning, welcome back to the course sustainability through green manufacturing systems and an applied approach. So, I am Dr. Amandeep Singh. So, this is my first recording in this course; till now Dr. Deepu Phillip had introduced few basic concepts to you what is sustainability, five Ms of management in which we introduced mother nature then simulation techniques, why simulation is important, in modern times why computer is required to do various analysis and various assessment for sustainability. So, finally, our goal is to have sustainable system, sustainable earth, sustainable nature for that we were working in its green manufacturing or manufacturing domain. So, today I will come to another part of this course that is life cycle assessment. So, this is lecture number-8, which is life cycle assessment in this I will tell you what is life cycle and how the assessment is done.

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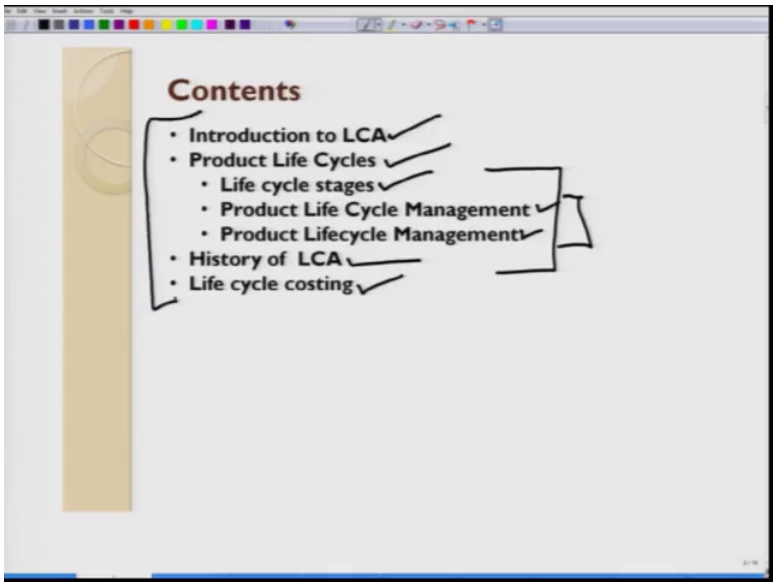

So, various contents we will cover here is introduction to LCA then product life cycles their various approaches to product life cycles. So, then various life cycle stages then product life cycle management, and product lifecycle management, we will see what is the difference between these two. So, there has various viewpoints people look into this one. So, then how does are this life cycle assessment evaluate, then I will introduce to the concept of product life cycle costing. There are certain other things that we will cover in this week only, but in further sessions.

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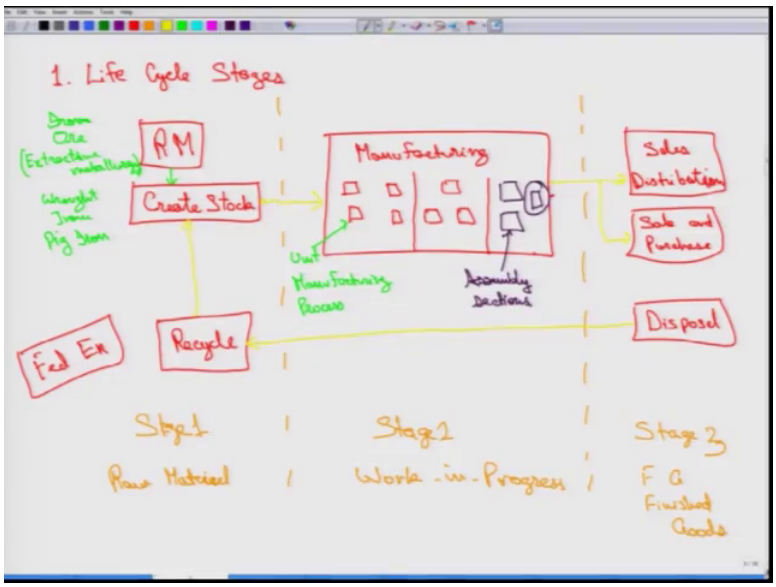

So, first of all I like to tell you what are life cycle stages, stages in what in manufacturing a product; not only manufacturing from the very extraction of ore to final disposal of the product. And for example, I taken example here I say I have a raw material right, then we create stock out of it. Now, what is raw material here? When I say creates stock, this stock is also something that is in processed form raw materials for example, here stock can be are wrought iron or pig iron in any form. So, what is the raw material for this, it is the ore, it is iron ore from which this is taken out right. So, now the iron ore has brought has given as this wrought iron after certain processing, this is called this process here is call extractive metallurgy that is not of much concerned here in our course.

So, now this stock goes into the second stage that is manufacturing. Second stage here is manufacturing. If you remember in the previous sessions, we discussed that we have certain types of layouts, it all depends what type of equipment or what type of product we are going to produce, and we have arrangement of machines various sections in the factory and this manufacturing is done. Maybe these are all unit manufacturing processes, so I will termed these as unit manufacturing process, a single unit manufacturing process. And also we may have here assembly, so these are assembly sections. And let me say these two assemblies, finally, produced its final product that is assembled here that is assembled here, and we get this product.

And in the third stage what we have in the third stage when the product is produced, here we have raw material, I will just start this from again beginning of the process, raw material. And this is actually to work in progress and finally, what we have finished goods. Now, these are called life cycle stages. This is stage 1, stage 2, and stage 3. I have do already these into only three parts, we made either for the divided into certain more parts, for example, first of all let me put stage 3 here; in stage 3 what does happens because finished product is obtained here and we distribute. So, here what happened in stage 3, we have obtained finished product here that is ready to go to end user and that purpose of this, this is actually sales department and its purpose is to distribute the product, then sale and maybe purchase, then another thing which I put in this stage only is disposal. So, in this case product is divided into three stages only.

So, further we can divided into further stages, one can even think disposal is a last stage, so that is considered that as four stage or one can even considering in certain products in certain cases packaging is very important, then we can consider that also one of the

stage. So, in that case stage one would be raw material, manufacturing, packaging then is sales and disposal. So, these are all life cycle stages. So, we will come to product lifecycle assessment to know what is that, what does we do lifecycle assessment and what are tools for lifecycle assessment, we need to know what are products life cycle stages. So, this was also discussed in the previous sections as well.

Now I will like to put one more thing here, now what happens here is from this side the product is going to manufacturing then sales and distribution, then certain logistics are all involved in this sales and distribution is put here. Because carbons foot print which we have talked in the previous lectures, the carbon footprint in transportation, transportation is very important part in overall green supply chain. We will discuss about green supply chain in forth coming weeks. So, like air freight, air freight is very expensive in comparison to a truckload.

For example, airfreight is about 4 to 6 times more expensive than regular road transport. Sometimes, but that is important even I will take value some example of packaging like Dr. Deepu Phillip told you that is it is a company name as Fed Ex, he told you about this thing Fed Ex right. So, this is also a kind of a courier company, but what do they transit they shift what they do this is shift organs or maybe animals like examples he said. So, what do we package them, how though we manage them whenever we need to like for example, shift an organ that needs to be freezed in that case packaging is important and that also has some energy associated with it. That also has some resources associated with it; that also need to be taken account into account while we do life cycle assessment.

So, these are all life cycles stages from here disposal sometimes people even recycle, you heard of this term before recycle. This recycling may go to stock again. For example, in paper manufacturing or all the metals now mostly all the metals almost all the metals are recycled. For example, whenever you dispose of your automobile or maybe your bike or car, all the metallic part, the plastics and like recyclable or thermoplastic materials and rubber all the parts, parts are sent to the respective recycling agencies those who can do, we will discuss about that in detail in the forth coming sessions in this week only. Now, this recycling is done here. So, even one can think of reusing the product in some other way, so besides recycling there are certain other things; reuse, may be reduce, and I will put another term here if you use, we will come to that.

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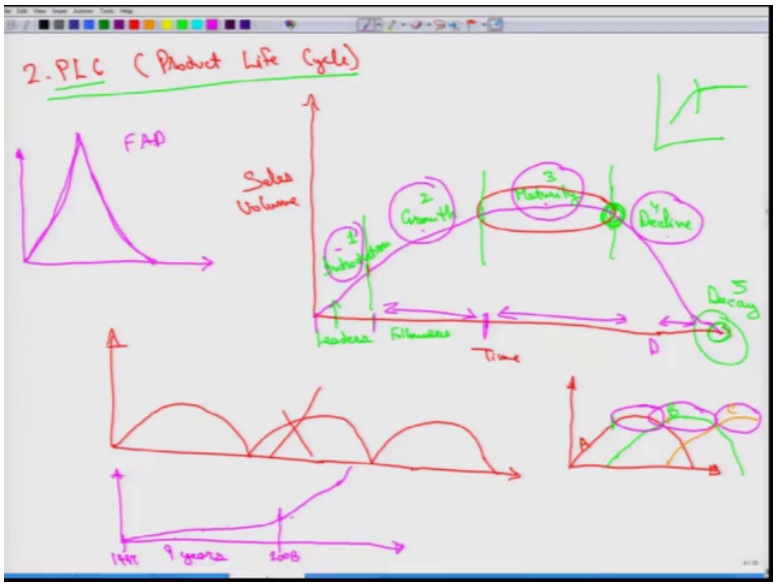

So, next is what is PLC - product life cycle. So, when we say PLC, the first thing that comes into mind is based on sales, based on the marketing perspective only, but we are not talking only about mass marketing perspective in this course. So, I will just tell you I will just give you a quick glance over this what is product life cycle here. So, what happens when a product is introduced into the market, it has certain stages in between, what happens the product sales go like this.

In this case, what is happening, this is our product sales volume, and this is our time. So, what this first stage is called introduction that is just introduction of the product the beginning of the sales. And this second stage is growth introduction of product like for example, a new mobile phone is coming within the market. So, only like people who are risk takers who are loyal to the company they will purchase the who purchase product here the leaders in the market (Refer Time: 13:55) market leaders. And after that who does that these are all followers. Followers who look into reviews and just make their own assessment and then they will do. After that this two stages stage one and stage two there comes the third stage that is maturity maturities when the growth is this I would say slope of growth is slow down here, here we have growth till this time the slope is either slow down or it becomes constant here, so that the that means, product is matured. So, people are now looking for something new some new segment in the market.

So, now, the companies came to know about that the product is going to this sale is going to decline at some time. So, this is four decline. Now, instead of noticed I did not touch this line here, I did not touch this line here because this sales would remain to some extent here. So, some product do decay here some products do decay. If this sales here touches zero; that means, the product is totally absolute not only absolute it is out of market for example, I like when CDs came the VCRs video cassettes audio cassettes all got out of market, no audio cassettes available now.

Now, certain new technologies are coming up. Now, we have like new kinds of mobile phones in case of mobile phones even android and IOS systems Iphone are available, but those button mobiles are still available, so in that case decays not there. So, this is product life cycle based on marketing prospective. So, how does a marketing manager or management people look towards product life cycle, this is in that case.

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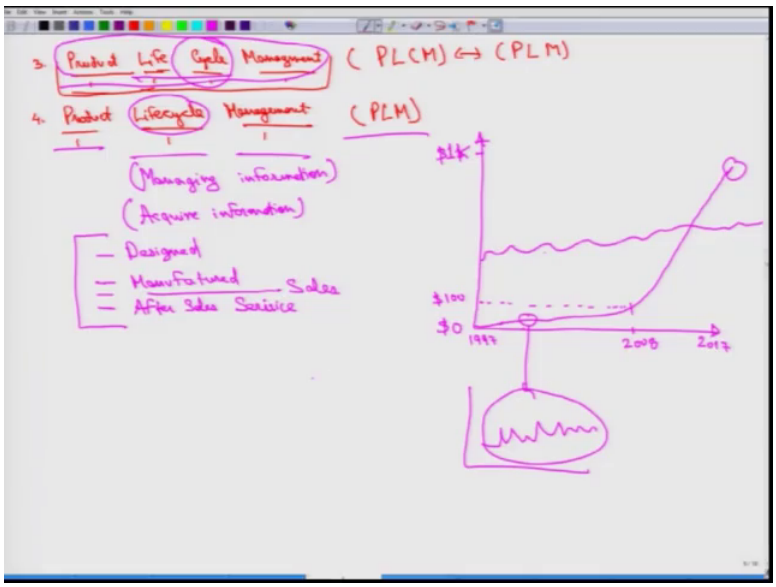

Next is product lifecycle management, product life cycle management. And fourth part I will bring here would be product lifecycle management. See what is the difference this is product lifecycle management, there are four words here. It is product lifecycle management, this is actually PLCM, and this is known as PLM. And people even do replace use and use this or call this as PLM only. So, what is the difference? This product life cycle management is actually managing different life cycles, these different cycles this is cycle A or cycle 1, 2, 3, 4 at each point the kind of strategies management use to

keep the product in market keep it the product prominent in market those are called product life cycle, the product life cycle management.

So, for example, I will tell you one example here. Whenever we need to whenever, so what do you think one would the marketing manager or the company put new product in the market. At this stage like a stage 1, maturities over or may be after decay of this product. Now, what does happened then if they put product in the market at this point when it has already been decayed, so next product would be like this. The next product would be like this, but this is not the actual scenario, what they do they want something to be at the peak stage. See this is the peak stage of sales; this is the peak stage of sales.

So, product life cycle product life cycle management needs to keep one product at the peak stage. So, this is product A I would say product A. So, product B would be introduced at the start of maturity here. So, whenever I know that actually this is all market forecast this forecasting is all done to obtain the information that when would are product mature and generally people know it is from the secondary data or the no market situations or non market trends that what would happen or what is the life of product. For example, a software product like for example, recent for software product considered to be market its life is generally 4 months to may be 1 year. Then updates are have to come up in the market otherwise other competitors would take its place. And mobile technology and its life is also too low here.

So, they need to introduce a product at this point, so as this product B here this is product B I will see one more product here, product C at this stage, this is a product C. So, one of the product in the market here is at its peak value product A, here we have product B, here we have product C. So, to manage and to maintain this scenario that is known as product life cycle management. And one thing more I would like to tell here that these stages, but different stages introduction growth maturity and decline, these stages may have different spans here. This is the span of introduction, in this case this is the span of growth, span of maturity span of decline.

Now, some product for example, this is one product this is known as FAD, FAD kind of curve. For example, some new song came into the market, the CDs or the songs went to the internet, and the sales becomes just like this one, it just grows up, and suddenly the trends go down. Now, this is one type of thing right; another type of thing may be for

example, this is another product. I will take an specific example here of Amazon. So, how does its stages went. So, Amazon had this kind of stage right, so this was this span of introduction and introduction to growth, it took it 9 years for Amazon to shoot up, to start shooting up from this point. It was I suppose from 1997 to 2008, since its growth start, but Amazon had vision. It was the time, it one point of time they used to have I read it somewhere that they used to have dollar 1.2 loss per sale per book. So, Amazon was actually like develop to sell the books only.

So, now, also then books market Amazon is leading you may know that now it took 9 years here to it, this one to shoot up. Now, at what stage is this Amazon now, it is at this stage even the growth is going up, it is at this stage now. So, if I could recall here correctly, the market stock value it was if I say dollar is 0, I will start from dollars 0 to dollar, it is dollar 1 K now. So, it was in 1997, and it is 2017 here. And here we already told you, it is 2008. And in 2008, approximate sales value was not sales value stock value was dollar 100 only. So, this is the primary stage.

So, when I compare when this is compared to Wal-Mart, Wal-Mart was something like this one its sales is also increasing, but Amazon as shoot up. So, actually is why I have drawn this curve like this, this is this curve also has certain stages the sales for example, if I draw only this portion and zoom it up, it would be like this. Now, this is this portion here zoomed up, so because the sales volume would go up and down like this. So, this was product life cycle management.

Next comes product lifecycle management. Now, what is product lifecycle management? Now, that is in this case the difference is in this word life cycle and lifecycle. Now, product lifecycle management is managing information. And before managing, we need to acquire information, for what, information to know how the product is designed, how the product is being manufactured right or being manufactured going to be manufactured right, then how do we provide after sale service maybe I think I skipped here one sales. So, acquiring all these thing is known as PLM product lifecycle management.

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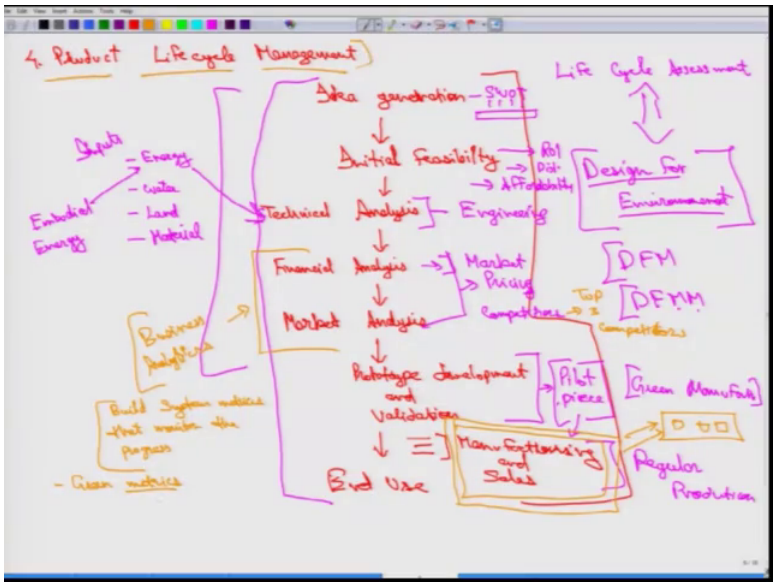

So, from the very it is starts from the very idea generation. So, we will put product lifecycle management here that is starts from very idea generation to finally end use and maybe till disposal of the product. So, in product development, the stages starts from idea generation. It certain all the possible ideas are listed down or obtained. And like in this case creativity techniques are used, for example, brainstorming maybe morphological analysis, there is gotten technique the certain techniques to have creative ideas from all sections of management all hierarchy levels - top management, workers, users, internal users, managers all people right.

Now, this idea generation after this idea generation, initial feasibility is checked. Now, what is initial feasibility? Initial feasibility is before taking this idea into a technical or some other analysis testing, initial screening is done, initial screening is this idea viable for this specific population for which we are making. If this idea viable at this present time or maybe would it come it like may be this product is required after few years. For example new products are coming like (Refer Time: 28:36) kind of band is there not that product is that concept is viable said you know what is (Refer Time: 28:42). In this case that we tie the band here and the mobile screen would come up and on your arm here and we can use that, but the cost is very high. In the beginning when new research is done the cost is very high. So, in the present time that product is not viable for mass production and this is initial feasibility kind of thing. So, in future maybe new technology might come up and those product might be produced.

So, after initial feasibility, if we come into the analysis part; analysis may be technical analysis, then we have financial analysis, then we have market analysis, then after doing certain things we do final prototype development and validation. Finally, after certain like they have certain more steps involved that is all manufacturing steps, which I mentioned in the previous slides here manufacturing and sales we have end product or end use.

Now, how is this connected with the green manufacturing or sustainability when you say life cycle assessment it is actually the assessment of the energy or maybe I would say inputs at all these stages, the inputs are energy then is water, and in some cases it may be land and material. So, to know or do we do the assessment we should know while this product development these stages are there and there is a another term that is very much related to this life cycle assessment that is design for environment. Design for environment like the product should be designed in such a way that it is it does not deteriorate environment in a very bad way or the green aspects or ecological aspects are taken into consideration.

There is one concept known as design for manufacturing DFM design for manufacturing. And second is DFMM design for manufacturing and maintainability, maintainability in itself is kind of the thing that is close to green think. Maintainabilities means something could be a repairs something that could be maintained or repaired again and again and could be used for longer time. And we have a new term here, not new term it is already there in market, design for environment. What is this? This will cover in detail in the forthcoming lectures. So, in this case, we need to connect all these two are green manufacturing concept green manufacturing.

So, like I will also again review the stages, idea generation we do SWOT analysis. SWOT is strength weakness is opportunities threat and we conduct various kinds of like initial feasibility, initial feasibility is the screening based on affordability may be returns on investment and distribution kinds of distribution that there those are possible or not. Then like in here we have no like initial feasibility we say affordability, then technical analysis technical analysis done, technical analysis all engineering part here that is how much energy is involved right. This energy is called embodied energy. Embodied energy is the energy that is consumed while producing the product like while manufacturing the product from the very raw material from the very extraction of ore or may be from the

start of the stock availability or stock two final end use till it is reaches the customer. Now, that is embodied energy embodied energy in maybe I will take some examples of embodied energy in manufacture of automobiles or maybe paper, I will this will come up in further sessions.

Then financial analysis; in financial analysis, we see about what is the market pricing like these two things because this market pricing the competitors. So, we know that things are moving this days like earlier we had only window ACs window air conditioners those who are very high heavy capacity and very heavy consumption was there. Now, we have star ratings in air conditions in refrigerators and certain even in automobiles also we have certain kinds of star or eco ratings certain kind of benchmarking things are there. So, things are moving in the market. So, those things also come in here marketing analysis.

Then is prototype development and validation, this is just actually the pilot product pilot product or I would say rather pilot piece here not product. The pilot piece like or pilot flies as through all the way, it is a pilot who is actually driving the plane and we are following him. And it is the pilot product that is being tested and whatever the characteristic whatever the analysis would be done on this, those characteristic involve all be assuming to be projected in the regular production. This is now a regular production. Now, though this is this is written in a small box here, but this in itself is the scope of this course manufacturing as we told you the all manufacturing the other things, this is this thing manufacturing and sales.

Now while screening or while this like its competitors the top three competitors top three competitors maybe I taken into account. And customers are these aware of green products, they are demanding green products. And the market is going to worth aside customer is these days aware or regarding ecology regarding its mother nature. So, they are demanding green products. So, even like this could also be possessed anyway its sustainability could any be possible if large social domain could participate if it participate only. So, that is why we have kind of in India we have Swachh Bharat or Make in India though all those kinds of thing like these all are associated with are sustainability concepts also.

Now, regarding this financial in marketing analysis, business analytics are involved. Now, what is business analytics that is to build system matrix, build system matrix that monitor the progress. So, we will introduce what introduce we will just come through certain green matrix as well, what are the metrics for green manufacturing. So, this is product lifecycle management. And in this case we will also come through a laboratory demonstration using the software that is available in our manufacturing in our system smart systems lab in our smart system lab, because this course is an applied approach. So, we will also take you to a lab demonstration in which we will make you conversation with certain soft tools that does this PLM.

So, we have PLM Siemens PLM software with us in smart systems and operations lab, in industrial and management engineering department IIT, Kanpur we have this software, this software is a licensed software. So, to make the students or make the participants of this course conversion to with the open source tools, we will also use some LCA tools. LCA tools that are open source.

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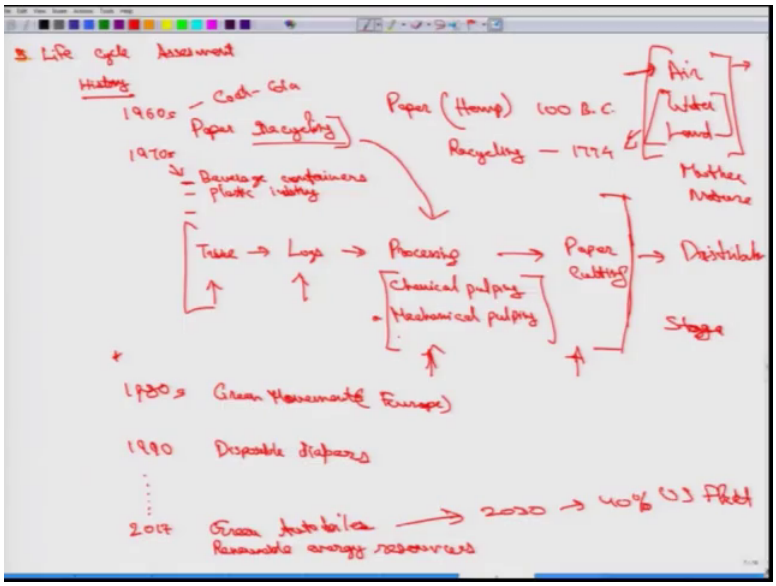

I like to tell you the history of life cycle assessment where does it come from. In 1960s and in early 1970s, there was a big revolution of paper recycling. This paper is a product that was first produced in 100 BC only in china like wrapping paper was produced that was made form paper that was made from hemp right this was wrapping paper in 100

BC. And the first concept of recycling of paper that came up in 1774 by a German scientist. Now, in 1960s and 70s, this is a big revolution of paper recycling.

Now, while this product this concept came to the mind of the manufacturers, so they thought of like analyzing each stage of paper manufacturing the right from like tree, tree cutting then producing logs, then we have paper processing right, paper processing and its processing is actually maybe chemical processing right chemical pulping we call it or may be mechanical pulping. So, this mechanical pulping maybe simple mechanical or thermo chemical there certain others process is available for processing of the paper and when final product produced then paper cutting is important. So, we have distribution. This is all will be say where this is actually fill product produced now this is the stage three if you could recall the previous slides in this lecture this is stage three of that.

So, this was not considered, till this stage they thought to analyze each step right each step in this that if we are thinking of recycling what is the energy that is associated with the like transport of logs, processing and all this right. So, certain other notable things who are there like in 1960 only Coca-Cola it explores Coca-Cola right it explores alternative containers besides glass bottles then life cycle analysis work performed by them then in 1970s US department of energy started net energy analysis net energy analysis and they call it. So, following this paper revolution in 1970s certain other industries like beverage containers like beverage container industries and maybe yes and the few plastic industries, they also started being this process of assessing the energy, not energy be resource that is used in manufacturing here, that resource was energy water.

So, when we say what are very basic needs of human being. When I ask this question in my class, the student said sir food, shelter and clothes. So, I would like to go into deep into that more basic thing, more basic things are here - air, water and land. So, this is being depleted, this is my mother nature. So, all these resources water and land are being used here; and air is being polluted by represent a manufacturing. So, in 1980s the green movement came up in US sorry in Europe and Procter and Gamble was part of it, and European industries did study for the pollution releases; and in 1990 again American people institute finds disposable diapers. It is still a big debate diaper or cloth, then I will not go into much detail. So, we are in 2017, when we are talking about green automobiles and we are talking about renewable energy resources, green automobiles it is a forecast that by 2030, 40 percent of US fleet would have green cars green cars what

are green cards these are actually hybrid cars that run on batteries or maybe using solar energy.

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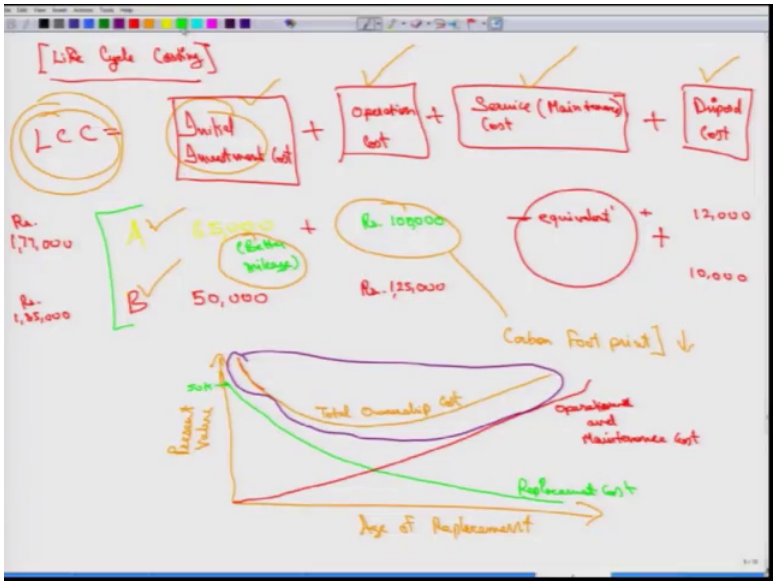

Life cycle costing right as we are discussing life cycle assessment here, we need to know what is the costing let is all involved in life cycle right. So, a life cycle costing we say what is cost of the bike, bike you purchase right the cost of the bike you say it is 50,000 yeah if it is Hero, Splendor it is 50,000; if it is passion, it is 65,000; if it is a Enfield bullet, it is maybe 1.25 lakh. So, this is actually your initial investment, this is your initial investment initial cost or investment cost. Now, this is not the cost that is the customer or you have to bear while using your product, the cost is actually during the whole life of the product from very purchase to final disposal of the product. You need to operate you need to drive your bike as well right, I have operation cost here right, service cost. A service mean service means maintenance then we have disposal cost then you have disposable cost. So, all this costs makes it to life cycle cost.

Now, what is life cycle cost of the product you purchase. For example, I purchase a bike or motorbike a right that is costing rupees 65,000, and another motorbike is purchased by my friend which is costing rupees maybe 50,000 right, but the bike A has better mileage. And let me say both of us - me and my friend drive this bike for next 10 years right then for 10 years if let me say its operation cost is rupees 10,000; 10,000 is very less amount, but let me say I will put it 1 lakh right rupees 1 lakh. So, in this case part b because the

mileage is not that good for running same kilo meters in 10 years its mileage might be let me assume to be this much. And service cost let me say both the service costs are equal right both of these are equivalent. And then its disposal cost, after 10 years 65,000 bike my might get its replacement value as may be 12,000; and this if I say maybe 10,000. So, what is the total cost here total cost is in this case is this 65,000 plus 1 lakh plus 12,000 that comes out to be 165 177. And for this bike it comes out to be 50,000 plus 1 lakh 25,000 plus 10,000, it is 175 185.

So, when I look into the initial investment only bike A is sorry bike B is my priority. So, when I look into overall life cycle costing concept here, and calculate all the operation cost, service cost, disposal cost here than my preference is the bike that gives me better output or better savings during its whole life that is bike A, and also because of better mileage here, the fuel that is consumed is less. So, its carbon footprint carbon footprint is less is lower right carbon footprint is lower. So, this is a green product in comparison as well. So, this is life cycle costing.

So, what is happening here is that we have present value and cost of replacement not cost I will put age here, age of replacement. So, the replacement cost here is like this with the age the bike was purchased here let me supposed bike B was purchased here at 50k rupees 50k. And its replacement value is this is replacement cost, replacement cost that is reducing. And the other cost that is its operation and maintenance cost that is all increasing, and not operations, operation cost operation right and maintenance cost. So, what is the total ownership cost. So, total ownership cost is the sum of these costs at any point of time right this is my total ownership cost. So, this is the graph this is the line that needs to determine what kind of product should be purchased. So, similarly if I talk this in terms of green carbon footprint, my carbon footprint would be better here.

So, with this I will conclude today's lecture. And here we discussed various life cycle assessment terminologies. What is products life cycles, life cycles stages, product lifecycle management per product, life cycle management and product lifecycle management, then life cycle costing and history of life cycle assessment where does is evolved from. And in that forthcoming sessions we will discuss what is actually life cycle assessment and how do we conduct that, what are matrix for that and we will also use all way need to have some overview of the softwares that are available or the soft tools that available in the market to assess life cycles, life cycle assessment.

Thank you.