Manufacturing Guidelines for Product Design

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Lecture-36
Design for Environment

Namaskar friends, so finally we have reached the 8th week of our discussion and we have finished the 7 weeks where our focus was primarily one the manufacturing processes and the design guidelines that we must follow. When we are designing a product which is to be manufactured by various manufacturing process, friends it is very difficult to cover each and every manufacturing process that falls under a broad spectrum of manufacturing.

We have tried to cover the processes which are most commonly used, for example sand casting, die casting for metals, injection moulding, compression moulding for polymers. And we have tried to see the design guidelines which are general in nature for machining. We have tried to understand the joining processes the we have reviewed the joining processes. We have tried to cover the design guidelines, the joint design configurations for various types of joining processes.

We have covered the design guidelines for welding we have covered for brazing, soldering, mechanical fastening, riveting. Friends we also covered some of the very innovative or latest type of joining processes which we can today cannot call them as latest. But are still may be the advanced joining strategies such as the induction welding, vibration welding, ultrasonic welding, microwave welding which is one of the latest.

Then we have tried to see hole making in advanced materials, so our focus primarily has been on hard aspects of product design mean comparison to the soft aspects of product design. We have talked about the last stage of the product design process where we think about how the product is going to be manufactured. So, broadly if you see whenever we are doing any product analysis there are 4 broad categories of analysis that we do.

So in product analysis first we try to do the do the marketing analysis, we to try a certain the need we try to see that who are going to be our customers, why they must buy our product? So, first is marketing, second are the product characteristics in which we try to understand that what are the functions the product is going to achieve, how the product is going to be operated, whether it can be manually operated or it can be automatically operated.

We try to see what is going to be the durability and dependability of our product. We try to understand that have the product will look like what are the aesthetics that are going to be associated with the product. What is going to be the colour combination what is going to be the surface profile what is going to be the surface finish. So broadly 2 things we have understood regarding product analysis. First are the marketing aspects, second are the product characteristics.

Then we try to see the economic analysis of the product, we try to do the break even analysis. We try to find out that what is going to be the break even quantity. We try fix up the cost price of the product, we try to find out the selling price of the product what will be our strategy for maximizing our profit. What are the standard parts that we must use in our product, so that the cost is minimised, how we can make our product in the most simplistic manner.

So all the economics related to the product design is taken care of and finally friends we try to see that how the product is going to be manufactured. So in any product analysis there are 4 major stages in product analysis the marketing stage the product characteristics the economic analysis. And finally the production aspects or the manufacturing aspects, so our course primarily is focused on the production aspects of the product design.

We have try to understand that what are the going to be the guidelines for various manufacturing processes that we must consider when we are designing our product. Why so, that the product is manufactured in the most efficient and effective manner. So that is the broad summary of what we have covered till date, we are going to start a completely new week of discussion where we will have five sessions of half an hour approximately each.

And today as you can appreciate and see on your screen our target is to discuss design for environment. Now how this topic is relevant to our product design or how it is relevant to the manufacturing guidelines for product design. Basically if you remember we have seen that the product quality depends upon 3 important factors, now what are these 3 important factors. The first factor is the product design.

The second factor is the materials for the product and third is the manufacturing process that we are going to use or the combination of manufacturing processes that we are going to use for manufacturing the product. Now friends these are the 3 important things and if you see each one of this is going to have influence on the environment. The materials that we choose for the product will certainly be derived out of the environment maybe from renewable sources maybe from non-renewable resources.

Then these materials are certainly going to have an impact in the way they are being used during the product in the service of the product. When we have bought a particular product we can very easily see that when we are running of car or an automobile. We are using a engine and we use raw material as a fuel the material can be petrol or diesel or gasoline. Now the fuel is burning it is liberating the gases, so gases are having an influence on the environment.

So, when we have a product some material we are using it is going to have a influence on the environment. Once the car has lived its life the life span of the car maybe 15 year, 20 year or the designed life has been lived it has outlived its life. What has to be done with the parts of the car what has to be done with the various components that has been used for the manufacturing of this car, where these components or parts will go, how much of this can be recycled, how many of these parts can be reused, how many of these parts can be put back into the environment without causing any harm to the environment.

These are the issues that we have to address during the product design stage only. So one is the materials that we need to focus on, another one is the manufacturing process. For example we are producing a product, during the production or manufacturing of that product we are liberating

may be harmful gases towards the environment, so our manufacturing process is having a negative environmental impact.

So, that process has to be changed, that process has to be improved, thus process has to be innovative. So that we can very easily reduce the emissions and the effect of this manufacturing process on the environment. So basically we have to select our materials for the product design in such a way that they are recyclable, reusable even if they are disposed into the environment. They do not cause much harm to the environment or they do not cause any harm to the environment.

Similarly we have to select our manufacturing processes in such a way that they do not cause any harmful impact on the environment. Now when we are designing the product we have to take care of these 2 things. We have to take care of the materials that we choose we have to take care of the processes that we propose for manufacturing our products. So that both the materials and the manufacturing processes do not have a negative impact on the environment.

And that is the basis of our design for environment, so our product design must be such that it is environment friendly. So let us now try to understand the basic aspects of design for environment, the lecture has been designed, it has been worked out from various sources. But the best source that is relevant to this topic is mentioned on your screen that is a book on product design and development the 5th edition by Karl Ulrich and Steven Eppinger.

So we can refer to this week much detailed information is given. So, you can read the information and brighten up your thoughts related to the product design aspect focussed on the environment. So let us quickly see what do we understand by design for environment.

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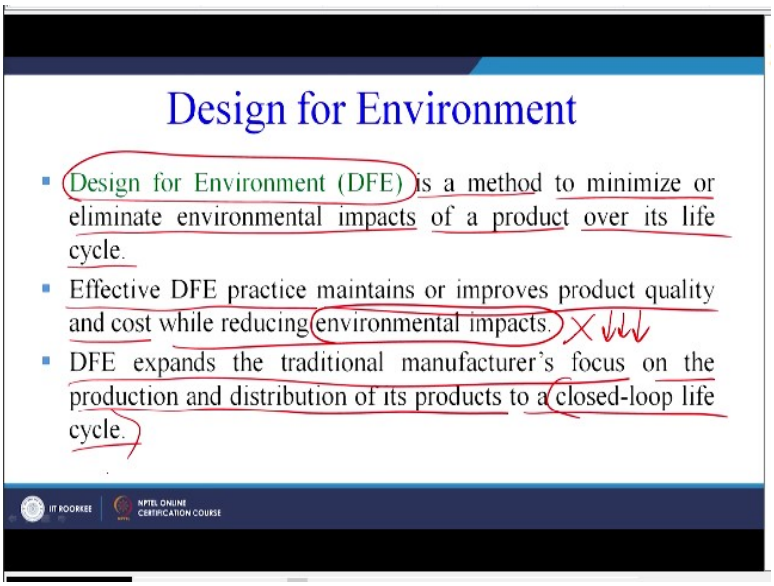

Now design for environment by design only we have written it in green colour because we want to choose the green materials, we want to choose the sustainable materials, we want to use the sustainable processes for making our products. So design for environment is a method to minimise or eliminate environmental impacts of a product over its life cycle. So our target is that the product must have minimal effect or even if it has a impact on the environment it must be a positive impact.

It must not be a negative impact during its life cycle. Now effective design for environment practice maintains or improves product quality and cost while reducing the environmental impacts. So, we want to reduce the environmental impact by our product design process by calling for the design for environment principles during the product design process. Now DFE expands the traditional manufacturers focus.

So usually the traditional manufacturer what the policy the traditional manufacturer is going to follow traditionally they will try to select the materials which are most commonly in use. Then at the next stage there going to select the process which is commercially viable which is profitable and then using the process the product design which is already final the material also is the conventional material.

They will try to make a product and sell it in the market without even bothering for the impact. This material is going to have on the environment, it can be a disastrous effect that the product can have on the environment. But our traditional manufacturing community or the fraternity sometimes are unaware or innocent and in the selection of the materials. Because technically they are not aware that how this product can have a negative or detrimental effect on our environment.

So that kind of training that kind of knowledge has to be created and disseminated among the traditional manufacturer. So that they become aware of the harmful effects of the products that they are manufacturing on the environment. So DFE expands the traditional manufacturer focus on the production and distribution of its product to a closed loop life cycle. So a closed loop life cycle may seem to be a very difficult word for a traditional manufacturer to understand.

But they can be explained in a very very simple many that once you derive any raw material from nature. We are using it for converting into an engineering product, so after the product has lived its life we must be able to dispose of the product or the materials that are used to make the product is easily into the environmental chain. So that there is no negative impact of these materials on the environment and that we will try to understand with the help of the diagram.

And it is very very important for the technologist, for the scientist, for the engineer for the engineers, for the manufacturers to look for materials which are environment friendly. And these days there is lot of focus on such type of materials why because we have understood the harmful impact of the traditional materials that we are using and we are now trying to look for materials which are environment friendly. So this is one thing that we have to focus on a closed loop life cycle of the products.

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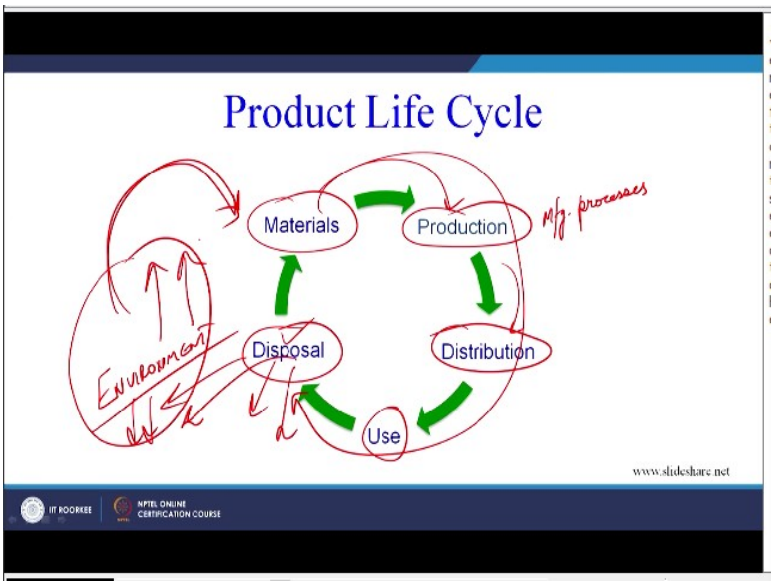

Now this is the product life cycle, I will start from materials, so we choose the raw materials then they go into production which is I have already highlighted manufacturing processes. These are the materials then they go to the distribution the product goes to the customer. Then it is used by the customer and finally it has to be disposed of, now suppose this is disposed into the environment.

So, our target will be that there is a positive impact on the environment because of this disposal process, there is no negative impact on the environment. So if it is going to the environment from environment again we can derive the materials in the form of various raw materials. And then these materials can further go through this cycle or product life cycle and again they are disposed of into the environment and again from environment derive this material.

So, that is a closed loop cycle that we can have but it is very very difficult to look for such materials which are easily available from environment can be converted into the engineering products. And then can be disposed off again into the environment, so that type of cycle is many a times difficult to conceptualize as well as implement. But yes research and development innovative minds can come up with similar solutions which can help us to keep a tab on the type of materials that we are using.

And come up with solutions which are environment friendly, so let us now try to see the life cycle assessment which is a very common term these days.

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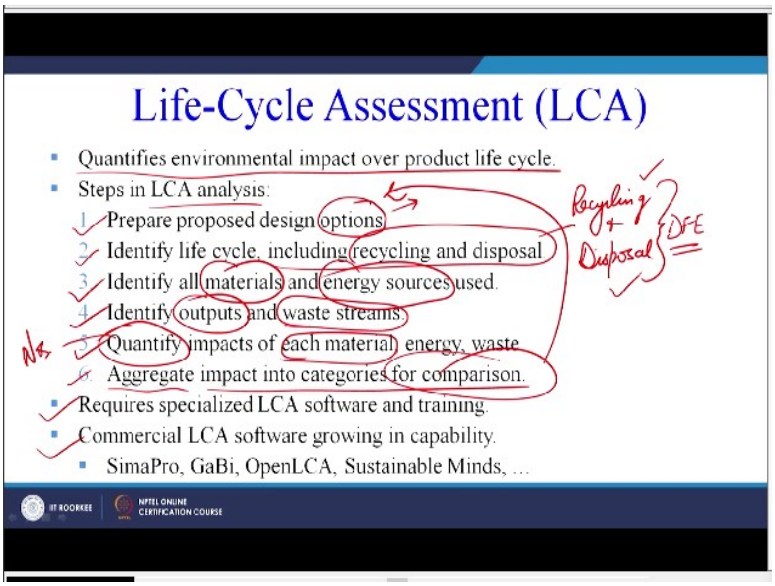

So it quantifies environmental impact over the product life cycle, so we have already seen that how a typical product life cycle looks. So what are the various stages of the product life cycle we have try to understand now we will try to understand the life cycle assessment why?. Because we can have alternative roots we can choose maybe 3 different materials. Now out of the 3 materials which must be chosen we will try to choose that material which is going to affect the environment in the most positive manner or which is not going to affect the environment in a negative way.

So we will try to list out the various steps in the life cycle analysis, so we can see in life cycle assessment that is LCA analysis, we will try to prepare the proposed design options already I have told that there can be different options available, identify the life cycle including the recycling and the disposal. These are the 2 key words that is recycling and disposal and these are important both are important from the design for environment point of view.

Because we have to see for each and every option what is our strategy for recycling, what is our strategy for disposal of the used products. So, that is very very important design for environment that when we are designing the product we have to take care of these issues at the design stage

only. So, in any life cycle assessment what we do we prepare the portions you identify the life cycle including who identify all the materials and energy sources proposed design options.

We identify the life cycle we including the recycling and the disposal we identify all the materials and energy sources that are used for producing the product. We identify the outputs and the waste streams output will be in the term of products or services that the system is offering, quantify the impacts of each material quantify in terms of numbers. So we quantify the impacts of each material, energy, waste on the environment.

And then we aggregate in some of the impact into categories for comparison, what we are going to compare already highlighted. We have the various design options available with us, so we have suppose 3 design options available we will try to do the life cycle assessment of each of these 3 options. We will try to see that how these 3 individual options are going to impact the environment, what are the materials that we are using.

What kind of energy we are using to convert these materials into the product, how the what is the recycling option available with us for the 3 different design options what is the reuse or maybe disposal strategies available to us for all the 3 options. And once we have quantified everything when squares of reactions and Wednesday quantified everything when we choose the best options which one will be the best option.

The best option will be which is going to be give as the positive environmental impact which means the design which is going to affect the environment in a positive manner which means that it is not going to harm the environment in any way out of the 3, if all the 3 are going to have a negative impact on the environment. We will try to choose the design option which is having a minimum negative impact on the environment.

So this is maybe a key strategy these days and for each and every product which is related to environment this life cycle assessment is a key word. And when we are designing a product we want to manufacture the product we will have to undergo this type of scrutiny we need to get

certified that the product that we are going to make the materials that you are going to be used for our product. The design of our product what is the end of life strategy forever product.

All these things have to be documented in order to get a permission to start the manufacturing process. So therefore life cycle assessment is an essential ingredients of any product development process. And design for environment will help us to keep a tab on all these criteria all these factors during our design stage only. So that when we go for the approval to the licensing authority or when we reach to the administration for approval we will easily get the approval why?.

Because we have taken into account the environmental impact of the processes the materials and the we can say the procedures that we are going to adopt to convert this materials into the final product. We have taken into account all these things the effect of all these things on the environment during our product design process only. So may be some of you may be wondering that how this can be done, now this can be done.

There are specialised people, there are specialised professionals who can help us to do this life cycle assessment for the processes as well as for the products or for the materials. These requires specialised LCA software training but there are people available who can help us out for going life cycle assessment. So there are commercial LCA software which are going in capability simaPro, GaBi, OpenLCA, Sustainable Minds.

There are end number of software which are available there are experts available. So, whenever we are designing a product we must take into account the design for environment issue. So, that we are easily able to manufacture a product which is good for the environment.

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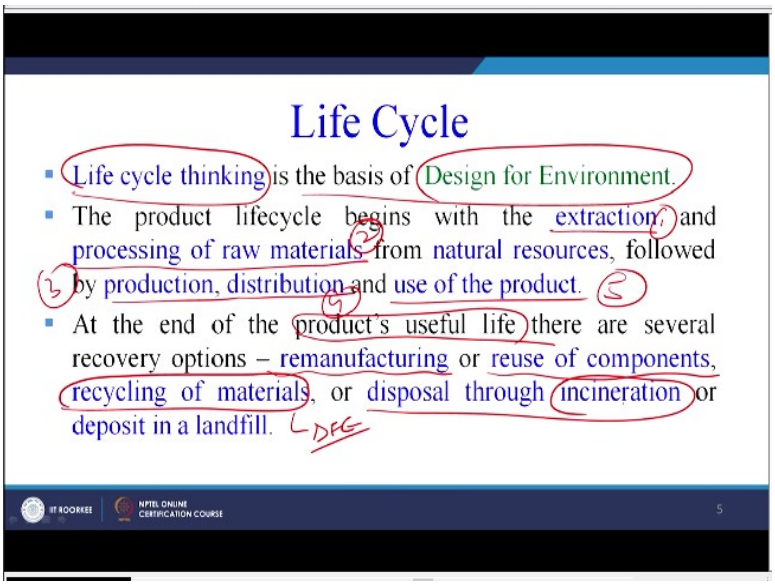

Now life cycle already we have covered we have seen the steps involved in life cycle assessment. So life cycle thinking is the basis of design for environment, so we have to see that over the life of the product how it is going to affect the environment. And that impact we need to take into account during the design stage only. So, that the product has a positive impact on the environment the product life cycle begins with the extraction and processing of raw materials from natural resources followed by production, distribution and use of the product.

Now we derive the raw material may be from the environment or nature we convert it into a tangible product. Now this product is used by the consumer and once the end of life of the product has been reached, the materials of the product is disposed off. Some of the part may be recycled the other maybe put into the land filling or maybe can be of incinerated. So, this is the stages extraction first stage then processing of raw materials.

Second stage from natural resources production, distribution to the customer use of the product, so we start with the raw material and finally we end up with the use of the product by the customer. Now what happens at the end of the products useful life once the product has lived its life there are several recovery options available. One can be remanufacturing or reuse of the components many times these days there is a policy of the companies, they try to buy back the old parts.

And they give you the brand loyalty bonus also, so if I have a product from company X and the company X upgraded the product. I can go to the company X and give the old products of the same company that I am using and they will give me a better or a modified or a updated version of the product with some cash back. So, that is we can say remain and how they are going to use the product that I have given them back.

They will take out the important components which are in the working condition and will can reuse them or refurbish them. So, reuse of the components is one of the options after the end of the life of the product recycling of the materials. So, this is important from the DFE point of view that when we are designing a product we must try to choose the materials which are recyclable many times we choose them choose materials which are non recyclable which have to be burnt or which have to put in under the land or for land filling.

So, that type of materials we must avoid when we are designing our products and this is as per the design for environment guideline that we must use the materials which can be recycled or disposal through incineration. I have already told that at the end of the life the products may be burnt. So many times we see the solid waste which is especially coming out from hospitals and other places sometimes it is burnt which is not good for the environment.

So, burning of solid waste is an issue or it is deposited into a land fill, so land filling also is not a very good option these days why? because of the leaching and other phenomenon that takes place the ground water may get polluted and which can have a harmful impact on the people living in the nearby places. So, they can contract different types of disease is also. So, land filling also is not a very good option.

Incineration can also lead to air pollution land filling can of course lead to water pollution. So, we can have different types of pollution emanating out of not being able to dispose of the materials in the best possible manner. So, the most important strategies can be reuse, remanufacture, recycle. And if we can recycle the parts of the component it is the best option for design for environment point of view.

Because in design for environment we will design the product in such a way that all the materials that are going into the product can be recycled.

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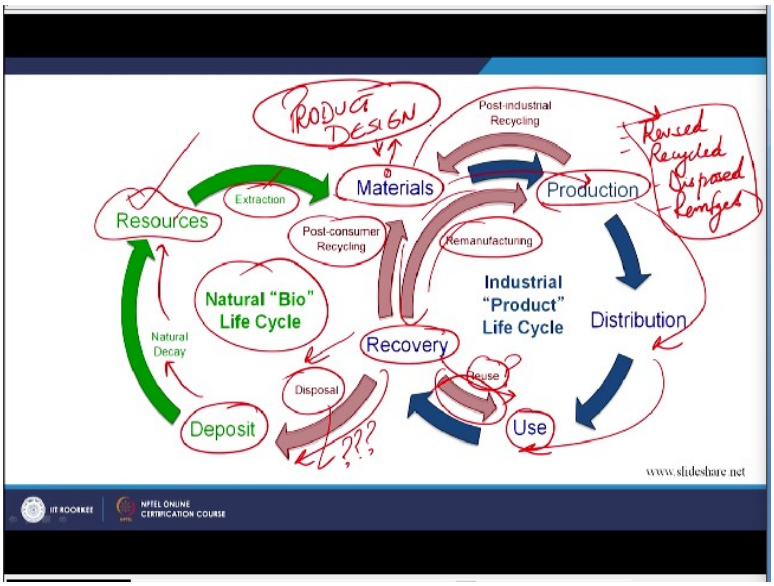

Now this is the very very important slide, so this is the natural or the bio-lifecycle we can see we have the bio resources we have trees, we have water, we have land, we have different resources from the nature. We can extract the materials from these resources and then these becomes our materials that we can use, so we have that natural resources, we can extract the materials are useful materials from these resources.

And then these materials can be used, now these materials can go into production from production they can go to distribution, already we have seen from distribution they go to use. And after the use that this is the major challenge, so once these materials are maybe non-biodegradable, they are non-recyclable means they cannot be recycled, they cannot be reused, they cannot be put back into the environment in the way.

We have process them or produced them, they have become harmful to the environment. Then once they have been use we must ensure that they can be reused. So there is a question mark here whether they can be reused or we have to recover whatever possible maybe in the form of energy or heat or we have to see that how what energy, we can recover from these materials or the other options can be they can be disposed off.

So, this disposal also is very very importance, so what type of materials we can dispose off we have to decide. All the materials cannot be disposed off in to the environment, so this disposal is very very important, the materials which are environment friendly we can dispose them into the environment. They will again form a deposit which will naturally decay, natural decay and again it will get converted into resources.

These resources can be again extracted and the materials can be use of this cycle. So the most important part is this part, the brown colour part which is remanufacturing also is there, reuses is there, post-consumer recycling is also there. So, these are the catch words, so we try to when we are designing. So, how where do we select the material, so these we select during the product design stage, so which means that when we are designing our product.

We must choose the materials which can be easily disposed of into the environment or which can be reused. So these materials when we are specifying these materials during our product design stage when we are selecting the materials for product design. We must ensure that these materials can be reused, these can be recycled or they can be disposed of into the environment or they can be remanufactured.

So we have to take all these decisions when we are specifying the materials during our product design stage. Otherwise these materials will have a harmful impact on the environment, so this is whatever we have already covered all these things are coming again in the form of sentences. So, I will read the sentences for you.

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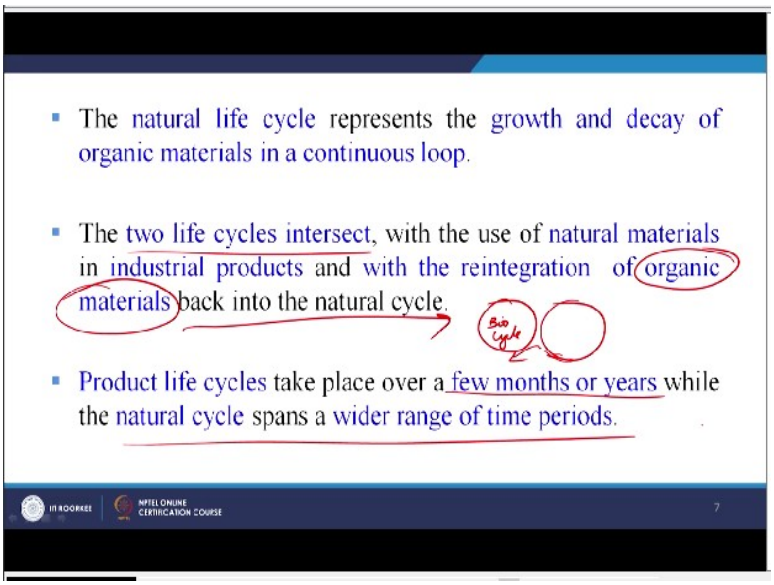

The natural life cycle represents the growth and decay of the organic materials in the continuous loop which is a left hand or the bio-cycle that we have seen. The 2 life cycles interact as we have seen the life cycle of the product and the natural life cycle for the bio life cycle. 2 life cycles interact as we have seen I can go back and show you this is first life cycle which are natural bio life cycle and this is the product based life cycle or the industrial product life cycle.

So, we have natural bio-life cycle and industrial product life cycle. So, both of them interact here these to interact. So 2 life cycles interact or intersect with the use of natural materials in industrial products and with the reintegration of organic materials back into the natural cycles. So, this is a very very important word here organic materials back into the natural cycles. So we have natural bio cycle industrial product cycle here.

And once the product has been used this material is disposed off again into the bio cycle. So this is very very important, but all materials that we are using for the products may not be possible to be disposed of into the natural bio cycle in environment friendly manner. So therefore this deposition or maybe this land filling or maybe this release of these materials which are not bio friendly or not environment friendly into the environment is what we are bothered about, is what we are concerned about?.

So, the product life cycles take place over a few months or years, so each and every product will have a product life cycle. While the natural cycles spans a wider range of time period, so a natural cycle takes lot of time for again get converting this decaying process long process for conversion of the material that we have disposed into the environment. Again it will get converted into the resources, so that is a long process whereas the product life cycle is very very short.

Today you buy a maybe laptop of a good company, after 5 years advanced version of the laptop will come. So your laptop you would like to dispose off, so the electronic e-waste is also a very very challenging task that how to manage the waste which is being created out of the use of the electronics equipment. So may be the natural process of converting the deposits into the resources through the decaying process is very long where as the product life cycle or the industrial products are short lived, that is the basic issue which is given in the previous slide.

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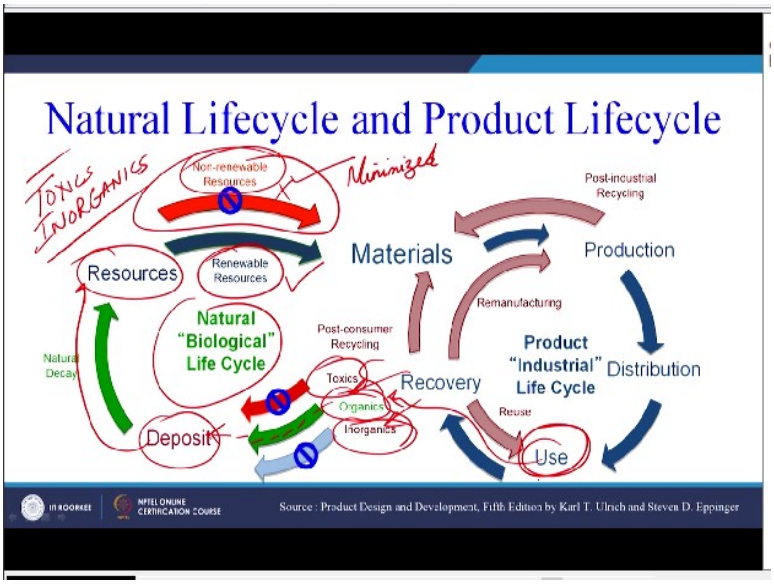

Now this is the natural life cycle and product life cycle already we have seen with little modification. Now here non-renewable whatever resources using renewable resources whatever resources we are using renewable resources very good for energy usually we say a hydroelectric energy sources are good. We are using water which is a renewable resource or we use a tidal energy which is a renewable resource.

We are using solar energy which is a renewable resource but maybe or non-renewable resources such as petroleum we should be very very miser in use of non-resources. And then rest remains same but we can see that once the use of the product has been done what has to be done either it can be reused or we try to try to dispose of again or send it back into the natural biological life cycle. So when we send it back we see that there are toxics also.

There are organics also deliberately shown in green colour and there are inorganics also. So these toxics and inorganics usually are not recommended to be disposed off again into the natural bio cycle. The organics can be sent back they can be into the deposit and then after the natural decay they will again get converted into the resources. So these are the important issues which are highlighted here.

The use of non-renewable resources must be minimised as well as the pushing back or maybe putting of toxics and inorganics into the environment or into the natural bio cycle must also be reduced. So, that is target for the scientists, engineers or the research community to reduce our dependence on the non-renewable resources as well as to treat this toxins or treat this inorganic are to design and develop and maybe synthesize the processes which can reduce the effect of toxics and inorganics.

So when they enter into the natural biological life cycle these are the 2 broad areas we are lot of research is being conducted, technologies are being developed and strategies are being adopted by most of the companies worldwide in order to reduce environmental impact of their products either by ensuring reuse or by ensuring recycling or by ensuring the treatment of the waste that they are producing. So that it can be disposed of into the environment with minimum environmental impact. Now we have to maintain the conditions of sustainability.

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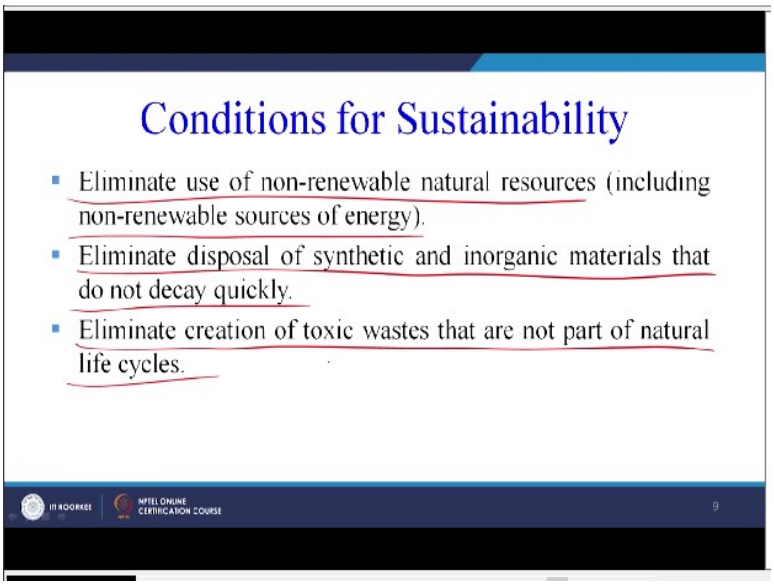

So what we can do as we have seen in the previous slide the this is the summary of the previous slide. We can eliminate the use of non-renewable natural resources as we have seen there are renewable resources I will again go back to the previous slide non-renewable resources we must try to eliminate their use try to propose the use of renewable resources, non-renewable we must try to avoid.

So eliminate the use of non-renewable natural resources including non-renewable sources of energy which example I already taken, eliminate disposal of synthetic and inorganic materials that do not decay quickly. We can see here this red colour are toxins, this is also inorganic materials which are being pushed back into the natural biological cycle. So that we can avoid eliminate the disposal of synthetic and inorganic materials that do not decay quickly.

And thirdly eliminate the creation of toxic waste that are not part of the natural life cycle. So, these all these toxics and maybe inorganic waste we must try to avoid. And how we can avoid them, how this topic is relevant to our course we are talking about the product design the manufacturing guidelines for product design. The materials that we need to propose for the various products, so we must be very very careful when we are finalising our design.

So that our design once the product has lived its life finally the materials that are used for making that product do not have a harmful impact on the environment. Now environmental impacts I think this is the worldwide known phenomenon these days.

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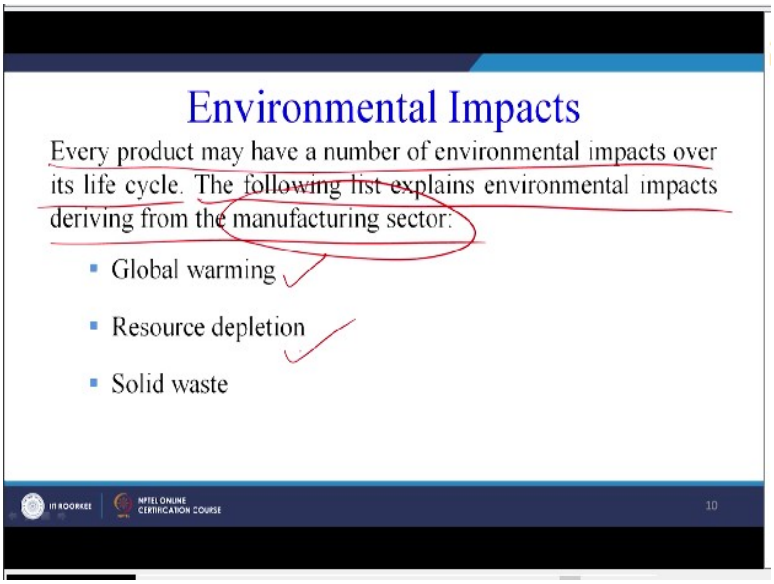

But just to summarise every product may have a number of environmental impacts, over its life cycle. Today's lecture is based on that impact , the following list explains the environmental impacts deriving from the manufacturing sector**.** Manufacturing guidelines for product design, how manufacturing is affecting our environment how manufacturing of engineering materials is affecting our environment causes are global warming, resource depletion. When we are using the renewable resources of energy, resources are present in abundance.

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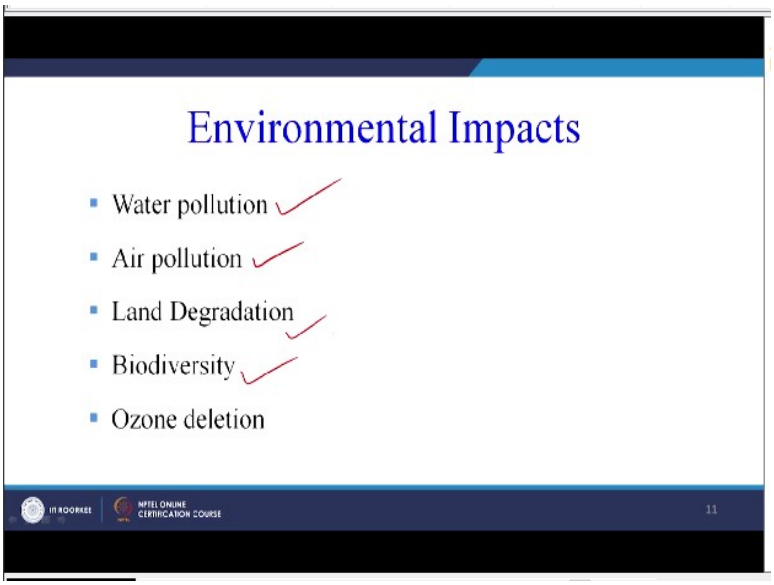

But we are using the non-renewable energy sources or non-renewable resources, the resources are getting depleted solid waste is generated. Other environmental impacts of water pollution already an example has been given because of the leaching of the various types of waste that is disposed into the land filling. Water gets affected or ground water gets affected which was water pollution, air pollution. Because of the incineration of the solid waste, land degradation also takes place. Biodiversity is also affected different types of we can save plants, animals are affected.

Because of the various types of harmful impacts of the material and the processes that we choose for making our products even the ozone layer is getting depleted which is of serious environmental impact of the type of materials that we use. We are not going into the details of each one of these but one of the reasons for depletion of the ozone layer sometime back was the use of the refrigerants that we use in our refrigerator.

So, there is a lot of research and development which have gone into the design and development or conceptualization of the refrigerant materials which do not have a harmful impact on the ozone layer. So therefore there is maybe each and every decision that we take related to our product, related to the design of the project, related to the materials of the product related to the manufacturing of the product, related to the use of the product is going to affect the environment in one or the other way.

And we have to ensure that during the complete product life cycle of our product that we are designing it must have a positive impact on the environment. So, design for environment may involve activities throughout the product development process as I have highlighted.

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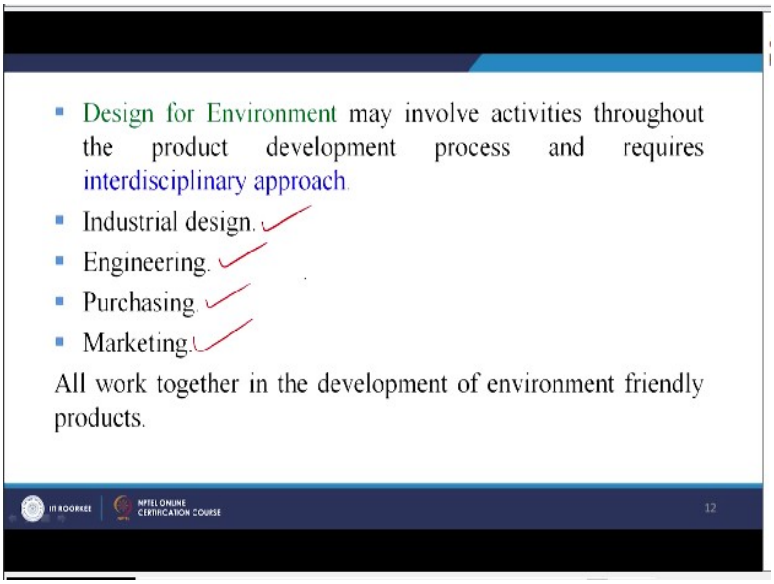

And requires an interdisciplinary approach, so we can have a interdisciplinary team of people who can work on the product life cycle or the product development cycle. So, that it has a positive impact on the environment and what are the important skill sets required industrial design, engineering purchasing, marketing. So all the work, all the team members work together in the development of environment friendly products.

So, basically in today's session we have to tried to briefly highlight only the concept of design for environment the life cycle assessment, the interaction between the or the intersection between the natural bio cycle as well as the industrial product life cycle. And where the interact and how we can make this interaction a friendly interaction that what type of material we must derive from the natural bio cycle.

And what type of materials we should push back into the natural bio cycle and how the industrial product cycle must change itself based on the impact it has on the environment or based on the impact it has on the natural bio cycle. So we must be very very careful we must focus on

renewable resources of energy or renewable resources of materials as well as we must push only the environment friendly materials back into the natural bio cycle.

So, that is basically the summary for design for environment and as I believe that the learners will definitely appreciate the importance of environment friendly materials and environment friendly processes when they were going to design their products that is the first thing. Second thing is that how we can include the design for environment approach in our product design process that we will try to cover in session number 37.

We will focus on the design for environment process, a step by step procedure which we must adopt in order to take into account that DFE guidelines. So, that the product that we develop is environment friendly, so with this friends we conclude the today's session.
Thank you.