

Manufacturing Guidelines for Product Design
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Lecture-37
Design for Environment: Steps

Namaskar friends, welcome to session 37 of our course on manufacturing guidelines for product design. So as you are all aware we are in the 8th week of our discussion and the last week we have tried to identify the topics which are most relevant in present scenario or in today's scenario and all of us are well away are there are different nations, different projects, different guidelines being established by the various authorities, governments, regarding the environment.

So lot of focus is there on the sustainable products, sustainable manufacturing, green manufacturing, green products, green furniture. So why such a focus in today's scenario because the environment that which are living in or in which we are living needs to be protected. We are seeing lot of catastrophes, lot of atmospheric changes climatic changes that are taking place all across the globe.

We are seeing floods, forest fires, number of other issues which are causing maybe lot of damage, lot of harm to the individuals, to the people. So there a lot of problems associated with the harming of the environment or by actions that we take which affect the environment in a negative way. So therefore we see all there are number of types of products that we see around us. And each of the product has got an connection with the environment both ways the traffic is both ways.

The environment affects the product and the product affects the environment but we are more focused on how the product is you going to affect the environment. So we see that there are lot of maybe changes that can be done in the way we develop our products, the way we design our products. The way we conceptualize our products, so I am coming in the reverse order. So first is I am coming from manufacturing we must focus on how we manufacture our products.

We must focus on how we design our product and in the long run we must also focus on how we use our products. So that we have a less damaging effect on the environment, or we must say that there is no damage to the environment that is the basic logic behind including these two sections that is session number 36 and session number 37, that today there is lot of focus on developing environment friendly products.

And therefore we must focus on the design aspects for environment aspects when we are designing our products. So, just to have a quick review of what we have covered in session number 36 we have seen that what do we mean by design for environment. We have seen that there is a natural bio cycle and then there is a industrial product cycle and there is a interaction between the two they intersect each other how they intersect?.

They intersect from the materials point of view that we derive the materials from the natural bio cycle. Then we convert them into useful products then the products are consumed and at the end of life the product have 3 or 4 options available. We can use them in remanufacturing, we can reuse them or we can dispose them off into the natural bio cycle. And we have seen that the 3 types of outputs go into the natural bio cycle.

Now these 3 outputs which are the inputs for the bio cycle or outputs of the product cycle that are they can be toxins, they can be inorganic waste, it can be organic waste. So we have to be judicious in deciding that what type of waste. We are pushing back into the bio cycle or the natural cycle and that is where lot of focus of the present day designers must be and it is it I am saying must be means we must focus those who are not focussing they need to focus.

And many of the designers have already started thinking in those terms that how this interaction between the natural bio cycle and the industrial products cycle can be made more effective in such a way that the overall interaction has the positive influence of on our environment. And that is only possible that can get two step process that when we extract materials from nature. We must focus on the renewable sources of or renewable resources or renewable sources of materials, renewable sources of energy.

And when we dispose of the material into the environment after the end of life of the products they must be biodegradable. They must be amenable to natural decay, so that again converted into the resources over a period of time. So, that is the focus where the engineers,

scientist must work in order to make this interaction between the 2 cycles more and more environment friendly.

So, basically in order to achieve these objectives today we are going to have a brief review of the various steps that must be taken into account while we are developing a new product, so it is not something that it is maybe at a particular stage during the product development cycle we will focus on environment. It is a universal phenomenon or universal approach right from the conceptualization of the idea in our mind.

We must focus on the environment, that means if this idea is implemented it is converted into a tangible product how it is going to affect the environment, what type of materials we must select for making this product, what is the total life of the product how this product is going to interact with the environment. And what is going to happen to the product after it has lived its life, so all these things have to be taken into account when the idea comes to our mind.

Similarly we also have to focus on that when the product will be manufactured which processes will be used to manufacture the product. How these processes are going to interact with the environment, how much maybe air pollution, water pollution, these processes are going to cause when the product is being manufactured. So right from the conceptualization to materials to manufacturing function to consumption.

For example I am using a particular product how it is going to affect the environment. So, from consumption point of view also we have to take into account again at the end of life whether the materials that we have use a recyclable, whether they can be reused whether they can be remanufactured or in which form they can be disposed of into the environment. All those things have to be taken into account.

So all through the product development cycle our focus must primarily be on how the environment can be protected, how the product can be conceptualized designed developed and consumed. So that it has a least impact or least detrimental effect on the environment. So, what is the step-by-step process in today's session maybe in the next 25 minutes we will try to just have a overview or a brief overview of the steps that are involved in the design for environment process.

So let us quickly now move towards the process that must be followed when we are designing a product.

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The slide is titled "Design for Environment Process" in blue text. Below the title, the text reads: "Effective implementation of Design for Environment includes activities throughout the product development process." The word "important" is written in red above "Effective implementation", and "Design for Environment" is circled in red. Below this, it says "Steps of the DFE process are:" followed by a numbered list of four items, each with a red checkmark: 1. Set DFE Agenda, 2. Identify Potential Environmental Impacts, 3. Select DFE guidelines, and 4. Apply DFE Guidelines to initial Designs. The slide footer contains logos for "BY ECORSE" and "NTEL ONLINE CERTIFICATION COURSE" and the number "2".

Now effective implementation of design for environment includes activities throughout the product development process throughout is very important here. So, it is not that at one single step we will apply the guidelines and then we forgot about the environment. It has to be throughout the product development process right from idea generation to the end of life of the product.

We have to focus on the environment or the interaction of the product with the environment. Steps of the DFE this is design for environment process are so we will see set the design for environment agenda, identify potential environmental impacts. So as I have already explained we need to understand that how the product is going to affect the environment, select the DFE guidelines there are standard set of guidelines, standard set of questions.

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Design for Environment Process

- 5 ✓ Assess Environmental Impacts.
- 6 ✓ Refine Design.
- 7 ✓ Reflects on DFE Process and Results.

Despite the linear presentation of the steps, product development teams will likely repeat some steps several times, making DFE an iterative process.

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That we must ask that we must follow when we are designing the product, apply the DFE guidelines to the initial designs assess the environmental affect of applying these guidelines that whether the overall effect of the guideline is a positive effect or which design is giving as a better environmental impact, better in the sense that is less damaging to the environment, less harmful to the environment.

Then maybe we will see that there are number of designs available with us one of the designs is better as compared to the other in our environmental impact assessment. And then we finalize that design and try to refine that designs further, so that we can even make the design better from the not only from the functional or aesthetic point of view. But also from the environmental impact point of view, then reflects on the DFE process and result.

So, finally we have to see that what is the process, what are the results that we have achieved after applying the DFE guidelines. Now despite the linear presentation of the steps now we have seen that going from step number1 to step umber7 we have followed a very linear approach one after the other but what usually that linear approach is not the one that we are going to actually see in practice.

Now despite the linear presentation on the steps product development teams will likely repeat some steps several times. So there with this is an iterative process we go to a new design then we see that it is maybe it is helpful in saving air pollution. But it may cause another type of pollution, so that is the again we revisit our design try to iterate, try to modify the design, so repeat some steps several times.

So, therefore in the overall step by step process steps may be repeated number of times until we achieve our value that is the maybe we have put a value of impact assessment or a criteria that the value overall value must be less than X. Now until unless we achieve that X value we will keep on iterating our design, making DFE or the design for environment as an iterative process. So it is iterative number of designs can or conceptualized.

Then their effect on environment is seen calculated and finally we reiterate finalize the best design which is causing the environment or maybe causing less damage to the environment and is below the critical value that is allowed by the various rules and regulations or the authorities who are taking care of the environment or maybe the impact of the product design is less. Because it is causing the environment pollution but the value is much below the critical value.

So that is what we can expect, now basically we can take a example to understand this that all vehicles that we are running or running on fuel. Now the fuel most of the vehicles that run on maybe petrol or diesel, so is a non renewable resource of energy. So we are using a non renewable resources of energy now during consumption well the fuel is burnt lot of gases are liberated. So, when these gases come out they are definitely causing some amount of air pollution.

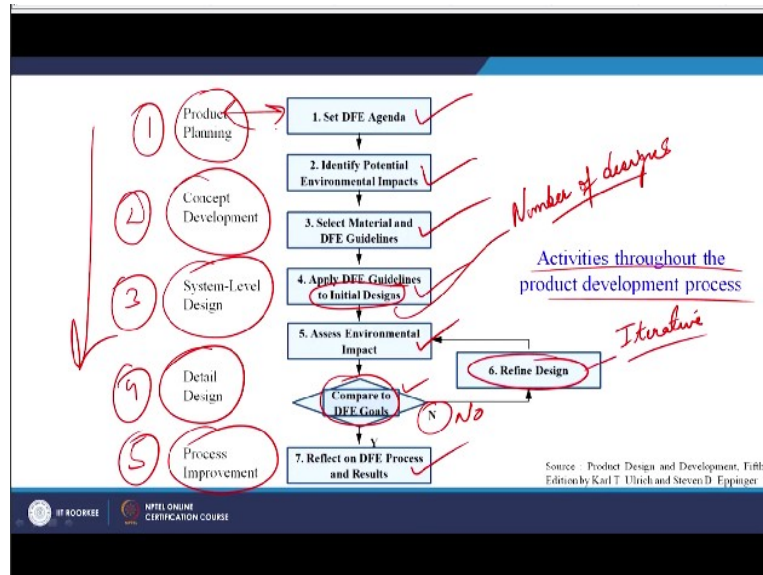
But now the various regulatory authorities have prescribed certain limits that the vehicle must not produce gases beyond a particular limit or a environmental check or air pollution check certificate is issued to the vehicles. So, there is a critical value below which even you can run the vehicle but if the vehicle emitting gases which are above the critical value then the certificate will not be issued.

So, similar is the case here also, we have to ensure that our design must be able to address the critical limits that have been lay down for the various types of products, various types of segments. And if we are able to design the product meeting those criteria or meeting those deadlines we will be very easily able to maybe get the permissions to produce the products.

So therefore this is a very important point from the product designers point of view that we must keep in mind. These things also or these criteria also when we designing the products.

Now these are the standard steps that are there now one by one we will try to understand them. So, let us quickly go to the approach how it is done?.

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So, we can see all the 7 steps are now reflected in a flowchart, so first is set the DFE Agenda which we have already seen identify the potential environmental impacts, select materials and DFE guidelines. Apply DFE guidelines on initial designs very very important because we need to have a number of initial designs. And then we have to finalize that which design is going to help us.

So we have number of designs which are available with us, assess the environmental impact of each design, compare to the DFE goals. So, DFE has a particular set of goals are criteria that must be met. So we will see that which design is satisfying the goals of DFE. So, if yes if satisfies our goals, satisfies the criteria we will focus on or reflect on the DFE process and the result.

And if this are not met no if the DFE goals are not met, so what we will do, we will redesign or we will refine the design. So, therefore we normally call it as the iterative process because again and again we have to revisit some of the steps. So we have to see the activities throughout the product development process. So, this is the overall product development process and our focus is on each and every step that is there in the product development cycle.

In the very first session we have seen that what are the various stages or steps involved in the product development cycle. So that is again coming into picture here, so we have product planning, concept development maybe I can number them 2 system-level design, 3 detailed design 4 and process improvement 5. So, this is maybe step-by-step approach for conceptualizing and developing a particular product.

And we can see that simultaneously our focus is on design for environment guidelines also. So when we are talking of concept development we have to focus on what type of materials we are going to use for making this product. And when we are finalising the materials our focus will be that we must select the materials which are environment friendly. So, step by step we will try to apply the DFE principal in our product development more importantly product design process.

Now there are 7 steps mentioned quickly we will try to review each of these and try to see that if we follow these steps religiously we will be able to come up with a product which is having minimal or no impact on our environment.

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The slide content is as follows:

Step 1 : Set the DFE Agenda: Drivers, Goals, and Team

The DFE process begins as early as the product planning phase with setting the DFE agenda. This step consists of three activities:

- ✓ Identifying the internal and external drivers of DFE.
- ✓ Setting the environmental goals for the product.
- ✓ Setting up the DFE team.

By setting this, the organization identifies a clear and actionable path toward environmentally friendly product design. *focus*

At the bottom of the slide, there are logos for IIT ROORKEE and NPTEL ONLINE CERTIFICATION COURSE, and the number 5 in the bottom right corner.

So, first is set the DFE agenda because it set the DFE agenda drivers goals and the team. So, first we have to see that how we are going to implement the DFE in our product design process. So the DFE process begins as early as the product planning phase which we have seen in the previous slide. Let us go back and see, this is set the DFE Agenda and this is product planning stage.

So, in the very beginning only we start to set our DFE agenda, maybe we will formulate a team we will set our goals that what is our target maybe our target maybe to develop a product which is based on completely waste materials. So we say that these waste materials which are otherwise going to go and damage the environment. We are going to use these waste materials to create our product, maybe in one of the very well known sports company has already set a agenda or we can say DFE Agenda in which they have told.

That all the plastic that goes into the manufacturing of there are polymers that go into the manufacturing of their product will be 100% reused polymers only they will not use fresh polymers for making the products so, that type of Agenda has to be set in the very beginning of our product development process. So why because now we know that this is the material it is environment friendly or it is going to cause less damage to the environment or if this material would have been disposed into the environment it would be environmental hazard.

So you select that material that yes this material now out of this material only we have to make our product. So you change the product design to change the processing the strategy that you are using you change the calculations maybe your calculation means change detailed design will change. So, all that is done based on our agenda, our goal that we are going to use X material only because it is less damaging to the environment or it is a waste.

So, we are going use the waste for producing a new product, so that type of Agenda has to be set in the very beginning of our product planning stage. So here we can see, so the DFE process begins in the very beginning of our product development cycle. So, as earlier as the product planning phase with setting the DFE agenda as I have already taken in an example. So, this step consist of the 3 important activities identifying the internal and external drivers of design for environment.

Setting the environmental goals for the product as I have already discussed setting up the DFE team. So, maybe we will have use the HR resources also the team the people who are experts in this area those will be selected. So, that is setting up the team, setting up the agenda, setting up the internal and external drivers. So, drivers can be that there are strict norms regulations set by the government that this has to be met.

So, this criteria has to be met, so that is one driver maybe external driver within the or from outside the company. Internal drivers can be that company wants to be creating a niche market for themselves in which they say that our products are the most less damaging products which are going to be environment friendly. So there can be internal driver that company frames the policy.

That they are going to make products which are not going to damage the environment as well as there can be external driver the government also pressurizes the companies to adopt the materials and processes which are less damaging to the environment. So both type of drivers have to be identified in the very beginning stage, so by setting this the organisation identifies a clear and actionable both are very important towards path the environment friendly product design.

So, this is a summary that we want to focus on environment friendly product design, so we have to setup very clear and actionable output. So, actionable means that may be the time also is limited we will time also is fixed sorry that we will be able to achieve it by 2020. So, that is actionable than this is what has to be done. So, the output is very defined and very clear that is the first stage.

So, we have we are very clear in our mind that this is what we are going to achieve this is the team which has been dedicated for achieving this objective what are the parameters or which are the internal external driver which are forcing us to change. Because we want to make products which are more friendly to the environment now after this has been done we identify the potential environmental impacts.

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Step 2 : Identify Potential Environmental Impacts

- This enables the product development team to consider environmental impacts at the concept stage even though little or no specific data are yet available for the actual product and a detailed environmental impact assessment is not yet possible.

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This enables the product development team to consider environmental impacts at the concept stage even though little or no specific data are yet available for the actual product and detailed environmental impact assessment is not get possible. So, in the very beginning only at the concept stage only the environmental impacts are considered. Why because in the very beginning we know that is we choose maybe this type of material or this type of process it is well established that it is going to have less impact on the environment.

But how much less what are the quantified terms that data is not yet available little or no specific data are yet available for the actual product. But in general the concept is build that because we are now using a biodegradable material for making a product. So, we assume that it will have less environmental impact on our environment. Why because this will the after the end of life the materials that are use for making the product will automatically biodegrade into the environment causing less harm to the environment.

So, we are not completely doing the detailed environmental impact assessment, but in general a concept is developed that this type of strategy can help us to mitigate or minimise the effect of our process, materials, product on the environment.

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- The chart shown below is an adaptation of the LiDs Wheel and the EcoDesign Web.
- To create this chart, the team asks, “What are the significant sources of potential environment impact in each life cycle stage?”

The chart displays five bars representing environmental impacts at different stages of a product's life cycle. The stages are Materials, Production, Distribution, Use, and Recovery. The 'Materials' bar is the tallest, followed by 'Recovery', 'Production', 'Distribution', and 'Use' is the shortest. A red line connects the top of the 'Materials' bar to the top of the 'Recovery' bar, with arrows pointing from 'Materials' to 'Production' and from 'Recovery' back to 'Materials', suggesting a circular process. The x-axis is labeled 'Life Cycle' and the y-axis is 'Environmental Impacts'.

Now the chart shown below is an adaptation of the LiDs wheel and the ECoDesign web to create this chart. The team asks what are the significant sources of potential environmental impact in each life cycle stage. Now life cycle stage is you can see here are mentioned maybe material selection is one production, distribution, use, recovery. So what type of environmental impact all these life cycle stages are going to have that is plotted here.

So, we can see materials have higher impact as compared to the use and the most important environmental impact is the recovery. Whether the materials that are going to use or the parts of equipment or the sub assemblies that are being used in the product can they be reused remanufactured recycled or can they disposed off into the environment without causing any harm to the environment, all those points have to be taken into accounts.

So, this is showing us a relative environmental impact at the various stages of the life cycle of the product. So we can make this type of chart and then we can focus on the important stage or a important phase which is having more value or maybe which is having more environmental impact like in this case we can see our recovery is very very important. So, recovery is also dependent upon the type of materials we choose and the type of production process that we use.

So we will try to focus on materials we will try to focus on production. So, that we can reduce their environmental impact also as well as reduce the effect of recovery also on the environmental effect. So each stage will have different impact, so we can see in the previous

slide again and I will go we can see materials, production, distribution, use and recovery. So, each one of these we can focus one by one.

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Life Cycle Stages	Questions
Materials	<ul style="list-style-type: none"> How much, and <u>what types of recyclable materials will be used?</u> How much, and <u>what types of non-recyclable materials will be used?</u> How much, and <u>what types of additives will be used?</u> What is the <u>environmental profile of the materials?</u>
Production	<ul style="list-style-type: none"> How many, and <u>what type of production processes will be used?</u> How much, and <u>what kind of auxiliary materials are needed?</u> How high will the <u>energy consumption be?</u> How much <u>waste will be generated?</u>

So, let us quickly see materials, how much and what type of recyclable materials will be used, how much and what types of non-recyclable materials will be used. How much and what type of additives will be used, what is environmental profile of the materials ,from the production point of view how many and what type of production processes will be used. How much and what kind of auxiliary materials are needed, how high will be the energy consumption how much waste will be generated after the process.

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Life Cycle Stages	Questions
Distribution	<ul style="list-style-type: none"> What kind of <u>transport packaging, bulk packaging, and retail packaging will be used</u> (<u>volumes, weights, materials, reusability</u>)? Which <u>means of transportation will be used?</u>
Use	<ul style="list-style-type: none"> How much, and <u>what type of energy will be required?</u> How much, and <u>what kind of consumables will be needed?</u> What will be the <u>technical lifetime?</u> What will be the <u>aesthetic lifetime of the product?</u>
Recovery	<ul style="list-style-type: none"> How can the <u>product be reused?</u> Will the <u>components or material be reused?</u> What <u>materials will be recycled?</u> Will <u>recyclable materials be identifiable?</u> How will the <u>products be disposed?</u>

Similarly from distribution what kind of transport packaging, bulk packaging and retail packaging will be used volumes, weights, materials, reusability of the packaging materials

which means of transportation will be used and how much maybe will be the carbon footprint for this transportation process only regarding the use how much and what type of energy will be required to use a particular product.

And this is very relevant to each one of us when we buy a electrical appliance we try to see how much star rating is there. Why because it depends upon the consumption of electricity. So, our type of energy will be required how much and what kind of consumables will be needed, what will be the technical lifetime, what will be the aesthetic lifetime of the product. So from use point of view also we must try to find answers to all these questions.

Then from recovery how can the product be reused, will the components or materials be reused, what materials will be recycled, will recyclable materials be identifiable. How will the product be disposed of answers to all these questions have to be asked during the product development cycle only. Because once our design is ready and it goes into manufacturing not much can be changed.

So during the product design stage only if we look for answers to all these questions we will be able to develop a design conceptualize a design which will be able to give a satisfactory answer to all these queries. So, we must be able to address these queries in a very positive manner, positive manner means that yes the product is recyclable. The materials can be reused material can be recycled.

Even yesterday there was a program in the TV in which it was shown that their eyes are focus that the use of single use plastic has to be minimised. So, which means that we have to not try to look for products or develop products which are maybe multiple use. So which is recyclables, so once the product has been use you recycle it and make a new product. Then it if the second product has been use you recycle it and make third one recyclable materials have to be used.

So, that the products can be recycled or the impact on the environment can be minimised. Now these are the 2 things that we have to focus in the very beginning now select the DFE guidelines.

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Step 3 : Select DFE Guidelines

- Each lifecycle stage has its own DFE guidelines that provide product development teams with instructions on how to reduce the environmental impacts of a product.
- Many guidelines related to Selection of Materials. This shows the central role of materials in DFE.

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Each lifecycle has its own DFE guidelines that provide product development teams with instructions and how to reduce the environmental impacts of the products. So, there are guidelines which we need to follow when we are doing our product design focussed on the environmental impact of the product design. So, when we are looking at the environmental impact we must look at these guidelines.

Many guidelines related to selection of materials this is very important. So, maybe as we have seen in the chart which was the showing relative impact of the various stages of the life cycle of the environmental impact. We have seen that materials contribute significantly to the environmental impacts, so many guidelines are related to the selection of material. This shows a central role of materials in the design for environment.

And in the previous sessions, session number 36 we have seen that there is a natural bio cycle and industrial product cycle which is focussed more on the selection of materials and disposal of materials into the environment after the end of product or after the end of life of the product.

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Life Cycle Stages	Design for Environment Guidelines	
Materials ✓	<ul style="list-style-type: none"> ▪ <u>Sustainability of resources</u> ▪ Healthy inputs and outputs 	<ul style="list-style-type: none"> ▪ <u>Specify renewable and abundant resources.</u> ▪ <u>Specify recyclable and /or recycled materials</u> ▪ <u>Specify renewable forms of energy.</u> ▪ <u>Specify nonhazardous materials.</u> ▪ <u>Install protection against release of pollutants and hazardous substances.</u> ▪ <u>Include labels and instruction for safe handling of toxic materials.</u>

Now let us see materials design for environment guidelines for materials, sustainability of resources sustainability is a very key word in the product design in these days. So specify renewable and abundant resources which I have already highlighted in the very beginning of today's session. Specify recyclable and/or recycled materials as I have given an example in today's class a very well known company has decided use the recycled plastics only in their product recycled polymers into their new products.

Specify renewable forms of energy, so this is sustainability of resources, healthy inputs and outputs, specify non hazardous materials, install protection against release of pollutants and hazardous substances. So, the pollutants and hazardous substances should not be directly disposed of into the reverse or should not be directly disposed field into the land fields.

Because of the leaching action sometimes the groundwater may get polluted. So, we have to very cautious of how we are interacting with the environment or however products are interacting with the environment include labels and instruction for safe handling of the toxic materials.

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Life Cycle Stages	Design for Environment Guidelines	
Production ✓	<ul style="list-style-type: none"> Minimal use of resources in production. 	<ul style="list-style-type: none"> Employ as few manufacturing steps as possible. Specify materials that do not require surface treatments or coatings. Minimize the number of components.
Distribution ✓	<ul style="list-style-type: none"> Minimal use of resources in distribution. 	<ul style="list-style-type: none"> Minimize packaging. Use recyclable and/or reusable packaging materials. Employ folding, nesting, or disassembly to distribute products in a compact state. Apply structural techniques and materials to minimize the total volume of material.

Now at the production stage we can say minimal use of resources in production, employ as few manufacturing steps as possible. Specify materials that do not require surface treatments or coatings, minimise the number of components in design for a assembly also we say use the modular design. Similarly distribution minimal use of resources in distribution, minimise the packaging, use recyclable or reusable packaging materials.

Employ folding, nesting or disassembly to distribute products in a compact state. Apply structural techniques and materials to minimise the total volume of materials, so basically we can see that right from the selection of materials to the production of material into the products right from distribution to the maybe the next stage is use. We have certain set of guidelines that we must follow.

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Life Cycle Stages	Design for Environment Guidelines	
Use ✓	<ul style="list-style-type: none"> Efficiency of resources during use. Appropriate durability 	<ul style="list-style-type: none"> Implement default power-down for subsystems that are not in use. Implement intuitive controls for resource saving features. Use feedback mechanisms to indicate how much energy or water are being consumed. Consider aesthetics and functionality to ensure the aesthetic life is equal to the technical life. Facilitate repair and upgrading. Ensure minimal maintenance. Minimize failure mode.

So, from use point of view we can see what when we are using the product efficiency of resources during use we must ensure that is implement the default power down for subsystems that are not in use. So, many times we have seen that whenever we go to a hotel the lights in the corridors automatically gets switched on. So, they are sensors that sense the movement and automatically switches on the lights.

So, that is during the use the power consumption is optimised similarly when we are designing the products we must designing the products in such a way that if they are not in use automatically it they can be switched off. So, implement default power down for subsystems that are not in use similarly implement intuitive controls for resource saving features. So, that is also very very important use feedback mechanisms to indicate how much energy or water are being consumed.

So, very quickly we can take into account that we can get a feedback and then make a review that how much energy we are consuming or maybe any other resource like water we are using. Similarly the intuitive controls for resource saving features, so we can have an intuition that maybe this thing or this particular part or energy is being used may not be optimally utilize during this period.

So, we can very easily using intuitive controls to optimise our resource use of resources. So, whenever we are designing a product we must design it in such a way we must include system subsystems in such a way that they are energy efficient. Then during use only we have to focus on appropriate durability, consider the aesthetics and functionality to ensure the aesthetic life is equal to the technical life.

So, that is very important many times suppose the product is not looking that good as statically although it is satisfying our requirement. So, usually we throw that product, so that is also basically misuse of the energy which has gone misuse of the materials that have gone into the product so, during manufacturing as we have seen when we are producing a product lot of energy is consumed.

So, we must try to design the product in such that the aesthetic values are equivalent to the functional values. So that as long as the product is in use or functionally satisfying the requirement for which the product has been designed. It must also be aesthetically long

lasting that is for long life it must be use, it must be good looking throughout its life, also facilitate repair and upgrading many times we do not want to get our products repaired.

And we want to change it to a new product or advanced version of the products. Why because a repair cost is high sometimes the repairing is difficult. We do not expertise or the people who can repair the products, so when we are designing the product we must take into account that the repair and upgradation is possible. Ensure minimal maintenance, minimise the failure mode.

So, that we are able to use the product for a long duration of time, so we have seen that right from the selection of materials to production, to consumption maybe to distribution sorry then to use we have certain set of guideline, so if you follow these guidelines we will be able to design and develop a product which is environment friendly which is consuming less power which is having less impact on the environment just to have the look review at what are the guidelines.

So, we can see that there are guidelines for materials, there are guidelines for production there are guidelines for distribution, there are guidelines for use.

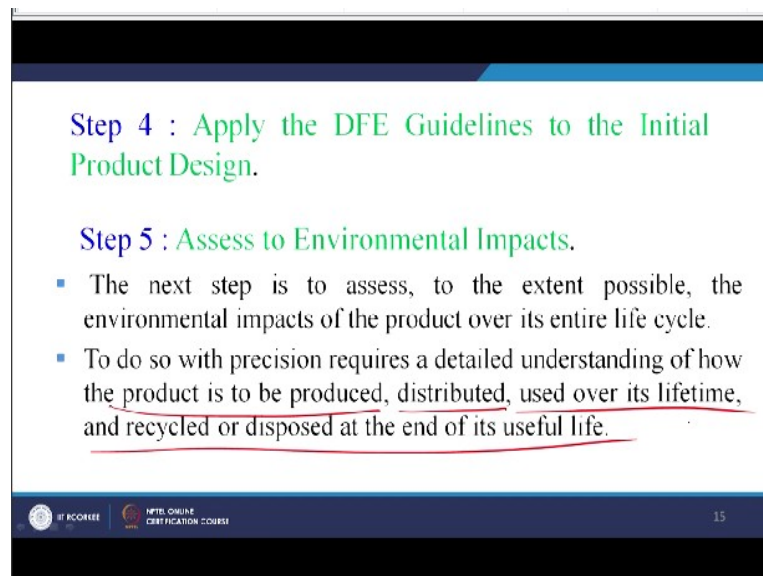
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Life Cycle Stages	Design for Environment Guidelines
Recovery	<ul style="list-style-type: none">Disassembly, separation, and purificationEnsure that joints and fasteners are easily accessible.Specify joints and fasteners so that they are separable by hand or with common tools.Ensure that incompatible materials are easily separated.

Then there are guidelines for recovery also disassembly and separation as well as purification ensure that joints and fasteners are easily accessible which may it is easy to disassemble the products specified joints and fastener. So, that their separable by hand or with common tools ensure that the incompatible materials are easily separated. So when we are specifying a

material for a particular product or sub parts we must ensure that we can separate them out at the end of life and then we can reuse them, remanufacture them or recycle them.

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The slide contains the following text:

Step 4 : Apply the DFE Guidelines to the Initial Product Design.

Step 5 : Assess to Environmental Impacts.

- The next step is to assess, to the extent possible, the environmental impacts of the product over its entire life cycle.
- To do so with precision requires a detailed understanding of how the product is to be produced, distributed, used over its lifetime, and recycled or disposed at the end of its useful life.

At the bottom of the slide, there are logos for 'BY COURSE' and 'NPTL ONLINE CERTIFICATION COURSE' on the left, and the number '15' on the right.

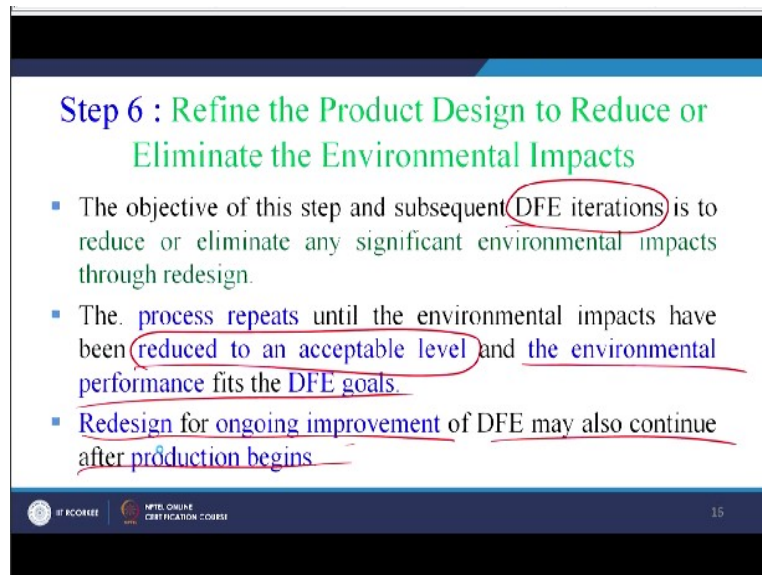
Then the step 4 apply the DFE guidelines to the initial product design. Now we have seen that initially we have to philosophically ensure that we have set the right agenda. Then we have to see that whatever steps we are taking or going to help us to design our product in a much better manner from the environmental point of view. Then we have seen that there are certain set of guidelines, we apply these guidelines on our product design.

So, that is a step 4, first step 3 is that we have understanding of the DFE guidelines, step 4 is apply the DFE guidelines to the initial product design. Then once we applied these guidelines we have taken care of this guidelines try to assess the environmental impact. The next step is to assess to the extent possible environmental impacts of the product over its entire life cycle which product or which design.

The design on which we have already applied the DFE guidelines to do so with precision requires are detailed understanding of how the product is to be produced distributed used over lifetime and recycled or disposed at the end of its useful life. So for each of these stages of product in the product lifecycle we have already covered the guidelines that have to be implemented from the DFE point of view.

So if we implement those guidelines we can very easily calculate the affect of these guidelines on the product design or from the product during the various stages of its lifecycle.

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Step 6 : Refine the Product Design to Reduce or Eliminate the Environmental Impacts

- The objective of this step and subsequent DFE iterations is to reduce or eliminate any significant environmental impacts through redesign.
- The process repeats until the environmental impacts have been reduced to an acceptable level and the environmental performance fits the DFE goals.
- Redesign for ongoing improvement of DFE may also continue after production begins.

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Refine the product design to reduce or eliminate the environmental impact. Now even after applying the guidelines some of the guidelines may not be applicable to our product design. So we have certain amount of environmental impact, so what we will try to do we will do the iterative process. We will try to redesign the product or the part which is higher environmental impact.

So, the objective of this step and subsequent DFE iterations already I have use the word iterative is to reduce or eliminate any significant environmental impacts through the redesign. The process repeats until the environmental impacts have been reduced to an acceptable level which I have already highlighted in the today's session. And the environmental performance of the product fits the DFE goals which we have already listed in the very first step of our process or the design for environment process.

Redesign for ongoing improvement of DFE may also contribute after the production begins. So it is not that once the production has started for the products we cannot focus on DFE. So DFE is a continuous process number 1 at each and every stage of the product development cycle. We can focus on the DFE guidelines and even after the production has started our focus on DFE can continue. Redesign for on-going improvement of DFE may also continue after the production begins.

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Step 7 : Reflect on the DFE Process and Results

With every aspect of the product development process, the final activity is to ask:

- How well did we execute the DFE process?
- How can our DFE process be improved?
- What DFE improvements can be made on derivative and future products?

Now step 7 reflect on the DFE process and the results, with the every aspect of the product development process the final activity is to ask how well did we execute the DFE process, all these steps that we have studied today. How can our DFE process be improved, what can be further improvements in our product design. What DFE improvement can be made on derivative and future products.

So this is a continuous process because everyday technology is changing, everyday scientists and engineers are coming up with new and new materials new and new processes new and new technology, new and new strategies. So, when there is a continuous change in the way we design our products, the way we produce our products. The way we transport our products, the way we recycle our products.

So with the change in technology everyday things are changing, so continuously we must try to strive for making our products which are much more environment friendly as compared to maybe today. So in 2018 suppose we make a product we are specific set of materials, specific set of processes but with time new and new materials are coming in the market. So we can plan to change our material to more environmental friendly material.

We can try to change our process to more environment friendly process. So, that is the overall objective of these 2 sessions that we have covered in our overall course on manufacturing guidelines for product design. So, we have seen what is DFE in the previous sessions, session number 36, today we have focused on the steps involved in the DFE process. So there is a long list of questions which are associated with each product life cycle stage.

So, if we are able to address all these questions the product that we will push into the market will be environment friendly. And will certainly gain importance from the consumers who are more and more informed today who want to use products which are environment friendly may be subsequent sessions our focus will be on other important topics like for product architecture, rapid prototyping.

And finally we will try to summarise the course in the last session that is session number 40, so with this I conclude the today's session.

Thank you.