

Manufacturing Guidelines for Product Design
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Lecture-08
Selection of Materials-I

Namaskar friends, welcome for Section 8 of our course for manufacturing guidelines for product design. We are currently in the 2nd week of our discussion and as we are well aware our focus in the week 2nd is on engineering materials because all of us know that for any product design to be successful 3 important things are very very important or very very you can say necessary. First thing is that it must be very very careful while designing product. So the first key word or the catch word is the design of the product.

Now for design of the product there are number of guidelines, there are number of steps that we have to follow, we have to ensure that the design is robust, the design is such that it satisfies the functional as well as the static requirements of the customer or the need for which the product is being designed. So the first catch word is design, the second catch word is the materials that are going to be used for making that product.

And the third important thing is the manufacturing process that is going to be used for manufacturing that product. So these are the 3 important things, again I will highlight and this we have already seen in our very 1st week of discussion that in a triangle identifying the quality of the product or defining the quality of any product, 3 important edges of the triangle or 3 important sides of the triangle play a very important role.

And one side is the designed the second one is as you are well aware is the material and the third one are the manufacturing process. So the importance of materials cannot be sidelined or neglected from product design point of view. So we have to keep in mind the product design or the importance of material in product design. So today we are trying to see that there are large variety of materials that are available with us.

So we try to select the most optimal material that is going to satisfy our functional as well as the other service requirements for the product being designed. Now let us see that how we select a material. So how we select material that we will study in selection of materials is 2

and in selection of material 1 we will see that what are the parameters governing the selection process of engineering materials for different types of product. So what can be the various guidelines that we will try to understand.

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Introduction

- Materials selection is an important part of a larger process of creating new solutions to problems. This larger process is called "**Engineering Design**".

Design of engineering components is limited by the available materials and new designs are made possible by new materials.

Diagram: A triangle with a circle around it, labeled $[x, y]$. Below it, another triangle is labeled $[x, y, z, p, r, q]$. A question mark is written next to it: "How to choose?"

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So the materials selection is an important part of a larger process of creating new solutions to problems. So we try to find out new solutions to the problems and it is an important part, materials selection is an important part in our problem solving approach or in our problem solving endeavour. So the material selection is an important part of a larger process of creating new solutions to problems.

Now we can take an example again of maybe furniture, we are seeing for so many years the design of furniture is changing day by day, why it is changing because new and new materials are being invented. So when new materials are available with the designer he can experiment, he can try to see, he can try to visualize his design in a different manner, because now he or she feels that yes this extra or this additional material is available with me.

And if we can use this material for making our furniture design or making a sofa set, or for making a chair or for making a table definitely new designs will come up why because now new material so the library of materials has increased or the family of materials may have new members. So this new members help the designer to think more creatively and coming with shapes which were not initially possible with the available materials.

So that is the important point in the first sentence that is material selection is an important part of a larger process of creating new solution. So now solutions will definitely involve creativity, it will involve design thinking, it will involve a step by step procedure for finding out the solution. But we cannot ignore the importance of materials in this larger picture. In this larger picture materials will also play an important role in defining the final product or the design of the final product.

This larger process is called engineering design. So when we talk of engineering design we cannot ignore the importance of engineering materials. So it means that engineering design will also require knowledge of the engineering materials and therefore we are discussing this topic that why engineering materials are important and what are the factors governing the selection of the engineering materials.

So design of engineering components is limited by the available materials. So this very very important sentence if we are able to understand this sentence we will be able to emphasize we will be able to highlight the importance of materials in product design. So you can just try to break this sentence into 2 broad categories, this is A and this is B. So if you look at A what is happening in A, design of engineering components is limited by the available material.

So suppose we have a design of a product and we have to choose a material we have limited set of materials that is x and y. So we have a design and we have available set of materials, so this design is limited by the available set why because we can make this design with these 2 materials only and there is no additional modifications in the product design possible because we have available materials only.

But if we come to be new designs are made possible by new materials, now suppose you want to change the shape of this product it was limited by the choice of materials that we have, but now we say we have different types of materials which are available with us now we can experiment with the shape of our product or component why because now we have additional materials.

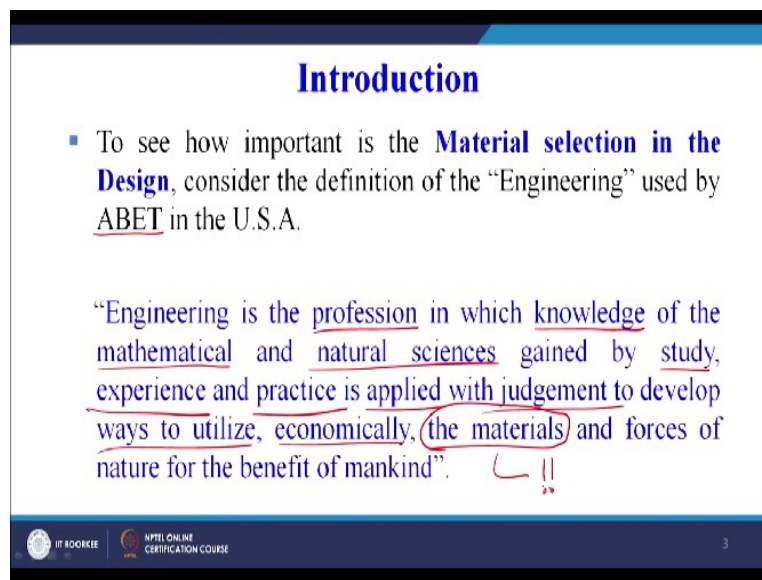
We have 4 additional materials which are available with us, so they are definitely we can experiment with the shape of the product with the size of the product, with the functionality of the product, with the aesthetic of the product why because now we have large variety of

materials that are available with us. But the problem is now if we have a large variety how to choose or what is the criteria that we must follow to select a material out of these materials.

And I think this we have already discussed with the help of a chair in one of our previous sessions. So these are tool we can say guide guidelines or guiding factor when we talk of material representation or importance of materials in context of product design. so limited materials we have limitations in terms of product design, a wide variety of materials we have a choice to design our product accordingly.

But then there is a problem that how to choose the best material for the product and for that we are trying to discuss today. Now material selection is important, another important a definition of engineering that is there on your screen.

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Introduction

- To see how important is the **Material selection in the Design**, consider the definition of the “Engineering” used by ABET in the U.S.A.

“Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgement to develop ways to utilize, economically, (the materials) and forces of nature for the benefit of mankind”.

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This is material selection in the design so the definition of engineering says now this is according to the accreditation board of engineering and technology in the USA. So we can see this destination this is very very important definition. Engineering is the profession in which knowledge of the mathematical and natural sciences. So in this profession we use the knowledge of the mathematical and natural sciences which is gained by.

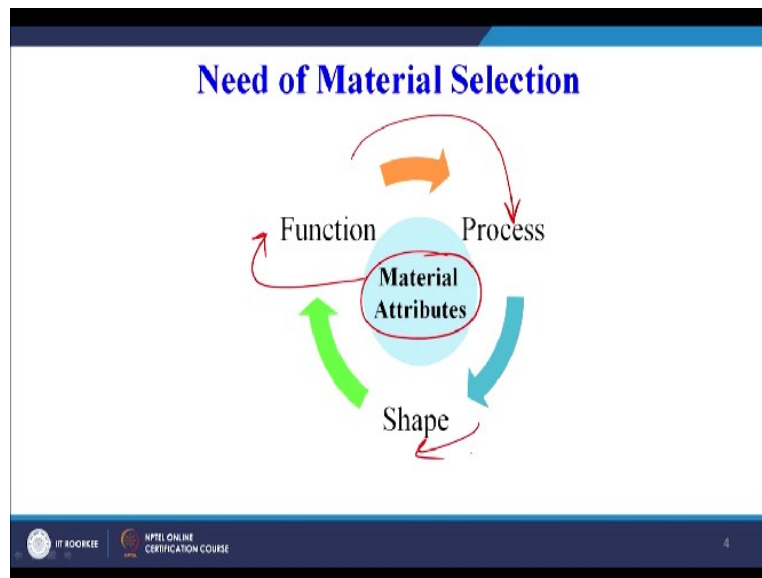
How do we get this knowledge by study, by experience and practice. This is applied with judgement to develop ways to utilize economically the materials, you can see the importance of materials here. So what we do in engineering, we try to apply our knowledge of

mathematical and natural sciences. Now how we have gained this knowledge, we have gained this knowledge by study, by experience, by practice.

And then we try to apply this knowledge to economically use the materials and forces of nature for the benefit of mankind. So we try to develop tangible products which are going to affect the mankind or which are going to make the life of people easy, life of people may be happy. So therefore the materials are also an important aspect in any engineering design which cannot be ignored.

So we have to highlight the importance of engineering materials and it is also highlighted in the definition of engineering. Now let us see the need of material selection already we have now I think amply address this point that what is the importance of engineering materials. Now let us try to see that what are the factors that will govern the selection of material. Now material attributes are very very important.

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And how they are important because they will define the function, the process which is going to be used for making the product as well as the shape of the product. So the need of material selection is important because it will further lead to the decision related to the functionality of the product, the process that is going to be used for making the product as well as a shape that can be given to the product.

Now if you remember in our 1st week of discussion we talked about the basics of manufacturing processes and shape was an important criterion there. So different processes

can make different types of shapes. Similarly we can say different materials can take different types of shape, there can be materials which are which we may not be able to give a very very complicated shape even with the most advanced manufacturing process, so shape, functionality.

The process that is going to be used are definitely going to be dependent upon the material attributes. So we need to have a basic understanding about the engineering materials, we have already discussed if you remember the classification of engineering materials and then we have taken the basic characteristics of the different materials, but we have 20 hours of discussion with us.

So we are going to discuss 2 and half hours on engineering materials which I believe is not adequate time to properly understand the concept of material. But why we have included it is that as a product designer every designer must have a basic idea about the materials. Because if that basic idea is missing that design that the designer proposes may be sent back from the manufacturing department.

Why because it may not be feasible to produce that product as per the material suggested by the designer or as per the manufacturing process suggested by the designer and therefore in order to avoid that iteration or to avoid that review of the design or to avoid that reworking of that design it is better that we have fundamental understanding of the materials as well as the processes before passing on the final design to for manufacturing or to the manufacturing team.

And in these days such situations are rare why because the product development team has experts from manufacturing also, from marketing also, from legal cell also, from copyright protection or IPR related, lawyers also are in the product development team. So therefore all these things are taken care of but when a designer is sitting and he is conceptualizing an idea he must have basic understanding of the materials, the processes.

And **this** there is an importance to study this course. So these material attributes are going to affect the functionality, the process as well as a shape that we can give to our product. Now what is the challenge in selection. We have understood now completely that engineering

materials play a pivotal role in the product design process. Now there is a wide variety of materials available with us, it is given in the very first sentence on this slide.

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The Challenges in Selection

An ever-increasing **VARIETY** of materials are now available, each having its own

- **Characteristics**
- **Applications**
- **Advantages**
- **Limitations**

Handwritten notes in red ink:

- Metals
- Alloys
- Polymers
- Ceramics
- Composites
- Plastic
- Product
- design
- Under water applications
- Boat
- Aerospace applications
- ???

“Select the optimal material according to the design and in-service requirements”

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The ever increasing variety of materials are now available, each having its own, now each material if you see a variety what is the variety, if we talk of variety we have if you remember metals, alloys, polymers, ceramics, composites and a lot of other families of materials. So we see just 5 families here but they are other family as well. So we can see that we have a large variety and our of this variety we have to choose that which one is going to be the material of choice for my product design.

Whether I am going to make it in plastic or I am to be propose this product design in metal or I am going to propose this product design in a ceramic, now that will depend upon the characteristics of the materials that will depend up on the applications that are possible with that material and this this application and advantages will depend upon the properties of the material which we have already covered.

If I ask you just I may give you 10 seconds to just remember what are the various properties of engineering materials. We have already taken 1 lecture of half an hour on that which was not a very exhaustive lecture. But still we were able to understand that what are the import properties of engineering materials and we have seen that there are physical properties, chemical properties.

As well as we have seen physical, chemical, mechanical properties, thermal properties. So all those properties will define the applications with those will define the advantages and limitations of the materials. So each of these materials will have their characteristic application, the advantages and limitations. Now we have to see that which one out of this we must choose for our product design.

Suppose we say that we are going to use a polymer, so it is going to be a plastic product that I am going to make. So have to choose this process or how to choose the materials. So we have a long list, we have to choose one, we have taken the this is and this answer we have to our problem, but how to choose that is one important point that we must all understand as product designer.

So therefore we need to select the optimal material, now this optimality is a big question mark, we have to select the optimal material according to the design, so this is 1 guiding factor here, we have to see the design and second thing we have to see the in-service requirement. So first thing is we have to focus on our design as I have already told you in the very beginning in today's session where we have taken that we have a design.

So we have to choose from a set of materials which are already available x and y but if we want to do modifications in our product design if we have a new material or a list of new materials available we have more choice in terms of changing the shape or changing the functionality of our product. But if there is a limited set of materials available we will be limited in our design thinking approach.

So that is an important point that has to be kept in mind. So that is what is governing factors here that we have to choose optimal material but that will define that will depend oh sorry on design as well as it will depend on the in-service requirements. Now in-service requirements can be that the it is going to be used for under water application, one important in-service requirement or it has to be always used in sunlight only or it has to be used for aerospace applications.

So in-service requirements in aerospace applications will be different as compared to ground surface applications. So depending upon the in-service requirement we have to choose our material. So the design and in-service requirements are the guiding factor for selecting a

material for any application. Now this selection will depend upon now we have seen that there is the challenge of selection.

There is the large variety of materials available we have to choose from among those materials, now how to choose, we will choose based on the design as well as the in-service requirement. Now how or what are the quantifiable parameters that we will use for selecting the material.

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Selection Depends on ...

- ✓ Mechanical properties (Hardness, Strength) *Modulus, toughness,*
- ✓ Physical properties (Density, Melting point)
- ✓ Chemical properties (Corrosion, Toxicity), *oxidation*
- Manufacturing properties (Machinability)
- Cost and availability
- Service life
- Recycling and waste disposable

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We can look at the mechanical properties, they are usually quantified we have hardness, there are scales in which hardness is measured, we have strength, we can measure the tensile strength using the universal testing machine UTM, and find out the strength of a material, now that data sheets are already available and if you refer back to our discussion in the properties of engineering materials towards the and one data table was given in which all the mechanical and physical properties of the different metals and alloys we depicted.

So those type of tables are available in which we have quantified properties means the values of the various properties like for steel or a particular type of steel what is going to be the strength specifically the tensile strength or the compressive strength or the shear strength all those values are already available. So when I am designing the product I will do the analysis of the product and find out that how much must be the strength of the material that I must propose for this type of a product design.

And for that I can refer back to the data book and find out that which are the material which have the strength more than or better than the strength that is required for my product. So I will definitely select the material which is having better strength. So similarly hardness also and these are not the only 2 properties we may also depending upon the application, we may also like to look at the toughness properties of the materials.

In many cases we may be interested in the modules of the materials that we are going to propose for our product design. So the mechanical properties play an important role and these are quantifiable values and these are may be mathematical value which will help us to select a material for a particular application. Some materials will automatically get screened out based on the mechanical properties.

Because the kind of strength, the kind of hardness, the kind of toughness that we required sometime that kind of 3 properties that we require may not be satisfied with a specific set of materials. So those materials will automatically get screened out. We will be left with the certain set of materials which satisfy the property as per our product design. So that is can be one guiding parameter for shortlisting or screening the materials for our product design.

The second can be the physical properties. So physical properties like density melting point, boiling point, all these properties will help us to screen out some of the material we will select the best material which suit to our product design as well as the application for which the product is being designed. So the physical properties will also help us select the material and if you remember just today's session only we have seen the material attributes they influencing the shape.

They influence the functionality, they influence the process, so physical properties may also help us to select or define that which process we can choose for making our product design. So basically once we select a material it is may be a cyclic process we will we may first like to you decide on the matter and then look for the manufacturing process or sometime we may have to change our design because of the manufacturing facilities that we have.

So if suppose I can propose a product design in plastic but we may not be having the machine which will be able to process the plastics. So therefore we may also be limited sometimes with the manufacturing facilities that the company has. So therefore physical properties will

also help us to select the materials accordingly. Similarly the chemical properties, such as corrosion, toxicity another one can be oxidation.

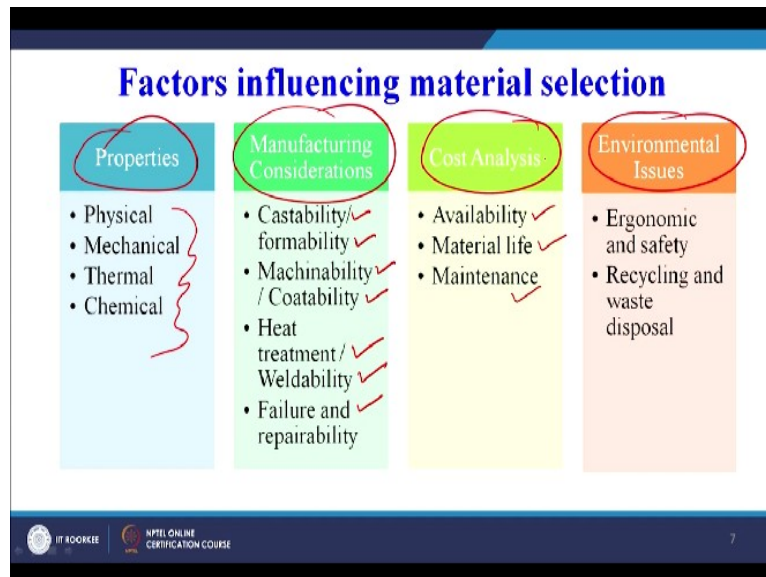
So all these properties will definitely help us to select the material, then the manufacturing properties such as machinability, we will see there can be other manufacturing properties also cost availability, weldability formability. So that will help us to select the materials cost and availability, service life, recycling and waste disposal. All these are also important parameter which have gained significant relevance in today's scenario.

Now waste disposal as all of you know is a very very important parameter these days and there is a talk about sustainability green environment, green product, green processes, so therefore we must select materials which are healthy which are we can say environment friendly which are easy to dispose of which we can dispose of into the environment without causing any harm to the environment.

So this waste disposal recycling are these days playing the most important role in choice of materials that we are going to make for our product design. So if our product can be made or must be made with materials which are recyclable materials which are easy to dispose or materials for which the waste disposal is not going to affect the environment. Similarly the cost and availability is an important criterion.

Even sometimes the material is not available so we may be forced to select a material which is having high cost or is expensive. So these are all the governing parameters, governing we can say criteria which will help the designer to select the material for the product design. So let us see now the summary of these and then quickly we will have around if criteria or maybe a listing down of important parameters related to material selection.

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So we can see here properties play an important role physical, mechanical, thermal and chemical as is clear on the screen then the manufacturing consideration in the last slide only we have written in machinability we can also talk of castability, formability, machinability, coatability, whether heat treatment is possible, weldability, failure and reparability. Similarly also it was mention cost analysis availability of the material what is the life of the material.

What type of maintenance is required for the materials especially for under water applications frequent painting of the surface of material may be required. So we can choose a engineering material which does not require frequent painting or maintenance requirement for the material may be less. So for specific applications like under water we may choose material which do not require much maintenance.

And the last part was environmental issues I already address related to the waste disposal I already address related to the recycling. So we have to see that the materials like economic and safety must be ensured similarly recycling and waste disposal also play a very important role in defining the choice or in defining the material that we are going to use for making our product.

So I think with the time constraint of 30 minutes for each session I will conclude the today's session here and the next session quickly we will have quick review of all these properties and then we will try to carry forward our discussion related to step by step or a systematic process for selecting a engineering material with the help of a case study we will try to understand.

So today's conclusion is that we have tried to find out the importance of selection of materials, we have tried to revise that what are the various types of engineering materials, we have tried to list out the criteria which will help us to select a engineering materials for a particular product design and finally we have tried to classify the factors that influence the material selection in this slide. So a summary of all these 4 parameters we will have in the beginning of the next session, thank you.