Manufacturing Guidelines for Product Design

Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology-Roorkee

Lecture 15
Ergonomics in Product Design

Namaskar friends, welcome to session 15 of our course on manufacturing guidelines for product design. As you were well aware the today we are going to finish the 3rd week of our discussion and just to have a review of what we have discussed in the last 3 weeks. We will just have a brief overview of the course, in the very first week we discussed about manufacturing, the term manufacturing, the classification of the manufacturing processes, the concept of process capability.

And then we saw the applications for different manufacturing processes as well as the process capabilities of few manufacturing processes, few I mean to say because we have in detail the process capabilities for most of the processes in our subsequent weeks. So, we just introduced the concept the process capability as well as took some examples of some of the manufacturing processes such as casting, injection molding.

And in many cases we have taken very general processes such as forging or compression molding. So, very very few plus a very limited discussion on the concept of process capability we have done in the very first week. So, when the first week was over we switched our attention to the another important aspect of product design that is the engineering materials. In engineering materials we saw the classification of engineering materials.

We have taken the properties of engineering materials with certain examples such as the physical, chemical, manufacturing properties of our engineering materials that we use in our day to day life. And then we have seen with examples the applications of the various types of engineering materials we have seen composites, we have seen ceramics, we have seen alloys, we have seen polymers, we have seen maybe some other materials or miscellaneous materials which do not fall under the specific categories which I have just mentioned.

So, the 2nd week was dedicated towards engineering materials, so for any product design there are 2 or 3 important the that have to be kept in mind. The first one is the design of the product, the other thing is the manufacturing process that is going to be use for manufacturing that product and then engineering materials that are going to be use for fabricating or processing or manufacturing that product.

Then in week third we discussed on the design aspect of the product, now we know there is going to be a selection about the manufacturing process, we have to choose the best process for our product. We have to choose the best material for our product, we have to choose the best design for our product and for designing keeping in mind the manufacturing and the materials in our mind or keeping in mind the manufacturing.

And materials knowledge we have to see that how we must design our product, so that it is effective. So, that it is easy to make, so that it is easy to assemble, so that it is durable, so that it is reliable, so that it is robust. So, in week third we started our discussion with the word robust, so we have seen that when we are designing a product we have to ensure that the product is insensitive to the variations in the environment or to the noise factors.

We have to select our manufacturing processes, select the process parameters for the manufacturing processes, select the engineering materials, select the class of the engineering material in such a way that the product that we develop must be insensitive to the variations. Then we switched our attention to design for x, x can take any value, so we have seen x can be manufacturing, x can be assembly, x can be reliability, it can be quality, it can be safety, it can be cost, it can be production.

So we have seen the concept of DFX, that when we are designing our product we must design it keeping all these aspects in mind and we have taken 1 example of design for manufacturing. In our 3rd week sorry third session for week 3 we shifted our attention towards product those are going to be assembled and assembled also manually. So what are the guidelines that what things, what factors, what characteristics of product design we must keep in mind when the product has

to be manually assembled or the sub parts or the constituents or the sub assemblies have to be manually assembled to get a final product.

And in that case we have seen that there are number of guidelines that need to be taken care of, the guidelines were broadly divide into 2 categories first one were the handling guidelines, the second one were the insertion and fastening guidelines. And we have seen that these guidelines will definitely help a product engineer or a product designer to design the product in the most efficient manner which will be easy to manufacture as well as easy to assemble.

In 4th session of week 3 we have covered another important aspect that was the DFMA guidelines, there we differentiated between DFM and DFA we try to understand the difference between design for manufacturing and design for assembly. And then finally we have seen the DFMA guidelines given by 2 renowned or well established authors in the field of design for manufacturing and assembly.

So, these guidelines will definitely help us to design our product in such a way that our product will be successful in the market. So, 3 broad things that are there for ensuring the success of the product we have already discuss the manufacturing processes, the engineering material and currently we are discussing the design aspects. So the product design, the materials and the manufacturing process are definitely 3 key important point or 3 key ingredients into the success of the product or responsible for the success of the product.

So from design point of view today as you can see on your screen our focus is on ergonomics, so ergonomics is also related to manufacturing and materials, how because once we design a product keeping in mind the ergonomic aspects, we have to select our manufacturing processes, we have to select our materials which will add to comfort of the worker which will add to maybe the productivity of the worker, which will help the worker to perform his or her task with ease.

So therefore we have to take such decisions that how to relate ergonomics with the manufacturing and the materials. So that is ergonomics will influence the design of the product and design will be indirectly influenced by the materials or the manufacturing processes or

otherwise manufacturing processes and materials will influence the design of the product and the design will certainly we influence by the ergonomics aspects of the product.

So, we have to take into account the ergonomic aspects also when we are designing our product and therefore we will have a brief discussion. This topic already we have discussed in our course on product design and development. So again we are trying to relate it with our design aspects related to our course on manufacturing guidelines for product design. Because once we start working on the ergonomic aspects of the product our manufacturing processes and materials also have to be adjusted accordingly.

So or have to be in place of adjusted I think selected will be the right one that materials and manufacturing processes have to be selected accordingly in order to ensure the ergonomic design of the product. So we will try to understand the word ergonomics we will try to see the different types of ergonomics and then we will try to take 1 or 2 examples and try to relate our subject that is manufacturing guidelines or product design with the concept of ergonomics.

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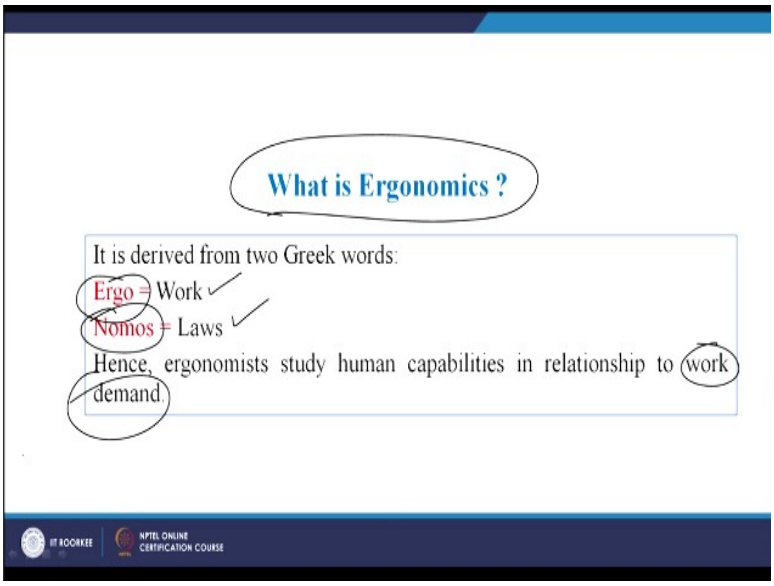

So, let us now start our discussion the word ergonomics is derived from the greek words ergo which means work and nomos which means laws. So, these are the laws governing the work and these laws we have to use, so that we are able to design the work or design the system or design the man machine interaction in such a way that the worker feels comfortable, worker feels safe,

worker feel can work efficiently and effectively as well as productively while performing his or her task.

So, hence ergonomics study the human capabilities in relation to the work demand, so there is a work demand or the work which has to be performed by the worker. And then the ergonomics are people who are expert in the field of ergonomics try to match the human capabilities with the work demand or the kind of work. So, they try to fit the job according to the capability of the worker or they try to design the equipment or the tools or the implements or the assistive devices.

In such a way that the worker enjoys doing his work or it is within his capability to perform the task. For example we can see a person is driving a car, now there is a concept of power steering, there is a concept of power windows, the gear box assembly has been redesigned and it the things have been designed in such a way that the person feels comfortable while driving the car.

So the design has been modified in such a way to ensure the human comfort, so the human capabilities are taken care of and the work is designed so that the worker feels comfortable, safe as well as productive, so we can see a basic definition.

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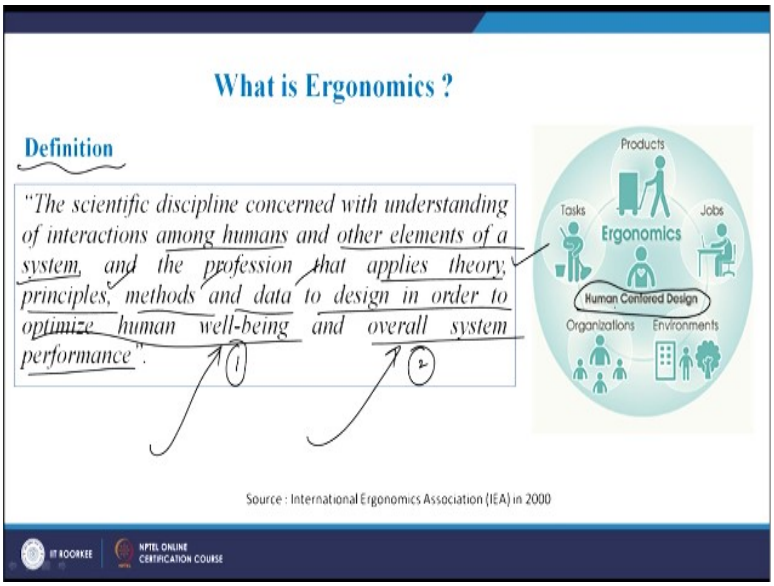

So, this a sources given international ergonomics association, so let us see a formal definition of the word ergonomics. The scientific discipline concerned with understanding of interactions

among the humans and other elements. So the human factor is very very important here and the other elements of a system and the profession that applies, it will applies the theory, principles, methods and the data to design in order to optimize the human well-being and overall system performance.

So, that there are 2 targets here we can see we have to ensure the human being or human well-being and we have to also ensure the overall system performance. So we have to design the system in such a way that the person also the persons well-being is ensured the person feels happy comfortable doing his work as well as the system performance must also not be compromised.

So, both these things have to be taken care of these are the 2 major objectives, now what is the target, the target is to design the man machine interaction or to design the interphase between the man and the machine in such a way that these 2 objective are made and how we will be able to do it that is also given in the definition, we will be able to do it by using the theory principles, methods and data.

So this will be our input, we will have a sound theoretical background based on the principles of ergonomics then we will may use the anthropometric data related to the design that we want to make and standard methods we will use to design this system or to design this interface in such a way that both the objectives are met. The worker or the human resources is also happy as well as a system performance is also not compromised.

So, this is basically there are few inputs then there are few objectives with which we have to design our system. So, this is a basic definition of the ergonomics and here we can see human scented design which is very very important aspect in case of ergonomic. So, the design has to be such that the comfort of the person is taken into account, that is very very important. Now what are the benefits if we include or if we incorporate the concept of ergonomics in our product design.

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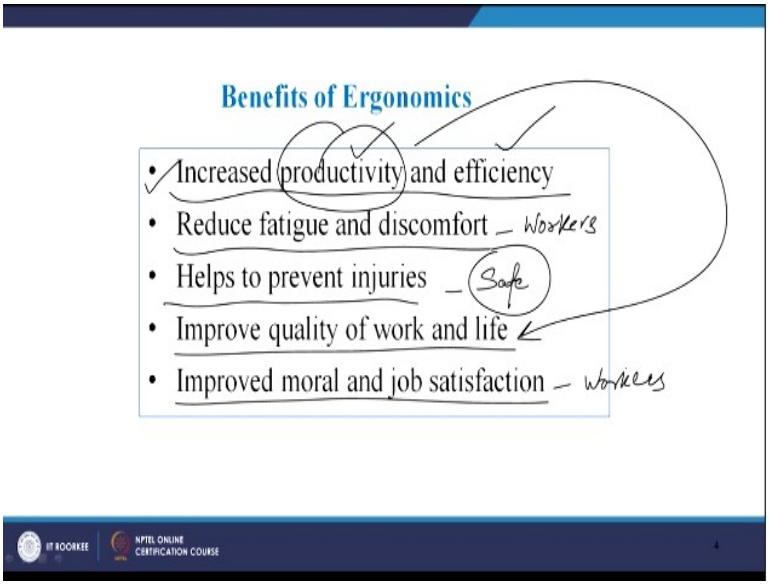

It will lead to increased productivity and efficiency, productivity will increase efficiency will be better, reduced fatigue and discomfort. This is for the workers, the workers fewer will feel happy if they are able to finish the work without much fatigue or discomfort. Injuries are prevented, so it will ensure safe working conditions for the worker, improved quality of work and life.

So, if the productivity will improve the benefits can be passed on to the workers as well as the it may lead to bonus or incentives in their wages. Because of higher productivity less accidents, better conditions for working, so it will overall lead increasing the standard of living of the worker. And since the system is very very safe there will be improved moral and job satisfaction for the worker. So if you apply the concept of ergonomics definitely we will be able to achieve all these benefits or all these advantages.

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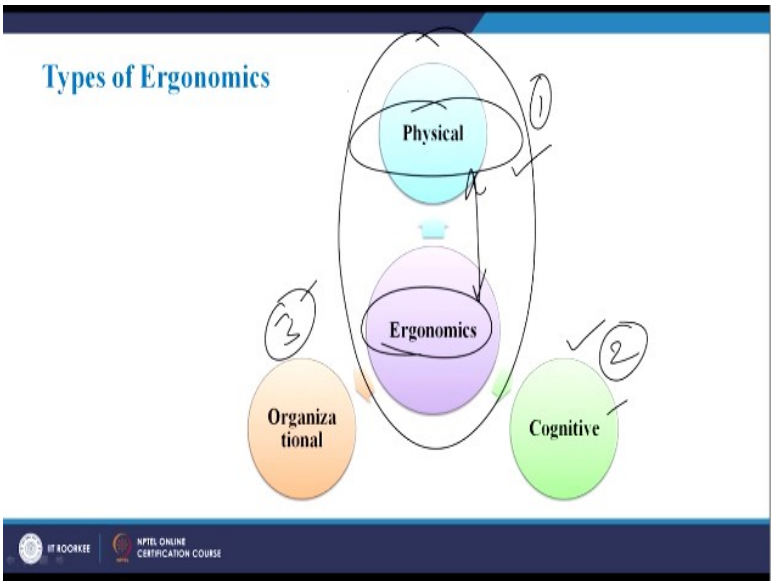

Now what are the different types of ergonomics, we can have physical ergonomics, we will take example of each one of these. We can have cognitive ergonomics and we can have organizational ergonomics. So ergonomics can be of different types but in most of the books in most of the literature that we see mostly we talk about the physical ergonomics only. We usually ignore the organizational ergonomics and the cognitive ergonomics.

In our subject also that is manufacturing guidelines for product design this is our major interface that we have to focus the physical part of the ergonomics. Because we have to design a system and then we have to fabricate that system and then we have to select the engineering materials that will be used for fabricating or manufacturing that system. So our domain is also limited to physical ergonomics only, but let us take example of each one of this.

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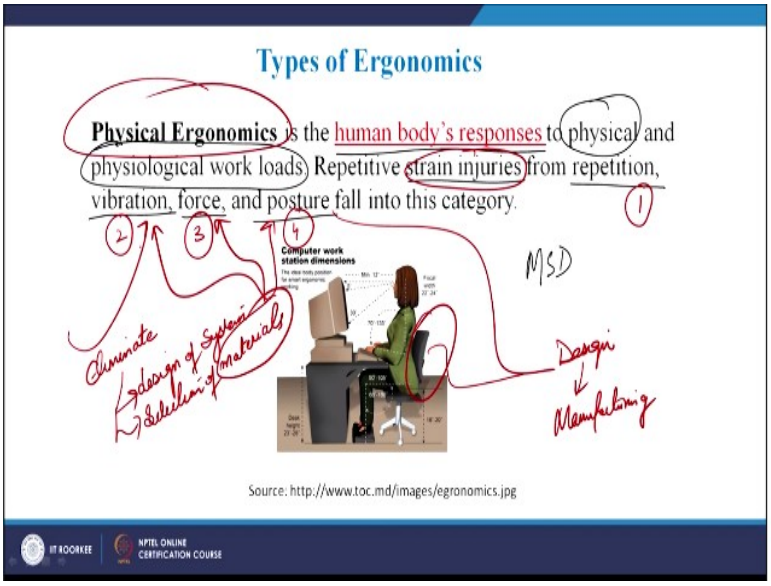

So, physical ergonomics is the human bodies response to physical and physiological workloads. So, human bodies response to physical and physiological work loads, so repetitive strain injuries from repetition, vibration, force and posture fall into this category. So, we can have different types of MSDs which are musculoskeletal disorders because of the poor design of the work system.

So we can definitely try to improve the design of the work system but repetitive strain injuries from maybe repetition, vibration, force and posture fall into this category. Now how we can use our knowledge of manufacturing as well as engineering materials in designing a system which is physically comfortable for the worker. Now we can see the strain injuries, we can see that the strain injuries can be because of repetition maybe 1 problem.

Maybe because of vibrations, because of force or because of the posture, now what we can do, we can try to eliminate the vibrations and how to eliminate. This can be eliminated by design of the system as well as one of the remedies can be selection of materials which can damp the vibrations. So you see materials play a very important role even to absorb the force also with the materials can help us in designing the system.

Now for overcoming the problem of posture what we can do, we can first of all change the design as we can see here, this is a backrest for the lady who is working on the computer. So, this

backrest the design can be changed in order to make the sitting comfortable for the lady or the worker who is sitting here. But when the design will change automatically the manufacturing process that is going to be used for making this seat may also have to be changed.

So, therefore once we change the design it is going to have a direct effect on the choice of materials, it is going to have the direct impact on the choice of manufacturing process. And in this case we have taken an example that our target is about physical ergonomics and in physical ergonomics we can see that vibrations, force and repetition can be maybe eliminated by the proper selection of materials.

And the posture can be done with a redesigning of the part which is required a modification in the manufacturing strategy or the processes. So, therefore this concept of ergonomics is also directly related to the manufacturing guidelines for product design. Because as soon as the design will change the processes and the materials also may require the change.

And moreover here what is our target, our target is to ensure the comfortable working conditions for the workers. So, we have to fit the job as per the workers capabilities, so many times we may require when we go for example to watch a movie we will not like to have a very very hard seat we have to sit there for 3 hours. So, therefore we will require a seat with a cushion, so the cushion we have to select the material of the cushion.

So, that there is proper breathing of the cushion material, so that we do not have lot of sweating. So, the selection of the material is very very important when we have to ensure the comfort of the worker or the comfort of the customer. So, therefore we can say that the are when we change when we consider the ergonomic principles in our design process we have to also at the same time discuss about the materials and the manufacturing processes.

That will help us to achieve our objective of helping the worker in performing his or her task in the most comfortable manner. So, this is the important relationship between man, material, machine, equipment as well as the manufacturing aspects.

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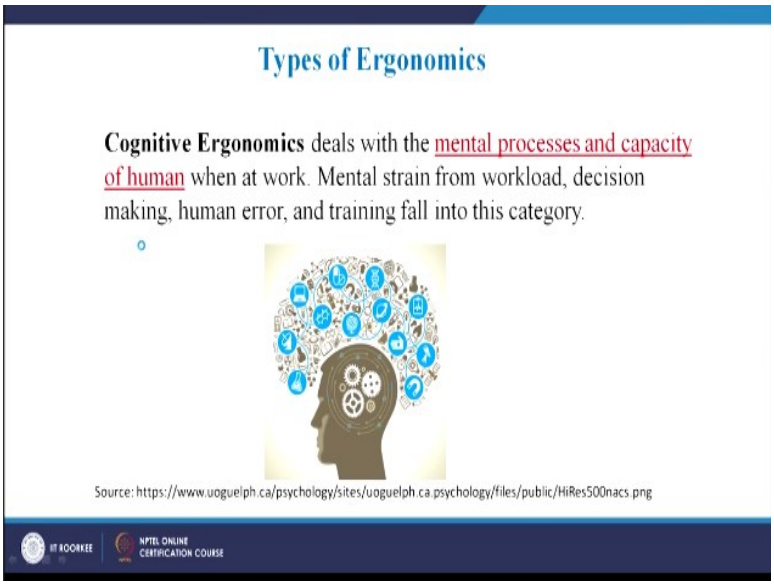

Now let us quickly see the other 2 types of ergonomics, the cognitive ergonomics deals with the mental processes and capacity of human when at work. Mental strain from workload decision making, human error and training fall into this category. So, this is not physical it is cognitive related to our cognitive or the mental faculties and we sometimes maybe once you see that you have to run for 3 hours you will feel definitely tiered.

But physically but if you have told to write a exam for 3 hours you will be tiered still but not maybe physically but mentally after writing the exam you may have some kind of mental strain. Because you have concentrated on the same topic for around 3 hours of time, So you will have that kind of mental strain, so cognitive ergonomics talks about the mental processes and capacity of the human when at work but not in physical term but in mental term. So, mental strain from work load, decision making, human error and training fall in this category.

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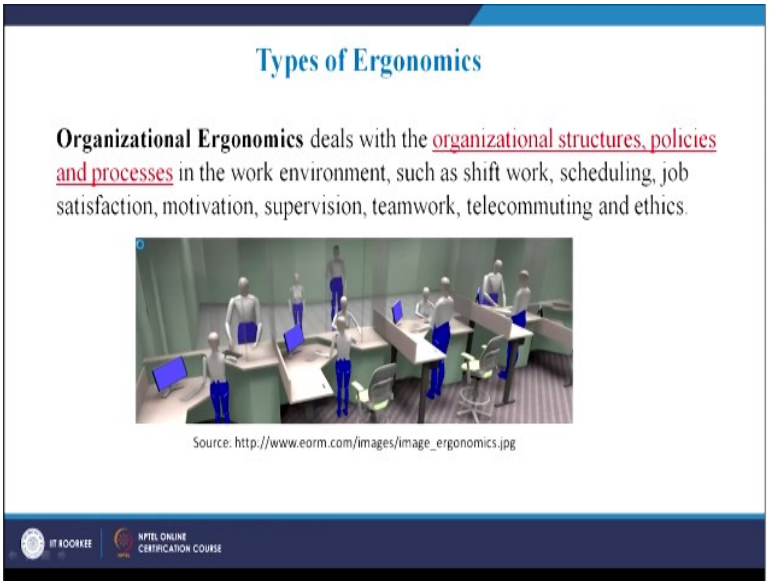

Then third one is the organizational structures, policies and processes these are related to the organizational ergonomics such as shift work scheduling, job satisfaction, motivation, supervision, teamwork and telecommuting and ethics. So, we have seen 3 types of ergonomics physical, cognitive and organizational. So we can say cognitive and organizational around the softer side and physical ergonomics is on the engineering side.

So, we need to work on the physical aspects of our design process, so that we design the product keeping in mind the comfort of the worker. And the design that we do is certainly going to affect the performance of the worker and before fabricating that design the design is going to certainly influence the manufacturing processes and the engineering materials or the choice of engineering material.

So, we have seen that organizational ergonomics is related to the organizational policies, moral, motivation or as well as the team work and communication among the various employees. Cognitive ergonomics is related to the mental strain caused by the kind of mental work the person is doing at the job. But the most important is the physical ergonomics on which we are going to discuss maybe further.

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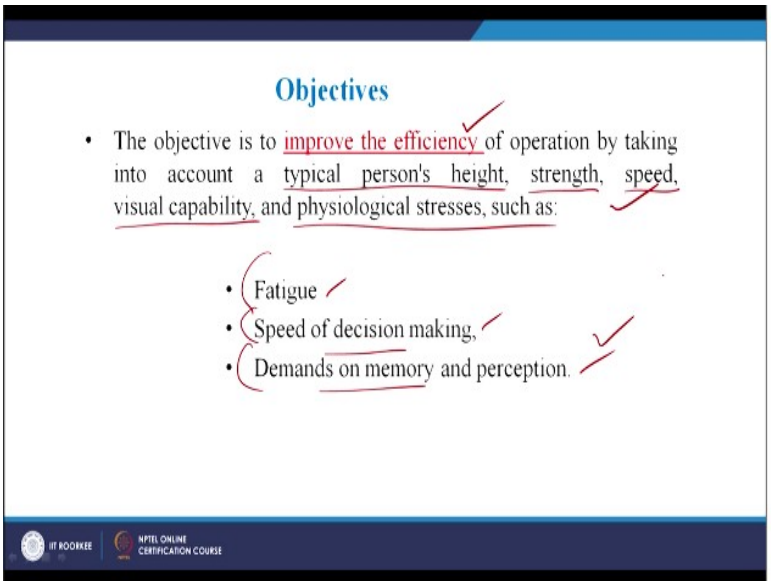

Now what are the objectives of ergonomics, the objective is to improve the efficiency which we have already highlighted. By taking into account a typical persons, so these are all physical attributes, typical persons height, strength, speed, visual capability, physiological stresses such as fatigue, speed of decision making, demands on memory and perception. So this is kind of combination of the work, so the work can be of 2 type can be physical work it can be mental work.

So, here the overall target is to improve the efficiency of operations by taking into account or by designing the system as per the human capability. Human capability in terms of person's height, strength, speed, visual capability, physiological stresses such as fatigue, speed of decision making and demands on memory on perception. So combination physical part is here maybe speed of decision making and demands on memory cognitive part comes here.

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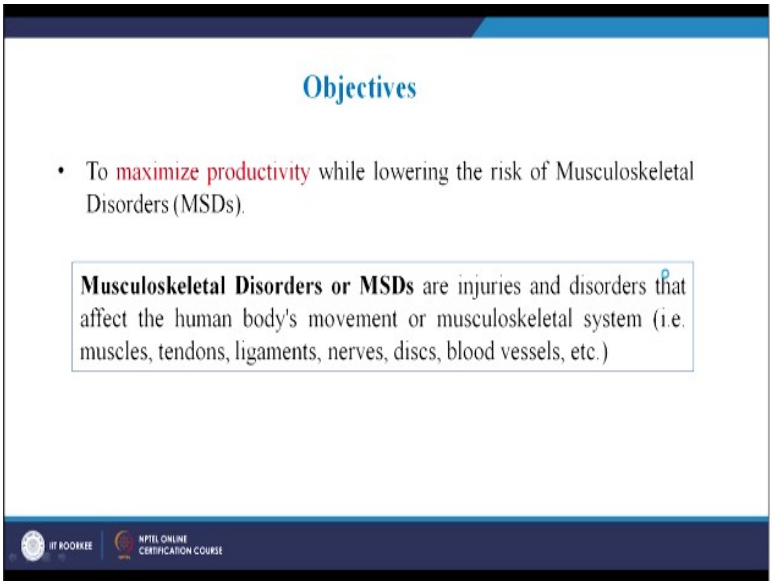

The second is to maximize the productivity while lowering the risk of musculoskeletal disorders. Already I have told in case of physical ergonomics the person is doing the same work again and again it may lead to musculoskeletal disorders. For example if a person is using a mouse all through the day maybe 10 hours in a day and then maybe 5 days of week and then maybe 25 days in a month.

So there may be a problem at his wrist which maybe developing over a period of time, it may not be quite apparent maybe after 1 week or 2 weeks or 5 weeks but maybe after a span of a year or the 2 or the 3. There may start showing the symptoms of a problem in the wrist, therefore the design of the mouse, the ergonomic design that where an elbow must be when we have to do the continuous work on the computer system, what should be the height of your elbow, what must be the height of the computer screen.

All those things have to be designed properly, so that you do not suffer from musculoskeletal disorders. Now what are these MSDs, MSDs are injuries and disorders that affect the human bodies movement or musculoskeletal systems. That is muscles, tendons, ligaments, nerves, discs, blood vessels, so there ought to be problems for doing a continuous work again and again we have just taken an example of a person sitting on a computer system and doing the work continuously.

But if we imagine a worker working on a road side and doing the physical labor everyday maybe 8 hours a day and 40 hours a week. In that case that person if he has to bend maybe 500 times in a day there ought to be some problem in his back. So, those kind of musculoskeletal disorders can be easily taken care of if we design the interaction between the man and the machine or the man and the work in such a way that the worker feels comfortable.

He makes use of the assistive devices, he performs the work using the best method of doing the job. So if he is trained properly these kind of problems can easily be avoided not only the training but the design of the system will also help the worker to avoid such types of problems.

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Now quickly we will take 1 or 2 case studies in the next 5 minutes, so the design of ergonomically efficient chair.

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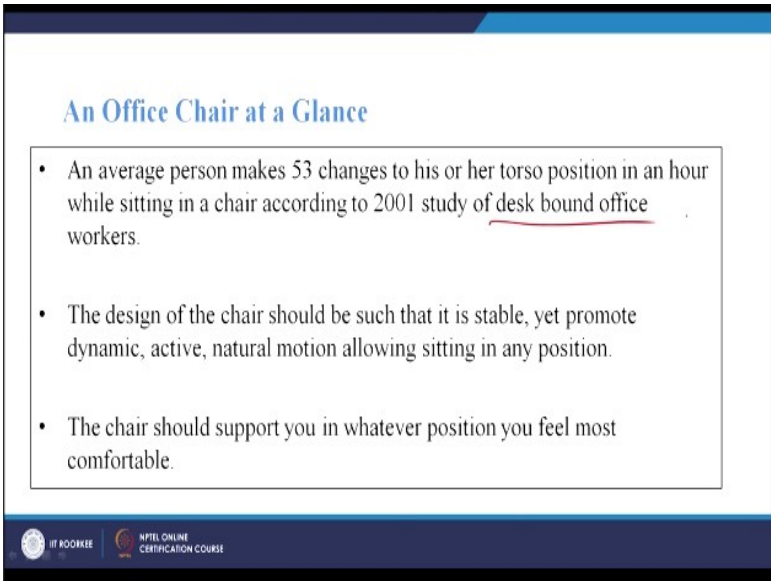

We can see I have taken an example of a person working on a roadside doing physical labor, I have taken an example of another person working on a computer system 8 hours a day, 40 hours a week. So, let us take an example of an office chair an average person makes 53 changes to his or her torso position upper waist position in an hour while sitting in a chair according to 2001 study of desk bound office workers.

So, people who were working on the desk in the office or working on using a table and a chair the design of the chair should be such that it is table yet promote dynamic active natural motion align sitting in any position. The chair should support you in whatever position you feel the most comfortable not each one of us use a chair. And therefore that design of the chair must be such that we feel comfortable, usually I have taken an example we go and watch a movie.

We are there only for 3 hours or maybe or these days we have movies for 2 hours only but suppose a worker has to work sitting on a chair for 8 to 10 hours in a day. Then that design of the chair becomes very very important and the design must help the worker to perform the task in the most efficient and effective manner without leading to long term problems. Such as the MSDs which we have already seen, so for that the design of the chair has to be modified.

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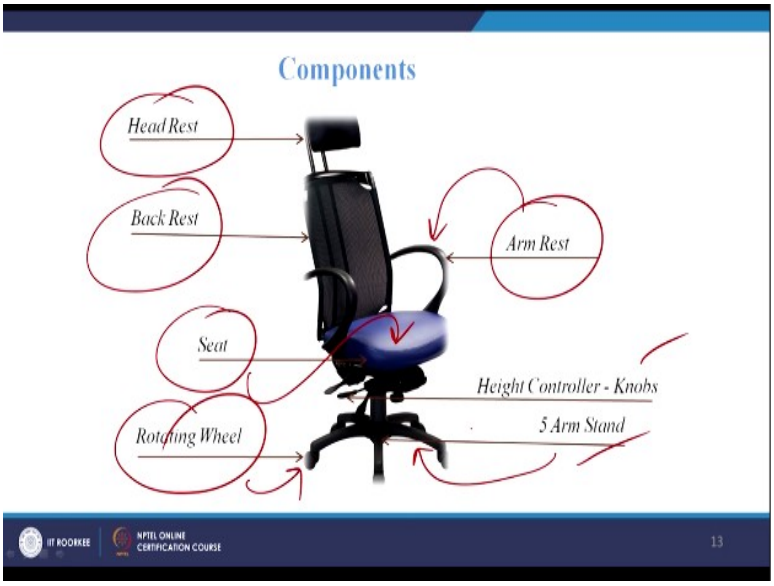

We have to see that what have to be the essential components of the chair which will help the worker to perform the task in the most efficient manner. So, here 1 design is given there is a provision of a head rest, back rest, seat, this is a seat, then rotating wheels here, height control knobs you can adjust the height of your chair as per your height, arm rest is there to provide seating comfort to the arm, then 5 arm stand is there which is having a rotating chair.

So, maybe we can say this type of chair is comfortable for the person if he has to perform the work sitting on it for a longer periods of time. Now for each one of these factors that we have seen for head rest there has to be a tilt angle the height at which the head rest can be adjusted. Similarly for arm rest also there will be guidelines that what must be the height of the arm rest above the seat, what has to be the width of the seat, what has to be depth of the seat, what has to be the thickness of the foam which has to be used for making this seat.

Then what has to be the material of the foam that is selected or the material of the cloth that is selected for covering the foam. So, all these things what has to be the material of the stand which is going to having maybe 5 leg stand, so what is going to be the material of that, what has to be the material for the arm rest. Because your arm is in constant contact with the arm rest, so the arm must not got sweating being in contact with the arm rest.

So, all these points have to be taken into account then once the design is final we have to move

to the manufacturing of this design. And there also we have to select the processes in such a way that we have to select the assembly operations in such a way we have to select the manufacturing processes in such a way. We have to select the parameters in such a way that whatever comfort index we have included into our chair, whatever comfort we have try to design in our product it is not affected by the manufacturing, so that is also very very important.

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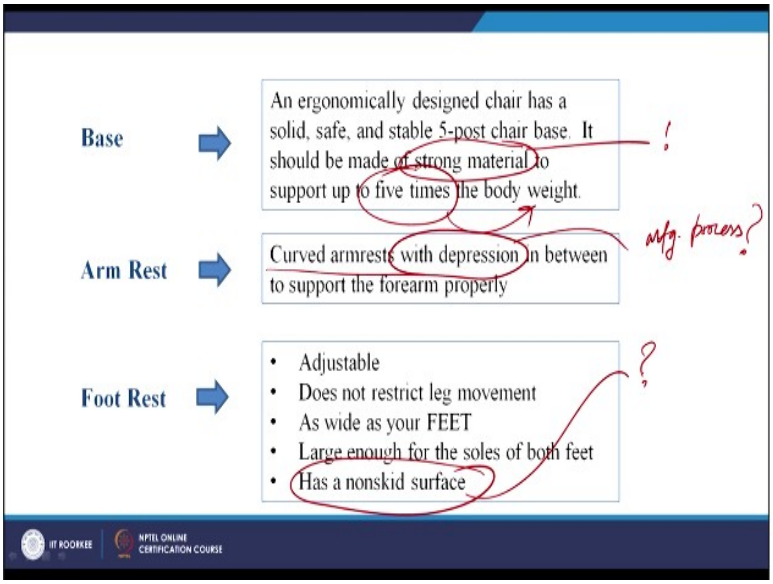

So, let us quickly now see that what can be the guidelines the base, an ergonomically designed chair has a solid shape and stable 5 post chair base. It should be made of strong materials, so you can see the concept of material is coming into picture to support up to 5 times the body weight. This is a guideline 5 times the body weight must be supported, so we have to select the material accordingly.

Curved arm rest with depression in between to support the forearm properly, now curved armrest with depression. So, which manufacturing process will be able to produce this type of a shape we need to take a decision about. Foot rest it must be adjustable does not restrict the leg movement, it must be as wide as your feet, large enough for the soles of both feet and has a nonskid surface how to produce this, which manufacturing process will help us to produce this nonskid surface.

So, therefore the concept of design, the concept of manufacturing the concept of materials, this is an integrated approach of coming up with products which will be successful in the market. Now

relaxed posture that helps relieve the person on your postural muscles which can decrease fatigue and increase comfort.

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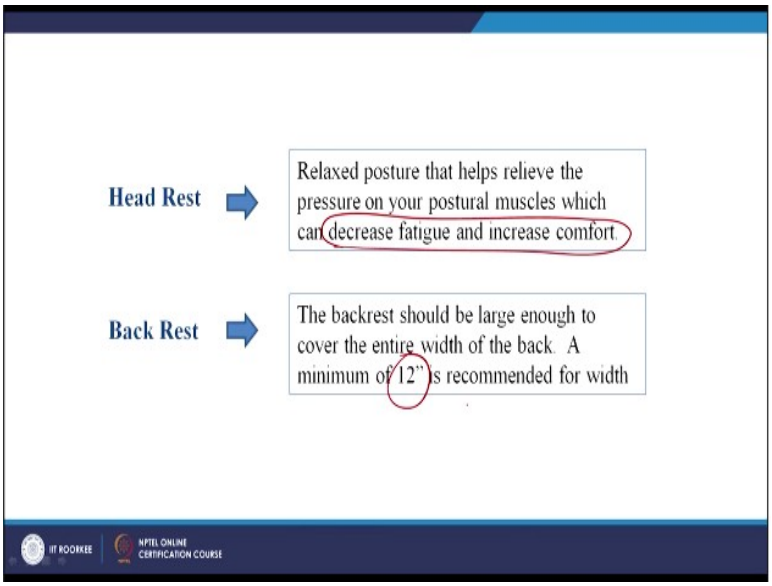

So, head rest we have to select the angle because we want to decrease the fatigue and increase the comfort of the person who is using the chair. Back rest, the back rest should be large enough to cover the entire width of the back a minimum of 12 inch is recommended for the width. So, this is just the standard guidelines which can be used for design of a chair but once the design is ready the role of materials and manufacturing will automatically creep in.

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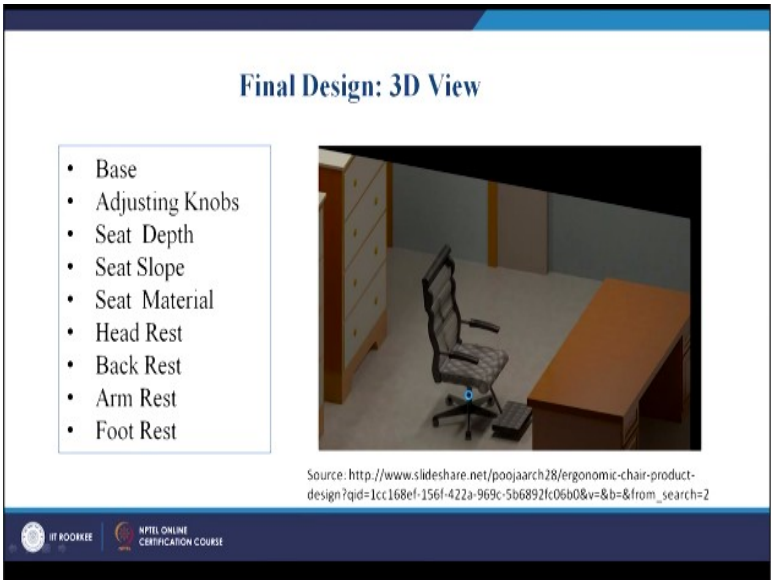

So, this is the final design of a chair.

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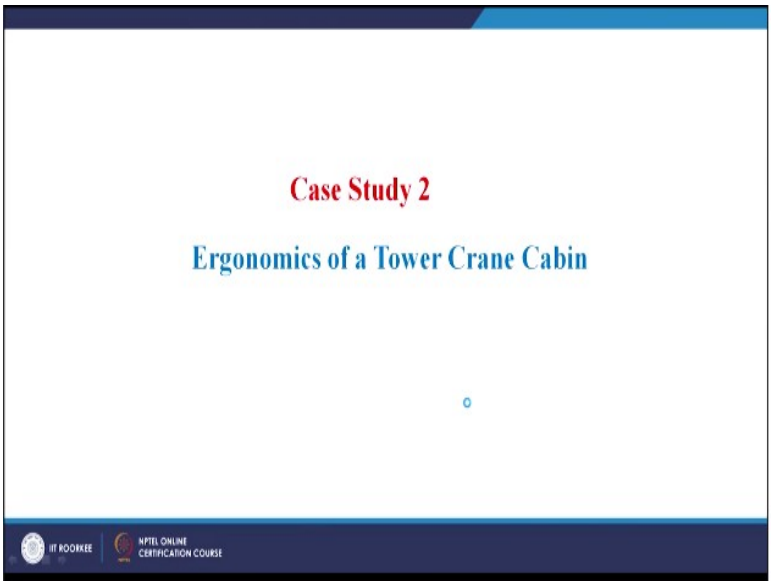

So, quickly let us now go to the second case study.

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Here we have this tower crane cabin where the person has to sit and operate at a height, this the height at which has to be operated. So, you can see a person is sitting here at a height and he is trying to operate, now what can be the guidelines for designing such type of a system.

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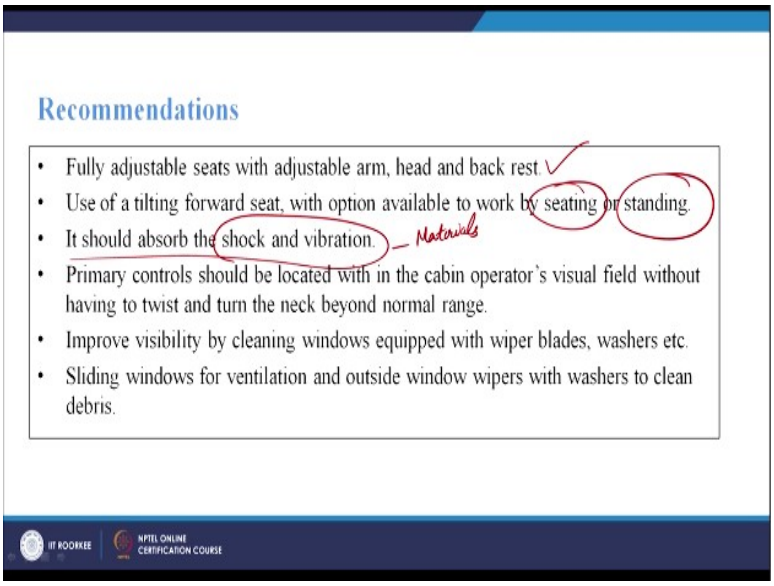

Fully adjustable seats with adjustable arm, head and back rest already we have seen in the previous case study that chair has to be properly designed. Use of tilting forward seat with option available to work by seating or standing, so we have to provide the flexible design to the chair. So, that he can work in sitting position also as well as in standing position also it should absorb the shock and vibration what type of materials must be chosen.

In order to ensure this shock absorption and vibration dumpling**,** primary control should be located within the cabin operator's visual field without having to twist and turn the neck beyond the normal range. So, whatever control mechanisms are there must be within the normal reach of the person, improve visibility by cleaning the windows equipped with wiper blades, washers etc.

Sliding windows for ventilation and outside window wipers with washers to clean the debris. So, these are few guidelines for a person who is operating the crane and he is using this chamber which we have seen here this is a tower crane cabin which is the person is using. So this design of a tower crane cabin has to be done in such a way that the person is able to perform his task in the most efficient and effective manner.

So, with this we can conclude the today's session with the important conclusion that when we are designing a product we have not only to focus on how the product will look like. But we have to see that the product has to ensure a good working condition for the worker. For example the

tower crane cabin we must not only talk about the aesthetic but also the functional aspects of the tower crane cabin.

And it must ensure a good interaction between a man and the system, the system in this case is a tower crane cabin. Similarly a chair has to be designed in such a way it has to be manufactured in such a way the materials have to be selected appropriately and judiciously. So, that the worker who is using that chair or the person who is using that chair feels comfortable sitting on it for longer durations.

So, with this we conclude our discussion for week 3 and in week 3 we have tried to address the basic aspects of the design process for the product. And we have seen the concepts of robust design, DFX, product design guidelines for products should be made by manual assembly, DFMA guidelines and the ergonomics. So, this is a complete compact design thinking that we must keep in mind while we are designing a product.

And this design is certainly going to affect the manufacturability as well as the assembling of the parts. So we will see that when we go to the next week we will try to focus more importantly on the selection of the processes as well as the design guidelines from the manufacturing point of view or maybe the topics like design for machining, design for parts to be made by injection molding, so all these topics maybe week by week we will be covering in our subsequent discussion.
Thank you.