Product Design and Development
Dr. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 15
Ergonomics in Product Design

[FL] friends, welcome to lecture 15 in our course on Product Design and Development. We have as you are aware broken down this course into 4 weeks. We have already finished the discussion of the first 2 weeks and in third week today is going to be the last session or last lecture.

To revise what we have discussed in week 3, we have taken 4 lectures or 4 discussion sessions in week 3; in first we have taken quality function deployment which is one of the tools for correlating the voice of the customers with the technical requirements of the product. Then we have seen the relationship matrix and the correlation matrix and the benchmarking of our product with the competitors product, which you can say outcome of the house of quality, which helps us in decision making and helps us to focus on the technical requirements or technical functionality of the product.

In lecture 2 we discussed a very important aspect of product design and development that was CAD that is Computer Aided Design. In session 3 we discussed the concept of robust design and we saw that the design that we are making should be free from any noise factors or variations in the noise factor. And in session 4 we have covered DFM and DFA that is Designed For Manufacturing and Design For Assembly.

In design for manufacturing we have taken one example of a sheet metal part that how the holes should be located in a sheet metal part in order to ensure the strength of the component, and in design for assembly we have taken 2 examples in which the number of parts going into the product were reduced, and which led to a significant reduction in the overall cost structure or the cost of the product. And a comparison was also discussed that how the product where after redesigning will help us to achieve cost, to achieve weight, to achieve the lower assembly cost, and in order to achieve the ease of assembly.

So, currently we are in the process of learning the tools that help a product designer in designing a product successfully. So, to name a few tools we have seen quality function deployment we have seen fundamentals of cad only the basic part of computer aided

design we have also covered DFM, DFA concept of robust design and in the same league. Today we are going to discuss the most important aspect, which is related to the interaction between the human and the product and the concept is called the Ergonomics.

We will see how ergonomics will help us to design a product; and what are the organ ergonomical factors that should be taken into account when you are designing a product. We will take 2 examples today and both examples have been selected very judiciously in order to ensure, that we can relate to those examples. It is easy for me as a mechanical engineer to take different examples and relate them to ergonomics which are specific to mechanical engineering students only, but I can understand the wide spectrum or the variety of learners who are joining this course.

The examples taken are simple in nature and related to our day to day life and we will try to relate these simple examples with the fundamental concepts of ergonomics, to start our discussion let us now see the meaning of the word ergonomics.

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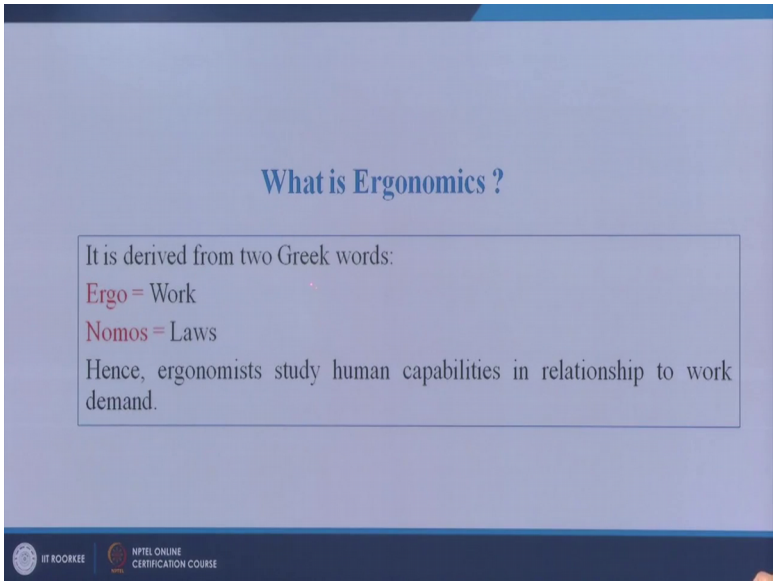

What is Ergonomics? It is derived from 2 Greek words Ergo and Nomos and Ergo plus Nomos make Ergonomics, Ergo means work, Nomo means laws. Hence ergonomist or the people who study, Ergonomics study human capabilities in relationship to work demand.

There are 2 things now, there is a human capability and there is demands of the work, now suppose I have to lift a 20 kg stone or a gunny bag from this place and have to place it 10 meters away, the principles of ergonomics will definitely come into picture why because there is a work demand. What is the work demand, I have to pick a 20 kg load from location A and then make it or place it at location 2 and transfer of this load from one station A to another station B, is what we call as the work demand and I as a human being is doing that job that is the human capability.

It relates the human capability with the work demand and this is done in order to ensure that I may feel happy doing that job and the job should be done successfully without any failure or without any issue or a problem. It is related to human where as capability or human potential we service the demand or the job demand or the work demand or the work that has to be accomplished. So, this is a basic very fundamental definition of ergonomics work and the laws governing the work.

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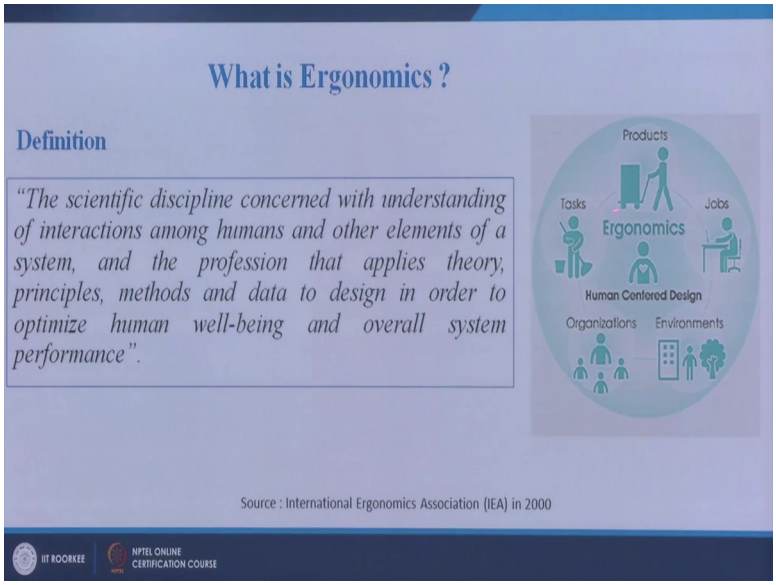

Now, here you see in this diagram the basic concept of ergonomics let us first see this definition, the scientific discipline concerned with understanding of interactions among humans and other elements of a system. So, this is a scientific technique and we what I, what is our aim, what we are planning to do here to understand the interaction between the human being and the part of a system. For example, in this recording studio I am a human being and my interaction with the whole system can be one concept of

ergonomics like I am standing here, I am delivering a lecture, whether I am comfortable, how I will feel after speaking for maybe half an hour, all that means, my interaction with the whole system, I am interacting with this board also, I am interacting with the pointer also, I am interacting with the cameras also.

It is the inter human interaction with the system that is scientifically we have to understand that the scientific discipline concerned with understanding of interactions among humans and other elements of the system, I have given the example and the profession that applies theory, principles, methods and data to design in order to optimize human wellbeing and overall system performance. We have to use theory, principles and methods as well as data; to ensure that we design this system in such a way that I also feel happy, I also feel a state of well being and the overall system performance also improves.

We have to understand this interaction between the human being and the elements of the system and try to improvise this interaction in such a way that my well being also improves, I feel happy working in the system as well as the system whatever is designed or whatever is required out of system is also achieved successfully. Now here you can see in human centered design ergonomics we can design products maybe this trolley can be one product which is assisting this human being to carry this load from one position to another position. So, here this person is interacting with this system or this equipment to complete the work, here the interaction is between the human being and a cart.

Here you see for the different jobs ergonomics can play a role a person is sitting on a chair and interacting with his system or a laptop, this complete system person, chair, table, laptop all this will comprise of one system in which a human is interacting with the work center or the workspace and in order to get maximum output for from the human being as well as from the system we should use the concept of ergonomics. So, that the overall productivity of the organization improves.

Similarly there are other examples also for different tasks we can design this broom in such a way that the productivity of this worker improves, similarly in organizations also the concept of ergonomics can be used, for example, the design of the workspace suppose 10 employees have to work together on us project each one of them require their individual space, how to design the workplace, or the floor, in such a way that the

productivity of each and every employee is maximum, as well as the overall system productivity is maximums all that are the basic concept of ergonomics. It is basically the interaction between the human being and the system which has to be taken into account and we have to use the theory, principles, methods and data to design this interaction in such a way that the overall system performance improves.

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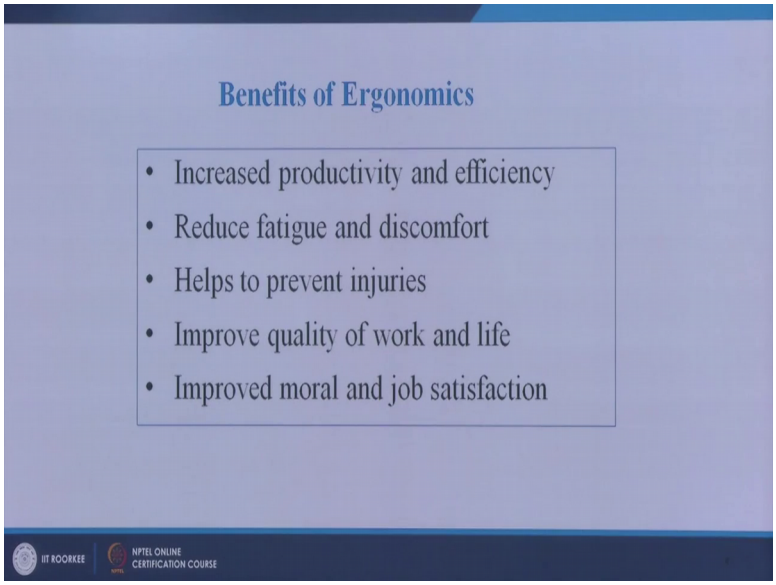

Now, what will be the benefits if we use these tools, techniques, methods, theory in order to design the system we will get increased productivity and efficiency, that is true reduce fatigue and discomfort. The worker will always feel energetic and enthusiastic to do his job, if the worker is given the job which is ergonomically designed or he is working in a system where he feels that he is feeling comfortable and he would be always motivated to do more for the organization.

It helps to prevent injuries improve quality of work and life of the worker, improved morale and job satisfaction, these are only maybe most important advantages or benefits of ergonomics. There are other benefits also for example, here we see helps to prevent injuries, if the system is ergonomically designed, the numbers of injuries are suppose less the company has to spend less money on paying the premiums or paying the insurance claims for the employees. There are other benefits also that are related to a ergonomically designed system, if our course is product design and development so, ergonomics also play an important role in the design of the product also.

We will see how ergonomics play a role in the design of a product with the help of a case study, it is not that since I am using a general term system that ergonomically designed the system, we can also say that ergonomically designed product. So, that when this product and the human interact with each other the overall performance improves not only for the employee, but for the system as a whole, these are only few advantages that we can accrue out of the ergonomical principles.

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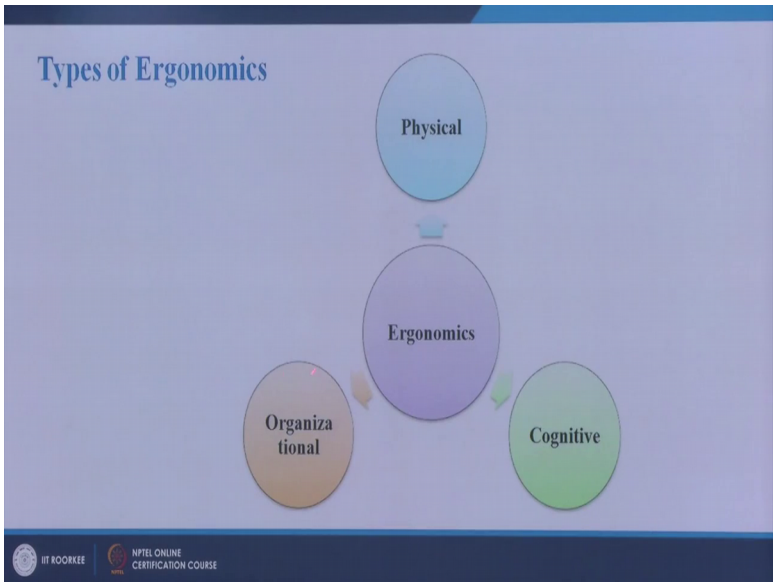

Now, types of ergonomics also we should understand that it is not only related to the tangible products only it is cognitive also as well as organizational. Ergonomics can be applied for tangible or physical products, it can be applied for cognitive domain also as well as for the design of the organizations or the systems or the workplace it can be used for design of floor area. The concepts of ergonomics are universal in nature and not only restricted to only the products, but they can be used for the overall system performance also, we will try to understand all 3 with help of maybe examples if possible.

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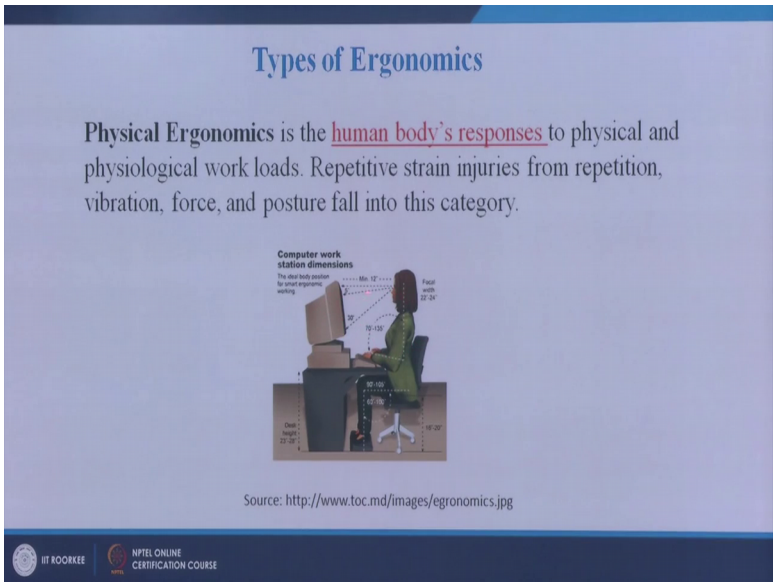

Let us see the physical ergonomics example is here on your screen if I think it is not legible we can see the angles are also marked here 30 degree this angle, 70 to 135 degree this angle between the spine and the elbows, this angle is 70 to 135 degree, height 16 inch to 20 inch given here, all this desk height 23 inches to 28 inches. So, all this is you can say ergonomic design of the physical system or physical ergonomics is the human bodies responses to physical and physiological workloads, repetitive strain injuries from repetition, vibration, force and posture fall in this category.

We have to avoid all these repetitive strain injuries by the design of the product in such a way that the overall performance of the worker improves the fatigue is minimum for the worker and his productivity and efficiency is maximum, that can only be possible if we follow these standard guidelines the ideal body position for smart ergonomic working. If we follow all these standard guidelines during the design of this overall system of a worker sitting on a chair, working on a desktop, if we follow the guidelines the overall performance will improve and the strain injuries because of vibration force and posture will be reduced.

So, physical ergonomics involve the design of the system you can see there is a footrest, also here there is a table with caster wheels, it is a rotate sorry not a table a chair.

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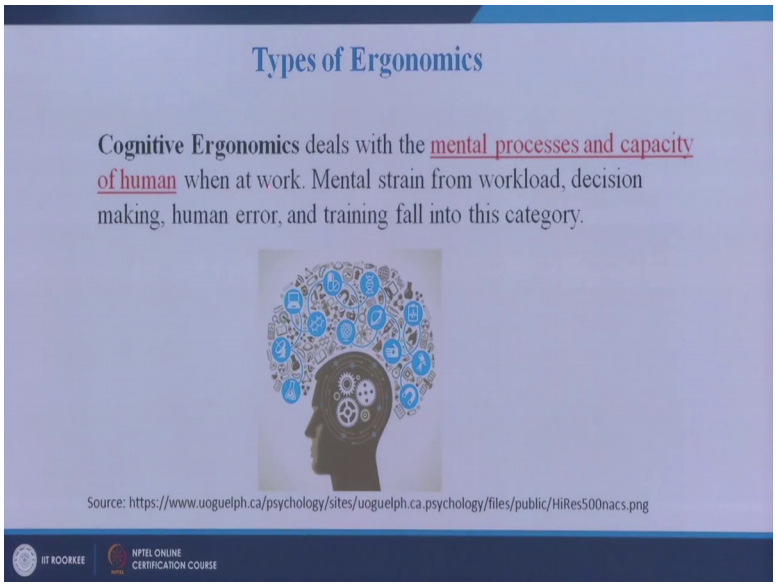

So, that chair is can have a it is a rotating chair, all these parameters can be taken into account in the physical ergonomic aspects. Second is the Cognitive Ergonomics deal with the mental processes and capabilities of human, when at work mental strain from the workload, decision making, human error and training fall into this category.

So, cognitive ergonomics maybe I can take an example that maybe after speaking for half an hour focusing on the discussion, related to the various topics when I finish the lecture I have to take a break maybe for 5 to 10 minutes to come back to my normal, you can say thinking process. Because the focus on this presentation drains out a lot of energy which is not physical, but it is cognitive energy that I spent focusing on the presentation thinking of examples that I can share with all of you. Similarly you will you can experience it yourself when you do a work which is related to lot of concentration you will be drained not physically, but you will be drained emotionally or mentally. If you come out of a very emotive picture or a very emotional movie you will see that you have been drained out emotionally.

Similarly, if you are writing the examination for a for a any subject when you come out of the examination hall you will be physically, but you will be mentally drained out. So, it is not that a physical work only comes under ergonomics, the mental work is also equally important and we can design the work in such a way that mentally also you feel alert and you feel after completing certain tasks. In many of the jobs you may not be

required to do any physical work, but only the mental work. So, the type of jobs can also be designed in such a way that your mental strain, mental stress is reduced to the minimum.

So, ergonomics is not only related to physical well being only it is also related to the mental well being of the workers as well as of the executives. So, 2 types of ergonomics we have seen the physical ergonomics and the cognitive ergonomics a third part a third type of ergonomics is organizational ergonomics deals.

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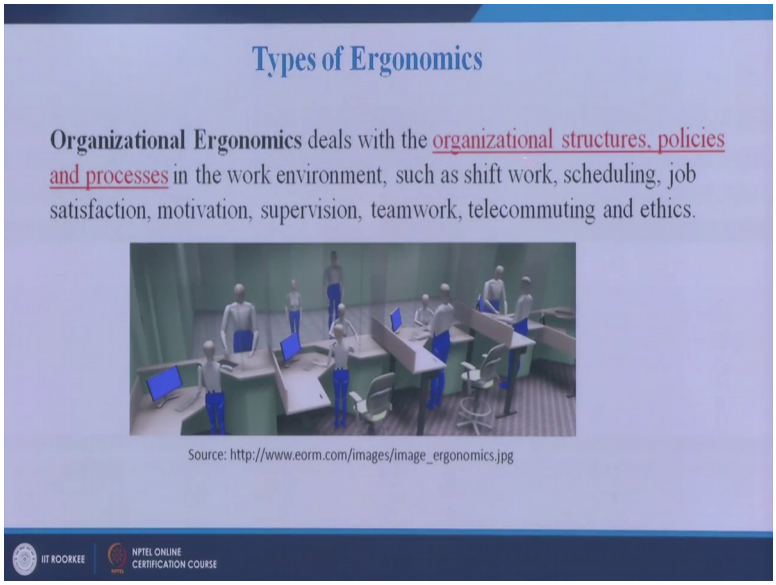

With the organizational structures policies and processes in the work environment such as shift work scheduling job satisfaction, motivation, supervision, teamwork, telecommuting and ethics. So, here we can see number of people working together who are interacting with each other**.** So, ergonomic design of this system can also be done, that if suppose maybe one of the examples can be the banking sector, a person is sitting and maybe most of that time he is in public dealing, and he is talking to people who are coming to him maybe for withdrawal or for depositing the money.

That can come under the organizational ergonomics that how the system can be designed in such a way that this person also feels happy, the customer who is coming to the bank also feels happy, his co workers also feel happy, and at the end of the day your office work is more productive and efficient; how this system can be designed. So, that the overall organization maybe is able to achieve it is targets successfully.

Organizational ergonomics would help us in deciding the work, scheduling, job satisfaction, motivation, supervision, teamwork, telecommuting, and ethics. So, the principles of ergonomics will help us to maybe monitor or control or design or develop maybe procedures and processes related to all these aspects.

So, ergonomics is not only related to product it is re it is related to our mind also, it is related to our interaction with the other system elements also. So, ergonomics can be applied maybe in diverse fields of engineering, and we will take few examples of ergonomics and try to understand it in a much better manner. Now what are the objectives if we have understood that, what is ergonomics where it can be applied then the next stage is that with what objectives we should move forward if we are going to have a ergonomic analysis or ergonomic study of any product.

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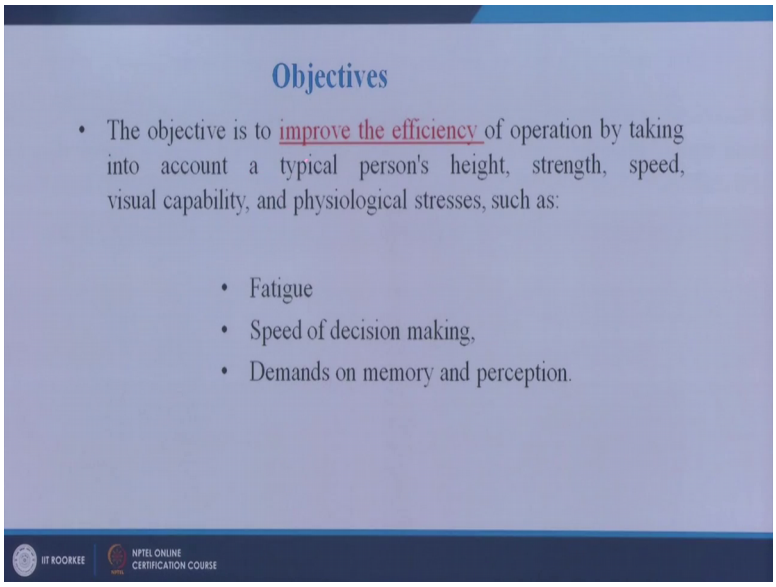

So, our objectives should be the objective is to improve the efficiency, productivity, effectiveness of the operation by taking into account a typical persons height, strength, speed, visual capability, and physiological stresses, such as; Fatigue, Speed of decision making, Demands on memory and perception. These are physiological stresses that are there.

The point is that our objective is to improve the efficiency and effectiveness with which the person is performing his task. So, that can be pos that is possible, if we provide him with a system, or the equipment, or the space in such a way that he is able to perform his

duties, or if he is able to perform his work, up to the satisfaction of his seniors or up to the satisfaction of the management.

This is the overall objective fatigue should be minimized speed of decision making should be maybe we can say fast demands on memory and perception should be such that he does not feel mentally strained out . Therefore, we have to design and we have to take into account his height, strength, speed, visual capability and physiological stresses. So, kp when we take into account all these things and we design the system then we can say that the design has been done taking into consideration the ergonomic aspects of work.

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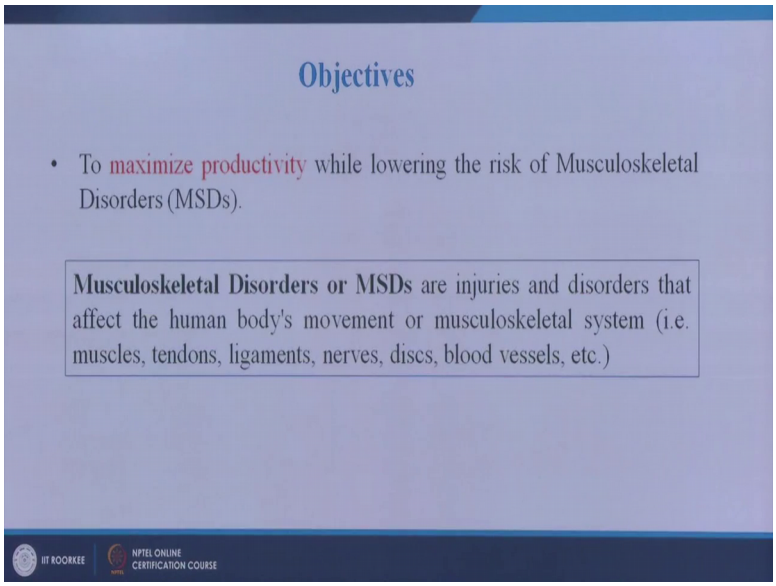

Second objective can be to maximize the productivity; first example was to improve the efficiency, second is to maximize the productivity by lowering the risk of musculoskeletal disorders usually in ergonomic terms they are called as the MSDs. So, Musculoskeletal Disorders, what are these MSDs let us see are MSDs are injuries and disorders that affect the human body’s movement or musculoskeletal system that is muscles, tandems tendons, ligaments, nerves, discs, blood vessels etcetera.

Now, suppose somebody is doing a repetitive job or he is working on the mouse throughout the 8 to 10 hour shift, maybe he may develop a numbness, in the thumb, or in the fingers, or maybe it can sometimes in the complete hand, sometimes his wrist may have some pain because of the musculoskeletal disorders or MSDs. So, repetitive work

strenuous work of any body part may lead to maybe kind of work related problems or work related musculoskeletal disorders.

So, that have to be eliminated or that have to be avoided, how we can avoid that we can avoid that by proper design of the system. So, that these types of problems do not arrive and if these types of problems will not happen your overall productivity will improve. So, ergonomics will help us to avoid this type of musculoskeletal disorder and when we are designing a product we should take into account this thing that if this product is to be used by a human being for a prolonged period of time.

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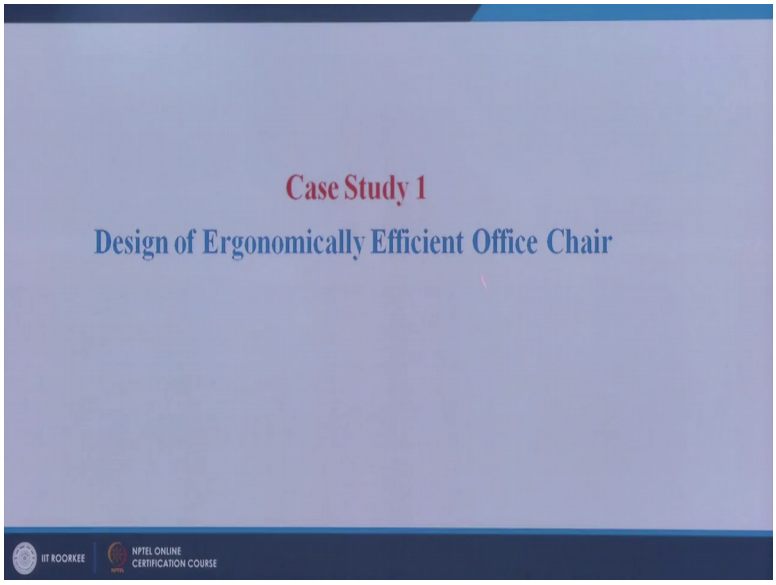

The product should not lead to the MSDs in the worker.

Now we will try to take maybe in the next 8 to 10 minutes case studies to case studies we are planning for today. The case study one is a ergonomically efficient office chair. So, we all of you are using chairs. So, we need to understand that how the concepts of ergonomics can be used for the design of a chair. So, that the person who is using the chair is able to perform his tasks efficiently and effectively.

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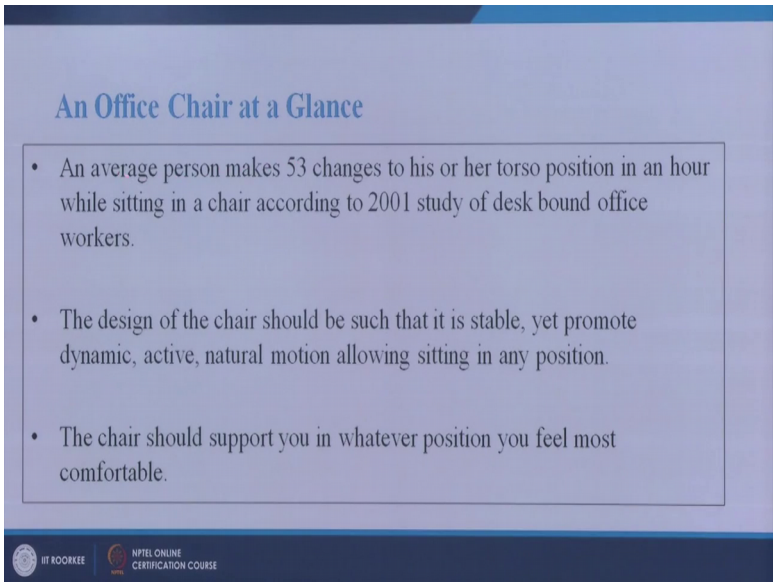

Now, let us see an office chair at a glass this is just a summary an average person makes 53 changes to his or her torso position in an hour, while sitting in a chair this is according 2001 study of desk bound office workers or 53 changes to his or her torso. So, torso is maybe this portion of our body. When we are sitting on a chair we keep on moving sometime we may move forward sideways, backwards so, we make different positional changes while sitting on a chair.

These changes may lead to certain issues related to our body, when we are sitting maybe for 8 to 10 hours in a day on the single chair and for continuous ours. If it is a sedentary type of job person sitting on the chair may have certain problems. And therefore, the concept of ergonomics should be used for the design of the chair. The design of the chair should be such that it is a ste it is a stable, yet promote dynamic, active, natural motion allowing sitting in any position.

So, the chair should be designed in such a way that a person who is sitting on the chair should feel comfortable and maybe after long hours of duty he should feel maybe enthusiastic and energetic, he should not feel lethargic after sitting on a chair for a long duration. So, we have to design that chair. Now just as a common sense if we if we I can ask you that what are the parameters that you will take into account. Most of you will be able to answer this question you will say sir the back should be adjustable, it should have a armrests, the seat should be adjustable, seat should be in z direction we should be able

to adjust the seat, there should be footrest, it should be a revolving chair. So, these are all common sense answers, yes all these answers are true, but what should be the ideal height? What should be the height of the armrest in inches or in centimetres, what should be the angle of the seat?

What should be the cushioning provided in the seat? What should be the material of the cushion? How many wheels should be there if it is if it is are aware revolving chair. So, all those design aspects have to be taken into account when you are manufacturing a chair, and when you are manufacturing a chair you have to first design that chair, and once you are designing that chair you have to keep into account the ergonomic aspects now what are these ergonomic aspects we will just see in the design of the chair.

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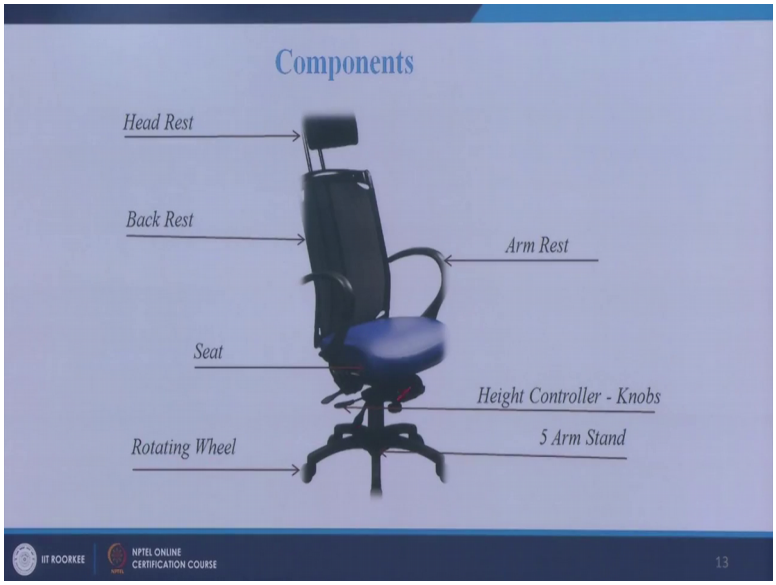

This is you can see the components already I have mentioned, it can have a headrest, backrest, seat rotating wheels, 5 Arm Stand, Height Control-Knobs here and the Arm Rest maybe these are the different components of the chair.

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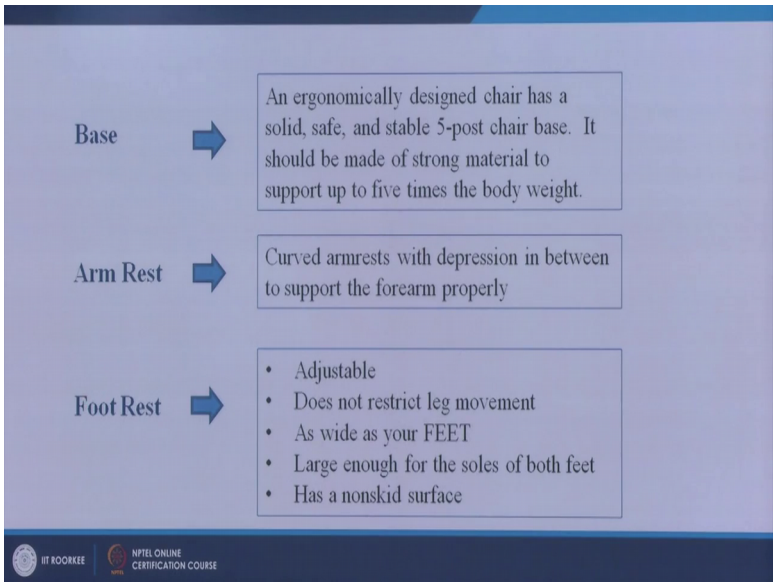

Now this is just giving a brief glimpse of what are the ergonomic things that, we should keep in mind, while we are designing the individual component of the chair. For base an ergonomically designed chair has a solid, safe, and stable 5-post chair base. It should be made of strong material to support up to 5 times the body weight.

So, one guideline is given 5 times the body weight maybe 60 kg if we take as the average weight. So, multiplied by 5 maybe 300 kgs weight it should easily support it should be solid, safe, and 5 we can say wheels can be there in the base. The armrest curved armrests with depression in between to support the forearm properly. So, maybe this will help in the proper design of the armrest, footrest it should be Adjustable, Does not restrict left leg movement, as wide as your feet, Large enough for the soles of both feet, has a non skid surface.

If you will see the accelerator or the brake pedals in an automobile they have a break they have a non skid surface of your foot your foot will not skid on that pedal. So, similar type of footrest should be there that the foot should not slide on that surface or the surface of the footrest.

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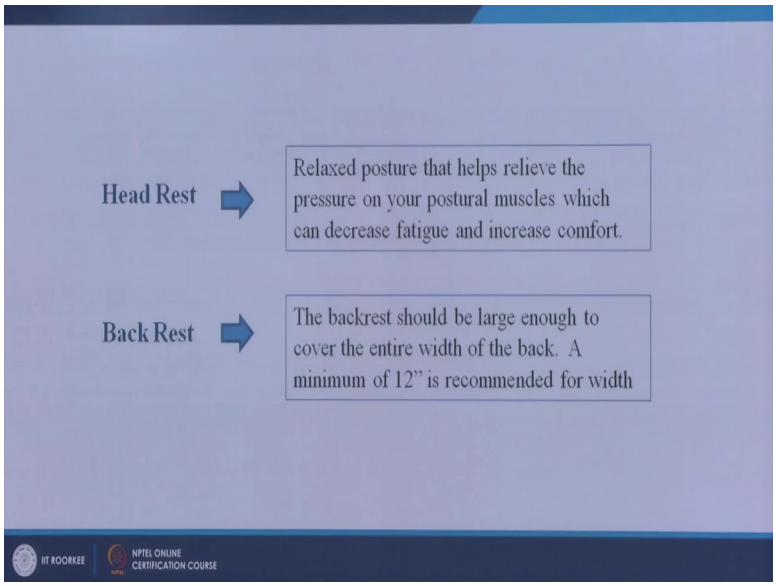

Similarly, head rest Relaxed posture it should ensure relaxed posture that helps relieve the pressure on your postural muscles which can decrease fatigue and increase comforts overall objective is to increase the comfort of the worker and to reduce the fatigue.

Similarly, backrest the backrest should be large enough to cover the entire width of the back a minimum of 12 inches recommended for width. So, you can see what should be the minimum width of the backrest. Similarly the angle at which the backrest should be adjustable is also recommended using the ergonomic principles; we are not going in much into the data because this depends on the ergono on the anatomical data database of a particular zone. May be if we are designing this ergonomically designed chair for a European country is the anatomy of person or average height, average arm length, average leg length may vary.

Similarly for Asian country the average height, average may be leg length; average arm length may be different. So, we are not going into the data of each and everything, but we are just discussing the fundamental principles that have to be taken into account when you are designing a chair using the principle of ergonomics.

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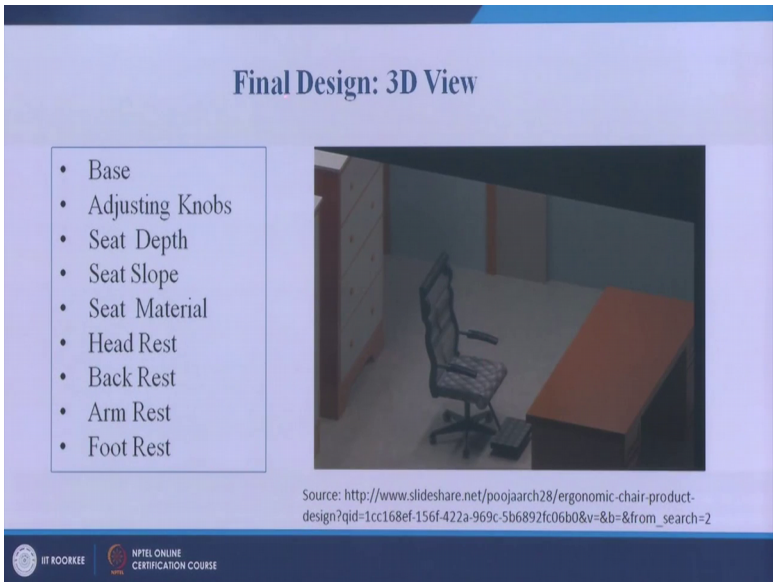

Now, this is a final design 3 dimensional view of a chair you can see there is a backrest 2 armrests seat footrest base.

All these things there is a headrest here. So, all the aspects when integrated into the product will help the product to behave in such a way that the worker or the person or the customer who is using this product would be happy and would be more than willing to recommend product to the other customers or in his peer group also.

These are some of the parts that have gone into the design of this product. If we keep in mind the concept of ergonomics while designing the product it is going to help us in achieve success in the market. Now this is case study 2 maybe the last part of our presentation today Ergonomics of a Tower Crane Cabin.

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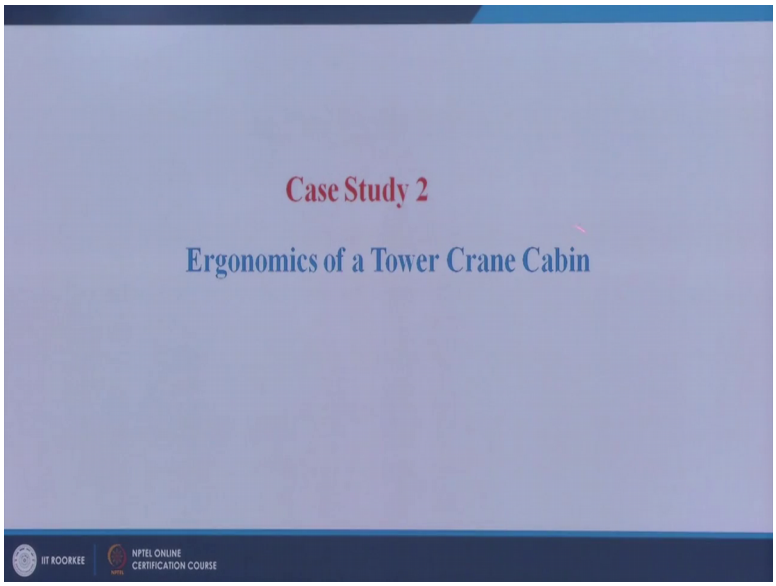

So, this is an example of a tower crane cabin the red circular portion this is a crane cabin you can see the person has to operate at a height.

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So, always he will be maybe at a particular height and he has to operate from here this is the inside view of a person sitting and operating the crane cabin.

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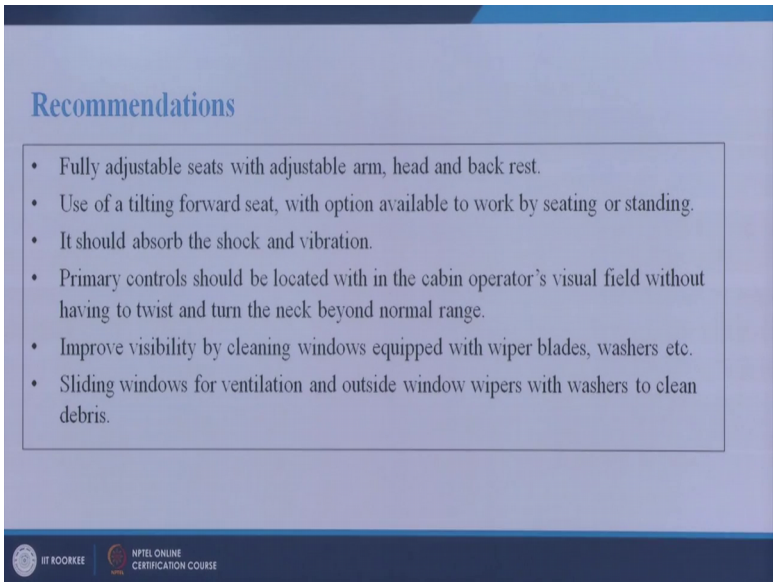

Now what can be the issues related to the ergonomic design here what can be the recommendations if we have to design this cabin. So, these are the recommendations here. It should have fully adjustable seats with adjustable arm, head and backrest or the chair design the principles remain almost same, use of tilting forward seat with option available to work by sitting or standing.

Now, suppose a person wants to see he should be able to stand easily if he wants to operate by sitting he should be able to do that if he wants to operate by standing he should be able to do that. Third the crane cabin should absorb the shock and vibration; because he is operating at a height and always there will be movement some kind of vibration the cabin should be able to absorb that. Primary controls should be located within the cabin operators visual field without having to twist and turn the neck beyond the normal range.

Whatever controls are there should be in his visual range only he should not turn his neck number of times in a day because it may lead to the musculoskeletal disorders. Improve visibility by cleaning windows equipped with wiper blades, washers etcetera you can see it ha it has the operator has to look all around for performing his operation. So, there should be adequate arrangement of cleaning of these glass windows, sliding windows for ventilation and outside window by wipers with washers to clean the debris.

So, maybe there should be adequate ventilation possible because during the peak summers it may become hot and humid inside the crane tower trolley. These are the you can see guiding principles only just to give you an idea that when you design something, what are the ergonomic things that you should keep in mind that the person who is going to use that product should be able to perform his job successfully and that particular product should not have any adverse effect on the health of a particular worker, health I am saying using a generic word because it can be a physical health it can be a mental health also.

As the product designers we should always keep in mind the principles of ergonomics while we are designing a product. So, that the customer feels happy with the performance of the product and the product becomes a successful product from the ergonomic design point of view also.

So, with this session we come to the end of week 3 and we have now finished the 15 sessions on different aspects of product design and development. In our next session we will start the discussion related to the last week that is the design for manufacturing and assembly we will also cover the rapid prototyping aspects also in our week 4.

Thank you very much.