Operations Management
Dr. Inderdeep Singh
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 09
Ergonomics in Product Design

[FL] friends, welcome to session 9 in our course on operations management; we are currently in week 2 of our discussion on the course on off on operations management and in week two, we are focusing on product design and development. Now just to have a brief review of what we are covering, we have covered the basics of operations management or fundamental aspects of operations management in week one, in which we have seen the scopes objectives and strategies of operations management.

In week 2 our focus is on product design and development, because when we have to manage the operations of an organisation we have to see that what we are producing, how we are producing, how well we are producing so, that the overall profits of the organisation increase or we are able to maintain a market share in the overall business environment.

So, basically our focus is on identifying that what is the market requirement, and what we should produce in order to be competitive in the market. And in that quest that what we must produce our product design and development session or section becomes very very important. So, we have already seen three session in this course; that is first was on product life cycle that how the sales as well as the revenue or the profits of an organisation change over a period of time. Then in session 2 we have seen a very important aspect of value engineering, which is usually not covered in the UG curriculum.

So, in value engineering we have seen that we have to focus on the functions of the product; we have to focus on the design of the product so, that we are able to achieve all the functions at the minimum possible cost to be competitive in the market. Then we have seen in the previous session, we have discussed the design for x we have taken few examples of design for manufacturing, we have taken a text as instrument example of design for assembly.

So, currently our focus is towards the design of the product, and in that context only we are today going to cover another important aspect that every engineer must keep in mind while designing a product, that the human product interaction should be very very good; good in the sense that both should enjoy the interaction. The person should enjoy and interacting with the product and the product should also enjoy interacting with the human being; and how that is possible? That is possible way if we take into account the aspect of ergonomics. Now in ergonomics we have we can see that there are different types or different faces, for different we can say aspects of ergonomics. So, in today's session our focus primarily would be to understand the basic concept of ergonomics, types of ergonomics and then we will try to understand it with the help of suitable examples.

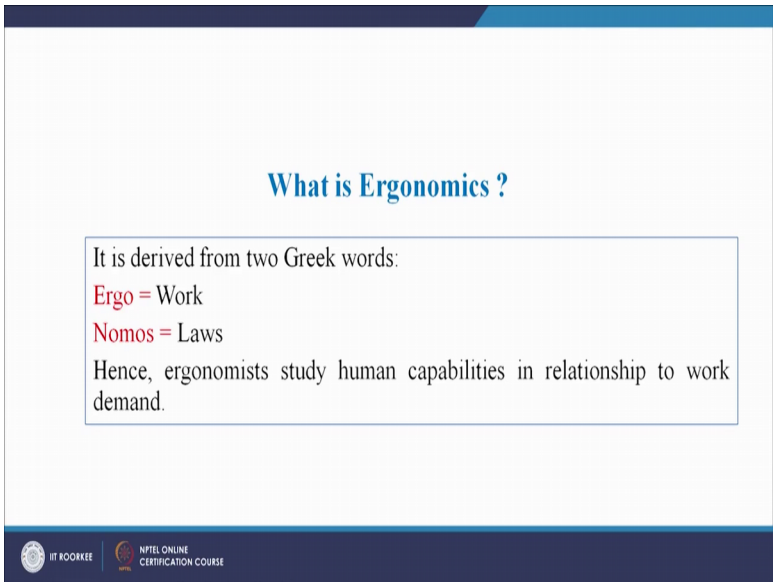
We will see that how we can apply the aspect of ergonomics, in order to improve the product designs. So, ergonomics is all around us for example, I am using this pointer; we can use the basic aspect of ergonomics in the design of this also. If you could see the shape of this particular pointer it is easy to hold in the hand. So, we are easily we can have one good example of ergonomics right in front of us, where we can see that how the shape has been designed. It would have been a straight rectangular cross sectional also, but a particular shape has been given. So, that I am it is easy for me, it is comfortable for me, it is enjoyable for me to hold this pointer.

So, that is basic aspect. So, we need to focus on that interactive aspects, that how the person is interacting with the product and how the product is interacting with the human being vice versa so, that we have to take into account, we have to fit the product to the needs of the person or to the benefits of the person, or to the comfort of the person or to reduce the fatique of the person or to reduce the tiredness of the person.

So, we have to design the product in such a way that the person is able to perform his task without any fatigue, without any extra effort that is the basic purpose of the ergonomic design, and I with this introductory we can say session, I will just now move towards the presentation in which we will try to understand the basic aspects of ergonomics from the fundamental point of view as well as we will have a structured discussion, with the help of slides and this presentation.

So, let us know quickly go to the term ergonomics, that what do you mean by ergonomics.

(Refer Slide Time: 05:20)

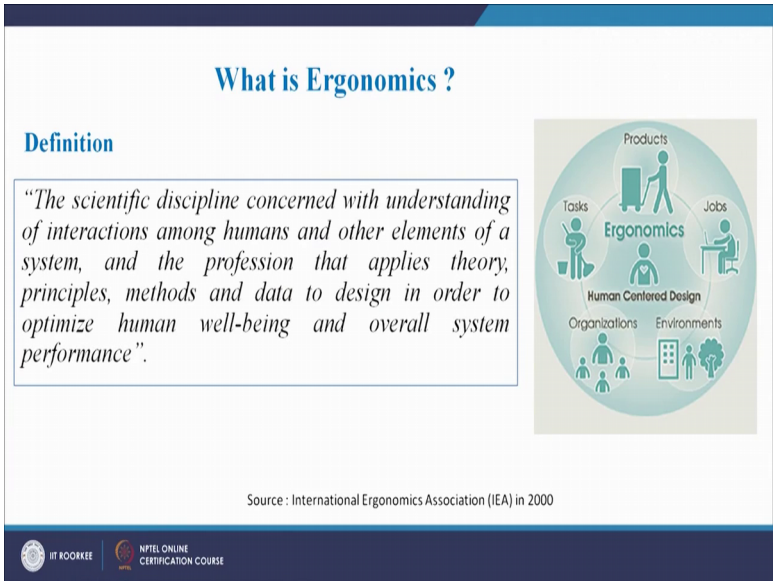


Now, it is derived from true 2 Greek words Ergo and Nomos. Now ergo means work and nomos means laws. Hence ergonomists study human capabilities in relationship to work demand. So, we will see that ergonomics will help a person to achieve his task with the minimum possible effort. Now task has to be achieved and ergonomic design will help us to match or to map the demand of the work to the capability of the human being. Sometimes it so happen that a person has to lift a very heavy load, which is beyond his capability, which is beyond the human capability now how that can be done. We can have a pulley type of arrangement or we can have a lever type of arrangement, which can help us to push that load.

So, that type of arrangement basically is a ergonomic design of a product, which is helping the human to exceed his human capability. So, we will try to map the 2 things together. We will try to see what is the demand, what is the capability and how that capability can be manipulated in order to satisfy the work demand or the demand of the work that has to be completed. One example I have taken maybe a very vague examples that just came to my mind, but similar type of facts or figures we will try to understand that, how we can make the work easy for the person who is going to perform that task. So, that is the basic concept of ergonomics again, I will read the last sentence which I have tried to highlight with examples. Ergonomist the people who are experts in the field of ergonomics, they study the human capabilities in relationship to the work demand.

The work demand means the specifications of the work that has to be completed. Now a more structured definition of the word ergonomics is given.

(Refer Slide Time: 07:30)



The source is international ergonomics association. So, I will read this definition and then try to explain this definition to the best of my ability, whatever example I can give related to this definition. The scientific discipline concerned with understanding of interactions among humans and other elements of a system; now the interaction between the humans and the other elements of the system.

Now, let us consider this system, where this recording session is being organised. Now my interaction with your system as a whole is what the ergonomics is all about. To study this interaction, now what can be the objectives? The objectives can be that I must feel happy in this environment, it should be easy for me to record this session of 30 minutes, I should not feel may be tired at the end of this 30 minute session, I must feel fresh after this session. So, how that can be ascertained? That can be ascertained by providing an environment which is we can say cordial, which is we can say congenial for recording of a session, that can be achieved through air conditioning, that can be achieved through a proper lighting system. So, we have to design the system in such a way that the interaction between the man and the system is good or efficient or affect

So, the first sentence I have tried to explain with the help of an example. The scientific discipline concerned with understanding of interactions among humans and other

elements of the system. I am a human and this recording studio is a system, and the profession that applies theory principals methods and data to design. Now for designing a system what is the basic information required? We require basic theory scientific theory, principals, different structured techniques, tools and data to design in order to optimise human well being and overall system performance.

So, the system performance must also be ascertained, and human well being also has to be ascertained; the system performance how we can ascertain? If we are providing good environment to a professor who is recording a session we can have more efficient recording, we can have more may better management of time we can have more sessions per day, if the system is performing well.

So, that is basic definition, the main point here is if we try to understand we can divide this whole thing into three. We can say broad categories or three broad areas, first one is that word interaction, second one are the elements the one is the human element another one is the system or an organisation and a third thing is what are the objectives now objectives are what are the objectives I think all of you must be able to address now, objective is to ascertain the well being the human being as well as optimisation or the maximisation of the system performance or the organisational performances.

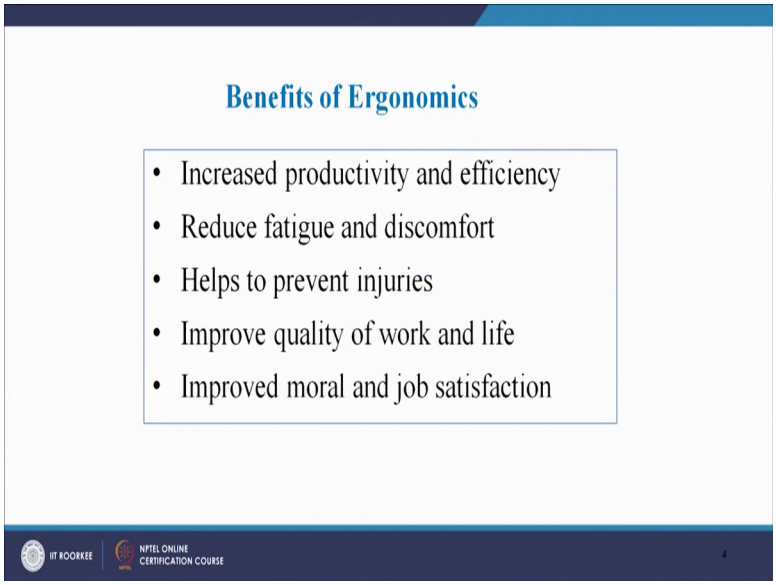
So, basically we are trying to understand or to modify the interaction between the man and the machine in order to improve the performance of both the man as well as the machine. So, that is the basic aspect of ergonomics and we will try to do this, we will try to understand this with the help of 2 case studies in today's session. Now what are the benefits if we take into account the principles of ergonomics in product design? So, the basic benefits in simple English language they have been highlighted on your screen, you will see increased productivity and efficiency. If I am happy in this recording studio I will be able to record this 30 minutes in 30 minutes only, but if maybe the system is not performing well, I key I maybe start sweating after 10 minutes of recording, I will stop I will just wipe off the sweat and then again get ready for recording there will be a break in the overall recording.

So, if the system is not performing well the productivity of a professor will come down. So, he will be recording a half an hour session maybe in one and half hour. So, overall effectiveness and efficiency of the system will also suffer. So, if we have a ergonomic

design I am feeling comfortable in the studio because of the principles of ergonomics, there will be increased productivity as well as efficiency. Reduced fatigue and discomfort example, completely clarifies that if it is happy environment if it is congenial environment, it will result in reduced fatigue and discomfort. Helps to prevent injuries; now it is really important where a person is doing physical work, especially where physical work is being done it will help us to provide injuries. The design is such that the ergonomically person is performing the task, and there are safety measures already incorporated into the machine design or the design of the equipment that he is he or she is operating.

So, chances of injuries will be minimised; more over there are musculoskeletal disorder specifically, where a person is using some muscles repeatedly over a period of time there are a MSDs or w s d s work related disorders. So, this MSDs can be avoided if we put into account or put into use the principles of ergonomics. So, from health point of view also, from accident point of view also the ergonomic design is more safe as compared to a normal design of a product.

(Refer Slide Time: 13:58)

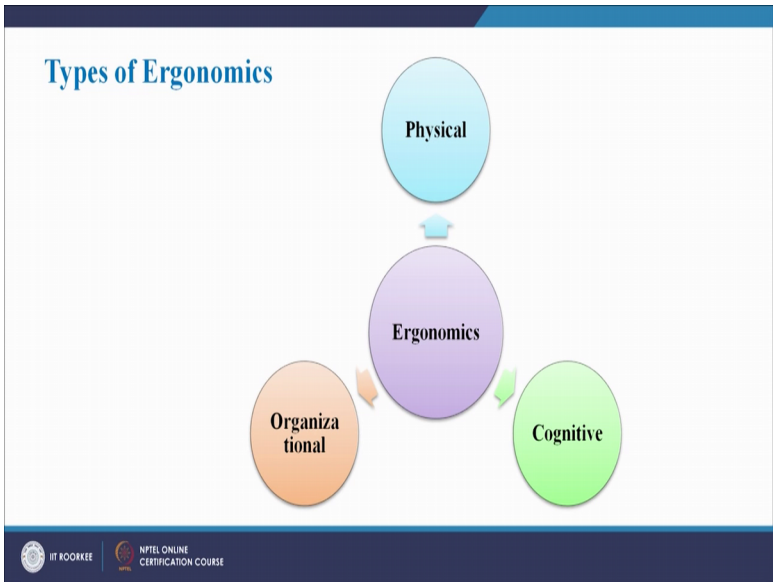


Now, it will improve the quality of work and life. So, when the both the system and the worker are getting benefited. So, the overall quality of work and life will improve and improved moral and job satisfaction. So, if the work environment provided to me is good for my health is good for my productivity is good for my efficiency, I would definitely be

satisfied with the job that I am doing. So, more or less if we see, that all the advantages will not only lead to the happiness or the enjoyment of the worker, but when the worker will be happy he will be more productive; if he is more productive the overall organisation will also benefit and the operations would be more smooth and efficient, and that will lead to the overall improvement in the profit of the organisation.

So, I wish that all organisations focus on the aspect of our ergonomics, and try to make their system try to make their operations much more comfortable for the workers. So, that their overall productivity improves, which will lead to the overall profits for the organisations. So, ergonomics has got lot of benefits, and I believe that all organisations must address this issue of an ergonomic design of the work system. Now let us quickly have a look at the types of ergonomics.

(Refer Slide Time: 15:28)



Now, on your screen you can see we can have three types of ergonomics. First is physical ergonomics, cognitive ergonomics and organisational ergonomics. Now I have taken an example of physical ergonomics that, I am recording if I feel comfortable I do not feel much fatigue in recording, I will be much more happier I will be much more comfortable in recording this session. So, that is related to my physical well being.

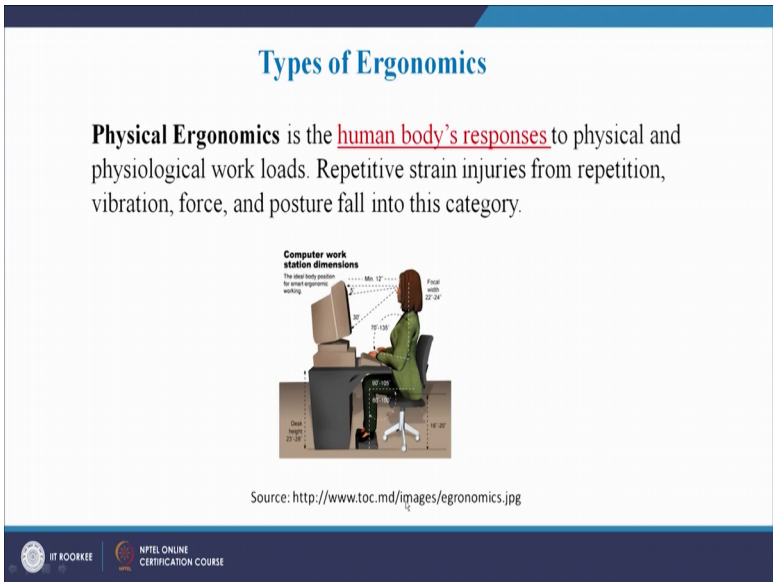
So, that is we can say an example of physical ergonomics. Cognitive ergonomics means that if you are doing mental task, if you are doing some coding, if you are doing the if you are developing some algorithm. So, we have to design a system in such a way we

have to design the work in such a way, that it does not put much strain much stress into your brain or into your thinking domain.

So, that is related to cognitive, that is related to mental stress as well as train as well as an anxiety that will fall into the cognitive ergonomics. And organisational ergonomics suppose 10 people have to do that ask they are sitting on the same floor and in different cabins, how the system has to be designed how the interaction among the various people sitting on the same floor in different cabins have to be designed so, that they feel comfortable, they feel efficient, they feel effective in the discharge of their duties.

So, the office ergonomics maybe an example of organisational ergonomics, we will try to understand each one of these maybe with a slide or 2. Now first we can see physical ergonomics and example.

(Refer Slide Time: 17:24)



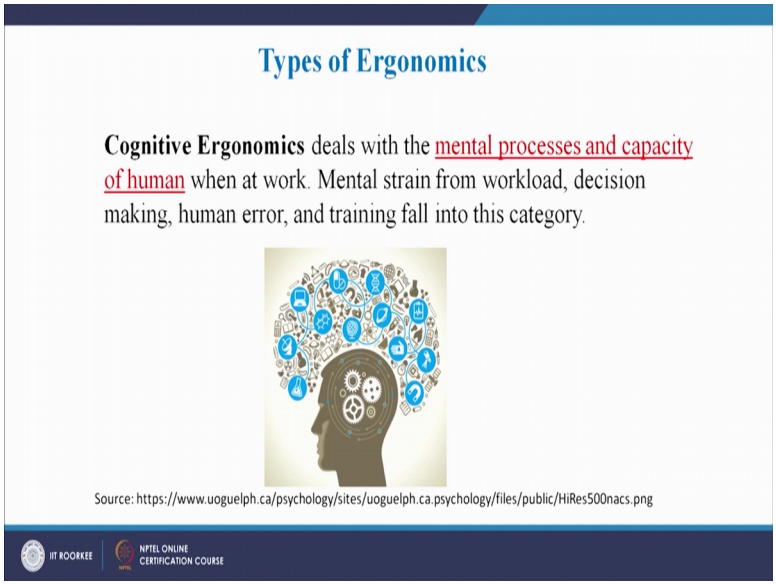
The source of the image is also given w w w dot t o c dot m d. Physical ergonomics is the human body responses, to physical and physiological workloads. Repetitive strain injuries from repetition, vibrations, force and posture fall into this category. So, if we design our product in such a way that it can avoid the repetitive strain injuries from repetition, vibration, force and posture, we will it means that we have achieved our target of the ergonomic product design. That is these are the focus areas, we have to avoid these type of injuries by our product design and it is related to the human body responses. So, here we can see on your screen, I think some of the information may not be available, but

you can look up in Google images, you will get lot of such images where all the design features are given.

So, there is a worker typing on the system and working on the computer systems. So, this is a overall work system and it has to be designed in such a way, that the person working on the computer feels comfortable. So, there are there is data that is related to this what should be the height it is given maybe 16 to 20 inches is the height of this chair, then desk height 223to 28 inches, what should be the angle of the elbow all these this thing what should be the distance between the eyes and the screen. So, these all things are designed in such a way, that are optimised in such a way that the person feels comfortable. So, this all is related to the physical responses and therefore, falls under the category of physical ergonomics.

Next is the cognitive ergonomics; in cognitive ergonomics we can see deals with the mental processes and capacity of human not the physical capacity of human.

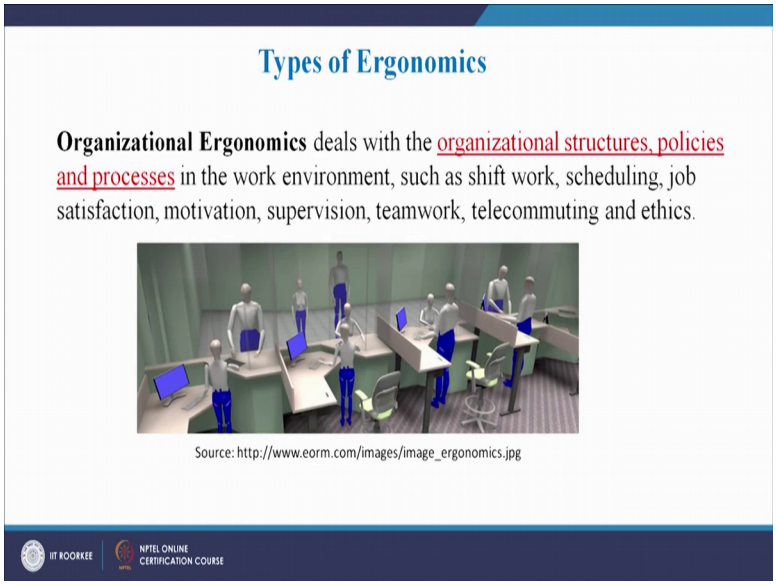
(Refer Slide Time: 19:31)



It is the mental capacity of human which we can sometimes objectively classify as the IQ So, 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 in this category. So, it is related to the mental work that a person is doing at his job.

Organisation ergonomics is the third type of ergonomics; it deals with the organisational structures policies and processes.

(Refer Slide Time: 20:02)



In the work environment; such as shift work scheduling, job satisfaction, motivation, supervision, teamwork, telecommunity, telecommuting and ethics. Now basically office ergonomics or organisational ergonomics is related to the interaction between the various workers or various engineers or various computer programmers, who are working with the overall system. So, they are working on a shop floo, how the shop floor should be designed how the office space should be designed to improve the interaction between these people. The people who are working they should feel pro more productive more efficient, more effective in the discharge of your duties.

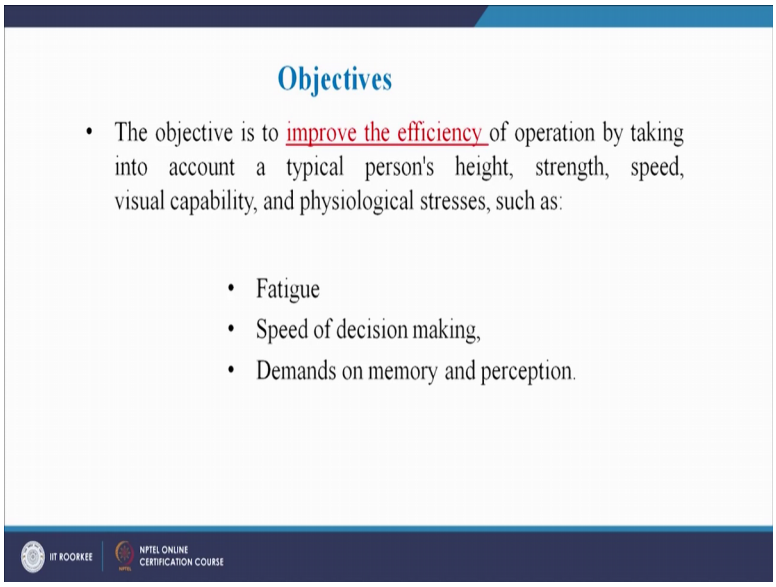
So, basically or organisational ergonomics is related to framing of policies, framing of we can say processes in such a way that the overall efficiency of the work system improves. So, three types of ergonomics focus areas we have seen; ergonomics can focus on the physical domain ergonomics can also focus on the mental domain that is the cognitive domain as well as ergonomics can focus, on the processes or the procedures or the rules or the guidelines of the organisation and try to improve the overall effectiveness of the organisation.

So, we can use the concept of ergonomics in the design of various we can say processes and systems within the organisation now some of you may be wondering where to apply

the principle of ergonomics. So, it is a global subject. So, you can apply it where a person is operating on a single machine single person, single machine yes you can apply the concept of ergonomics. There are 20 people working on 10 different machines, yes there also you can apply the principal of ergonomics. There are 10 office people working on the accounts of the organisation which is producing maybe automobiles or cars or motorbikes, yes in that office space also you can apply the concept of ergonomics. Basically where ever any kind of work is being done, the work maybe physical work the work maybe mental work.

So, all those places you can apply the aspect of ergonomics in order to improve the overall system performance as well as the overall workers performance. Now what can be the objectives, all the I think I have already highlighted what are the objectives.

(Refer Slide Time: 22:40)

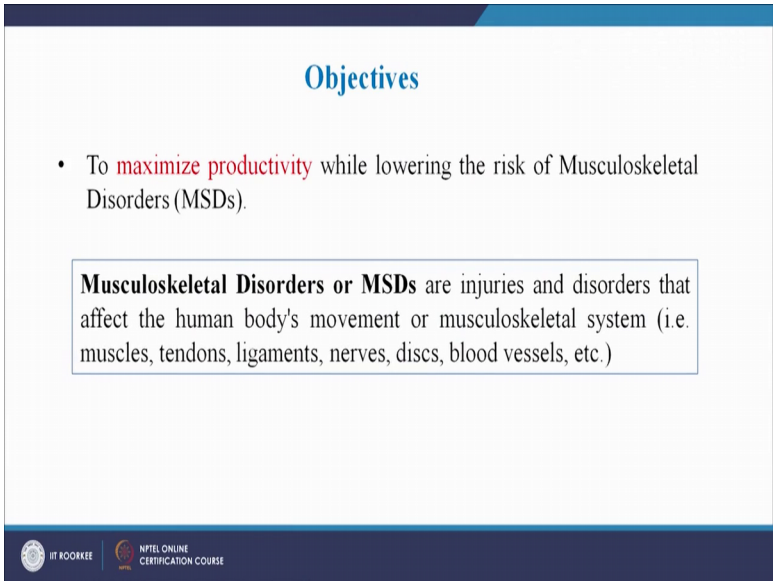


But to have a more structured information to all of you we can have a just reading of what are the objectives. So, the objective is to improve the efficiency of operation by taking into account, the typical person height strength speed, visual capability and physiological stresses such as fatigue speed of decision making demands on memory and perception.

So, basically our focus is to improve the efficiency of operation or efficiency of the system. So, we will take into account as we have seen earlier also the capability of the human being. Now capability can be in terms of his strength, in terms of his speed, in

terms of his vision. So, those are the human capability similarly from cognitive point of view we can also take into account the speed of decision making and the how much demand the work is putting on his memory or how much information how quickly a person can bring from his memory or memorize the things. So, all those things are taken into account, but the overall objective as highlighted on the screen in the form of red colour font is improve the overall efficiency. to maximize the productivity by lowering the risk of musculoskeletal musculoskeletal disorders MSD.

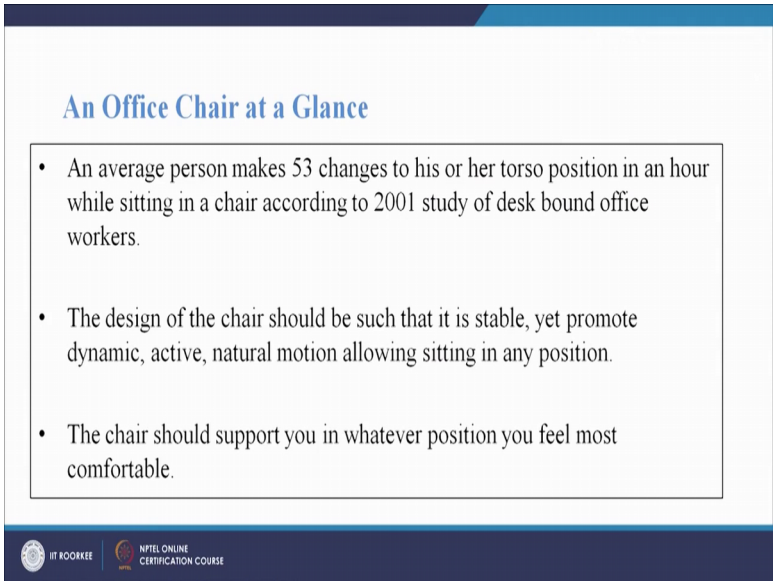
(Refer Slide Time: 24:15)



So, the other aspect can be to make a safe design, which is good for human being causes less fatigue as well as causes less injuries and lead to lowering the risk of musculoskeletal disorders. Now musculoskeletal disorders what are these? These are injuries and disorders that affect the human body's movement of musculoskeletal system, that is muscles tendons ligaments nerves discs blood vessels etcetera. Now why MSDs do happen in office or in the shop floor? Because of the repetitive nature of the work that a person is performing MSDs do happen and have been reported in various types of organisations. Wherever a person is repeated repeatedly working with his hands if you observe the hands of a person who is doing manual work, you will be able to understand that yes they are shape of the hand and the shape of the fingers has changed because of the working of this person maybe for last 10 years or 15 years or 20 years.

So, many such cases do we do observe in our day to day life, and those can be avoided if we design the system in such a way that it does not lead to musculoskeletal disorders. Now let us very quickly see the case study. So, we will see case this is a case study 1 that is design of ergonomically efficient office chair. So, we will quickly go through this case study.

(Refer Slide Time: 25:58)



An average person makes 53 change to his or her torso position in an hour while sitting in a chair according to a study. So, this is a maximum changes that a person usually do usually, when we are sitting on a chair we move slide back and sometimes you move forward. So, these are the changes that have been counted maybe scientifically, that 53 changes to his or her torso position. Torso position is the body position above the waist height I think that is what I know anatomically the design of the chair should be such that it is stable it should promote dynamic active natural motion allowing sitting in any position.

So, you should be able to move comfortably while sitting on the chair, that is the thing that is objective of a office chair or for the design of the office chair. The chair must support you in whatever position you feel most comfortable. So, it should provide us with four or five different options of sitting, and be each position should be comfortable. So, these are you can say expectations of a chair that out of a chair, which is ergonomically designed all of us use different types of chairs and in some kind of chairs

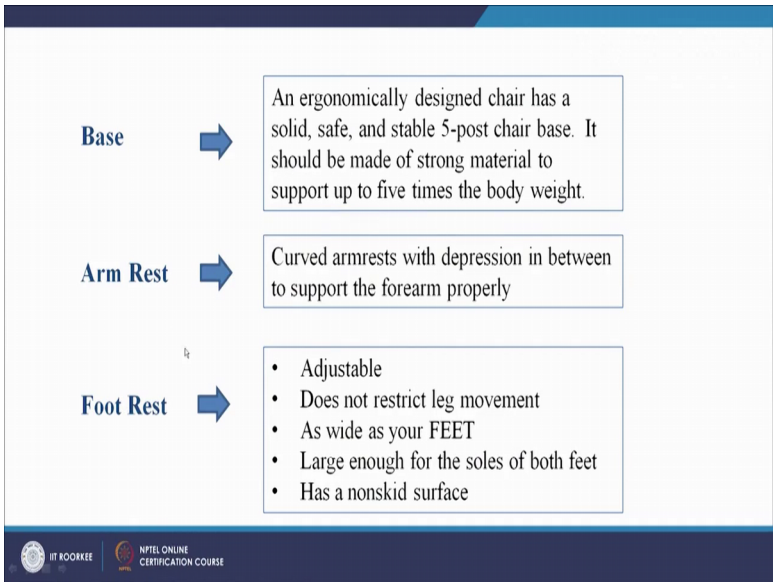
we feel very comfortable, in some other chairs we do not feel that comfortable if we have to sit for a longer period of time. And why design of a chair is very important in office because a person has to sit on the chair maybe 6 to 8 hours in the whole day and maybe 5 or 6 time in a week and maybe 25 times in a month.

So, therefore, the chair is very very the design, is very very important because if the person is feeling comfortable for long hours of sitting on the chair, he will be more productive and effective.

(Refer Slide Time: 27:44)

Now these are the components usually in office chair, there is a headrest there is backrest there is a seat, there is a rotating wheel at the bottom castor 5 arm stand; 1 2 3, 4, 5 height control knobs and armrest. Now this is a typical design of a chair. Now what we can design, we can design the seat separately, we can design the backrest the angle at which backrest should be placed make we can give 2 or 3 options, as we have in the these days the buses high end buses as well as in aircraft sometimes in trains also where you can slide back your back rest. So, that is another versatility or another you can see option given to the user, then armrest can also be adjustable as per your requirements. So, the components have to be designed in such a way that the person sitting on the chair feels comfortable.

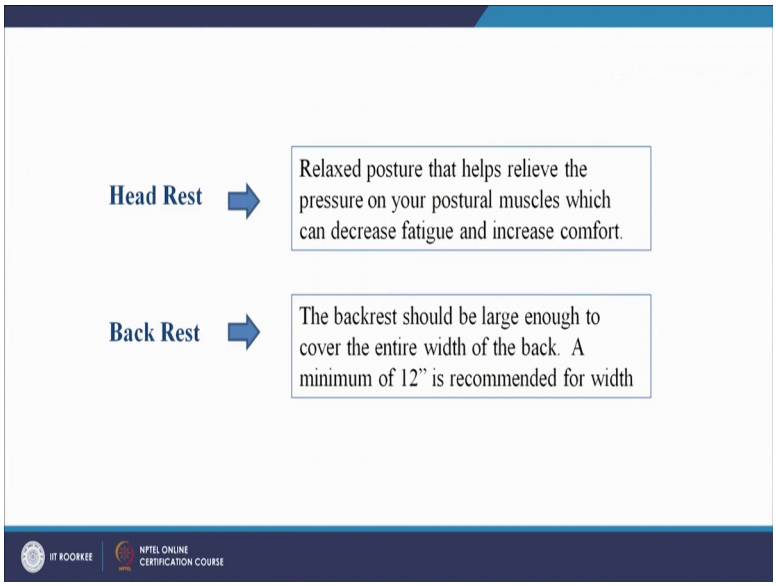
(Refer Slide Time: 28:40)



Now, we can see the base, armrest, footrest there are different guidelines, that for base it should be ergonomically and ergonomically designed, chair has a solid safe and stable 5-posts chair base, it must be made of strong material to support up to five times the body weight. Now just one factor of safety is given that if we are designing the chair for hundred kg person it should the base should be able to take a load of five hundred kg. So, it should be five times the body weight we have to design then armrest are there curved armrest with depression in between to support the four arm properly

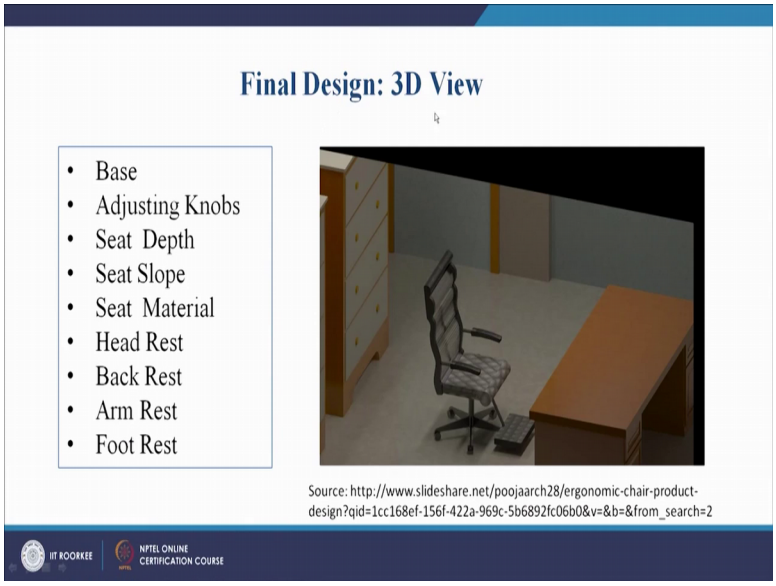
So, guideline for arm rest is given similarly the guideline for foot rest is also given footrest must be adjustable does not restrict the leg movement if we want to move our leg the foot rest should not maybe come in the on the way in the direction in which we want to move our legs as wide as your feet at least it should be as wide as our feet. So, that we can feet our feet comfortably large enough for the soles of both feet has a non skid surface it should not happen that we are putting our foot on the foot rest and foot is sliding again and again. So, it should be non skid surface. So, headrest we headrest must.

(Refer Slide Time: 30:02)



We can say facilitate relaxed posture that helps relieve the pressure on your postural muscles which can decrease fatigue and increase comfort the back rest should be large enough to cover the entire width of the back a minimum twelve inch is recommended for width. So, the back rest is also very important headrest is important footrest is important seat is also equally important there is lot of work people have done on the design of the seat also

(Refer Slide Time: 30:34)



Now, this is we can say the final view or three d view the source is also given here of a office chair. So, maybe this is one design and the design of the office chair will also change as per the geographical location maybe far east if we go from India perspective we are saying we will have a different design of a office chair the different dimensions of the office chair the seat will be designed accordingly backrest and other dimensions or the specifications will be accordingly because that depends on the average data of the human beings of that particular country.

Similarly from Indian perspective if we go to the western side we will have a different design or different we can say the dimensions of the similar type of design because of the anatomical change in the anatomical or the we can say anthro anatomical sorry may not be the right word as a mechanical engineer I am not that convergent with the biological terms, but yes the anthropometric data is very very important.

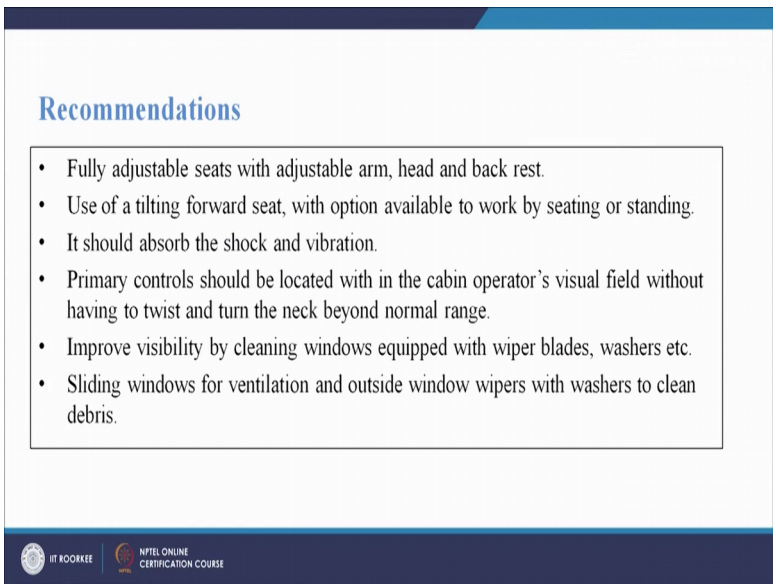
So, based on the anthropometric data we will have a different dimensions on the western side of India and western side of the world as per Indian perspective and different dimensions on the eastern side of the world from Indian perspective, but the overall objective of the design of ergonomic chair will be to improve the performance of the worker who is seating on that chair in terms of overall productivity more over the person must also feel comfortable fitting on the chair or seating on the chair, well it should also be providing him some space where he can move or change his posture comfortably that is one design and the case study 2 is of ergonomics of a tower crane cabin

So, quickly we will go through this.

(Refer Slide Time: 32:35)

We can see this is a person on seating; so in the tower crane cabin. So, this is the tower crane cabin and this is what we look for outside and this is the position inside. So, you can see all the controls are within his reach minimum reach he can look down there are glass cabin this is a glass cabin. So, he can look down he can look sideways he can look straight. So, it provides good visual you can say comfort for the person because he can look sideways as well as what is happening just behind the tower crane. So, what are the recommendations for these tower crane fully adjustable seats with adjustable arm head and back rest.

(Refer Slide Time: 33:15)



So, you can see in this system again the chair is playing an important part. So, it is not that ergonomics can be applied to one system only it is a global principle which can be applied to different you can say areas in engineering as well as in sciences

So, fully adjustable seats with you can say the chair now if we have designed ergonomically our first point is taken care of then use of tilting forward seat with options available to work by seating or standing this is very important this may be an additional thing as per this system requirements the first person may be able to lean forward to look down what is happening which may not be the requirement in a office chair. So, this is a specific requirement from the tower crane cabin point of view now it should observe the shock and vibration yes that is specific requirement for these particular design primary controls must be located within the cabins operator visual field without having to twist and turn the neck beyond the normal range.

Now suppose I am operating that crane I must have all the controls within my reach easy reach and second thing is I must not be required to turn back beyond normal position in order to get to a particular control. So, that is very very important improve the visibility by cleaning windows equipped with wiper blades and washer because we are proposing the glass windows are there must be arrangement in case of a dusty environment sometime the glass may get covered with dust and the it may affect the visibility outside. So, there must be wiper arrangements; so that the glass can be cleaned properly sliding windows for ventilation and outside window wipers with washers to clean the debris.

So, this is a specific requirement where there is lot of dust and dusty environment is there we should always clean the glass window. So, we can see for a particular application where the cabin is there on a tower we need to design it properly. So, few recommendations are given here and if we follow these recommendations in the design of this tower crane cabin very easily the work environment the work you can say performance of the person who is performing the task will be improved and overall system performance will also improve.

So, we have taken 2 examples one a design of a chair the another the design of a cabin in which a person is going to operate. So, basically we can see that ergonomics is a phenomenon or it is a science which can be applied in various aspects in order to

improve the interaction or in order to study the interaction between the man and the machine and overall objective is to improve the system performance.

Now, in our session on ergonomics we have tried to highlight the basic aspects of ergonomics only in the next session we will see that if we have designed our product how we can make a prototype easily. So, our overall product design and development five sessions will equip us with the latest tools which are helpful for the product designers in designing of successful products and if the products are successful the organisation is successful and the organisation makes lot profit.

So, in next session we will now focus on rapid prototyping. So, with this we close the today's session.

Thank you.