**Industrial Engineering**

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**Module - 03**
**Lecture - 14**
**Ergonomics**

Dear students, as you know that for increasing the productivity of an organization, various strategies are used and these strategies include the development of the research process, development of the processes through research and the installation of the new and high capacity system. In addition to these two strategies, the effective and the better continuous management is also a very commonly used which helps to reduce the work content of, work content related with the job and the ineffective time.

So, for reducing the work content and the reducing the ineffective time, one of the common techniques known as work study is used. This work study involves the method study and the work measurement related techniques. And in work study the first technique that is method study, which is mainly used for improving, the existing method of doing particular job. So, that time required for completing the job can be reduced and in work measurement, the ineffective time is identified.

At the same time, the standard of performance is also set and these standard of performances are extensively used in estimation of the requirements, forecasting the cost or optimization of the manpower and the resource utilization. In order to increase the output by the worker, it is necessary that whatever system he is using, is efficient and effective, so that, it needs the minimum mechanical effort, minimum efforts are required for carrying out the job, using a given system.

And that is why the systems which are to be used by the worker, for producing output which is desired, with the given inputs, the systems should be design in such a way, that they can be used effectively, easily by the worker with minimum effort and with application of the minimum time. So, in order to design and develop such kind of systems, one broad area which is used in the industrial engineering, is the ergonomics.

Ergonomics is a area of science, which includes the different areas, like engineering sciences, anatomy, like the engine, the man and machine systems and physiology and the

psychology. So, the experience of a person, a person having the experience in these areas will be able to work effectively, on the ergonomic aspects related with the design different equipments. So, for designing such kind of system, which can be used by the operator or human being effectively with the minimum effort and cause and leads to the maximum comfort in their use and application fall in category of the ergonomics.

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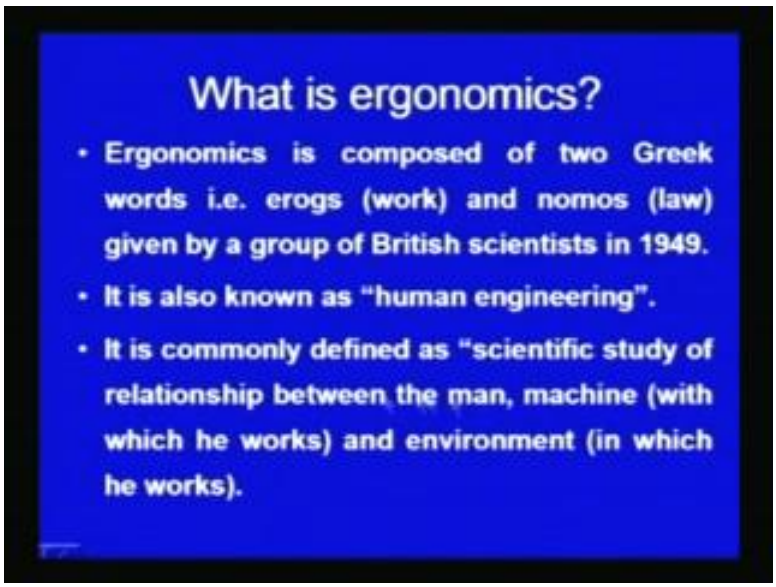


So, ergonomics is basically composed of the two Greek words, which are erogs and the nomos, erogs stands for work and nomos means the law. So here, the laws or rules related with the work, are the word meaning of the ergonomics and these ergonomics word was given by a group of, this name was given by a British. A group of British scientists in 1949 and this, the ergonomics is also known as the human, engineering and in different countries.

So, it is commonly defined as the scientific study of the relationship between the man, machine, with which he works and the environment. So, basically it is targeted to or related with, with the aspects or scientific study of the relationship between the man and the machine and the environment, man and machine are being used. So, here how a man is working with the machine, how comfortable he is, how much efforts are being put, in using a given machine and how the environment in which he is working, is affecting the performance of man and a machine both.

So, in total, that the relationship between the man, machine and the environment, in totality it forms, the ergonomics and the relationship between these three is effectively used for such kind of system, which will result in the desired output and minimum effort of the worker. So, here the environment component is particularly related with, that how the environment or the conditions in which work is going on, will be effecting the desired output. The ergonomics is a, as I have said is a hybrid science, because to work on the ergonomics related aspects, it is required.

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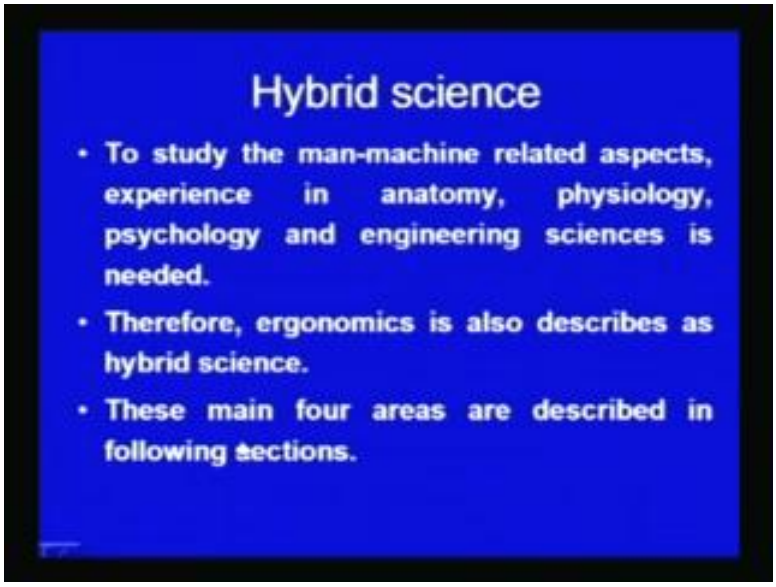


Knowledge is required in the area of anatomy, Physiology, psychology and engineering sciences. Anatomy basically deals with the human beings and the animals and is physiology is about the strength, speed, the body dimensions and the psychology is about, that how the information is processed by the operators or worker during the operation and what kind of action he takes, while he is in work.

So, the response after the human being during the operation and in the working conditions of the mentally strain and fatigue, how he receives the information and that information is processed falls in category of the psychology. And the engineering science is basically deals with the design and development of the mechanical systems, which will be used by the operator in course of production or the manufacturing. So, ergonomics therefore, is described as a hybrid science and these are the four main areas, which have been described in detail in the following sections.

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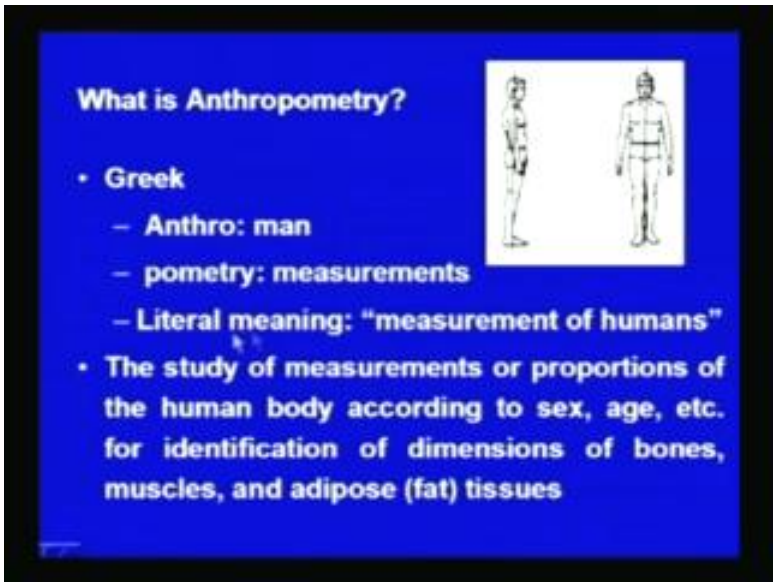


Anatomy, whose one component is anthropometry, it means anthropometry is a combination of the two words, which involves the anthro and pometry, in, these are the two Greek words, anthro means the man and the pometry stands for the measurements. So, the here the literal meaning of this anthropometry is about measurement of the humans, which involves the measurement of the body dimensions of the human being, with respect to the different reference points.

So, these dimensions are used, in designing, design of the engineering, in designing the engineering systems, the study of the measurement or proportions of the human body, according to the sex, age, etcetera. For identification of the dimensional of bones, muscles and adipose tissues are fall in category, under the anthropometry.

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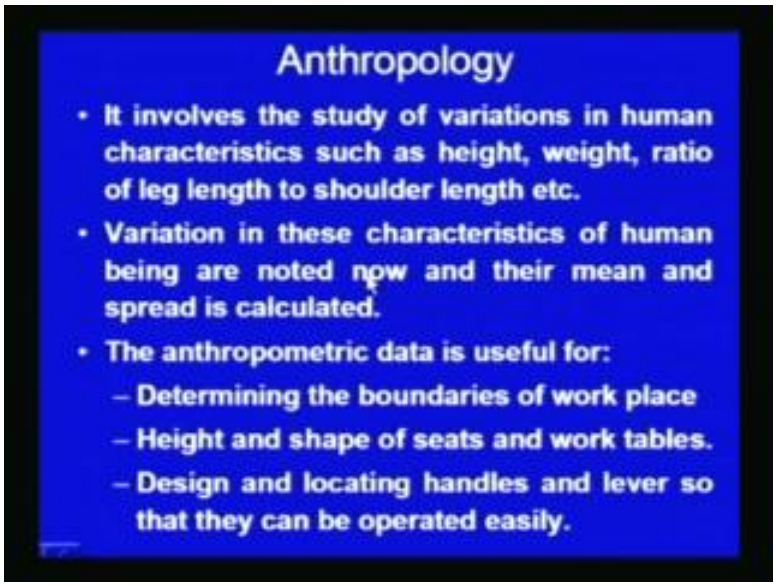


Anthropology, which involves the study of the variation in human characteristics, such as height, weight, a ratio of leg length to the shoulder length and like this, many other dimensions of the human body. So, anthropology, in anthropology the body dimensions are measured and the data is collected about the human beings, for whom the systems are to be designed, whether it is a group of operators or the targeted, group of the persons who will be using are given designed, device.

So, here the height, the weight, the ratio of the leg length to the shoulder length, like head dimensions, the neck dimensions, the foot dimensions, the fingers, arm, means all the dimensions related the body parts and the measurement of these dimensions and the way by which these dimensions vary, for a group of people are measured and the recorded. So, and all these things fall in category of the anthropology, which involves the study of, the variation in human characteristics.

These are the different characteristics and in addition to the other characteristics of the human body, also included in anthropology, the variation in these characteristics of the human being are noted and their mean and spread is calculated. So, according to the system which is to be designed, the target or the possible users are identified and for those users anthropometric data is obtained.

And what is the mean of the anthropometric data of particular characteristics, which will be used in operation of particular device, that is obtained and it is spread, either in terms

of the standard deviation or in form of range is obtained, which will help in identifying the minimum or maximum dimensions of the engineering systems, which will be used by the targeted group of population.

These anthropometric data, which has been generated and for which mean and the spread values have been calculated, can be effectively used to determine the boundary areas of the workplace and the height and the shape of the seats and work tables. The designing and locating the handles and the lever, so that they can be easily operated by the operator, during the use.

So, once if the data about the arm, about the wrist, about the maximum reach, about the normal working area, about the upper arm, lower arm, fingers, means if the dimensions of these different body parts are available as per required in operation of a given device, these dimensions can be, these data can be effectively used in identifying the boundary areas of the workplace. So, that you can locate the different compartments, where materials or sub assemblies or the tools will placed, during the use, for use of, use by the operator.

Height and shape of the seat and the work tables are also designed, in light of the anthropometric data of the operators, who will be using these seats and the worktables. The designing and locating the handles and the levers like in designing the hand breaks, designing of the different levers, which are used in the mechanical systems and the machines are based on the anthropometric data, of the operators who will be using these systems. These are designed and located in such a way, that operator can use them easily without much effort and without spending unnecessary time.

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The physical devices are used in one or other form, every day in our life, the comfort and the performance of the people when using such devices, is influenced by the extent to which these facilities fit to the people. So, because now a days, every time, we are using one or other kind of the mechanical system in our daily life, like right from the morning, we use bed, after the bed like we use motor cycle or a scooter or bicycle for moving from one place to the another.

Then, we use chairs and tables in the offices and hand pumps or any other kind of device, which is being used by the human being and if it is dimensions are not proper, then the operator or the human being will not be comfortable in handling and using those devices. So, the comfort and the performance of the people when using such devices, is significantly influenced by the extent to which these facilities fit to the people, a fitting of the, these devices to the people means, the compatibility of the human being in using of these devices.

If the diameter of pen is say 4 inch, then it will very difficult to grip and handle in one particular way. So, that the, it can be used effectively as desired, but normally diameter of the pen, can be of say 10s mm or 15 mm or 8 mm, which can be gripped effectively by the hand. If it is too thin also, then it will be very difficult to have proper control over the, over the pen and it will be difficult to control it is movement, as desired. So, the

dimensions of these physical devices, significantly effect the comport and the performance of the operator in their use.

If they fit properly, and the, then the people will feel comfortable and they can use those devices effectively for long, but if they do not fit in, then it will be difficult to use and operate them, they will not be able to deliver the desired performance. For example, the discomfort is experienced by driving the bicycle of the child, discomfort experienced by child in driving the big bicycle or when an adult drives the children bicycle.

There is mismatch, children is driving big bicycle, will not be able to operate properly or in it, he will be very uncomfortable in using the big bicycle. The same way, the adult will also be uncomfortable in driving the children's bicycle, so the, for children's small bicycle will fit properly, he will be able to use it comfortably and can go for long, while inconvenience he will experience, while driving the big bicycle. So, we can say that, big bicycles will not be fitting to the child and that is why, it will require the change in dimensions. So, the dimensions of the devices should be such that, they will fit to the people who will be using those devices.

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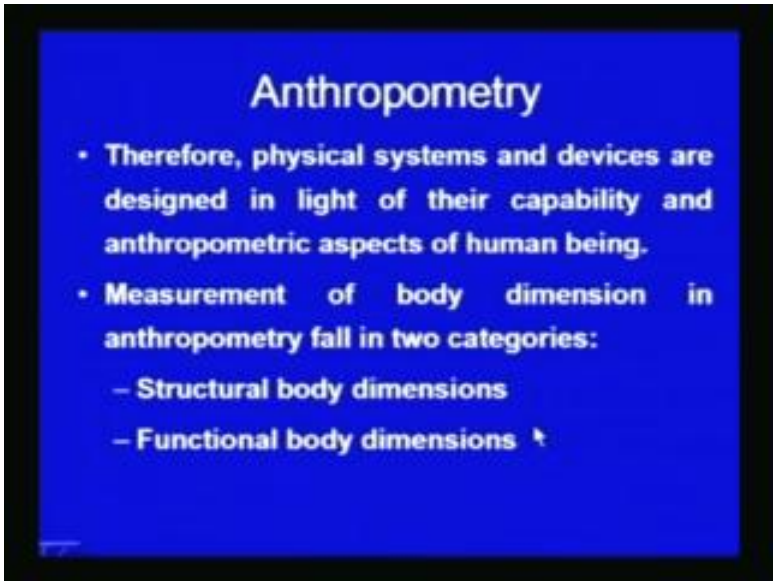


And therefore, physical systems and devices are designed in light of their capability and anthropometric aspects of the human being. The anthropometric data or of the population, targeted population is always kept in mind, while designing the engineering systems and the measurement of the human body, dimensions in anthropometry falls in

two categories, one is a structural body dimensions and the second one is the functional body dimensions.

When the body dimensions are measured in anthropometry, these are, these measurements are carried out in two different ways. In one case, the body is, body remains in a static position and in another case, while operation body is moving and under those, under moving conditions, the measurement of the body dimensions represents to the functional body dimensions, when body is functioning, what will be the dimensions, which will be possible related with the different body parts.

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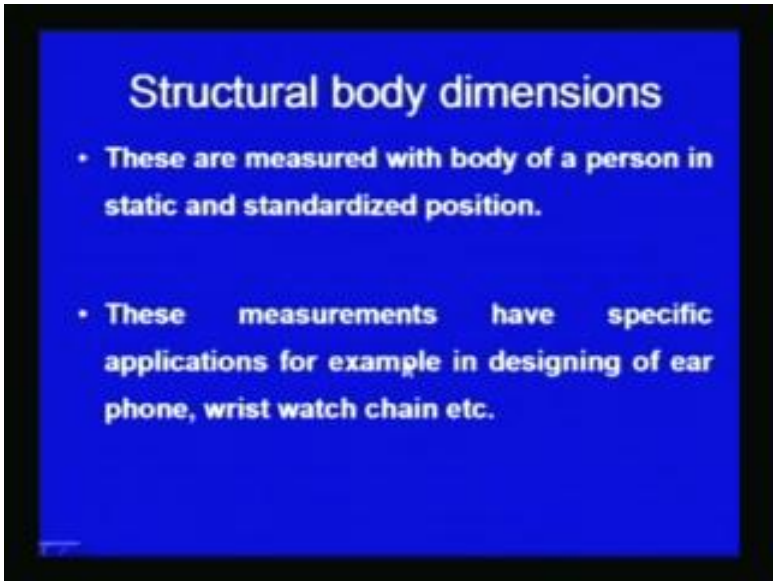


So, structural dimensions are basically, measured with the body of a person in a static and standardized position. Like, if you go to the tailor shop, he will ask us to stand in a particular position, so he will be basically measuring the structural body dimensions in a static and standard position. These measurements have specific application, for example, designing of ear phones, wrist watches or the goggles are also designed, using the structural body dimensions for the people with the different, the structural body dimensions.

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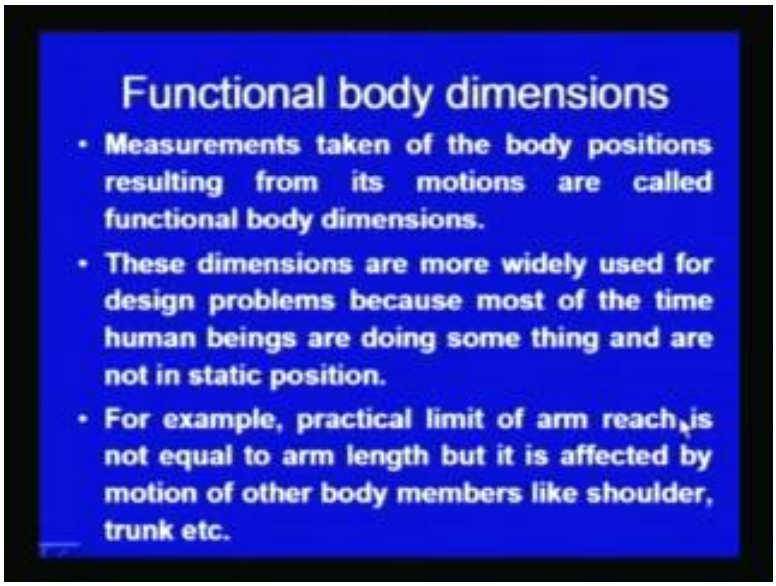


While the functional body dimensions are measured, by taking the body, in these measurements are taken of the body positions, resulting from it is motions are called functional body dimensions. These dimensions are more commonly used in designing the engineering systems, because most of the time, body does not remain in a static and standard position. It is in working or in use, in one or other position, so these dimensions are more widely used for the design problems.

Because most of the time, human beings are doing something and they are not in a static position. For example, practical limit of arm reach is not found equal to the arm length, but it is affected by the motion of the other body members, like shoulders and the trunk. They way by which these body parts are moving, that decides the practical limit of the arm reach, not simply the length of the arm decides the reach, reach limit of the arm.

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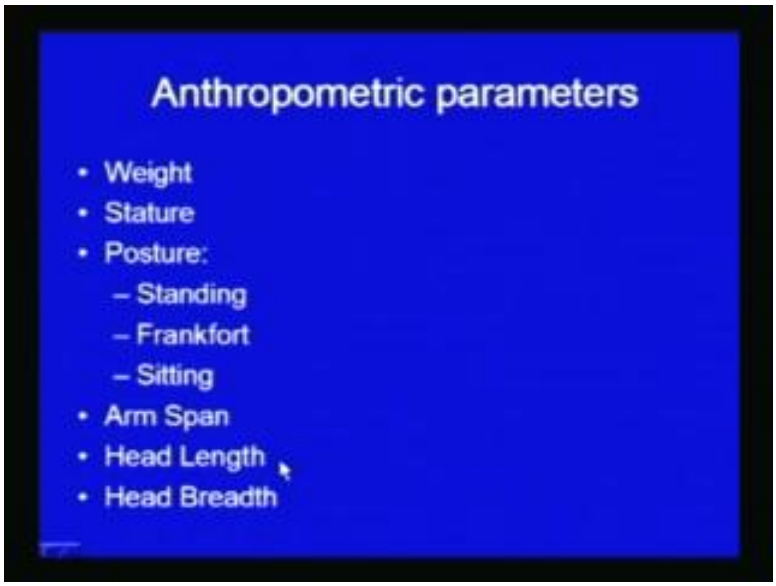


So, functional body dimensions are more commonly used in designing the engineering systems, as compare to that of a structural body dimensions. The anthropometric, the data that is collected for designing the different engineering systems, include the weight, like the chair is designed in such way that it will be able to take the weight, either of kid or of adult or the person of the different weights. A stature, the posture, in standing, frankfort and the sitting conditions and the arm span, the head length and the head breadth. These are the some of the dimensions of the body, which are measured and used in designing the structure and designing of the physical systems.

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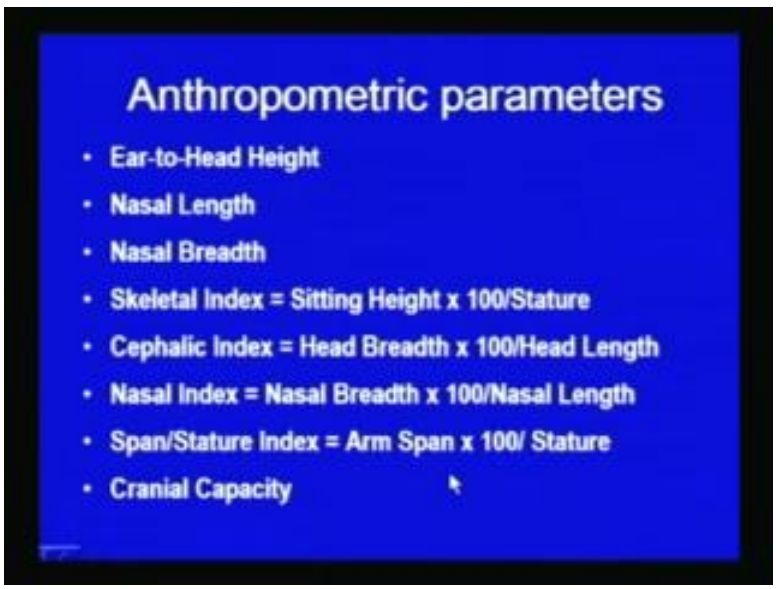

And other dimensions, which are measured under the anthropometric are ear-to-head height, nasal length, the nasal breadth, skeletal index that is equal to the sitting height into 100 divided by a stature, cephalic index that is equal to the head breadth into 100 divided by head length, nasal index that is nasal breadth into 100 divided by nasal length, span of leg, stature index is found with multiplication of the arm span into 100 divided by stature, cranial capacity.

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So, these were the some other anthropometric dimensions, which are measured in, for designing the engineering systems and these dimensions are measured using various tools, to collect the data and find the average and they spread in the data and these are, can say tape, medical scale, spreading caliper, anthropometer and spring caliper, the large and a small in size.

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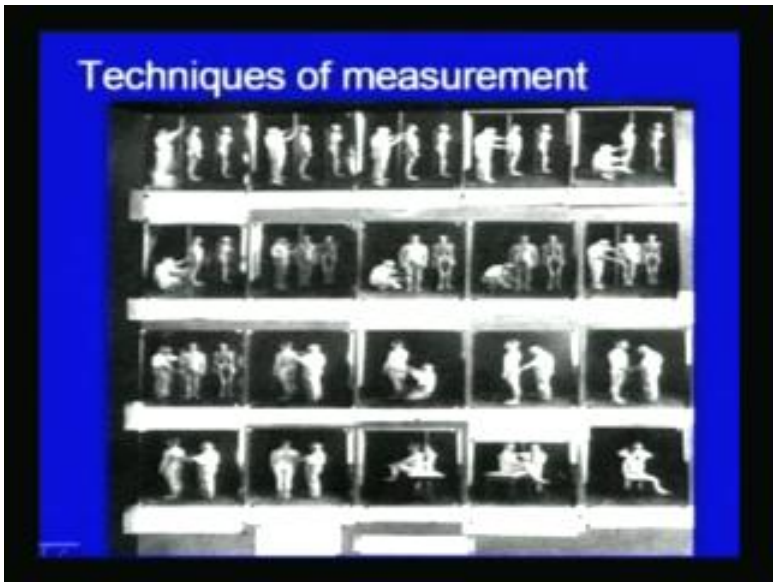


And these different diagrams, shows the way by which, the different body parts, dimensions of the different body parts in different positions are measured.

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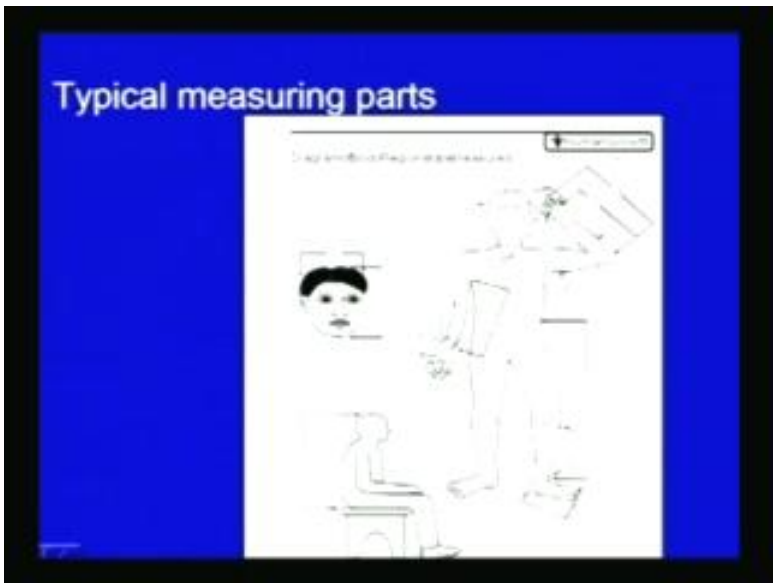


Here, you can see, the different body dimensions have been given and the way by which, they are measured, here the height of the person in sitting position from the head to the, this sitting position is indicated by say 21 inch. The same way the different body dimensions for feet and for this, from this portion and to here, the rest waist portion and the arm length.

And here, the this length of the finger and the length low of the lower arm, the head dimensions, the neck dimensions and the arm length, fingers, different dimensions of the body parts like breadth of the head and the height of the head has been shown and the way by which, different body dimensions which are measured in anthropometry. These body dimensions are effectively used in designing the engineering systems, the another area in ergonomics is the physiology.

Physiology in ergonomics is mainly concerned with the three areas, of the man machine and the systems and these include, the way by which the body parts can be applied. The one area is the way be which body parts can be applied, regarding the accuracy speed and the magnitude of the force, because the different body dimensions have the different accuracy speed and the capacity to apply force. If we know about the ability of the different body parts to apply force at different speeds and the accuracy.

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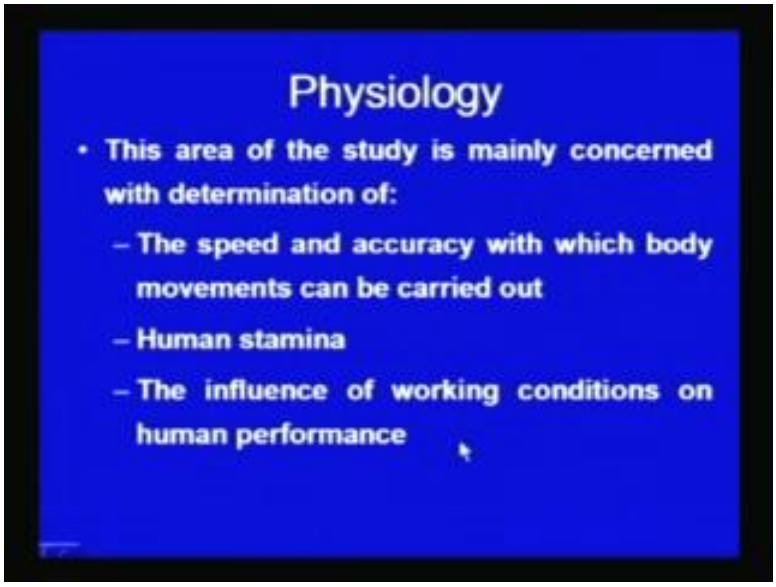


Then, these the engineering systems can be design in such a way, that the heavy muscles and a strong muscles are used for applying the heavy force and the light muscles are used for applying the light force. The another aspect related to the physiology, is the stamina of the human being, human being can deliver energy for carrying out the operation at particular rate. If the excessive energy is required for carrying out the job, then he needs break.

So, in which way breaks should be designed, if the heavy work is to be carried out by the operator, then that is covered under the human stamina. On an average, a 4 kilo calorie energy per minute can be delivered and by the operator or the human being, without need of any rest, but if the energy requirement of the work is much higher, then he will need rest after certain time of the work. The third aspect related with the physiology, is the influence of the working conditions on the human performance.

Like the vibrations, light or the ventilation illumination, these are the, some of the conditions, which significantly affect the performance of the human being, so in which way the different working conditions related with the work area, affect the performance, and the efficiency of the human being is covered under the effect of working conditions on the human performance and these aspects will be covered in detail one by one.

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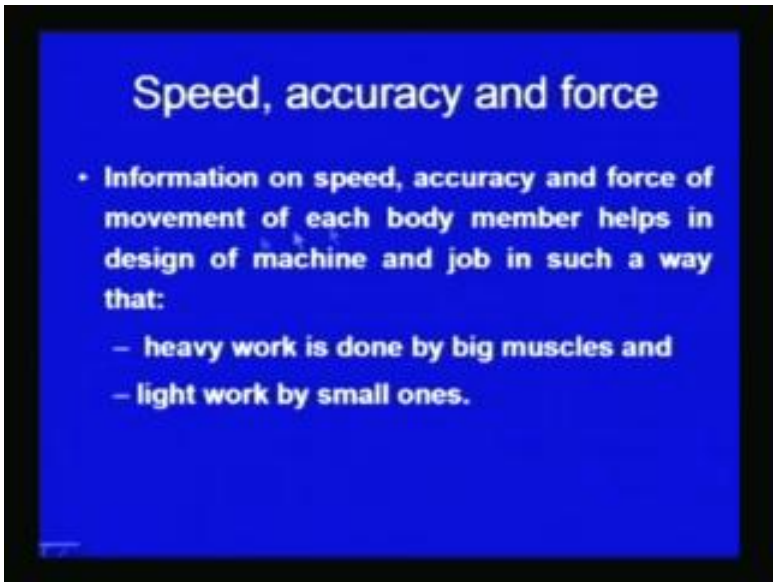


Speed, accuracy and the force, with which a body part can be used information regarding the speed, accuracy and the force of movement of each body member helps in designing of the machines, and the jobs in such a way that heavy work is done by the big muscles and the light work is done by the small ones.

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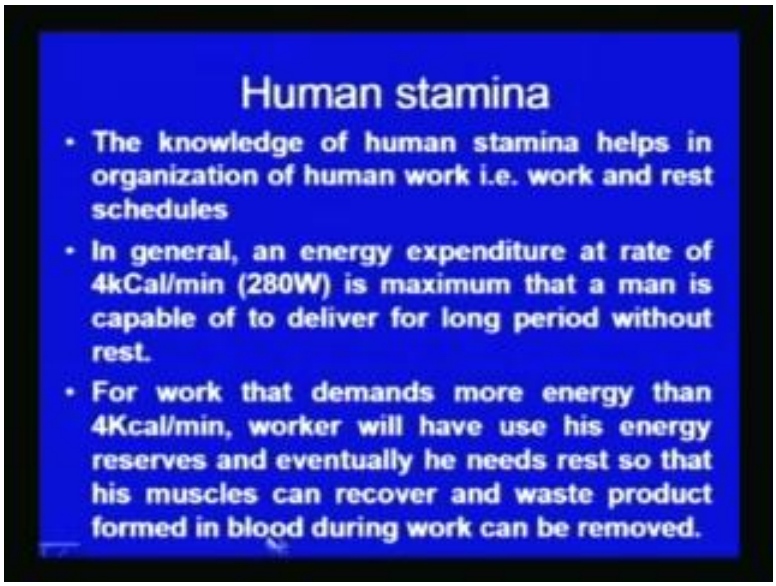


On the other hand is the stamina, is about the knowledge of the human, stamina human being, knowledge of the stamina of the human being helps in organization of the human work. That is about, at how long work will be continued and after how long time, the rest should be given and what it should be the duration of the rest, so that operator can recover from the fatigue and again he can restart the work. In general, an average energy expenditure for a human being is, at the rate of 4 kilo calorie per minute.

That is equal to 280 watt, is maximum, that a man is capable to deliver for long period without need of rest. So, an operator or a human being can deliver energy, at the rate of 4 kilo calorie per minute, but if the energy requirements are more, then he will require rest after certain period of time. So, for the work that demands more energy, than the 4 kilo calorie per minute, worker will have to use his energy reserves and eventually he needs rest, so that, his muscles can recover and waste products have formed in blood, during the work can be removed.

So, here whatever undesirable in chemical products, which have informed in the blood during the work, are gradually removed from the blood, during the rest period, because when physical activity or exercise is carried out, those undesirable chemical products are generated in the blood, which are automatically removed by the chemical reaction and with the oxygen and those undesirable chemical products.

So, oxygen is and during the rest period and taking the sufficient amount of the oxygen during the rest period, the undesirable waste products are removed gradually from the blood and the operator becomes ready for another cycle of the work. So, the rest is required only in those cases, where energy requirement for carrying out the job is greater than 4 kilo calorie per minute.

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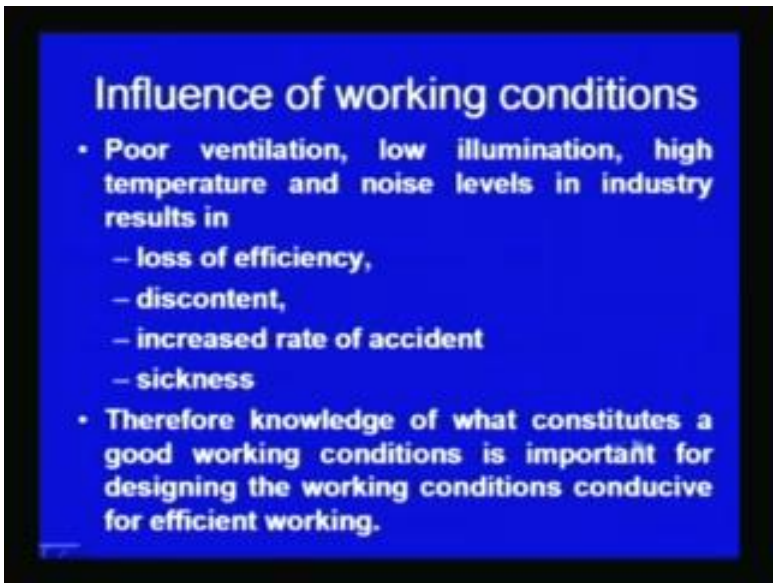


The third aspect of the physiology, is the influence of the working conditions, the working conditions are known to significantly influence the performance of the human being, because if the working conditions are not proper, they lead to the very poor performance by the operator and which in turn will reduce output from the worker and therefore, the working conditions must be in proper shape. A poor ventilation, illumination, high temperature, noise level in the industry are frequently encountered.

And these lead to, the loss of efficiency, discontent, increased rate of accidents and the sickness of the operator. So, if the working conditions are not proper, it will reduce, it will adversely affect the operators performance and his health. At the same time, it will increase the tendency of, the increased tendency of the accidents will be there and the operator health is also ((Refer Time: 30:24)) irreversibly affected. Therefore, knowledge of what constitutes a good working condition is important first.

We should know what is required, so that what is required as far as working conditions are concerned, so that operator can work effectively, without losing any efficiency or

without leading to a situation, where accidents may occur. So, the knowledge of the things, which constitutes good working conditions is important for designing the working conditions conducive for the efficient working.

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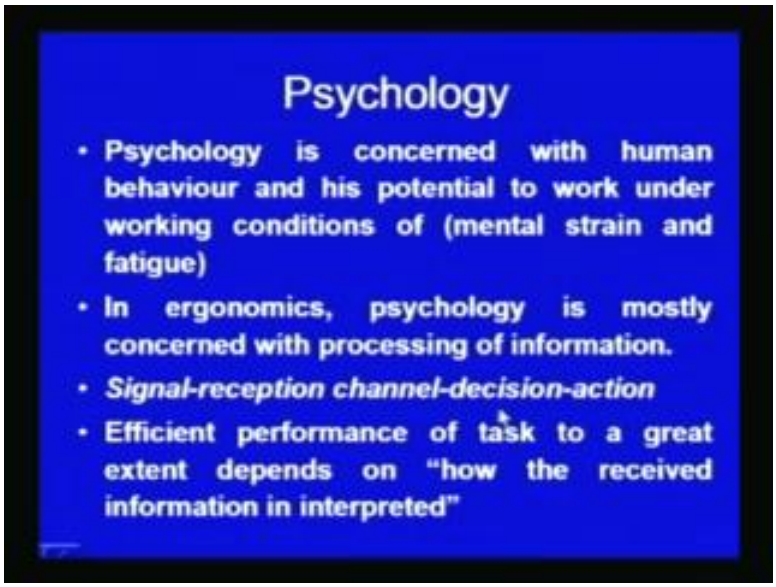


Psychology is the third area of the ergonomics, although they are so many things in psychology, but will be targeting the things, which are relevant to the ergonomics, under the design of the mechanical systems, in such a way that, operator can perform the function effectively. The psychology, in ergonomics is mainly concerned with the human behavior and his ability to work under the working conditions. That is, mainly related with the mentally strain and the fatigue.

How effectively he can work, under the conditions of the mentally strain and the fatigue, by receiving the information from the engineering systems, which are being used by him and how effectively he makes the interpretation of those informations and then process them to take the suitable corrective action for producing the desired output. In ergonomics, psychology is mostly concerned with the processing of the information and the which, basically involves the sequence of the signal.

So, which are, they are with the system or with the machines which is being, a machine which is being used by him and these signal are received by the operator and based on the receiving of these signals, operator interprets them and based on the interpretation, he take suitable decision and after taking decision, he take suitable action. These may be

related, to the use or not to use, a start or a stop, the particular step or when to move ahead based on that the decision is taken, and the action is taken for success of the process.

For efficient performance of the task, it is necessary that, the operator receives the information correctly, process the information properly, makes the correct interpretation and based on that it takes suitable decision and then corrective action, or the action which is required for success of the process. The efficient performance of the task therefore, to a great extent depends on, how he has received the information and the how information has been interpreted, for taking suitable decision. In the mechanical systems, this area, this is the fourth area of the ergonomics, which is mainly related with the mechanical systems, which will be used by the worker.

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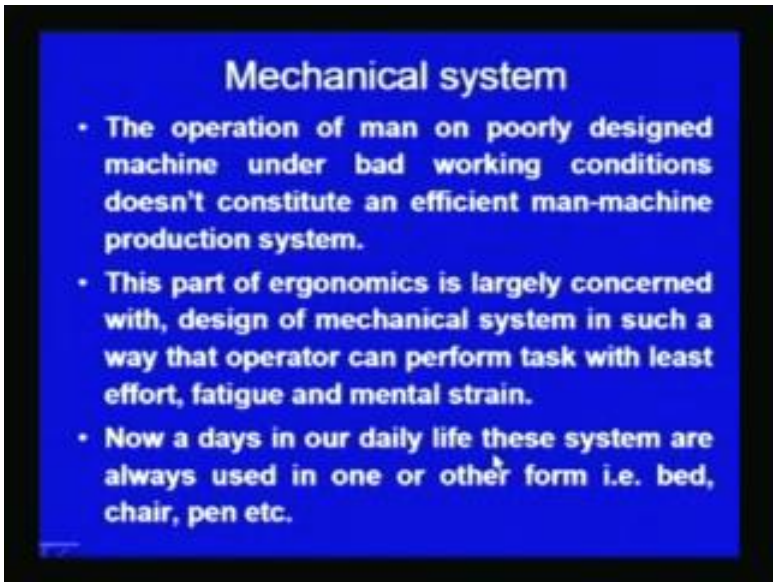


An operation of the man, on poorly designed machine, in bad working conditions does not constitute an efficient man machine system. The man should get the proper system for carrying out the desired job and the good working conditions, in which the work will be done, then only it will constitute good man machine system. The, this part of the ergonomics, that is the mechanical systems is mainly related with the design of the mechanical systems in such a way, that the operator can perform the task with the least effort, fatigue and the mental strain.

So, objective is to design the systems, which will be used by the operator during the work, is that takes less effort and that causes less fatigue to the operator and the mental strain, during the operation. So, that he can perform for long, without need of frequent breaks and so that, the operators output can be increased and the, if productivity of the system can be increased. Nowadays, in our daily life, these systems are always used in one or other form.

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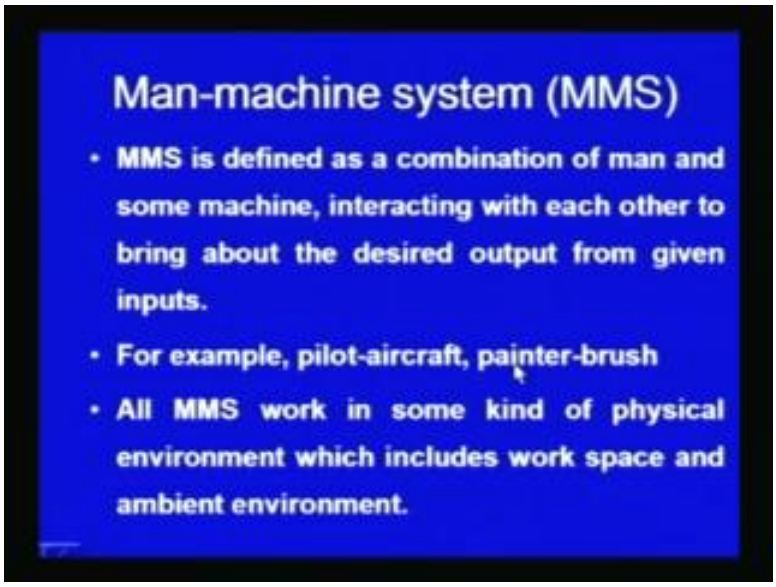


So, mechanical systems are the systems, which are used by the human being or by the operator, in course of the operation, production or manufacturing, the man and mechanical systems the what, the man who is working on a particular machine, combination of the both or combination of the man and machine leads to form a system, which is commonly known as man- machine system or MMS. The man machine system is defined as a combination of the man and the some machines, interacting with the each other to bring about the desired output, from given inputs.

For example, a pilot is driving aircraft, to get desired the desired output, of transporting the people from one place to the another or painter is handling the brush in controlled manner, so that, he is able to come off, with that kind of drawings or designs, which he wants to put in, on the paper. So, here the painter is a man and the machine or the mechanical system being used by him is the brush and in the first case, pilot is a man and the aircraft is the machine, which is being used by the pilot for getting the desired output.

All MMS work in some kind of the physical environment, so the man machine systems, which are working in some kind of physical environment. These are basically includes the work space and the ambient environment, the work space should be designed in such a way, that the operator can use the machines effectively without under fatigue and the mental strain and the environment in which work is being done, should be such that, it does not adversely affect the operators performance.

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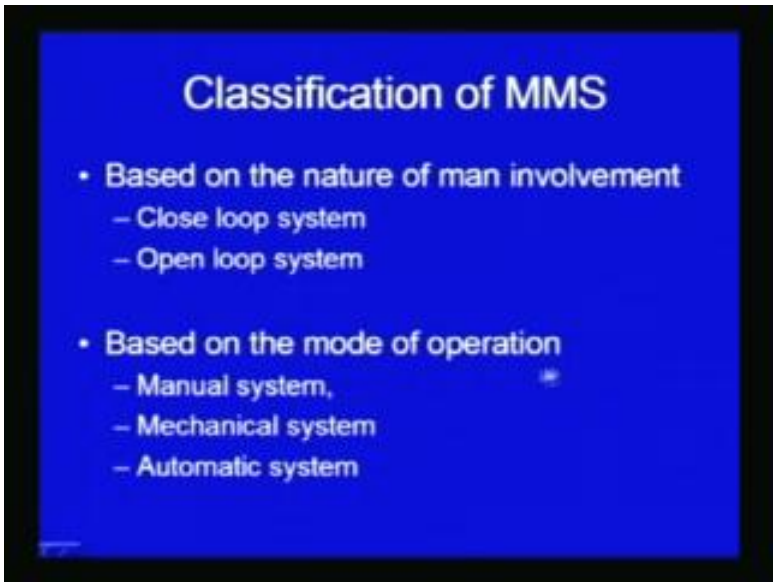


The man machine systems can be classified, on the basis of the various factors, the two main factors based on which man machine systems are classified will be covered here. Based on the nature of the man involvement, the extent up to which, the man interferes with the machines, for the success of the operation, we can classify the close loop systems and the open loop systems and the another factor based on which man machine systems can be classified is, the kind of the operation which is there.

The manual systems, in which the energy required for success of the operation is delivered by the operator, while in mechanical systems, these are power driven systems, but the operator receives the information, takes the suitable decision, and then takes corrective action for the success of the operation. While in automatic systems, the receiving of the signals taking suitable decision and then action, is also taken by the man, by the machines itself.

So, not only the power driven systems are there, for delivering the required energy, for success of the operation, but the activities like receiving the signals, taking suitable decision and the action, is also taken by the automatic system. So, these classifications will be covered in detail one by one.

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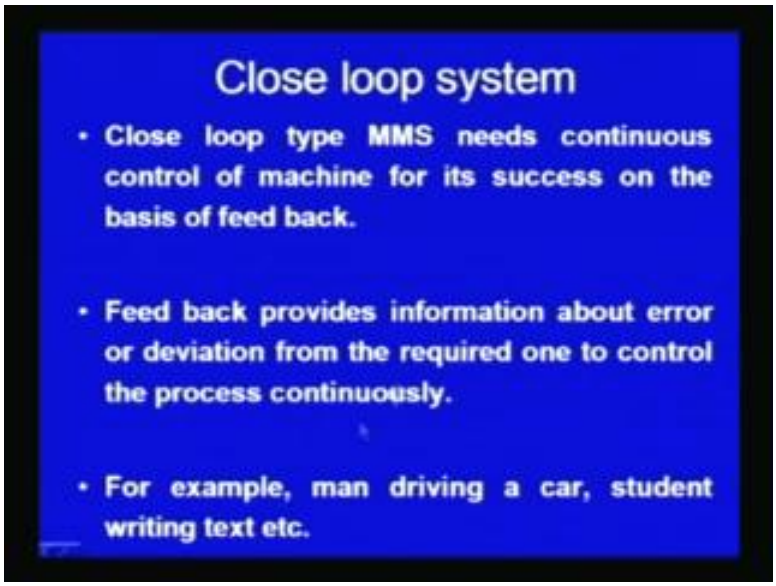


Here, close loop systems are those in which, continuous control of the machine is done by the operator for it is success. These systems work, on the bases of the feedback, like for success of these operations, it is necessary that, the feedback is continuously given by the operator to the machines and it then he takes the corrective action, so that the desired functions, can be performed by the machine to deliver the desired output. Feedback provides the information about the error or deviation from the required one, to control the process continuously.

Like while driving, the driver continuously steers the car or the automobile to reach from one destination to the another, so driving of a car needs a continuous control, so that is a close loop system, where continuous attention is required by the machine or the mechanical system for the success of it is operation. So, close loop systems are based on the feedback and this based on the feedback, the corrective actions are taken continuously by the operator for the success of the operation.

So, here this example, I have given a man driving a car or a student writing the text, for writing also the, a student or the teacher has to continuously control the movement of the

pen, during the writing. So, for writing perfectly as per requirement pen, movement of the pen is to be controlled continuously.

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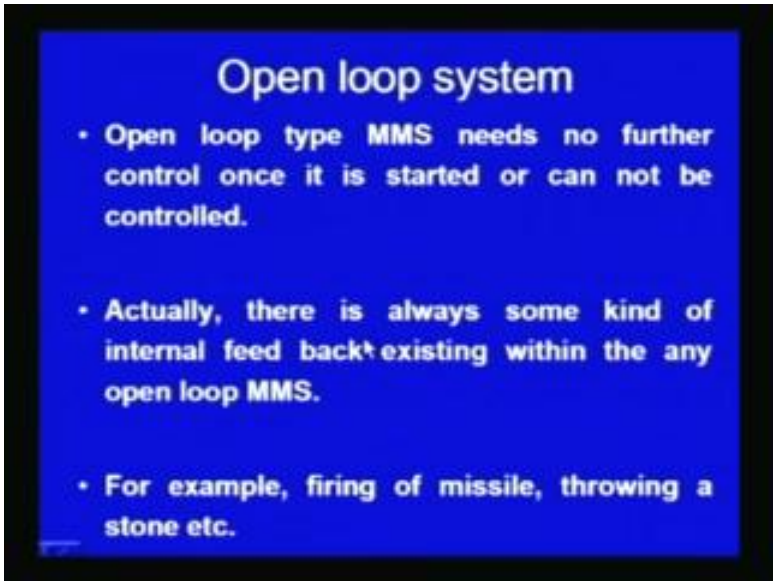


In open loop systems, these systems need no further control, once these have been started or rather these cannot be controlled, once these have been started. Actually, there is always some kind of the internal feedback, existing within any open loop system, for example, firing of the missile, firing of the missile is continuously controlled by the gravitational force, but manually it is not controlled by the operator or by the persons, who are using these devices.

Similarly, throwing of the stone, once the stone has been thrown, it cannot be controlled, but it can be, it is controlled actually by the some sort of internal feedback, which is existing in form of the gravitation force. So, such kind of systems, which are once started, need no further control or other, they cannot be controlled further. These are known as open loop systems.

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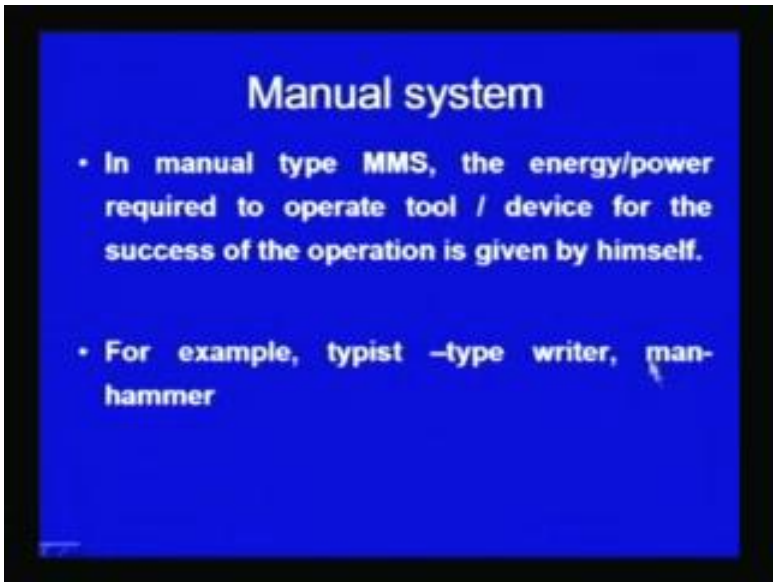


Manual systems are those in which energy or the power required to operate the tool or device for success of operation is given by the operator himself. For example, the typist working on the type writer or the man with the hammer, the hammer is operated by the man to give the desired shape to the raw material. So, here the desired force is applied by the typist, for the typing and the desired force or the energy is delivered by the man, for handling the hammer and to get the desired results.

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In mechanical system the man in mechanical type, man machine systems, the man with the power driven machine. These are the two components, the man operates the power driven machine, he actually does not deliver the power required for success of the operation, but he controls the machine, the function of operator here is essentially to process the information, takes the suitable decision and control the machine, so that, operation can be successfully performed.

These kinds of systems are also called the semi automatic machines, for example, a turner working on the lathe, so the desired power for turning operation, it is delivered by the electric motor, while the desired feed can be given by the operator and he can start or stop the feed as per requirement. So, regarding the staring or a stopping or giving the feed, the action is taken by the turner while the desired power for, rotating the tool is delivered by the power driven, electric power driven motor.

In the same way the black smith using the powered hammer to get the desired size and shape of the raw material. So, such kind of systems are called semi automatic systems, in which power required for success of the operation is delivered by the power driven machine or the electric motor itself, while the control functions is basically performed by the operator itself.

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In the automatic man machine systems, in these systems, these system, automatic type of man machine systems consists of machines, that are expected to perform all operational

functions, like sensing information processing and decision making. In addition to the running and delivering desired power required for success of the operation. Still in these systems, certain functions like monitoring, programming, maintenance are performed by the human being. These systems also need human intervention, at certain interval of the time for regular maintenance or for the, for giving the desired program or for feeding the desired programs, the automatic lathes and automatic landing aircrafts are the typical examples of the automatic systems.

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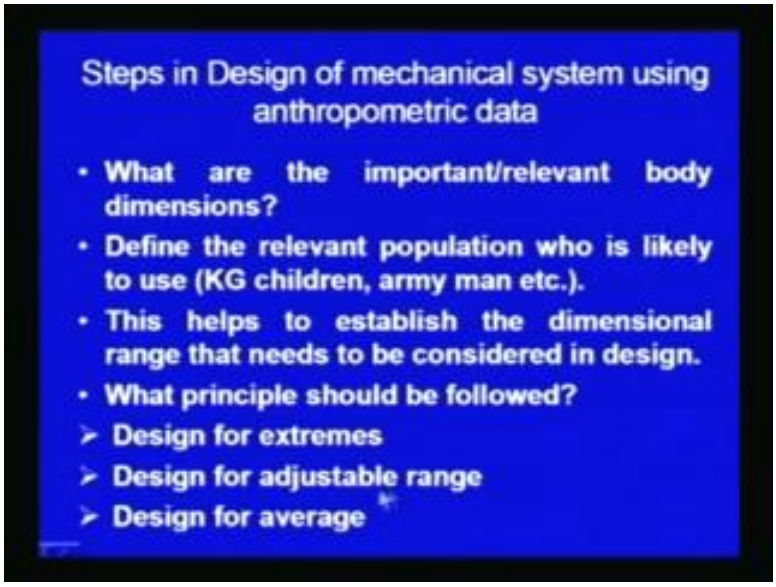


These systems which are being used by the operator, for carrying out the desired jobs are designed in light of the anthropometric dimensions of the operator or the targeted, in the people who will be using these systems. So, it is important to identify, what are those relevant body parts and which will be used for carrying out the job, using the mechanical systems. So, what are those important and the relevant body dimensions, which should used in design of the engineering systems.

And then defining the relevant population who will be using, the design engineering systems, whether these will be the KG children's or the army mans. These help will the definition regarding the relevant population will help to identify the range of the anthropometric data, which can be there. This helps to establish the dimensional range that needs to be considered in design, what principle should be followed, in designing a given engineering system.

This is largely based on the engineering system, which is to be designed and the targeted population. These principles are based on the design for the extremes, like the design will be targeted for the people of the highest dimensions or the minimum dimensions, that is about the designs for extremes. The design for adjustable range is about, the using a particular device by the people of the varying anthropometric data, while the design for average is this principle of the design is used when, there is no fixed targeted population, who can use the given engineering system. So, these the principles will be discussed in detail one by one.

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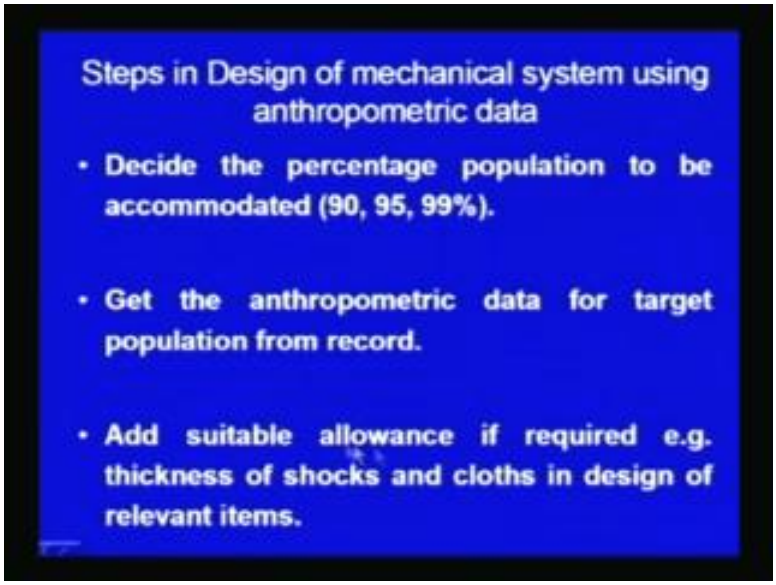


For designing the mechanical systems, we need to identify, what percentage of the population will be accommodated and will be covered by the given engineering design, we have to take suitable decision, whether it will be 90, 95 or 99 percent. Get the anthropometric data for the targeted population from the record and add the suitable allowances, as per needs. So, for example thickness of shocks or the cloths in design of the relevant items.

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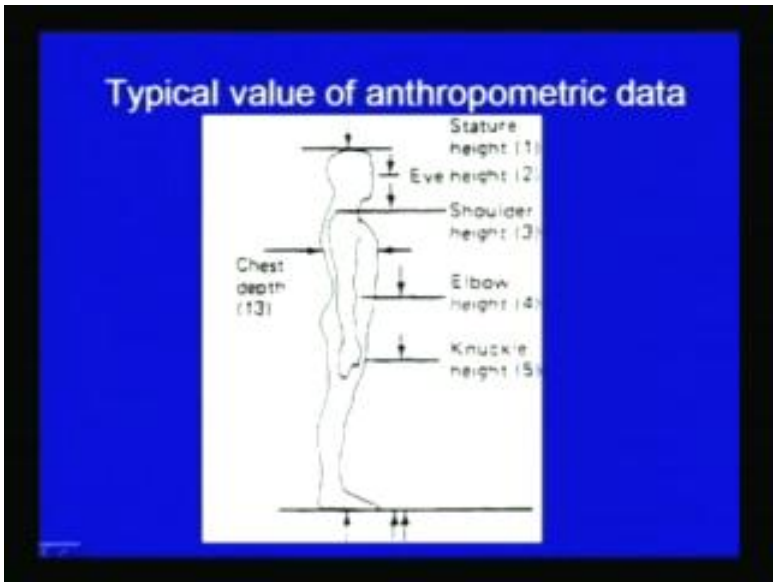


The typical anthropometric data, which is generated and taken from the record for design purpose, here the stature height, this the 1 represents the stature height, for the complete height of the person, right from the bottom to the top. The eye height is the, given the stature height, number is given 1, say eye height number is given 2 and shoulder height, then elbow height 4 and the knuckle height 5. These typical body dimensions will be shown for both male and female, persons in this slide.

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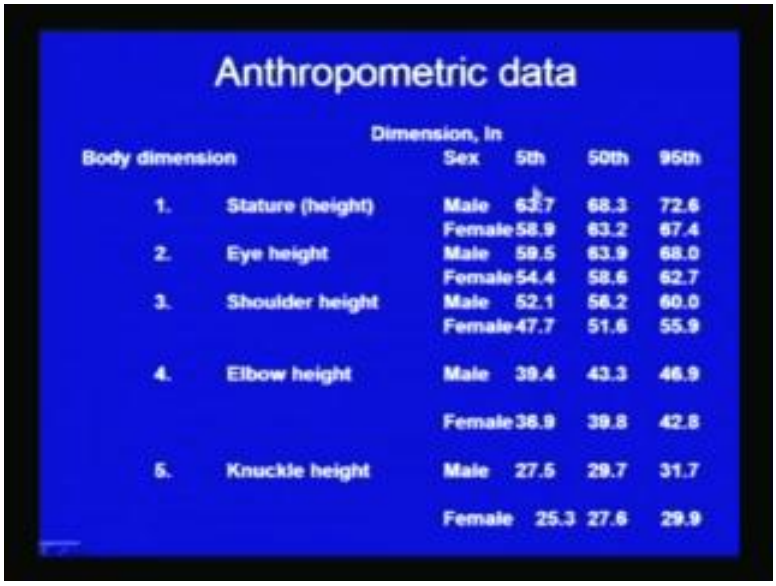

We can see here, the different body dimensions, like stature, eye height, shoulder height, elbow height and the knuckle height. These are heights from, the horizontal portion on which, the someone or the person is standing, then depending upon the sex of the person, whether he is male or she is female, here the body dimensions are different, for the different percentileth of the person, for different percentile range, for 5th percentile, it is on the lower side and for 95th percentile, it is on the higher side.

So, height or the stature, for the male it is say for 5th of percentile, it is 63.7 inch, all these dimensions are in inch, in the same way, so from this table, we can see the different heights from the level, where person is standing for male and female and for the different percentile ranges, so here, these dimensions can be effectively used in designing the engineering systems, which are to be used by the human being.

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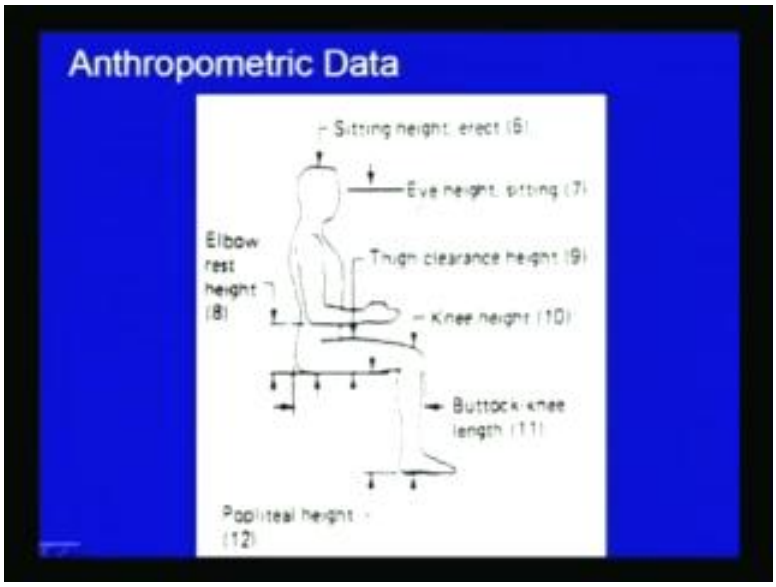


Now, in this slide, we will see some other anthropometric dimensions which are measured, like the eye height, is this one from the ground level. In the sitting position, this elbow rest height, that is this height and here the knee height, the buttock knee length here, that is this length and the thigh clearance height, that is this one and the eye height in the sitting position. So, different numbers have been given and the corresponding, the values have been given in the next table.

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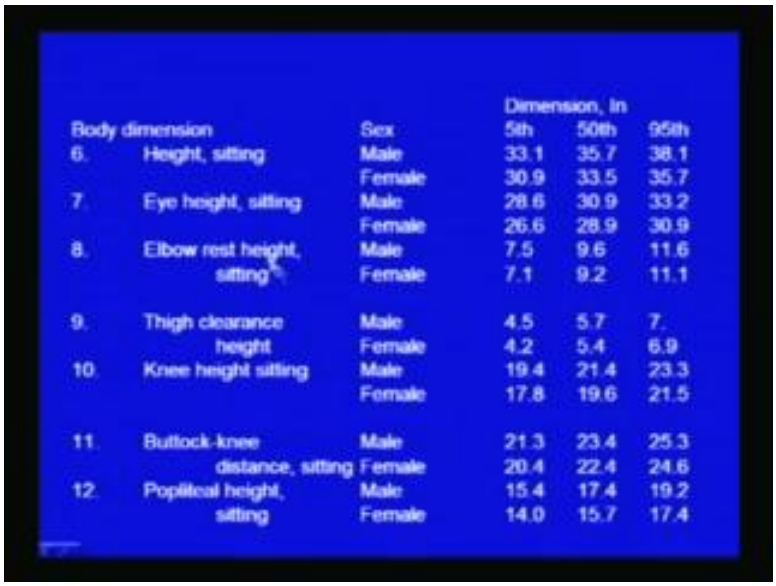

| Body dimension | | Sex | Dimension, in 5th | 50th | 95th |
|---|---|---|---|---|---|
| 6. | Height, sitting | Male | 33.1 | 35.7 | 38.1 |
| | | Female | 30.9 | 33.5 | 35.7 |
| 7. | Eye height, sitting | Male | 28.6 | 30.9 | 33.2 |
| | | Female | 26.6 | 28.9 | 30.9 |
| 8. | Elbow rest height, sitting | Male | 7.5 | 9.6 | 11.6 |
| | | Female | 7.1 | 9.2 | 11.1 |
| 9. | Thigh clearance height | Male | 4.5 | 5.7 | 7. |
| | | Female | 4.2 | 5.4 | 6.9 |
| 10. | Knee height sitting | Male | 19.4 | 21.4 | 23.3 |
| | | Female | 17.8 | 19.6 | 21.5 |
| 11. | Buttock-knee distance, sitting | Male | 21.3 | 23.4 | 25.3 |
| | | Female | 20.4 | 22.4 | 24.6 |
| 12. | Popliteal height, sitting | Male | 15.4 | 17.4 | 19.2 |
| | | Female | 14.0 | 15.7 | 17.4 |

Here some other body dimensions with respect to the different reference points, in sitting positions have been given here, for the male and female for 5 th, a 50th and 95th of percentile, and all these dimensions are also has been given in the inch. So here, these dimensions can be used in designing of the seats, the work rest heights, the locations where the different levers and the tool should be located during the operation and likewise, the engineering systems can be designed in such a way. That the operator and the human beings are of the targeted population can be, use the systems effectively.

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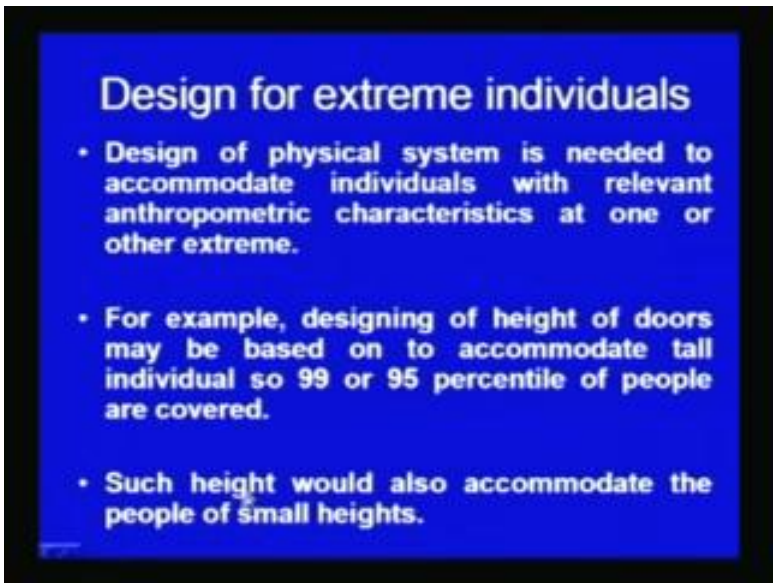

And these designs are usually based on the three principles, as I have described earlier, the designs for the extreme individuals is based on the extreme anthropometric data for the human beings, who are to be covered. The design of the physical system is needed through accommodate, the individuals with the relevant anthropometric data, at one or other extremes. For example, designing of the height of the doors, may be based on to accommodate the tall individuals, so that, either 95 or 99 percentile of the people are covered. Such height would also accommodate the people of a small heights.

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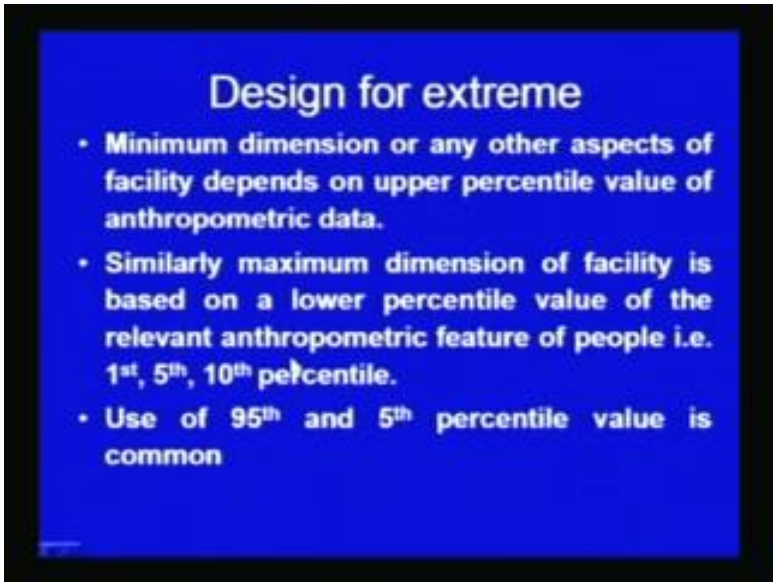


The minimum dimension of a system depends on the upper percentile value of the anthropometric data. Like, what will be the minimum height of the gate, that is decided by the upper percentile of the people, who are to be covered by that height. So, in the same way, the maximum dimension of the facility is based on the lower percentile value, of the relevant anthropometric feature of the people who are to be covered, like a target is to cover only the 1st or 5th or 10th percentile of the people will be left out. So, what will be the, now a percentile of the people, who will be considered or who will not be considered in designing the engineering system. So, but it is very common to use a 95th and a 5th percentile value, for that designing of the engineering systems.

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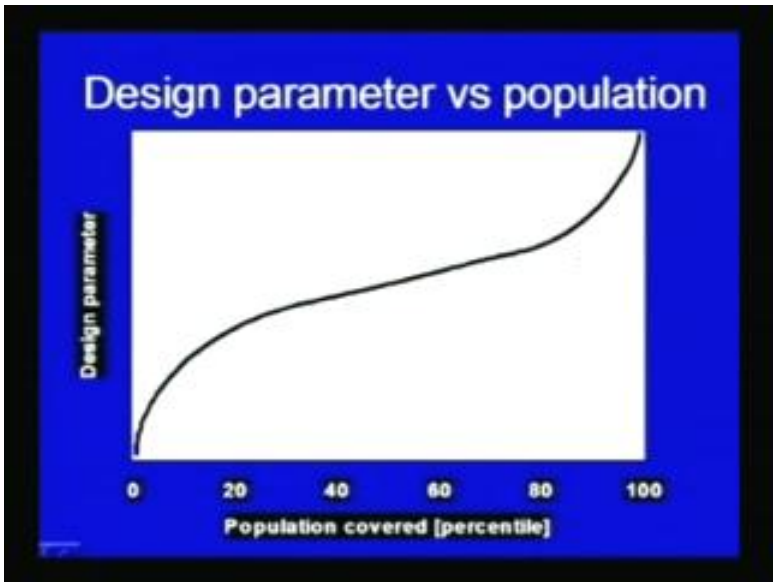


If you see here that the way by which, the percentile of the people who are covered with the change of the design parameters. So, if we select very low range of the design parameter, very minimal number of the people are covered and these will go on increasing, this number actually, the increase in the number of population, increase in the percentile of the population increases non-linearly at the extreme ends.

Here, it increases very rapidly or on the higher side, on the extreme side also it, the percentile of the population increases very rapidly, it means non-linearly, if you see here, the linear range exist only in between. So, here, if the design parameter, a design parameters are normally selected in such a way that neither too low or neither the too high side, the design characteristics are there for a mechanical system. And normally 95 percentile of the people to the 90 to the 5th percentile of the people are targeted to be covered in designing the engineering systems.

So, the design parameters are selected in such a way, mostly the 95th percentile of the anthropometric data to the 95 percentile of the anthropometric data, related people are covered by the given engineering systems, if the efforts are made to cover the entire 100 percentile of the people, by the design range unnecessary it will increase the cost of the product, which may not a significantly increase the number of the populations will, which will be covered, because most of the population fall in the range of 5th to 95th percentile range.

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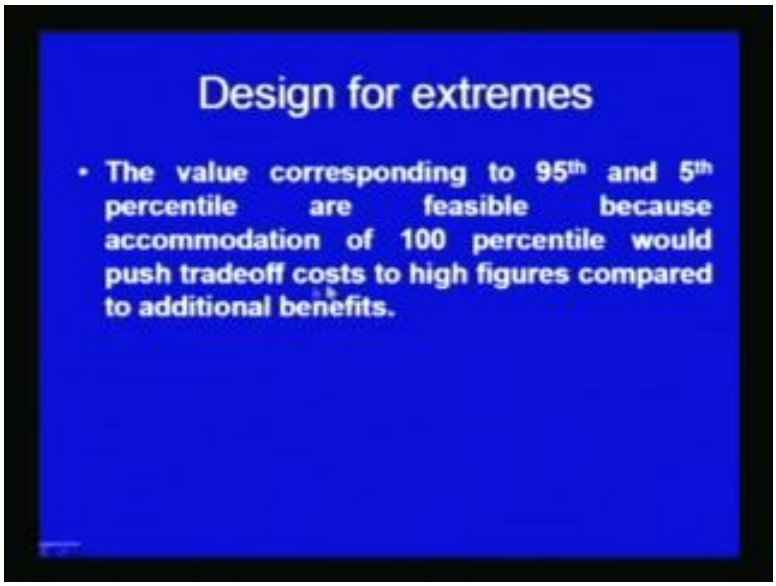


So, the value corresponding to 95 th and the 5 th percentile are feasible, because accommodation of the 100 percentile would push the tradeoff costs to the high figures as compared to the additional benefits to the benefits which will appear in form of increased number of users.

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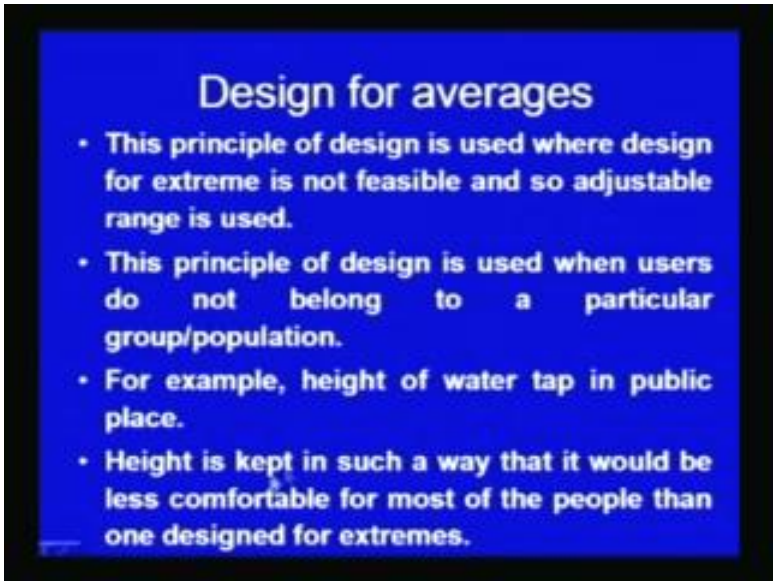


Design for the averages, this principle is used where design, for extremes is not feasible and the conditions where the engineering systems can be used by the any kind of the people or there is no fixed targeted population who can use the given engineering

system. The principle, this principle of the design is used when users do not belong to a particular group or the population, like height of that water tap in public place, the public place water tap can be used by the any kind of, by the person of any height, he may be as a children or he may be adult also.

So, the height of their water tap is decided in such a way, that it would cause less in convenience, to the persons who can who will be using the water tap. The height is kept in such a way that it would be less comfortable for less uncomfortable for most of the people, than one designed for the extremes.

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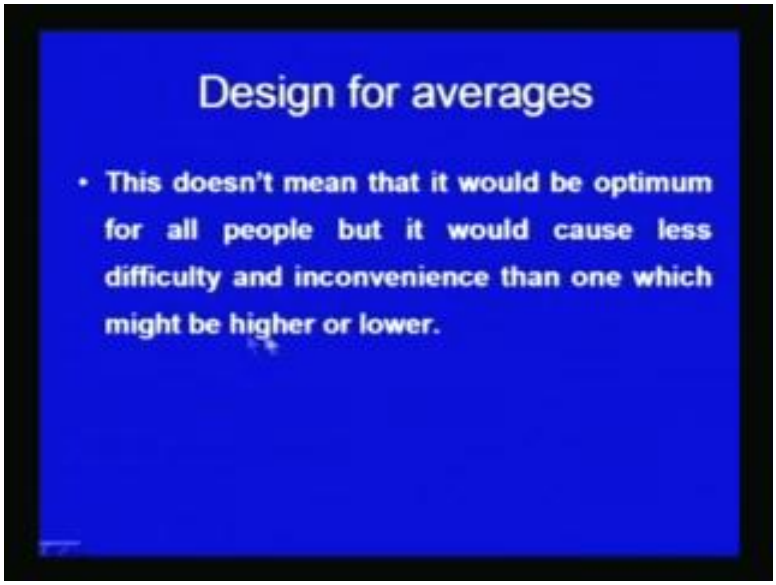


This does not mean, that it would be optimum for all, but it would cause less difficulty and inconvenience than one, which might be of or higher or the lower heights.

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To accommodate the people of varying anthropometric feature, some of the features of the engineering systems are designed using the principle of adjustable range. For example, height of the computer chair in the computer lab or the distance between a crank and the seat in bicycle or designed for adjustable range. Adjustable range is commonly designed for 5th to 95th percentile range of the population.

Now, I shall conclude this presentation, in this presentation mainly, you have seen that ergonomics is very effectively used in designing the engineering systems, but it needs the knowledge of the anthropology, physiology, psychology and the engineering sciences. So, that the engineering systems can be designed in such a way, that the operators can use them comfortably with the minimum effort.

Thank you for your attention please.