Work System Design
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Lecture - 54
Man-Machine System - I

Namaskar friends, Welcome to session 54 of our course on work system design, and currently we are in the 11th week of our discussion and the topic that we are discussing during this week is ergonomics. So, we have seen that there are standard techniques for developing the better method of doing the job. There are standard techniques that we can use for finding out the time required for performing the task.

So both the things we have already discussed in detail and various tools and techniques that are required to undertake both these operations or both these functions that is finding out the best way of doing the work as well as finding out the time required to do the work using the one best method already we know. Now we are trying to understand the work system in totality. We are trying to understand that how we can do design the work system.

So that we are able to achieve our major objective of enhanced or improved productivity and here we are trying to understand that if the system is ergonomically designed or if we are able to successfully design a system where the work is being done taking into account the ergonomic principles we will be able to achieve our target of higher productivity or the maximum productivity and in ergonomics if you remember during this week we have already covered the basic aspect of ergonomics.

Then we have seen certain examples of ergonomics. Also, we have seen an important topic that is anthropometry and in anthropometry you remember in the last session we have seen that based on the vital dimensions of the body we can design the system so that the productivity improves. As an example the tools that are to be frequently used must be in the close vicinity of the worker or the operator.

Thereby based on the anthropometric data we develop a minimum working area and a maximum working area in which the worker can work efficiently or he can work productively. So the important point that I want to emphasize today is that now our focus is on the complete system as a whole instead of focusing on a very micro area of a person operating a single machine. So now we are trying to understand the basic concept of ergonomics as well as the basic concept of the design of the work system as a whole.

And in that we need to understand that how the man and a machine will interact. Now for the whole system for example we can say that where there is assembly line in which a particular model of a car is getting assembled. Now this assembly line can be a fully automatic line without any human intervention, not even a single operator required to operate this line. It is possible with the technological advancements that have taken place in the field of science and engineering.

It is possible. It is must we go for this type of a system or a fully automatic system or there are certain areas where we must have certain human intervention. So therefore we need to understand that how a man and a machine will interpret and how this interaction can be improved in order to improvise on the work system. In order to take advantage of the work system, in order to make our work system more and more efficient, more and more effective leading to more and more productivity for an organization.

So our target is to understand the man machine interaction so that we are able to realize our goals, realize our objectives, and realize our aims. So therefore we have designed this particular week into ergonomic aspects, anthropometry, and finally the man machine interaction. So today we will discuss the basic aspects of man-machine system as you can see on your screen this is first session on man-machine system.

And in the second session we will again cover the important aspects of man-machine system. So basically, we need to understand that what do we mean by a man-machine system, what are the different types of man-machine systems and what are the advantages if we use a man as a

productive element and what are the advantages if we take a machine as a productive element because in a fully automatic system.

Our productive element will be a machine or a set of machine or a sequence of machine or a cluster of machines whereas in case of a fully manual system our productive element will be a human being or a group of human begins or a team of human begins who will be working for a common goal of developing the products or for fabricating the products. So with this background that why we are now focusing on man-machine system because now we want to take a call.

We want to decide we have to do the decision making that what type of system we must develop that also is required because now we know this is the best way for doing the task. It can be done with a robotic arm also or by a human being also. We need to decide whether we have to go for a robotic arm or we require the services of a skilled human being who can do the same task. So that is there may be crux.

Or that is the dilemma with which the production manager has to deal with and therefore the basic understanding of the man-machine system will help them getting over this dilemma and taking a decision in a more judicious as well as in a more informed manner. So let us start our discussion for man-machine system. So first we will start with the basic definition for man-machine system.

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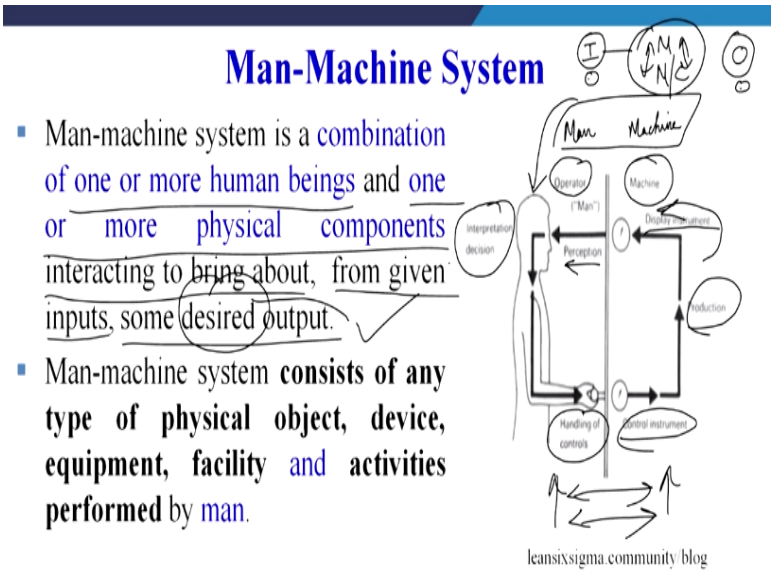

You can see here on your screen, there is a man here and he is operating a machine. So this is the operator. So we can call it as a man and on this side we have a machine. So it is a man-machine system in action and here you can see this is he is handling the controls here. This is the control instrument which is changing something in this direction and this is a display instrument which is displaying what he is controlling and based on the display that he is seeing or based on the perception developed because of the display he is doing the decision making.

He is using his mental faculties to do some interpretation and taking the decision. So this side is man and this side is machine and this interaction we need to understand when we are designing our work system. So let us now see the definition if we have understood the figure. Man-machine system is a combination of 1 or more human beings and 1 or more physical components interacting. So basically it is an interaction between the 1 or more human beings.

And 1 or more physical components. They are interacting to bring about from a given set of inputs, some desired output. So, basically there is an input suppose this is an input and this is the output that we want to desire so in between we have a system in which there is men and as well as there is a machine. So both of them interact, man and machine interact to convert a certain set of input into a certain set of output. So that is the basic meaning.

Now in every organization there will be set of inputs for example if a company is manufacturing chairs and the set of operations are completely manual. So the raw material can be wood that they are purchasing and the output can be the chairs that they are manufacturing. So from wood they are manufacturing the chairs. So this is the input, this is the output, but in between there is an interaction between the man or the carpenters.

Or the specialized people who are working with this wood to create the chair or to develop a chair or to fabricate a chair. So there are men and then certainly they are using some tools, they may be using certain machines, wood working machines, and these machines and these men are working together to convert the input that is wood into the output that is chair. So that is the basic we can say definition and this interaction between man.

And machine is very, very, very important because if we are not able to control this interaction in the best possible manner what is going to happen? The output is going to be faulty and the output is faulty means the organization may suffer lot of losses. So therefore there is an importance which governs or there is an importance that has to be given to this interaction between the man and the machine.

So the man-machine system is a combination of 1 or more human beings and 1 or more physical components interacting to bring about from given input some desired output. So, this is very, very important desired. We do not want any output which is undesired or faulty. So we want to get the desired output on their good quality output.

So man-machine system consists of any type of physical object, device, equipment as we can say for example it can be a wood working machine or a facility and activities performed by man. So it is interaction between the physical objects, devices, equipment, machines with the human being. So this is an example of a man machine system.

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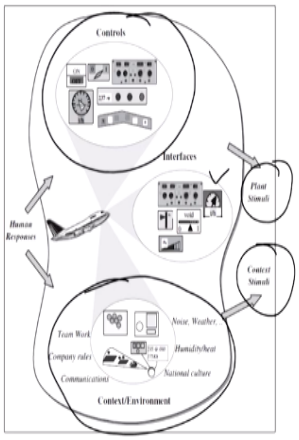
Man-Machine System

- Man-machine interactions and processes always occur in realistic contexts.
- They are **characterized by the plant or machine under control**, in direct contact with the operator, and by the socio-technical working context, in which the interactions take place.



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You can see these are the controls here and these are the environment or the context in which this interaction takes place between the man and the machine and these are the interfaces. This is a plant stimuli and this is context stimuli. So this is you can say an interaction. So how do I interact? How am I interacting with all of you? We are interacting with the help of certain equipment with the help of the video capturing cameras, with the help of this console.

So we are interacting with the help of certain equipment and how the environment is playing into picture. There will be a certain set temperature for this particular recording studio. There has to be a control over the humidity level. There has to be control over the acoustics when I am speaking the things must be recorded in the most clear manner there must be no noise. So noise dumping is also very, very important.

So these are the, we can say context or environment and then the physical things are the things that we are using the console, the video camera which is a part of the physical object or the equipment. So equipment controls plus the context or the environment they all add up to the interaction between the man and the machine. So the man machine interactions and processes always occur in a realistic context.

They are characterized by the plant or machine under control. So that is one thing characterized by the plant or machine under control in direct contact with the operator so there is a direct

contact between the man and the machine like here we have a direct contact between me and this system that I am using and by the socio-technical working context in which the interactions takes place.

So there is a socio-technical context which in this example is given here as a team work, company rules, communications, humidity, heat, noise, weather. So this is a context and the environment under which the interaction between the man as well as the physical objects or the machines or we can say equipment is taking place. Now man-machine system interacts with the human operator through its interfaces and control.

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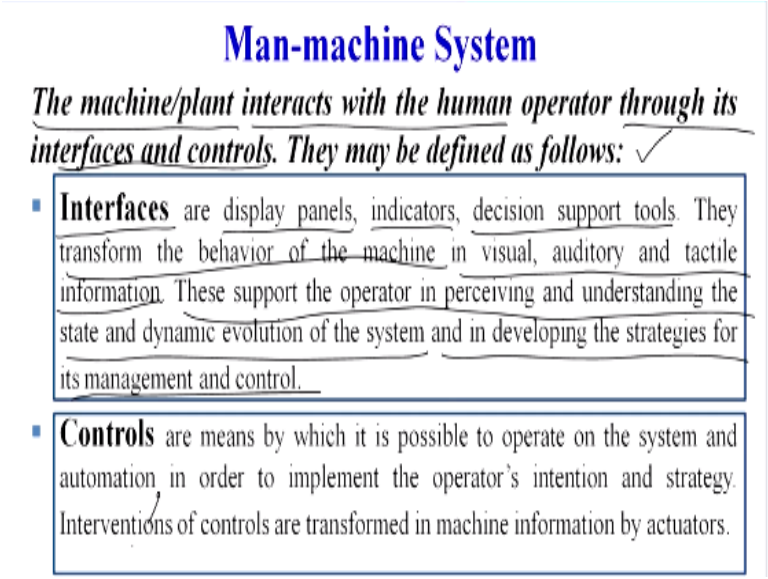

They may be defined as follows. So we can see that basically the man-machine system is a interaction or a interface between a man and a machine. Now how the machine or the plant will interact with the human being or how I can interact with the machine. For example, if suppose I am driving a car, I am a human being, how I will be able to interact with the machine which is a car or an automobile.

So there has to be some control mechanism so I have a steering, there is a gear shift lever. There can be a switch through which I can switch on the lights. There can be a switch through which I can switch on the air conditioner of the car so this is the way I am interacting as an individual with the car or with my automobile. Why this interaction is important because we want to

develop this interface between the man and the machine in a such a way that I feel comfortable while performing all these control tasks if I have to spend lot of time.

Or I have to spend lot of energy in managing these controls I may feel tired not only physically, but mentally also if I have to locate suppose I have to change the song that I am playing on the audio player inside the automobile and I have to press it 4 or 5 times, I may get tired of changing the songs and if it can be a single click I will feel that the control mechanism is much better why? Because even a single click I am able to listen to the song that I want to play.

That is the interface or the you can say interaction that we have to design between the man the machine which will help ease out the task of the man under question. So let us see now what are the interfaces and controls or what are the scientific definitions for these 2 words. So the machine or the plant interacts with the human through its interfaces and controls. Now what are the interfaces and controls that we will try to understand? Now what are interfaces?

Interfaces are display panels indicators, decision support tools. They transform the behaviour of the machine in visual auditory and tactile information. These support the operator in perceiving and understanding the state and dynamic evolution of a system and in developing the strategies for its management and control. So basically the interfaces are the display panels are indicators. Now we can take any example.

Now one of the examples can be a digital watch in this particular recording studio. Now this is a display panel which is showing me the time. Now I am operator or a, you can say a worker working in this system and there is a display panel. Now based on the display panel I have to receive the information, I have to process it, and then take the action accordingly. So interfaces are display panels or indicators or decision support tools.

Now this is acting as a decision support tool also for me why? Because I have to see that I have to cover the entire syllabus or whatever is outlined for today in 30 minutes. So it will help me to decide to speed up the things or to skip few examples or to skip few slides so that I am able to

cover the topic in 30 minutes only. So this is the interface between me and the display panel which is helping me as a decision support tool also.

So interfaces are display panels indicated decision support tools. They transform the behaviour of the machine in visual auditory and tactile information which is not specifically (()) (17:05) our example, but these can help in transforming the behaviour also. These support the operator in perceiving and understanding the state and dynamic evolution of the system and in developing the strategies for its management and control.

There can be hundreds of example when we are using the indicators or the display panels and then we perceive the information, we process that information and see that if we can do certain things or take certain decision which will help us in the management and control of the system. Simple example for a mechanical engineer can be that if you are machining a hole in a plate and suppose you see the forces are being displayed on a digital board.

So if you see that the forces are beyond the critical level of forces you have to quickly adapt to the machine and quickly you have to stop the machine and see that what can be the problem area now this is the information on the display board. We have seen that information. We have done some decision making based on that information and action is that we have stopped the machine to check that what is the problem? So that is basically the interface.

Now what are the controls? Controls are means by which it is possible to operate on the system and automation in order to implement the operator's intention and strategy. Now I have seen the information that is the interface I have understood, proceed, process the information, found out there is something wrong. Immediately, I need to pull a lever so that machine must stop that basically pulling the lever, the lever is acting as a control.

So controls are means by which it is possible to operate on the system and automation in order to system and automation in order to implement the operator's intention and strategy. Now what is the operator's intention in our example? That he wants to stop the machine because the forces

have gone beyond a particular level. Now interventions of controls are transformed into machine information by actuators.

Now whatever the lever has been pulled through the actuator, the machine will be stopped. So this interfaces and controls are very, very important because they act as like you can say the elements through which the control is exercised or elements through which the man and the machine interact with each other. Now characteristics of man-machine system let us try to understand.

Now we know that in any work system there will be a physical object or equipment or machine or an interface and there will be a man who is a operator who is working on these systems to convert the inputs into the desired outputs. Now we have to design as work study analysis or work system designer. This interface and interaction between this man and the machine in such a way that, we are able to achieve our overall target of improved efficiency and productivity.

Now for that we need to understand the salient characteristics of this man-machine system. Already we know what is a man-machine system? Already we have understood the definition. We have taken 1 or 2 examples also. We have understood the interface and the control which kind of links that 2 the man and the machine. Now let us see that overall as a man-machine system what are the characteristics.

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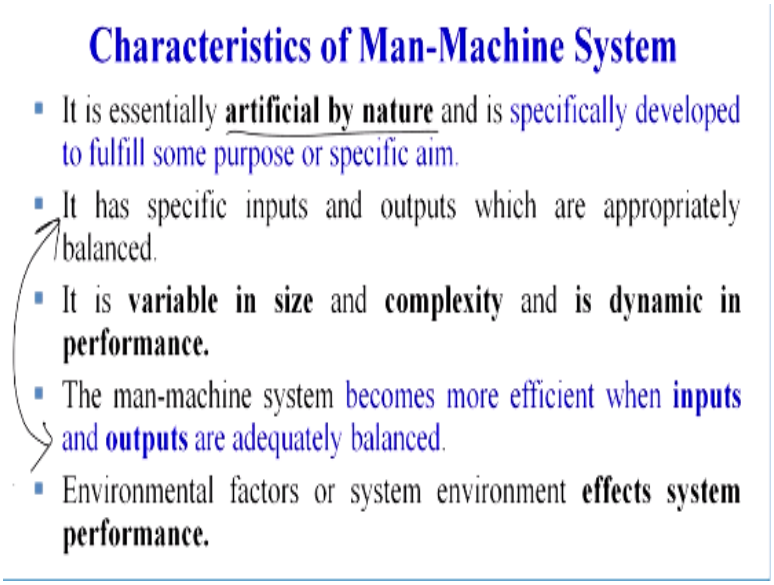

So it is essentially artificial by nature created by a work study analyst or the production managers and it is specifically developed to fulfill some purpose or specific aim. Now suppose the person is working on a wood working machine and certain hand tools in the carpentry shop to convert wood into a chair or into a wooden chair so that is basically the system has been developed in order to convert a input into the output.

So artificially you are making a machine and a man to interact with each other to convert the input into the output. So it is essentially artificial by nature and is specifically developed to fulfill some purpose or a specific aim. It has specific inputs and outputs which are appropriately balanced. So we have balanced that this is the input going to be and this is the output that we are going to produce from this specific set of inputs.

It is variable in size and complexity and it is dynamic in performance. So we can have different types of man-machine system based on the size, based on the complexity. Then it is dynamic in nature. Things may change from time to time. The man-machine system becomes more efficient when inputs and outputs are adequately balanced which we have already seen that we have to ensure that they are adequately balanced.

So the efficiency will be better if they are adequately balanced. Environmental factors are system environment affects the system performance as we have seen in the second or third slide

today only. There is a technical interaction between man and machine which takes place under a set of environment in which we have seen noise, weather, and all other important points related to the context under which the interaction is taking place so environmental factors do affect the system performance. Now let us see classification of man-machine systems.

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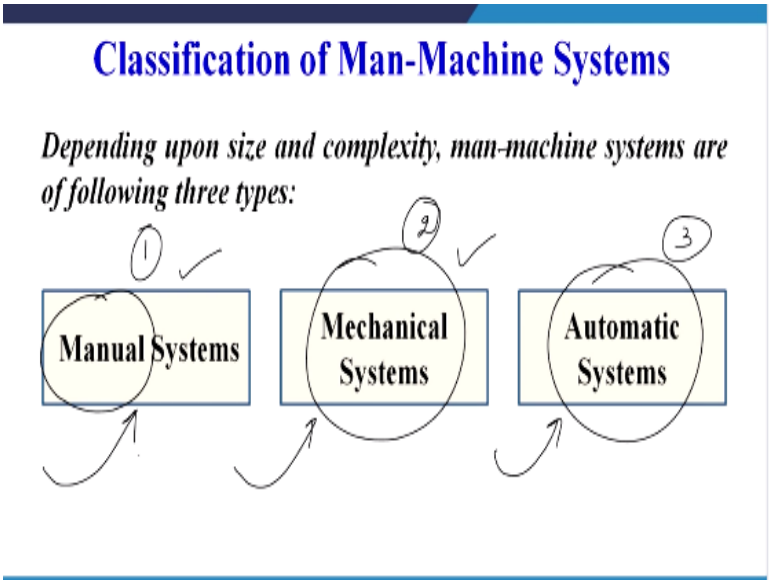

Now depending upon the size and complexity man-machine systems are of following 3 types. First one are the manual systems. Second one are the mechanical systems. Third one are the automatic systems. This is second and third. First, second, and third. So automatic systems are there mechanical systems are there and manual systems are there. Now depending upon the requirement, depending upon the output that we want to desire.

Depending upon the quality of output that we want we will choose. Depending upon the volume of output that we have to produce, we have to choose between the man-machine system, which is manual in nature or it is mechanical in nature or it is fully automatic in nature. Now let us see the 3 very quickly.

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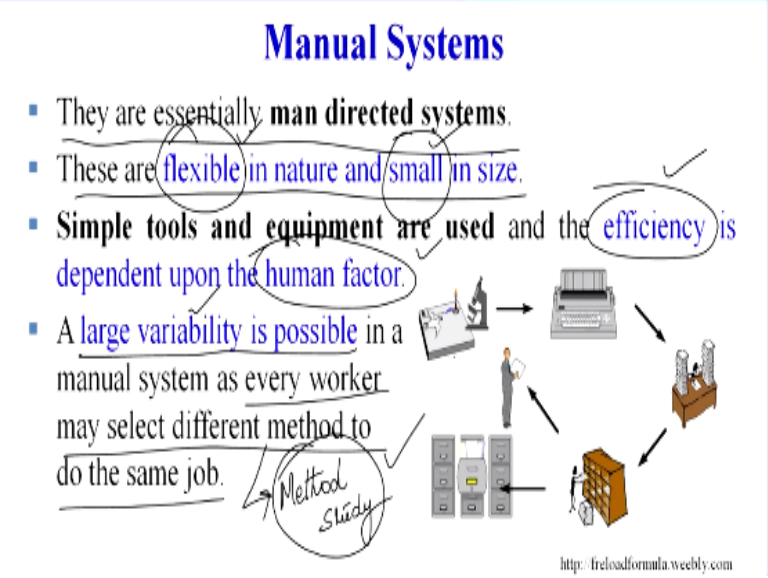

From the word also or from the Basic English definition also it is very, very clear so but we will again see a manual system. Manual systems are essentially man directed systems. These are flexible in nature and small in size. So 2 words are important here flexible and small. Simple tools and equipment are used and the efficiency is dependent upon the human factor. Another word efficiency. So the efficiency is dependent upon the human factor.

A large variability is possible in a manual system as every worker may select different method to do the same job. So one thing is very, very clear here a large variability is possible why because every worker may select different method to do the job and this emphasizes on the topic that we have already studied that is method study. We want to find out 1 best method, 1 better technique, one you can say standard protocol.

one standard operating procedure which each and every worker who is performing that task must follow and that is basically the underlying principle of conducting a method study. So this large variability we have to minimize using the method study. So in human intervention we can quickly see that it is more flexible, small size efficiency is dependent upon the human factor and large variability is possible which we can try to eliminate by conducting a systematic method study.

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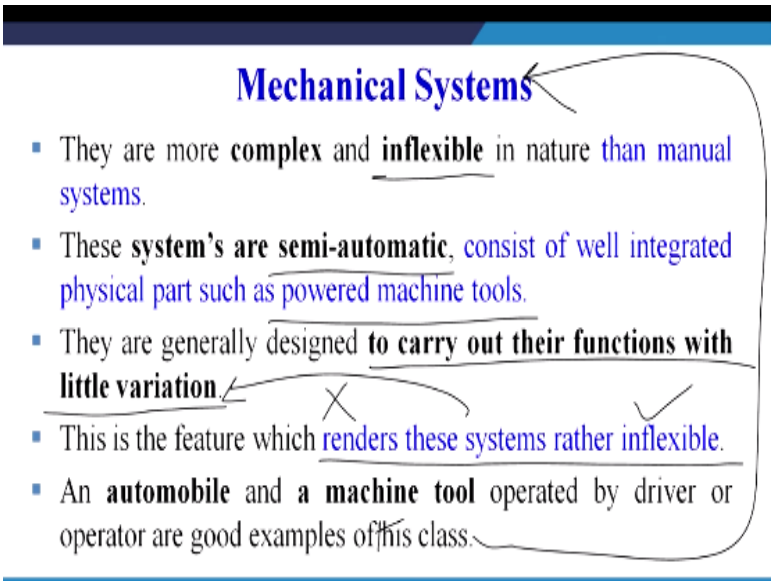

The next is a mechanical or it is also called a semi-automatic system. They are more complex and inflexible opposite of flexible in nature than the manual system. These systems are semi-automatic consist of well integrated physical part such as powered machine tool. So in most of the work in manual type of system is done by human intervention, but here we have help of machines which are semi-powered tools that is possible or semi-automatic system.

They are generally designed to carry out the functions with little variations so the variability part is also reduced in case of mechanical system. This is the feature which renders these systems rather inflexible. So when the variation is minimum, so that the system becomes inflexible. An automobile and a machine tool operated by a driver or an operator are good examples of this class of systems so what is the class of the system that is the mechanical systems.

So the example will help you to remember the things in a much clearer manner that automobile and a machine tool operated by a driver or an operator are examples of the mechanical type of systems.

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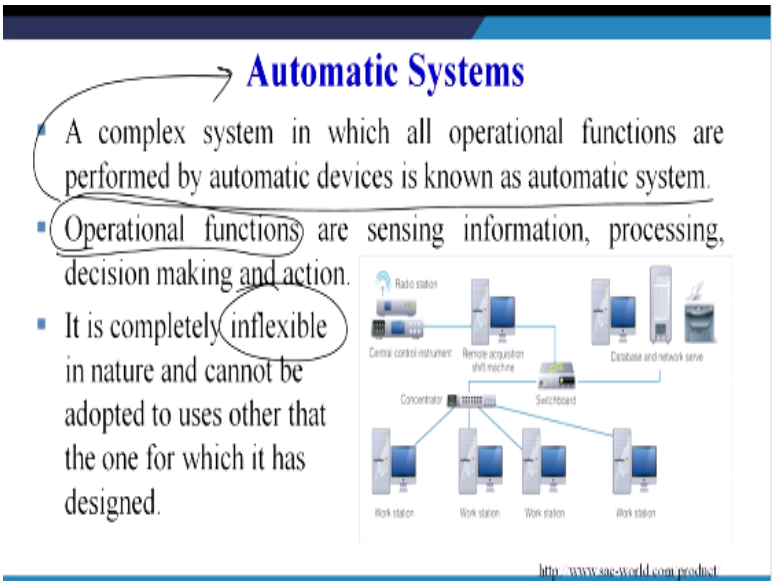

Then the fully automatic systems or complex system in which all operational functions are performed by automatic devices is known as automatic system. There can be better definitions of automatic system than the one that we are doing, but we are doing it in context of differentiating the automatic systems from the manual as well as the mechanical systems. Now operational functions are sensing information, processing decision making, and actions.

So these operational functions are automatic in case of automatic systems. It is completely inflexible or we can say rigid system and cannot be adapted to uses other than the one for which it has been designed. So when an automatic system is designed for example we can say that an assembly line has been designed which is fully automatic in nature and which is used for assembling a particular product or for a particular automobile so it becomes a rigid system.

Now it will work efficiently productively for the product for which this line has been developed, but may not be useful or I must say with experience that will not be used full for any other product if it is entirely different in its shape, size, and the volume of production. So when the product will change, the line will need substantial changes in order to make it suitable or in order to adapt it to the product or the new product which is entirely different from the existing product. So automatic systems are much more rigid in nature and are less flexible in nature.

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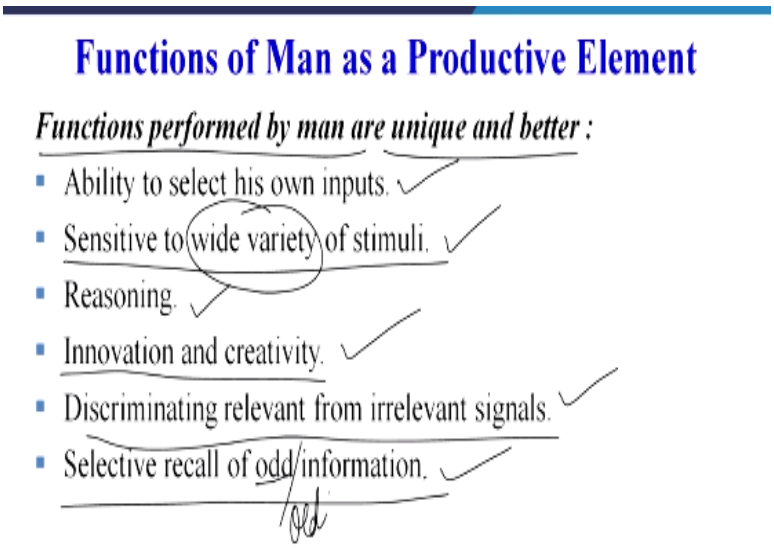

Now let us quickly see functions of man as a productive element, because now there are 2 things that are interacting together and the system as a whole we know is of 3 types. Now we can see where we must focus on man as a productive element. Functions are performed by a man are unique and better. So let us see what are the functions ability to select his own inputs. In case of automatic system, the input has to be fixed.

But here the manual system or man wherever the man is in command or in case of a manual system it has ability to select his own inputs, sensitive to wide variety of stimuli. Now a machine can also be made to react to different types of stimulus, but man has by nature different types of activation or stimuli which is ingrained because of the biological nature. So we may be weak or we are sensitive to heat. We are sensitive to extreme cold also.

We are sometime our skin is sensitive to different types of variation, humidity also. So we are naturally developed to adapt 2 different types of stimuli or to adapt 2 different types of stimuli where as the automatic systems will have to be developed so that they react because of a particular type of stimuli. So man as a productive element is sensitive to wide variety so this is important wide variety of stimuli.

Man can do reasoning whereas the fully automatic systems will work as the pre you can say developed programs only. Man can have innovation and creativity. Discriminating relevant from

irrelevant signals, selective recall of odd information or may be this can be odd as well as old information wherever it may not be possible for a completely automatic system to retrieve specific set of information although these days the technology has developed and reached to a very advanced level where this is also possible using the systems.

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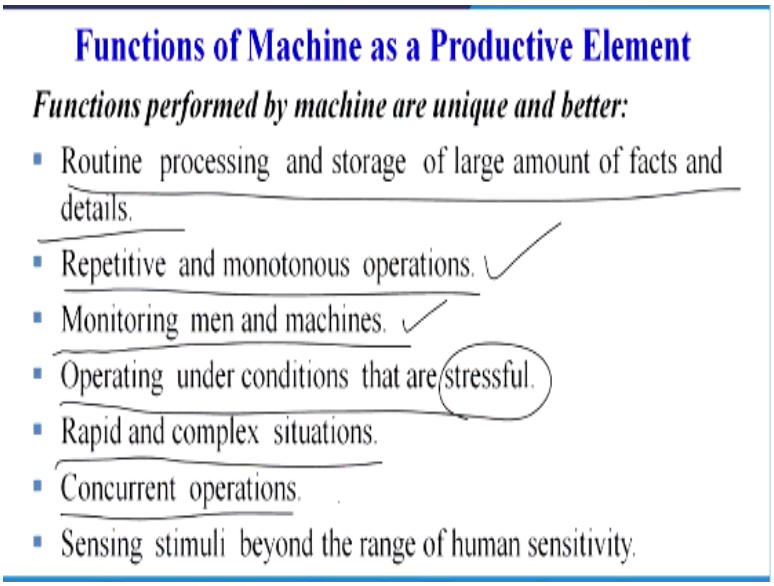

Now functions performed by machine which are unique and better. Routine processing and storage of large amount of facts and details which I have just highlighted as one of the exceptions in the last point in the previous slide. So machines can be used for storage of large amount of facts and details. Repetitive and monotonous operations which becomes dull for the operators can easily be done by the machine.

So machines do not tire, they do not get may be monotonous in nature. They keep on working so the monotony which is a problem with the worker is not at all a problem with the automatic system. Machines can be used for monitoring men and machines as you can say take an example of a camera so it is also a machine which can be used to monitor the movements of a man on a (()) (31:37) load.

So monitoring a man and machines can be done in automatic manner operating under conditions that are stressful. So if man feels stressed out in a specific type of working environment machines can be used there. Rapid and complex situations or calculations can be done using the

machines or they can be used for different types of complex situation where human being or human capability does not come good.

So concurrent operations man can focus on 1 or 2, or 3 operations at a time, but machines are automatic systems can do concurrently different number of jobs depending upon the complexity of the automatic system sensing stimuli beyond the range of human sensitivity. Now our human body has got certain physical capability to react to a particular type of stimuli, but this is within the range.

But if the stimuli is beyond the range machine is better capable to react to that kind of stimuli as compared to the human being. So we can see now that we know and understand that where the machine has got an edge or the automatic systems have got an edge and which is the situation where man has got an edge or as a productive element human intervention is better.

Now if we know where human intervention is better as well as we know that where the machine intervention is better we can design the work system in such a way that it takes advantage of the best parts of both the human as well as the automatic system and we try to combine them, develop a better interface between the man and the machine so that our overall output is better.

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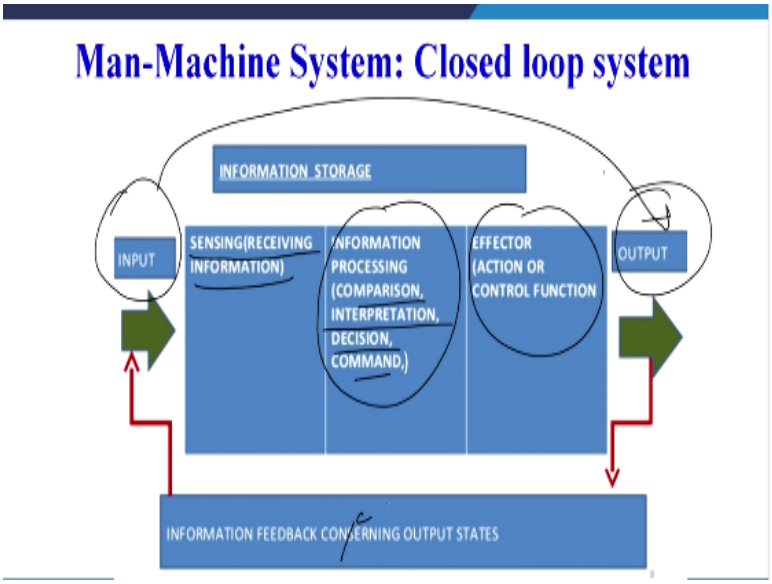

This is an example of a man machine system. Quickly we will have a look. Already we know there is a specific set of input which has to be converted into the output. How it is done through the sensing receiving the information, information processing, may be comparison, interpretation, decision command and then there is an actuator or a control function and then finally it is converted into an output.

So the information feedback confirming output state. So this is a feedback mechanism from the output to the input. So we will try to understand the various aspects of this man-machine system in our last session for week number 11 and beyond that we will try to take different case studies and try to understand the design of a work system. So with this we conclude the today's session.