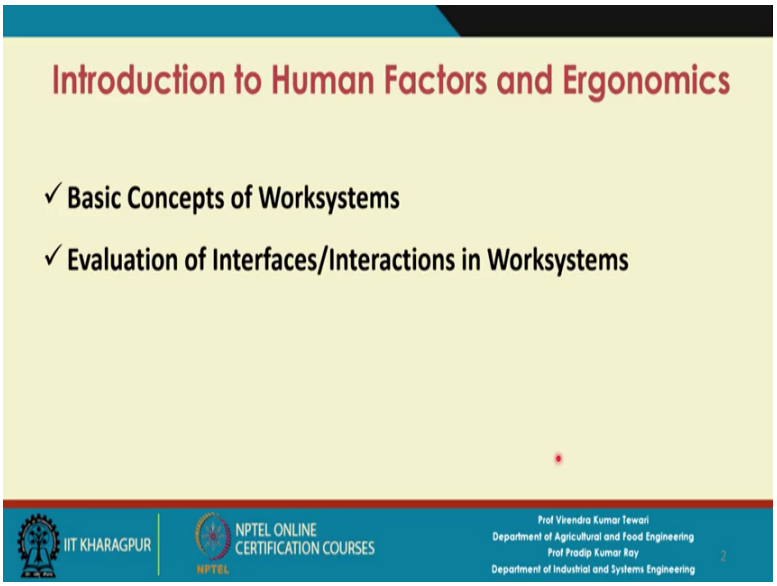
Human Factors Engineering

Prof. V. K Tiwari
Department of Agriculture and Food Engineering
Prof. P. K Ray
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

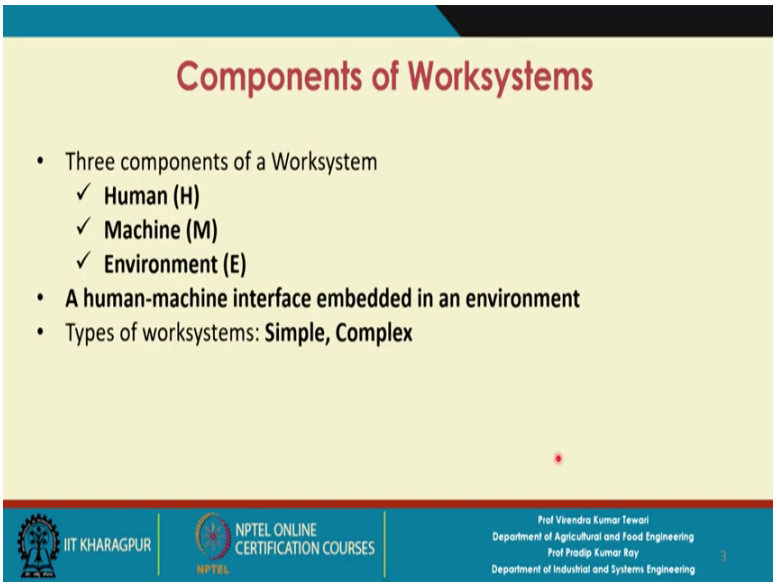
Lecture - 02
Types and components of worksystems, their interactions and evaluations

(Refer Slide Time: 00:20)



So, the next half an hour or so in the next lecture sessions, I am going to discuss the basic concepts of worksystems and how to evaluate different kinds of interfaces in worksystems.

(Refer Slide Time: 00:33)

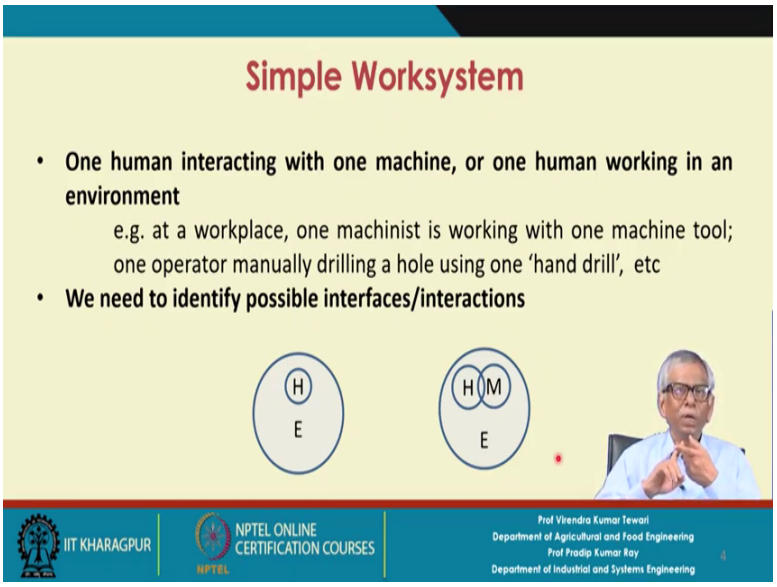


Let me first explain what is a worksystem? As I have already mentioned that whenever you talk about ergonomic design, the design is applicable for a worksystem. What is a worksystem? We should identify the components of the worksystem.

These are the three components of the worksystem: human, machine and environment. Essentially, we talk about the interaction or interface between human machine. Many times, it is referred to as a human machine interaction embedded in an environment and when you talk about the environment, the boundary line we have to specify.

Now, there are two kinds of worksystems – simple worksystem and the complex worksystem.

(Refer Slide Time: 01:53)



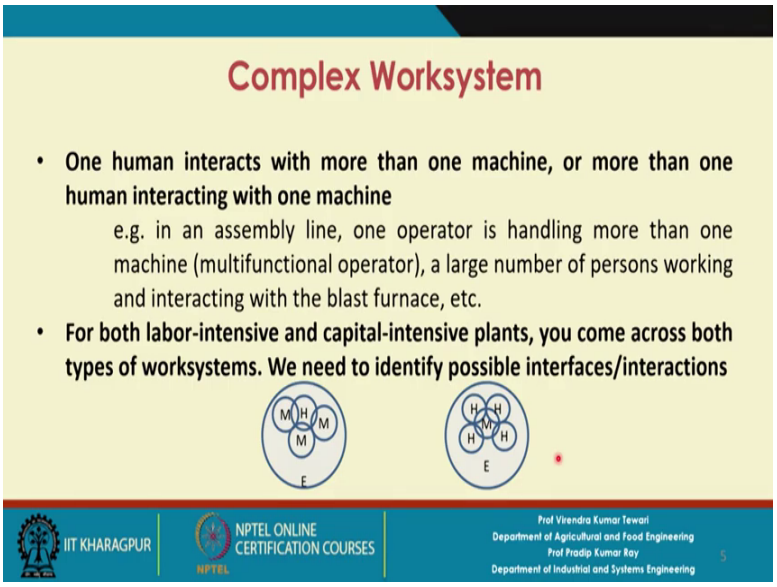
If one human is interacting with one machine. So, I am the worker and I have been given one machine tool and I process certain parts or certain components, I am the machinist. Essentially, I am interacting as one individual- one with one machine. This is referred to as a simple worksystem or there could be many instances where you will find that one human being is working in an environment. So, this is referred to as the simple worksystem.

For example: at a workplace one machinist is working with one machine tool, one operator manually drilling a hole using one hand drill. Many such examples where we need to identify possible interfaces and interactions.

This is just a pictorial representation, one human being is working within an environment and in environment, there is a boundary line. While defining the worksystem you have to specify the boundary line. There are the internal factors and there are also external factors.

Another way in which you can define a simple worksystem is; one human is interacting with one machine, there could be several examples and this interface is existing within the environment or embedded in an environment.

(Refer Slide Time: 04:01)



One human interacts with more than one machine. There are several examples, like the U-shaped layout of an assembly line, that is one example of the complex worksystems.

Another way you can define the complex worksystem is- more than one human interacting with one machine. Like 50 or 100 persons are working in front of a blast furnace which is just one machine unit or one process. The one machine is interacting with not only one human being, but several human beings.

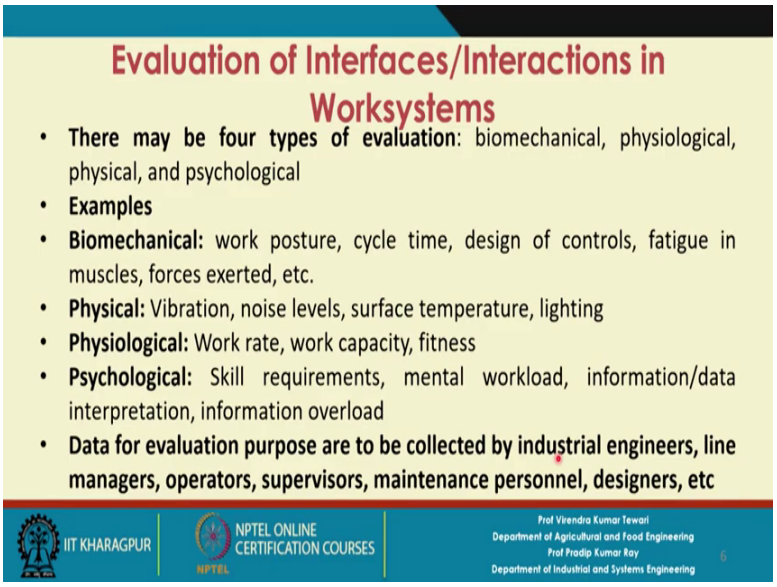
In an assembly line, one operator is handling more than one machine multifunctional operator. These days you will find that this concept is being applied where multifunctional operator can run several machines.

A large number of persons working and interacting with the blast furnace. Look at your work systems. Definitely you can identify not only 5 not only 10, but at least 100 worksystems which are referred to as the complex worksystems for both labour intensive and capital-intensive plans.

First you define your worksystem, whether it is simple or complex and then you have to identify the interfaces and you have to define these interfaces.

These are just pictorial representations, within the environment what you find that one H is interacting with three M and in the other diagram what you find that one machine is interacting with four humans.

(Refer Slide Time: 06:40)



There may be four types of evaluation as far as the ergonomic evaluation is concerned or human factors best evaluation is concerned. First one is the biomechanical.

The second one is the physiological evaluation like the job is given to you and whether your work capacity is allowing you to work with the job in effectively and efficiently. That is to be judged. Physiological evaluation you must do.

Third one is the physical evaluation; that means, we refer to the physical environment. To what extent the thermal environment or the auditory environment, or vibratory environment affecting your performance. And the last one is the psychological evaluation.

There could be several examples like when we refer to biomechanical evaluation, we refer to work posture. This is a very important issue because you have to prevent the occurrence of bad work postures. If someone is continuing with unacceptable work postures for extended period of time, his or her occupational health will be affected. There are several instances.

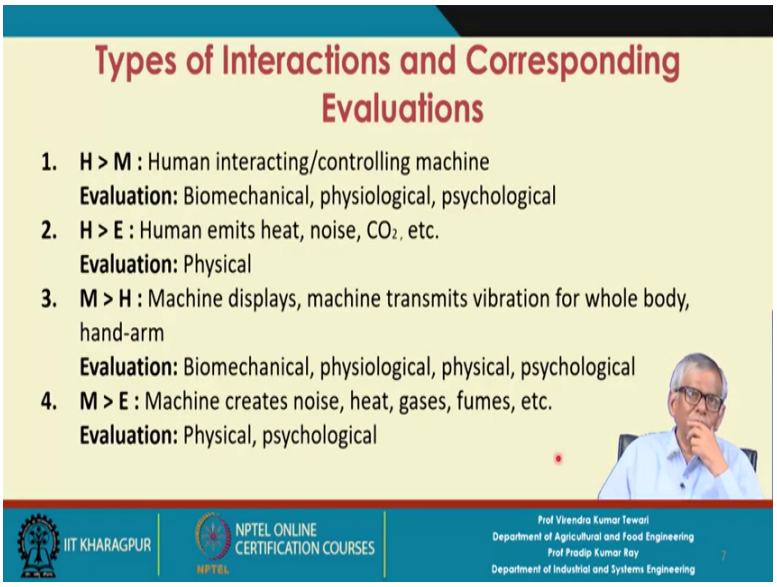
Next one is the cycle time for the job, how do you decide the cycle time. Design of controls fatigue in muscles forces exerted. Next one is the vibration, it could be whole body vibration or full arm vibration. To what extent the noise levels is affecting your performance, the surface temperature and the lighting.

When you refer to the physiological evaluation, to what extent the work rate or your production rate or your performance is affected. Work capacity and the fitness is very important. In fact, this particular term is used with respect to a job only.

And, the last one is the psychological evaluation; that means, the skill requirements, mental workload, information or the data interpretation and information overload.

Data for evaluation purpose are to be collected by the industrial engineers, line managers, operators, supervisors, maintenance personnel, designers, ergonomists. Most of these the problems must be dealt with by a group by a team of the persons drawn from different disciplines. So, you must follow an interdisciplinary approach.

(Refer Slide Time: 10:47)



These notation means H is influencing M or H is interacting with M; means, the human interacting or controlling machine, that is the notation we use. Evaluation: biomechanical, physiological, psychological.

These are the three important Evaluation. When you refer to the next interaction; that means, the human is interacting with environment. Human emits heat, noise, carbon dioxide etcetera. To what extent this emission from the human body is affecting the quality of environment. This evaluation must be physical.

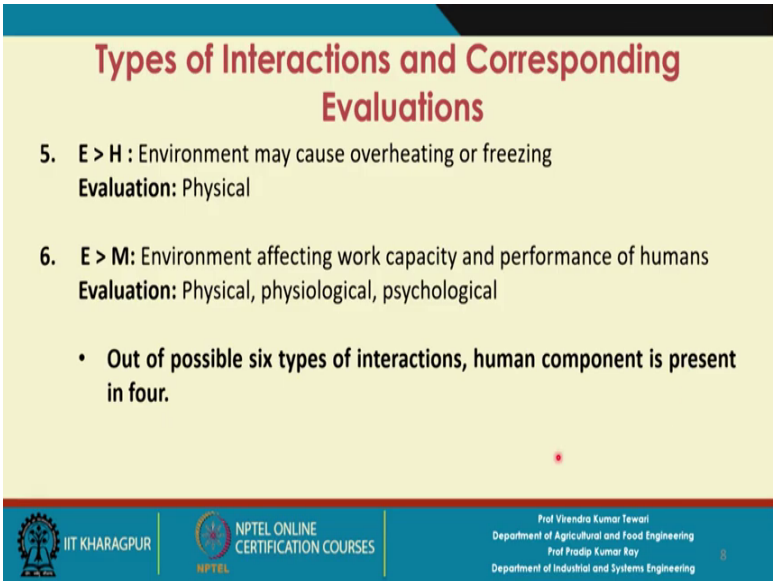
Then machine is also influencing the human other way around, the machine displays machine transmits vibration for the whole body. There are many cases. The person is working in front

of the machine tool and what you find that that the machine is installed in such a way that you stand in front of the machine and you find that entire floor is the vibrating.

If this vibration is influencing your body for a long time, what will be it is impact? Obviously, there will be negative impact on your health, the status will be very poor. This is a very common occurrence in many industrial workplaces. Evaluation is biomechanical, physiological, physical, psychological, look at a particular interface or the interaction and then you decide which kind of evaluation is relevant for a given case.

Machine is affecting the quality of the environment. The machine creates noise, heat, gases, fumes etcetera. It is definitely defining the quality of the environment. So, evaluation is physical and psychological.

(Refer Slide Time: 13:32)

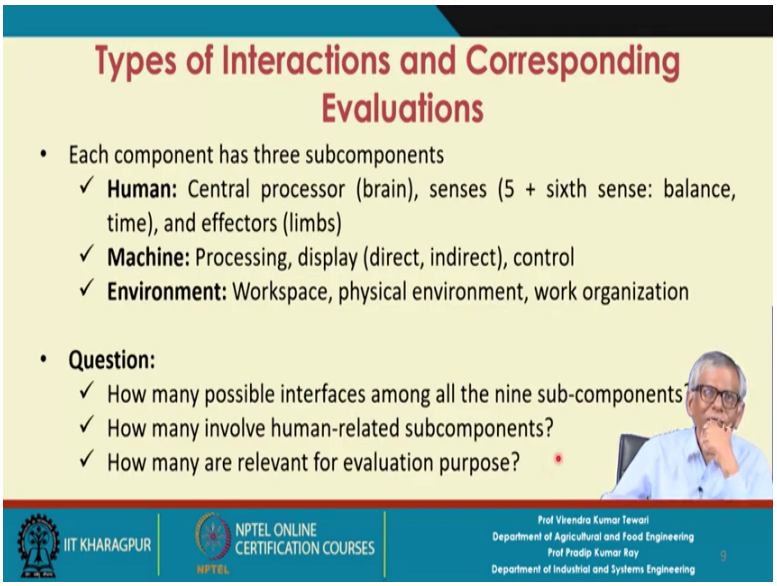


Environment is affecting humans; that means, environment may cause overheating or freezing. When we talk about heat stress or the cold stress and to what extent the cold stress or the heat stress affecting your performance. The kind of evaluation we refer to is physical.

And, the last one is that environment is affecting machine; that means, environment is affecting work capacity and performance of humans, and machines. So, the evaluation physical, physiological and psychological, ultimately the machine is affected and once the machine is affected it is also affecting the humans.

Out of possible six types of interactions human component is present in four. So, our focus is human component.

(Refer Slide Time: 14:37)



Now, each component has three sub components or elements. We have to design the system, but make sure the design should be as simple as possible. We will represent the human worksystems, but we do not want to make it very complex.

Against human component there are three elements, against the machine component there are three elements and against environment there are three elements. Against human the first one is the central processor that is actually your brain and the kinds of activities you do above the neck. So, we refer to the brain as the central processor.

Next one is the senses. You already aware of that there are five senses, but sometimes we also refer to the sixth sense. Now, what is this sixth sense? Like the concept of balance.

And the next one is the sense of time. One example, in a cold country during the afternoon session you perform excellently whereas, in a hot and humid country only in the early morning time you perform excellently.

You will have a different sorts of mental makeup.

Last one is the effectors that is the limbs. That is, your arms on the legs like for the activities below the neck; that means, the physical activities which you carry out. As far as the machine

is concerned there are three elements. First one is the processing, second one is the display, direct and indirect and, the third one is the control. When we define the environment again there are three elements. First one is the workspace- you have to define the workspace depending on the type of job and depending on your psychological impact.

The workspace has many rules, there are many assumptions we make. Physical environment – there were four types of physical environment and the last one is work organization; that means, when we define a job it is defined as an organized activity.

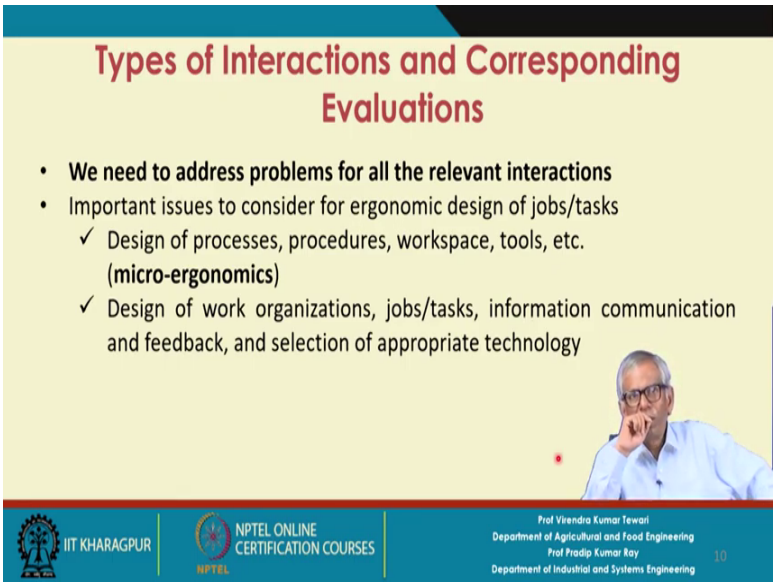
Within the organizations I am working. I am given a job whether the job is designed as per the ergonomic principles or human factors principles or not. So, the work organization when you design the shift schedule, the rest periods.

Whether it should be a 24 hour work. The day shift you will propose or how do you define the work cycle.

Three important questions: first one is how many interfaces given a particular worksystem you can identify? you just take one example of worksystem and try to find out.

Next one is how many involve human related subcomponents and how many are relevant for evaluation purpose? So, whenever you say that how many interfaces are to be evaluated related to a particular worksystem you must list down the kinds of problems as of now you are facing or the persons working in an environment or a worksystem have been facing.

(Refer Slide Time: 20:23)

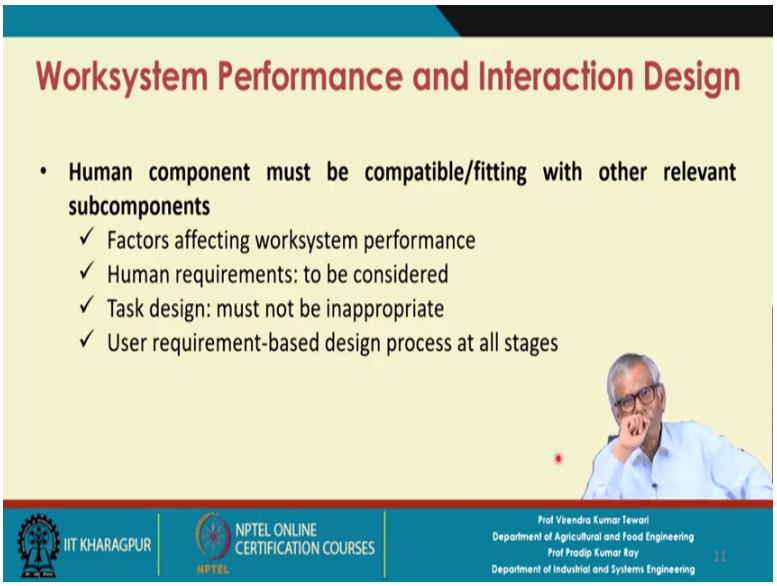


Related to problems you face you need to identify the evaluation norms. We need to address problems for all the relevant interactions. That is why we say that you propose a new design as per the ergonomic norms, but they make sure that is a better design.

Important issues to consider for ergonomic design of jobs and task – First one- you have to look into the design of existing processes, existing procedures, existing workspace, tools etc. This is sometimes referred to as micro-ergonomics; that means, at the soft floor when with respect to the job design, absolutely at the bottom line, you need to specify or you need to design the processes. Ultimately when you apply the concept of ergonomics in human factors, the workers or the operators at the shop floor level should get the maximum benefits, it is made for them primarily.

Design of work organizations that is also an important issue. Jobs and tasks, task design, task analysis, these are the important terms we use information, communications and feedback for many kinds of jobs. the information, communication, then the feedback based on your interpretation is also to be properly designed and selection of appropriate technology.

(Refer Slide Time: 22:14)

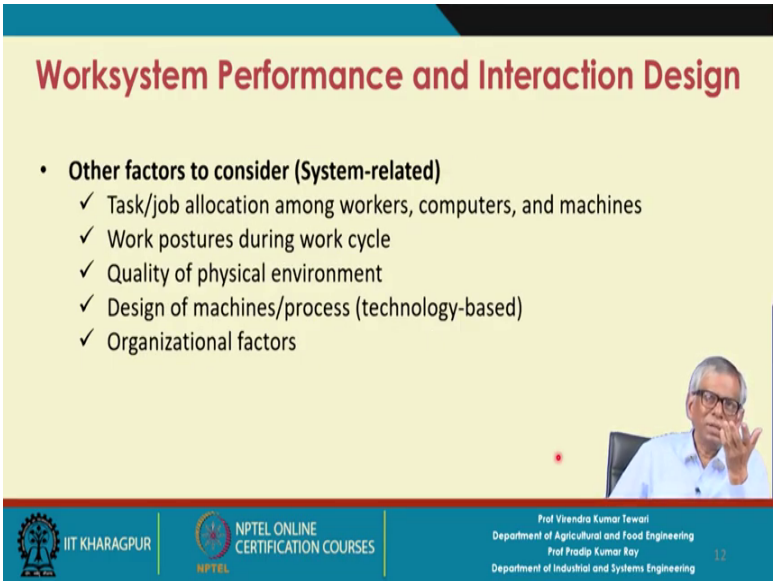


Human components must be compatible fitting with other relevant subcomponents. Our core issue is to what extent you are fitting the humans with the jobs you have designed whether the humans are accepting the jobs or not.

Factors affecting work-system performance. Human requirements to be considered. That is whenever we believe in the concept of application of ergonomics and human factors, we say what kind of person someone is.

Based on his ability, based on his capacity, based on his fitness why do not you would design the job. That means, fit job to man, but previously for the last 200 years, first you create a job and then you search for the person. Whether the job is good or bad or ugly, there is a basic assumption is definitely you will get someone who will be willing to do the work. But now the situation has changed; you say that 80% of the jobs you design, 90% of the jobs you design based on the concept of fit job to man. Task design must not be inappropriate and user requirement-based design process at all stages. It is not only the quality of design, but it should be quality of performance.

(Refer Slide Time: 24:28)



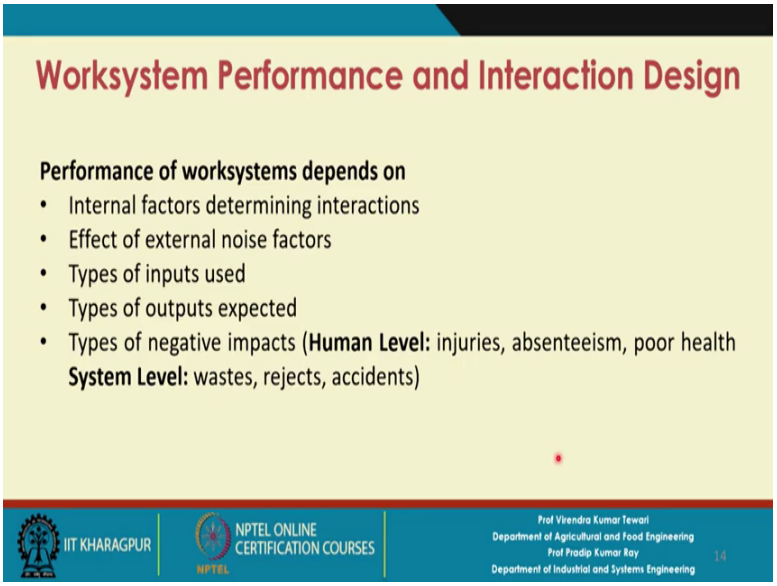
There are many other factors- these are all basically the system related.

Whenever you design the job, first part is human labour, the second part is the machine and the third one is the computer. You say if the labour component is minimum or the machine component is minimum.

Even for automated system, there is a intervention by the persons or the humans. So, obviously, you have to apply the principles of ergonomics on human factors. The quality of physical environment that you must look into. How to improve the quality of physical

environment? Design of machines processes technology based. While you adopt a new technology the idea is that whether that technology fits to humans or not. That is our baseline. And, the organizational factors you need to consider.

(Refer Slide Time: 26:13)



When you talk about the performance of the work systems first you need to consider the internal factors determining the interactions. The second one is the effect of external noise factors external noise factors.

Third one is the types of inputs used and the types of outputs expected. Here is a system. In the work systems you will find there are many external factors affecting your performance. Can you identify those factors?

What are the external noise factors or what are the the internal factors affecting. The quality of the machine that you are using right now is creating lot of the noise, lot of vibrations may directly affect your performance.

The types of outputs expected; certain acceptable outputs you get, but along with the outputs there could be wastes, there could be reworked items, there could be bad quality parts, there could be lot of dusts and the fumes also. These are the types of outputs expected or it may be energy intensive.

The types of negative impacts these are certain examples. At the human level the injuries, absenteeism, poor health. And, at the systems level there could be wastes there could be rejects and there could be accidents.

So, you have to create a safe workplace, accidents are just not acceptable. So, that is our bottom line, you need to identify those factors. Just start thinking of that what are those factors given a worksystem.

(Refer Slide Time: 28:35)

What is the role of HFE in today's industrial context? How it can help you? First is, it will help you to design and quantify human machine interface and the comprehensive or generic format that you have to establish. Suppose, you have started a new company, even at the micro level you cannot avoid these issues.

Even if it is a small organization, this a generic format or a comprehensive format defining the human machine interfaces.

To assess and improve job design with respect to human-machine interface; that means, common and special characteristics you get from the technology part, but certain other characteristics you get from the interaction.

To model human-machine interface from design perspective- use of human modeling software. There are many applications, SAMMIE software you can use, JACK software you use and the CAD-based design.

Physical environment and work norms and the standards- physiological cost of work and work scheduling. What you need to do, here is your workplace, there are certain common features, but there are also some special features.

What we have found is that if you try to apply the human factors-based concepts; special features or special characteristics of your work systems you have to highlight, you have to define, you have to quantify. Who will be the gainer? The designer or the company owner will be the gainer; that means, you have to create a sustainable production system.

The job design: fitting to human at individual level and job design for anyone. When we talk about the sustainability, first one is the economic sustainability, next one is the environmental sustainability and the third one is social sustainability.

There are numerous cases where you find that if your worksystem is ergonomically designed, human factor based designed, then what you will find that ultimately your system become becoming socially sustainable.

(Refer Slide Time: 32:49)