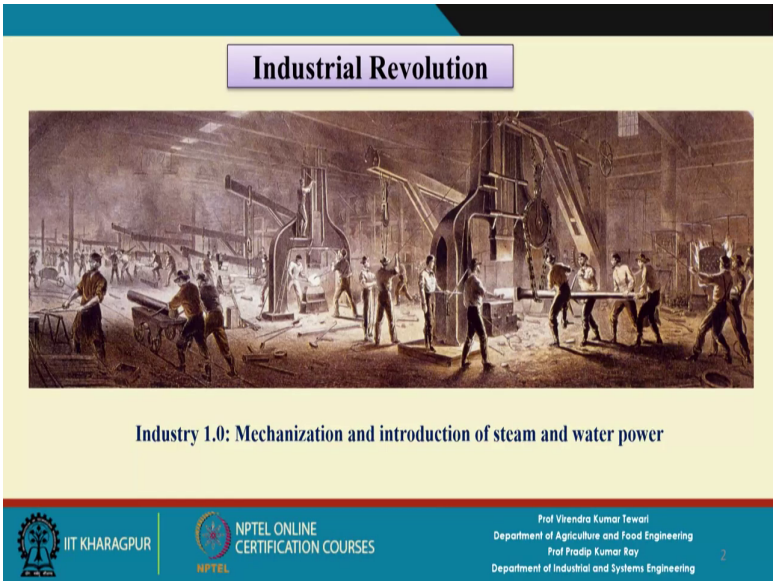
Human Factors Engineering
Prof. V. K Tiwari
Department of Agriculture and Food Engineering
Prof. P. K Ray
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Lecture - 05
Contribution of human factors in systems design, engineering and management

Dear students and participants, this is the last lecture of the week that we have started and we wanted to understand what introduction to human factors and ergonomics means. We have talked of various aspects; we will talk of how evolution of this ergonomics has taken and how it is relevant to the various industries? What are the things which are essential? How far the problems come up to the workers and what is going to happen next because of the high level of automation particularly in the industries like Industry 4.0.

The revolution in various types of gadgets which are coming in front of us and we need to work with them. Virtually we have become paperless; we are thinking of even not handling cash, so everything is dependent on the apps and mobiles. Therefore, in this context how does it go about the ergonomics part of it?

(Refer Slide Time: 01:19)

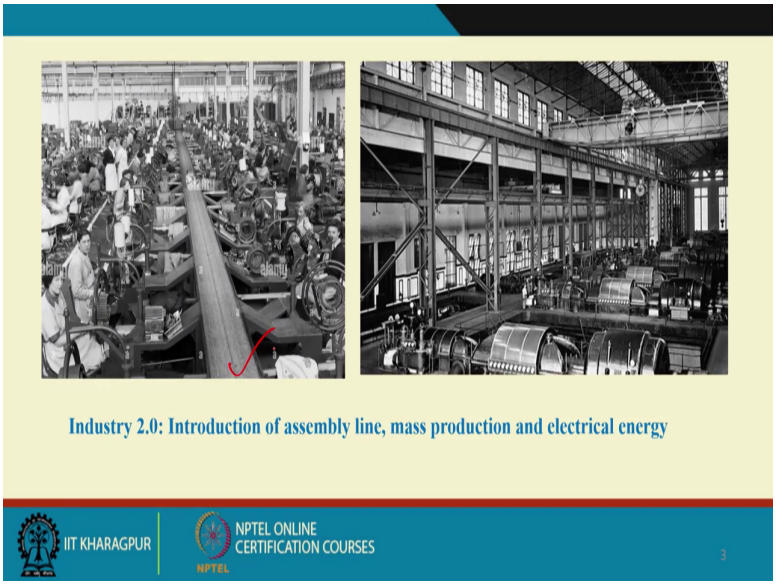


The industrial revolution- Mechanization and introduction of steam and water power. Initially we are talking of 0 level mechanization when everything was done by hand, by the people for

doing every activity in the ancient time. At that time people were not aware of what are the tools and techniques but they were trying to survive somehow or the other with all the ingenuity and knowledge that they had with themselves.

Later, when they knew something about how best they can harvest the power of water as well as the power of steam, they wanted to utilize and some mechanization took place and introduction of these powers started giving a certain relief to the work which was going on. But still that was also in a crude state.

(Refer Slide Time: 02:27)

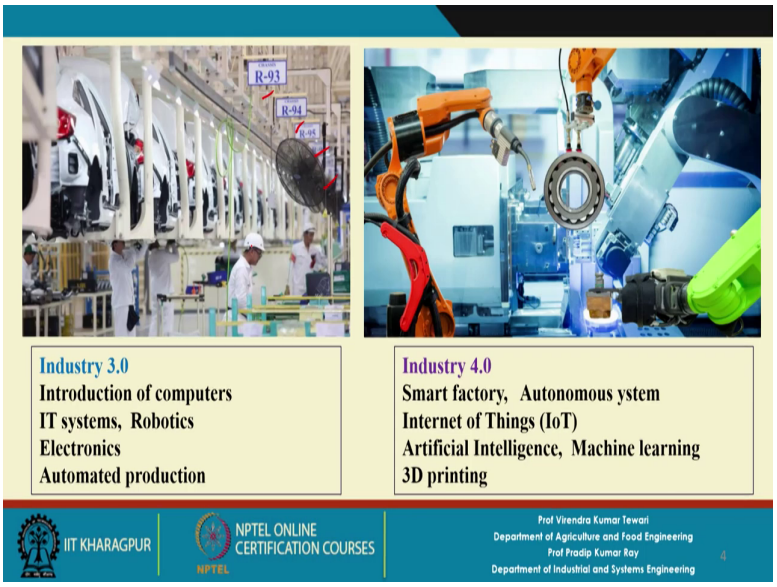


How does it look into the industry 2.0? When we wanted to have mass scale production and many people involved with this assembly line. For example, utilization of electrical energy.

We can have a look at this on the left-hand side the size in which a mass production is going on and you can see that how people are situated with regard to their tools and devices or the equipment, which are there and on the right-hand side you can see the total equipment alone and the complete infrastructure which is given.

This the second level when we call Industry 2.0. There are certain locations where we have assembly line, mass production and utilization of various other forms of energy which give higher production in unit period of time.

(Refer Slide Time: 03:46)



Beyond that we came up with the introduction of computers maybe about 30, 40 years back or so then IT systems came into picture, the robotics into electronics and automatic production. Here you can see how best we are utilizing, what are the various aspects you can see the various demarcations and the various aspects of this of a assembly line and how the workers are involved? The size of the population involved in the production has increased but it has increased in a different sense. For example, the requirement of the cognitive part of the human mind is more involved, because as the industrialization increases, we will require more utilization of our cognitive power, our brain power and the knowledge that we have gathered in the various as fields; for example, in computers and robotics or IT systems which are involved in production line.

Because some situations will come here which has been seen that the people are now not in a position to go to that location. For example, in the welding industry welding at different locations where it is difficult to even reach; there you will require somebody else and there we are talking of the robots, we are talking of people who can take care of those repair and maintenance jobs or those operations where human being is not involved.

We are thinking that in this Industry 4.0- everything will look smart here autonomous systems, internet of thing, artificial intelligence, machine learning, 3D printing. When we consider the industry 4.0, the involvement of human being needs to be looked into. There you are requiring a different level of knowledge for these people.

But the fact remains that you do require people for this and hence ergonomics is important; even the most automated system you require a human being. But you require different attributes of him; the knowledge which he has is not going to help, he needs to be given different types of training, different types of tools and techniques and other essential things which you will be able to work and do the best.

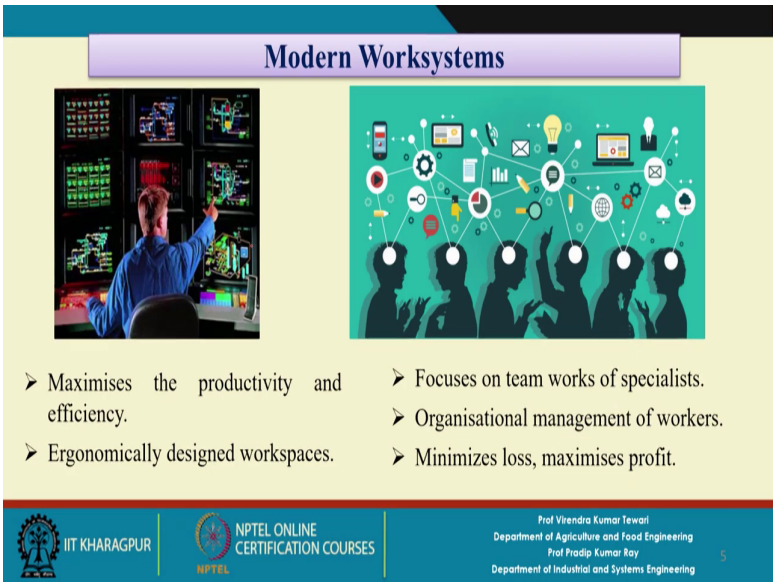
The production will be increasing and the safety of the person will also increase to a great extent. While we are considering the safety of this we are now talking of smart factory, we are talking of artificial intelligence because these are the information which we need to have lot of data; artificial intelligence and machine learning is a data driven technology.

In future these decisions will be taken by the robots or taken by people who are not actually people with flesh and blood. But the concept and the feeling about ergonomics or human factors will continue to stay.

The industry 4.0 which we are talking, sometimes it talks of the difficulties which are felt in. For example, you are talking of a welding and if the weld is not good or there is some defect in the weld, we will not be able to identify the defect online. What will happen is the lot of scrap will come out and we have to throw that material. But if you have artificial information and knowledge about such things and software by which it will identify on the go and take on course corrections while the welding is taking place.

These are the things which will come up. This will talk of advanced manufacturing well the introduction and the involvement of people may reduce. But the level of involvement which will require is very high from the cognitive point of view, the brain power point of view.

(Refer Slide Time: 09:19)



Now, let us look at these modern work systems how do they look like, what are the features which are there? The aim has been the maximize the productivity and efficiency. But you see how on the left as well as on the right the various decisions are to be taken the different gadgets and different monitors are there in front of the operator; he needs to he or she needs to have a decision, which is always perfect and correct.

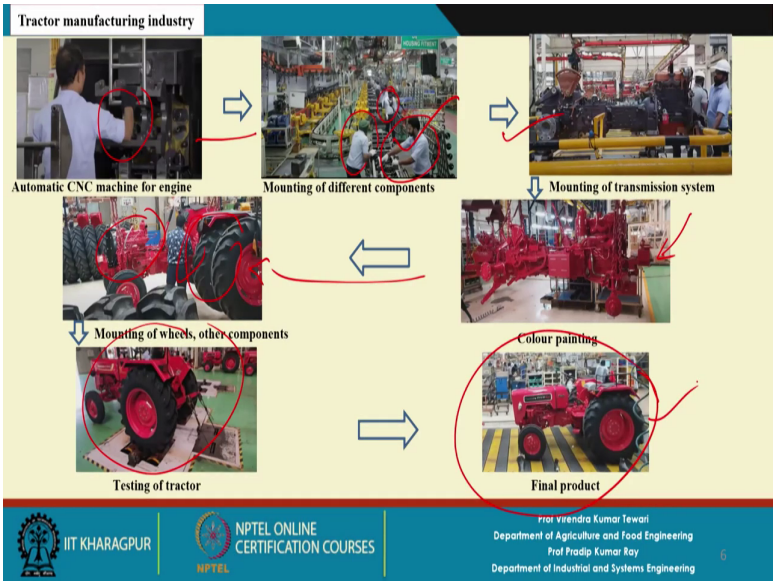
In order to maintain that, this is another aspect where the human factor will come into play, because it is not possible for a human being to be alert throughout the period of time and therefore you will have to have some sort of safety where he will be able to save himself or including the system while he is working along with these attributes; whether we are talking of the monitors, we are talking of several gadgets or the data which is there in front of him ergonomically design workspaces.

You need to have those workspaces ergonomically designed with respect to the person and with respect to the gadgets in front of him. The information which you want to put to him focus on teamwork. It is going to be a work with a group.

For example, in assembly line people have to be perfect to finish their part, because when the particular part is standing in the assembly line for a certain period of time, he or she must complete that part and immediately release it so that it goes to the next person. This requirement of camaraderie and the people together is very essential and hence we talk of organizational management of workers.

We need to manage the workers, a lot of management appears to be coming up when we talk of ergonomics, when we talk of machines, when we are talking for environment, which comes into play and the aim is to minimize the losses and maximize the profit in the production system.

(Refer Slide Time: 11:45)



We have a look at the various other examples see tractor manufacturing industry.

In an industry you can see on the left-hand side automatic CNC machine for engines, from here different components are mounted at various locations like first on the body we will have the engine, then the other parts slowly, then comes to mounting of transmission system here, then transmission comes to this place where we are talking of may be painting.

Painting has to go simultaneously so that the whole production line is taken care of. You can see that the involvement and the requirement of the people at various locations. While CNC machines at the engine you see what is his involvement here? What are the different components are to be added? Everybody has to be in on his job, everybody has to complete his portion of the job. Then it comes to the second part of the assembly.

When the transmission has been loaded, this needs to be painted because after it goes into the system the whole tractor will come up and if you do not paint it. Now, you see how the whole structure has been put or the frame of the tractor generally- we say that it is a frameless construction.

When the engine is removed, the other portion, the whole length of the tractor becomes smaller but it has a certain base, not exactly like our cars and trucks. It has a base on the axle because it has the axle on the whole frame then the mounting of the wheels takes place, as you can see here mounting of the wheels are taking place at the various locations; here the whole engine the radiator and everything has come up.

Ultimately the tractor is now completed and then it comes here for testing, the testing will be required. So, the these are the various steps in which in a tractor industry how things flow. This is this just an example to understand as to how involvement of people is there in a tractor industry. Similarly, it could be for an automobile industry.

Then it comes to the final product that we are getting here.

(Refer Slide Time: 14:55)

Contribution of modern ergonomics in system design and management. You manage all the three components- we have talked of human, machine and environment. All the three components need to be managed properly.

Otherwise, there is any mismatch the output is going to be decreased. If the human and machine are not properly adjusted with regard to fitting the job to the man or fitting the man to the job so that there is good harmony between both and they have to work in the overall environment which comes into picture. So, there is need for management.

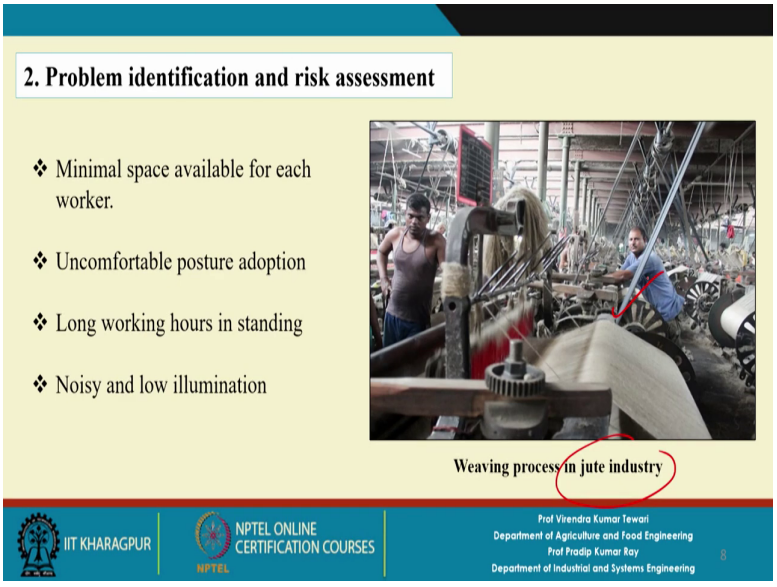
The design has to be user-centered design; then the you will find that the person is properly situation in the system. For example, if you take this ecosystem of the man machine interaction or the human machine interaction you can find that these are some of the gadgets in front of him some and this is the chair in which he is seated. You see the space availability for body movement.

In this chair, there has to be arrangement for him to move, because he may require to go to the printer, he may require to stretch something else or he may require to get out and get in faster for attending to any call inside on the computer or on the phone. What are the physical factors? The body size, the body shape and mobility.

User center design will be user friendly. Today we are talking of each and every aspect of design that user friendly and we call affordable; that is the cost involvement. But here when we are talking of the ergonomics, we are talking of user friendly and if it is user friendly, if it is accessible, if it is repairable and reliable, the human being will be involved in either production of the same or use of the same.

Then this will improve the comfort ability. Overall, the basic aspect of user friendly and comfortable system which is being offered to the operator is that he will be able to deliver the maximum. We cannot forget the output at this point of time when we are talking of ergonomics as such.

(Refer Slide Time: 17:54)



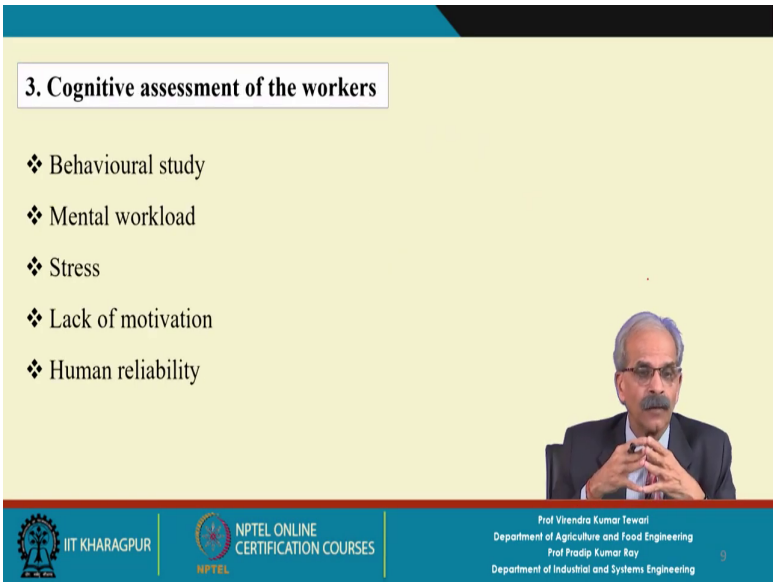
Problem identification and risk assessment. Those design aspects with regard to human, with regard to machine, with regard to environment. What are the identifications and risk assessment that may come up?

Minimum space available for each worker, there has to be certain level of space availability for each worker whether in the assembly line or in the location where he is for the job he is doing or the task which he is performing. Uncomfortable posture adoption is going to be a risk and is going to be problems for maximizing the output. Long working hours in standing posture or even in a seated posture both are not acceptable from the health point of view. Therefore, we have to also take care of this because, human being is a biological system and when you are interacting with a biological system with several other automated system or machine system or hardware systems or non-biological systems., you will have to take care of these very properly.

Noisy and low illumination. We should not have any noise.

If you go to a jute industry you will actually feel the effect of the different aspects of the problems which the workers feel- not only the production problems, but there are health issues.

(Refer Slide Time: 20:55)



We need to look into as to how to identify and assess the risk. Cognitive assessment of the workers. When the automation increases, when the person is involved in the industry where

lot of smart gadgets are there and one has to remember many things then do things in front of him.

For example, we have seen that the gadgets are there and the person has to only take information, and see certain things, visualize perceive the answer and accordingly take an action by either operating a joystick or operating a knob or pressing a button and therefore, more of cognitive assessment of the worker is essential from behavioural point of view.

What happens to his behavior? Because we have seen in the particularly in the IT industry that the workers or particularly the IT professionals, they continue to be there in the seated posture for hours together. And that talks of their health, particularly the vertebra and many of these get affected because of the mental problems, the feeling of loneliness and repetitive work and boredom.

What is the optimum mental workload? While we are maximizing the output and we are also giving a congenial and a good atmosphere for the person to work, we need to also see what is the mental workload which the person is subjected to and hence the behavioural studies are required to be done. What is the level of stress because of the task which he is doing?

When we are talking of the total stress coming on the worker, it could be physical stress, it could be mental stress, it could be a cognition, you can see both of them together, you may have either a physical or mental or both physical and mental. We need to understand the type and nature of the task the person is involved day in and day out.

It may also lead to lack of motivation and reliability of the person's performance.

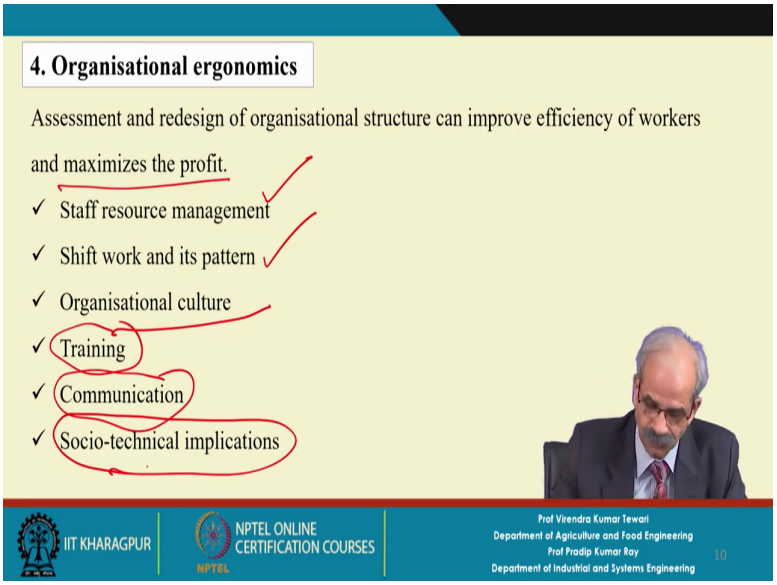
The cognitive assessment of the worker on the task irrespective. What is the type of task, even for the pilots we need to look at the nature of the task which they are doing, the nature of recreation which are being given to them or they are being asked to do. These are some of the things which have to be taken into consideration when you are considering a high level of automation coming up in the future.

In years to come, ergonomics is going to stay because human beings are going to stay and hence irrespective of the level of automation.

You must have seen that the working professionals are now talking of yoga and detaching themselves from the work during the period of time. Why it is essential?

They can keep their mental health, take care of their cognitive mind and remain motivated. Lack of motivation is one which is going to bring boredom and going to bring down their efficiency. In order to keep this, we will have to consider these aspects and the person always remains motivated in the task.

(Refer Slide Time: 25:24)



Organizational ergonomics when we are talking of the human, machine and environment, starting from simple to a very complex system. Now there the organization or the people machine materials and the whole ecosystem has to be taken care of properly.

Otherwise, the person will feel that the output is up to this and he will not bother about the previous job, the back end and the forward linkage. Backward linkage and forward linkage has to be connected in such a way that the person understand that I have to complete my task in order to see that the component ready by the end of my term.

When the job is coming to the next person, he has his job ready. Otherwise, if this person does not do it then there will be a weak link in the whole system and the whole production system will get reduced or get affected overall. There is need for ergonomics that is organizational ergonomics, you will have to understand what exactly is this assessment and redesign of organizational structure can improve efficiency of workers.

If you organize the whole ecosystem of human machine environment and the details of this while keeping in view the health and care of the worker, health and care of the machine as

well and also the changing environment, which is going to take place because of the task being performed.

Staff resource management. You need to have the staff right in place. For example, in a staff of 20 people, if 1 or 2 go, either because of medical reasons or leave the job, you will have to have a right kind of person to be introduced at that location and you need to have a right kind of training to that person, because he has to be fitted into the system.

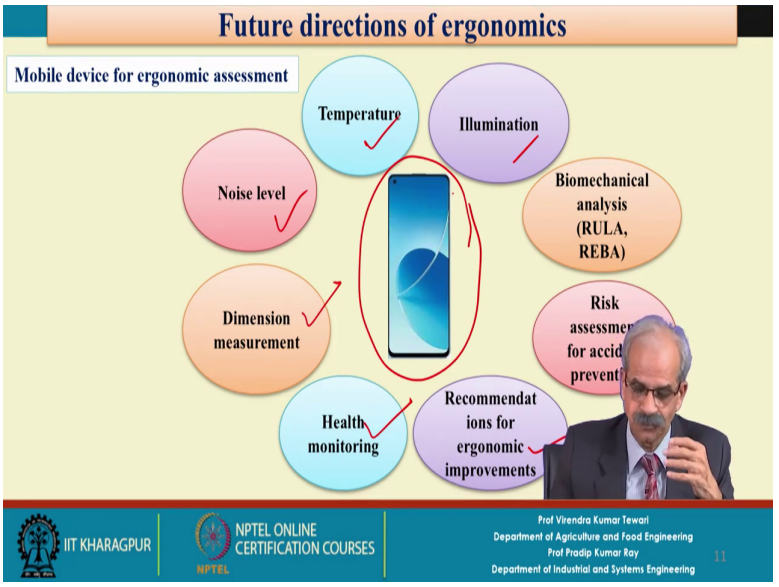
The organizational ergonomics that we are talking of shift work and how do you manage the shift work and the pattern of that shift work has to be there. When you are thinking that the whole ecosystem or the production system will go without any hindrance, without any loss to the overall production.

An organizational culture has to be brought in while we are talking of the safety, we are talking of the staff resource management in with their view is to maximize the profit. Therefore training is essential; proper communication between the workers and the organizational people the components.

They now become components and we think as to how best their capabilities and limitations, the mental capabilities limitations, their motor capabilities and limitations, their strength capabilities limitations, their behavioural capabilities and limitations are taken care of. Therefore, finally you are thinking of socio technical implications and how do these affect the total organizational ergonomics.

It is essential because until and unless we take care of the whole organization output is not going to commensurate with the total investment; the whole management has done for the production system or for the organization. Therefore, it is essential that organizational ergonomics is looked into, that is why we call that organizational ergonomics is a factor while we are talking of maximizing the profit.

(Refer Slide Time: 29:12)

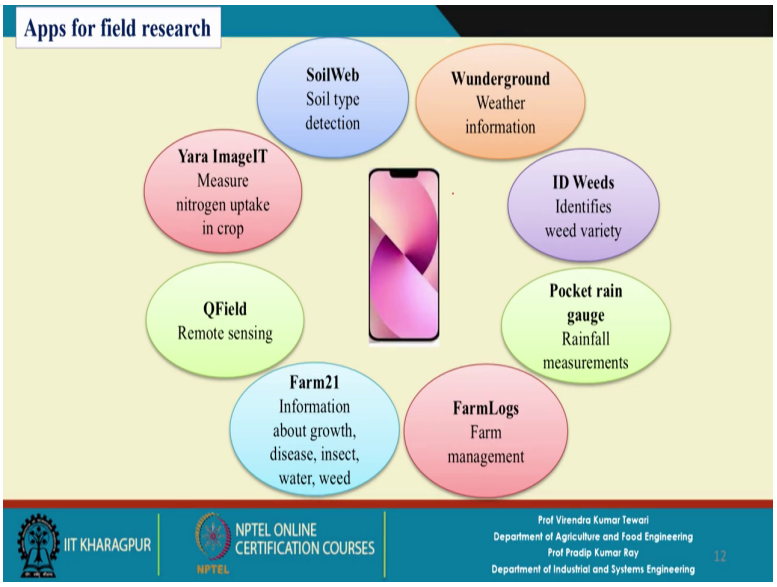


Future directions of ergonomics, now we are looking at as to what future yes, now we have we are talking of the various types of gadgets and devices which have come up. Everything everybody wants to have this in his lab pump top or in his hand with the several android applications he would like to see these apps would information.

He would like to use an app and see that what is the illumination level, what is the temperature, how are the biomechanical analysis of this through the different apps. We can do risk assessment recommendations for ergonomic improvements, then health monitoring dimension measurements, noise level temperature, illumination etcetera. This is going to be the future direction of ergonomics.

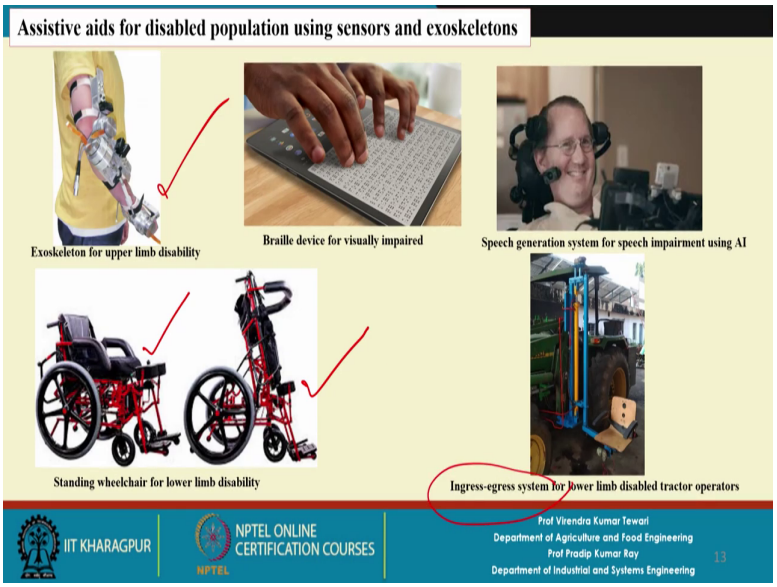
Human being will be more concerned with these aspects with deviations of this various types of such devices and the attributes of these devices and the high level of complexity of understanding those apps and immediately coming to a particular app and utilizing that in the nick of time. More and more of cognitive knowledge of the person is going to be subjected and less of physical. The risk factors are going to play greater role in the future as ergonomics is leading towards more and more of gadgets and automation.

(Refer Slide Time: 31:05)



This is just an example of how do the field research with regard to the apps. Various types of apps will be there, which will talk of what is the level of soil data, the field data, how remote sensing and the rain gauges all sorts of devices and apps could be available to the farmer and once he gets this information, he will be in a better position to plan his activities and crops.

(Refer Slide Time: 31:44)

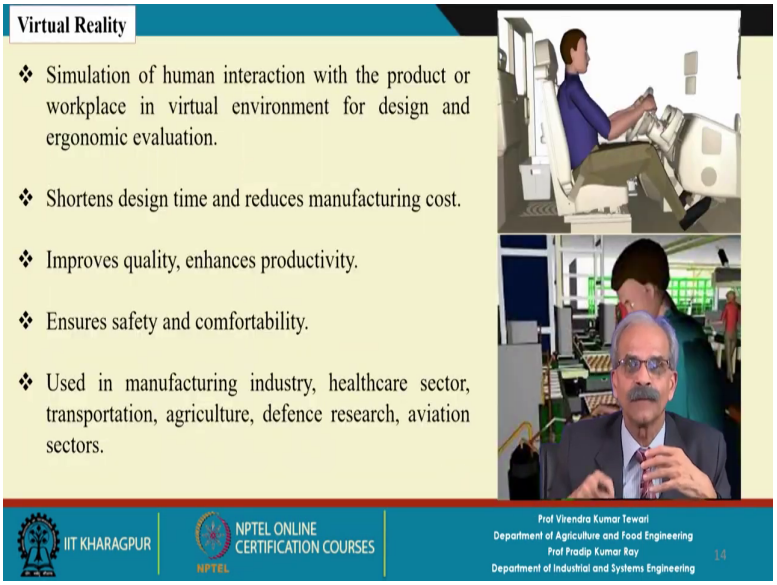


Some of these essential things need to be taken - assistive aids are the ones which have come up in a big way like for visually impaired people Braille. Then special arrangements for

people who can we cannot speak at all. For them use of AI, you can think of people who have the lower limb disability, you think of the upper arm limb disability.

These gadgets have come and the people will be in a position to do their task. Ingress and egress system, this is an example which we are giving, which we have developed at IIT Kharagpur. There is a person with lower limb disability, you will be able to get into a tractor and instead of operating everything by leg he will have everything to be operated by hand and this could be gender free. For example, male and female both could be taken care of with this.

(Refer Slide Time: 33:04)



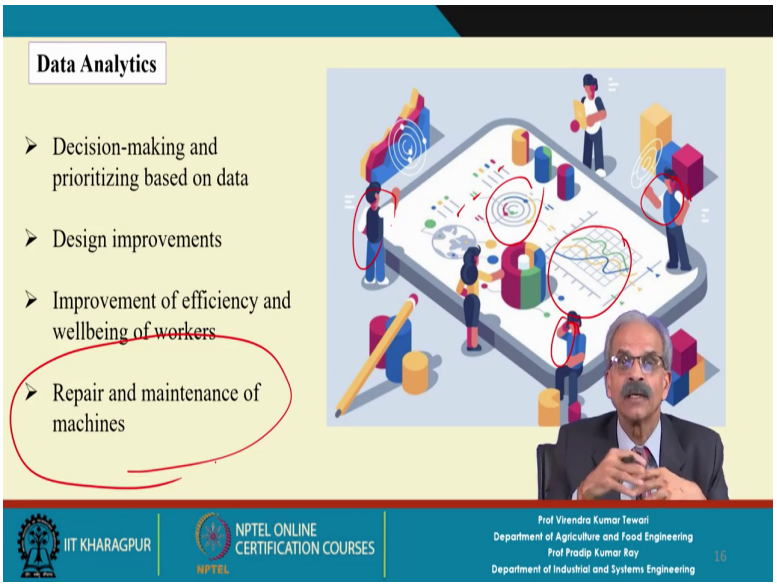
We are talking of virtual reality in order to ensure safety and comfort ability. We are talking also of the augmented reality.

(Refer Slide Time: 33:18)

We should be in a position to superimpose the digital information into the real world.

There you can make certain changes and understand, in the physical situation, in the real situation you may not be able to do that. But if you have the superimposed digital information, in that you will be able to understand the difficulties, you will be able to understand the whole system as such.

(Refer Slide Time: 33:52)

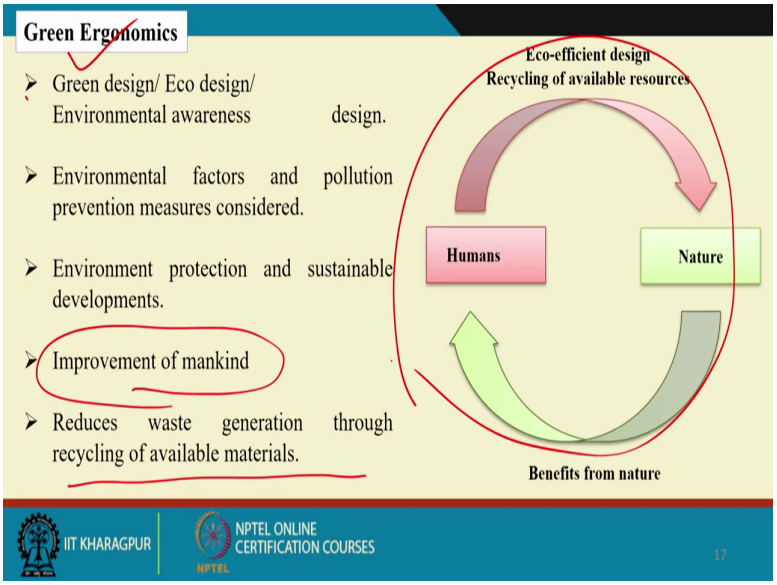


Data analysis. As I was talking of artificial intelligence and machine learning, lot of data will be available to people. We are thinking of explainable AI particularly for solving the problems of thousands and lakhs of code cases piled up in the codes. It is not possible for persons to finish this in period of time; we need to take help of these new modern tools like explainable AI and so on.

When lot of information in the form of graph, in the form of pie charts and other information which are there how people will think, what sort of decision they will take so that the output is tangible and they are in a position to take cognizance, as well as take advantage of the data which is available. This is going to be the future repair and maintenance. Machines will definitely take care with regard to the data that we will have and then you will be able to take proactive maintenance requirement so that the downtime can be reduced.

You see here how ergonomics has changed from the primitive ergonomics of just a tool and a person to so much of data driven technology where ergonomics is still playing a greater role.

(Refer Slide Time: 35:10)



Green Ergonomics. It is essential that we keep the ecosystem of the human being where the nature is involved so that the environment does not affect and when we are talking of ergonomics, we are talking of the environment of noise pollution, we are talking of air pollution, we are talking of water pollution, we are talking of soil pollution, everything is taken together. We are talking of green ergonomics as such reduce waste if you see that the minimum waste is generated and if you can recycle the waste.

When we are talking of organizational ergonomics we are talking of green ergonomics as such in the near future to come in the data driven technology of ergonomics, which is going to come to us in future.

(Refer Slide Time: 36:33)