

**Human Factors Engineering**  
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**Lecture - 03**  
**Human components, machine components and environment components of  
worksystems**

Dear students and participants, my faculty colleague Professor P.K. Ray has already given you details of what is the history of Human Factors Engineering and Ergonomics. Well, I think he has explained many things right from the beginning of the starting of ergonomics and the history and the various factors which are involved in these. I would like to go to 3rd lecture in this series, because first two lectures he has taken.

Before I talk of the 3rd lecture in the series, I would like to have some recap of what has been discussed by him, I will put in a slightly different fashion. When we talk of human factors engineering or ergonomics it has been told that human factors engineering is the term which is used in US and the ergonomics is the one which is used across in the Europe and also in India.

Human engineering is another term which is used. But that is mostly used by our people in the humanities sections, more of so because that is a cognitive science which people are thinking of.

I would like to say why this particular course or this subject is essential. Let us see how it affects our daily life? Right from the first morning activity that we do, we get up from the bed. Imagine that the bed is not of the height standard height of 18 inches, it is about 20, 25 or 30 inches, what will you get? How insecure you will feel to get down of the bed?

Supposing that the bed is of 10 inches only from the ground level and supposing you are totally on the ground, then what will be difficulties and other things that you will feel when you are to get up from the bed, when you get out of the bed. That means, there is some imbalance between the bed and the human being irrespective of whether he is a male or female or a small boy or an adult person, there will be certain things which will vary.

Then next activity is we go for brush. Now you see the tooth brushes which are there, different designs of toothbrushes have come into the market you must have seen what sort of flexibility they do have, because that has to enter to the various parts of organ and clean the teeth properly. And therefore, this is another device which talks of how ergonomically; that means, what are the construction and our morphology of our mouth accordingly those small devices are met.

These are thought of keeping in view that the work is done efficiently and also the equipment which is used is not harming the person. So, why we are talking of the comfort of the job to be done also talking of the efficiency of the job and both the job done, the equipment as well as the man understand that the environment of doing this task of brushing is taken care of properly.

Similarly, when you go into the your car, you assume that the car height is different and you have to get into the seat, assuming that the steering is of different size, but then these will have difficulties and those difficulties are the one which we are trying to understand through the course of human factors and the ergonomics.

There are certain rules and regulations we need to follow while we are doing a task. For example, when you are doing a task, you must have things organized well when you want to perform a job. If those things are not properly put you will find that the order in which the process must flow will not be perfect and therefore the loss have to be found.

Say, for example, you have to apply certain force and if the capability of the person is not within that force he will have problem and accordingly if the item to be reached is away from his hand or he has to assume a different posture to reach to that then also there will be a problem.

These are the aspects which we need to understand through this course of human factors and the ergonomics that we are trying to make you understand and try to see that you utilize in your daily life, in your systems. Whether it is a simple system which is all completely manual driven or a system which requires certain equipment to be handled or a system in which a group of people are working.

Everywhere human factors engineering and ergonomics is going to be utilized. You must have seen several types of new ergonomic design of chairs have come, various comfortable

chairs have come various types of devices which people have been given. For example, the people who are visually impaired they are given braille to interact with people; who have lower limit difficulty they have been given certain appliances by which they will be in a position to do their daily activities, etc.

These activities, these appliances, the tools and techniques which have been given to the people to facilitate their work and that maximum output we get from the persons while keeping in view his welfare and safety in mind.

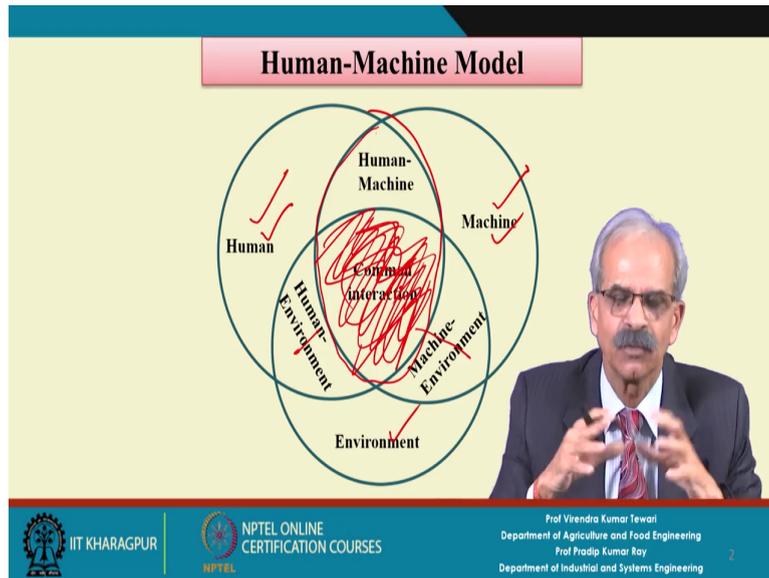
This is what exactly is the ILO definition of ergonomics talks. It is the science which deals with the application of engineering in conjunction with biological sciences with a view to design develop a system or a product a keeping in view the welfare and safety of the person.

This is what is the actual definition which of ergonomics is. Therefore, it can be utilized in any industry, in any work system, in any field that you can think of. Even if you think of your management systems; when you will have to manage people what sort of behavioural aspects which you need to take into account while you are trying to interact with these people.

Even the doctors now-a-days use several appliances. If they have difficulty in using those appliances, they will be not be able to use those things properly and because they stand even for operations for about 6 hours, 7 hours and those things if they are not taken care of properly, there will be difficulty.

Whether you are talking of agricultural operations, the industrial operations, we are talking of work systems, production systems various things which are coming up and the total environment which is there. We talk of Man, Machine, and Environment.

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Here we are talking of Human-Machine and Model. Human we are talking with respect to male, female and all sorts of ethnic groups, therefore we will call this as human-machine model.

There are three circles made here. One is of the human, the other is talking of the machine, the third one is talking of the environment. If you see the interaction between human and machine, there is a certain portion between the human and the machine. When you talk of the environment and the machine as well as human, then you are getting this area into consideration.

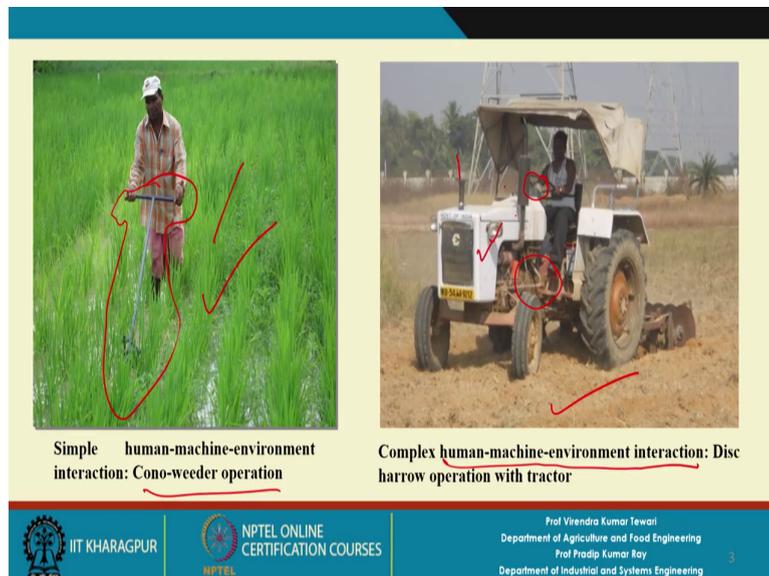
When you say that a person has to work in this area, he has to be careful that all the three aspects of human, machine and the environment are taken care of. You see here that the common interaction is this, then human environment is this much, machine environment is this much. But this is the common which you have to perform and the efficiency has to be maximum.

While we are thinking of the comfort and safety of the person, we have to also think of the maximum output, the whole aim is to maximize the input resources and get the maximum output. While keeping in view the other aspects of the human being's safety and comfort in mind.

This is what exactly we are talking with respect to human machine model. There are two types of environments-one is the immediate environment. For example, in front of me there is a desk and then in front of me there are certain knobs and pen and table chair keyboard etcetera. This is an immediate environment.

Environment when we talk of what is there in this particular room, the illumination level the noise level or any vibration which is coming up or any other thing which is there or the people around or these next outside environments. So, when you talk of all these the man machine environment model, we have to consider all these people into picture.

(Refer Slide Time: 11:01)



Here two examples are shown. One example is a simple example of human-machine environment, you see the person who is working in a crop production system where he is using this particular device to clean the weeds in a standing posture. A human-machine now is working with one of the devices known Cono-weeder. What is the environment here? It is the crop here. Then the water in this particular field and the posture in which he is maintaining himself to see that he remains comfortable yes, it is a standing posture he has to operate.

This is a device in which it has to be operated. Supposing the same thing has to be done in a seated posture, it will be very difficult and that is why this device has been designed to see that he stands in a standing posture and does the job. Similarly, when you come to the tractor

driving slightly more complex as compared to this, you will see that we are talking human machine environment interaction here.

Because the person here has the steering wheel, then there are leg controls and similarly they are hand controls over there, the exhaust is coming out from here, there will be lot of noise because if the engine is kept over here lot of noise. Because of this, the vibration which is coming through the seat on which we are being seated.

All these things will make him a person in a complex environment and he needs to perform the job as well. We will keep him comfortable with the vibrations with the other controls etcetera in such a way that it comes within his limitations and capabilities and he does the job.

But at the same time, he must do the job to the greatest extent, we will give him all sorts of comfort while the output is not commensurate with the total investment or the total infrastructure which is given and therefore, we need to think into this.

(Refer Slide Time: 13:12)

**Human Components**

**Anthropometry:** Science dealing with human body dimensions.

Factors affecting anthropometry: Age, Gender, Ethnicity.  
Differences: height, size, shape, weight, strength, body segment proportion

The slide features a photograph of a diverse group of people of various ages and ethnicities, circled in red. The slide footer includes the IIT Kharagpur logo, NPTEL Online Certification Courses logo, and the names of Prof. Virendra Kumar Tewari (Department of Agriculture and Food Engineering) and Prof. Pradip Kumar Ray (Department of Industrial and Systems Engineering).

When we are thinking of the Human Component, the people of different age group, gender, ethnicity and different height, size, shape, weight, strength, body segment, proportions.

The human component is also a very complex component, because he or she has certain capabilities limitations- height, strength, all these parameters. And therefore, we would like to have details of the human component like what is his height, what is his weight, what is his

capabilities and what are a strength parameter and often beyond that there are certain components which come close to this or the next ones we will see here.

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Now, some of these anthropometric problems, science which deals with human body dimensions. These dimensions are essential because once you get the body dimension of that person you will have to design the thing in such a way that he is comfortable to either sit there or stand there or come out of a particular thing.

The knowledge of the human body dimensions including the strength is known as anthropometry. When we will talk of Anthropometer by which we can measure the various dimensions of the human body, male or female and as well as take the strength parameters that portion will be known as anthropometry.

This anthropometry then affects anthropometrical problem, what are the problems. If these are not properly designed, if the facilities or the posture in which the task has to be performed or not proper, there will be difficulty of the person to give his maximum output and hence it will affect the total efficiency of the operation.

For example, you see the control levers here is in the reach of this operator here, while you can see that the legs are here at this location. Then she is seated over here and when it works it goes in front here; when the device goes in front in the field you will find that lot of things along with vibration come. So, she has to operate the controls here.

You find here that the anthropometry has a big role into design of the equipment that we are talking of interaction with man and the machine or the human and the machine.

(Refer Slide Time: 16:26)

**Physical factors:**

**Five senses:** Make human beings aware of their surroundings.

Vision	Display design
Hearing	Warning signal, voice recognition system design
Touch	Control design, feedback
Smell	Act as warning signal for smoke, chemical release

**Cognitive factors:**

Skills, Training, information processing, working methods, work pace

**Senses**

The diagram shows five senses: Sight (eye), Touch (hand), Smell (nose), Taste (tongue), and Hearing (ear). Each sense is represented by a colored circle with a corresponding icon and a red checkmark.

**Footer:** IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, Prof. Virendra Kumar Tewari, Department of Agriculture and Food Engineering, Prof. Pradipt Kumar Ray, Department of Industrial and Systems Engineering.

You got to know what are the physical factors because limitations and capabilities of the person have to be thought of. For example, all the five senses will come into play, like we have the touch, we have the smell, we have the hearing and the taste right as well as the sight.

Now, these senses are definitely coming and sometimes the 6th sense that comes out of experience and out of some of the gut feeling that we generally call.

You might have seen in the cricket match sometimes a person is given last over 2 ball and then you find here that the person either he and he does havoc or he does very well and the you win the match.

Warning signals, the voice recognition system, design control, design feedback, act as warning signals for smoke chemical senses. These visions or these senses make us to do the task as per the requirement of the task. Some of the dimensions we are talking: below the neck.

When something is above the neck which is those cognitive factors, we are talking of how best you have used your brain, how best you have used the knowledge which you have gathered during the training or the information which you have processed through the

trainings or the work methods you have done or the work pace in which the whole particular task is to be done.

If you have learned those are the cognitive factors which will also come into play when you want to think of the complete output of the system of human machine and environment output.

(Refer Slide Time: 18:42)

**Machine components**

**Control panel**

- Controls: Inputs from human to machine.
- Includes levers, knobs, wheels, verbal information, key boards.
- Should be compatible to any operator. ✓
- Coded according to location, colour, size, shape, labelling, mode of operation.

The slide features two photographs of control panels. The top photograph shows a control panel with various gauges, buttons, and levers. The bottom photograph shows a person's hand reaching for a specific knob on a control panel, with a red circle highlighting the knob.

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What are machine components? There will be certain controls inputs from human to machine, there is a control shown over here that includes the levers knobs. You can see here the levers, knobs, buttons, all these are shown over here; see how a person is trying to reach into different locations; he sees the data over here and then should be compatible with any operator.

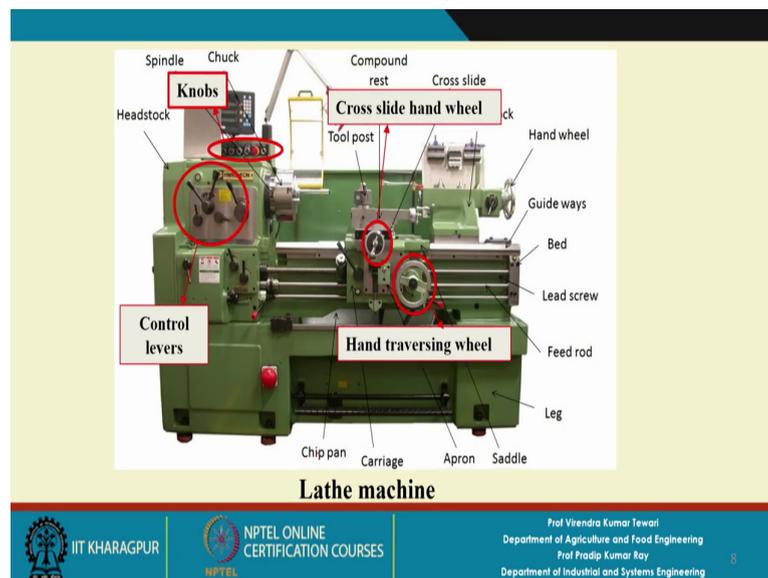
You can see that how the person is trying to reach to this particular knob, either he has to turn something or he has to press or things like that. So, therefore, the machine components are to be properly designed and situated with respect to the person in such a way that he gets the maximum benefit of that in a comfortable way and operates.

Coded according to the location, color, size, shape. Sometimes, it happens you might have seen that the cockpit of an aircraft, so much of knobs are there and lighting is very difficult. But the training which is given to the pilots in such a way that he knows that on the left side

what is there on the right-hand side what is there, what is there on the top and what is there in the bottom and what are the emergency stops and emergency buttons and knobs.

In an organized manner these levers and these buttons are to be operated and that is why when a person is to be put in a job some sort of training is required and by that training the inherent knowledge that he has got will get expanded and then he will be able to brush up things and take better decisions when the situation comes to that path.

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Now you see in here in this, we have shown a Lathe job, even you are talking of the production systems. In production system, a human being- whether male or female- he has to operate or she has to operate a lathe machine for either you want to design a thread or you want to design a shaft.

When you have to design these, I think you need to do this a certain task. For example, hand traversing wheels. But what is important is the knobs, what are the knobs over here, the control levers which are there. One must know what are these control levers, how they are operated and what is the consequence of operating left or right to a particular one.

Then the cross-slide hand wheel this hand wheel has certain task, we must know or the operator must know then hand traversing wheel. How it will be in a position to shift the whole carriage that is being shown through this? While a person is in front of this, there are

many hiccups in between because supposing the person is a shorter person, he will have difficulty to reach to every part of this particular lathe controls levers or the wheels.

If the person is very tall then also there will be difficulty. So, we need to match the requirement of the person with regard to this. This is an example given through a lathe machine.

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The slide is divided into two main sections: 'Quantitative displays' and 'Qualitative displays'. Under 'Quantitative displays', there are two examples: an 'Analog Display' (a pressure gauge) and a 'Digital Display' (a digital readout showing '175.5'). Under 'Qualitative displays', there are two examples: a 'TEMP ENGINE OIL' gauge with a needle pointing to a value between 140 and 170, and a speedometer showing '0 9 7 5 3 8 90 100 MPH'. Below the displays, a definition states: 'Display: An output for presentation of information. Design and selection depends upon the requirement, background and job specification.' The slide footer contains logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and Prof. Virendra Kumar Tewari, Department of Agriculture and Food Engineering, Prof. Pradip Kumar Ray, Department of Industrial and Systems Engineering.

Some of the displays are very important because the person has to see and then interpret the information and act accordingly. These analog displays are there, then digital displays are there and some of the displays which are qualitative displays we do require that because many times we do not require the exact value. But we do require the qualitative information which helps us in taking a particular decision and hence some of these and some of these will talk of the qualitative displays here.

Display and output for presentation of the information design and selection depends upon the requirement background and the job specifications. Whenever you are talking of what is the interface between the human and the machine, these factors will come into play depending upon the type of job or type of task which the person has to perform.

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**CRT display in workstation**

**LCD monitor in workstation**

**LED display in production industry**

CAST HOUSE - B					
DAY	SHIFT	A	11/11/11		
Planned Lathes 10	Planned before		10-23:09		
Completed 10	Completed by				
Pending 22	Pending at				
Total metal handle	All time	Left material by disc			
SL NO	YR NO	LATH NO.	Time	Slot pos.	
	ET NO.		since		
			entry		
1	001444	5	10:10:3		
2	001445	6	12:12:4		
3	001446	7	13:12:5		

**Advantages of LCD**

- Compact system, requires minimal space.
- Very light, easy mobility.
- Consumes less power.
- High resolution, very bright images, no distortion.
- Minimal heat production.

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There are certain advance from a very simple system to a complex system to far complex system and then go to very advanced systems. When you go there you find various aspects, say for example CRT display in a workstation. You can see what are the LED displays which are given here, the person has to read this, the person has to understand these which are written here and take a particular decision. It is production industry; the displays are given here.

For example, the time since entry what are the slot parts, then what is the date given what are the different instructions which you have got in the total metal handle. These are the things which are some information written information is displayed in case of a production industry. Then you get here LCD monitor in workstations.

This is a gamut of LCD in a workstation, in a workstation people there are many things he has the knob, he has the display here. Then he has the different boards because he is trying to seek some information from here, some information from here, some information from here and act accordingly. Because possibly this workstation is serving a large workstation.

Advantages of these will definitely lead to compact system which requires minimum space, very light and easy mobility of the person, consumes less power, this is essential high resolution, very bright images, no distortion, minimum heat production yes because when the system is there it will definitely have some sort of a heat production. These are the

advantages and disadvantages as the system proceeds from a very simple one to a complex one.

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**Environment components**



Low illumination level at workstation



High illumination level at workstation

❖ National Optical Astronomy Observatory, US, recommended light level in different work spaces where visual task is occasionally performed is 100–150 lux.



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11

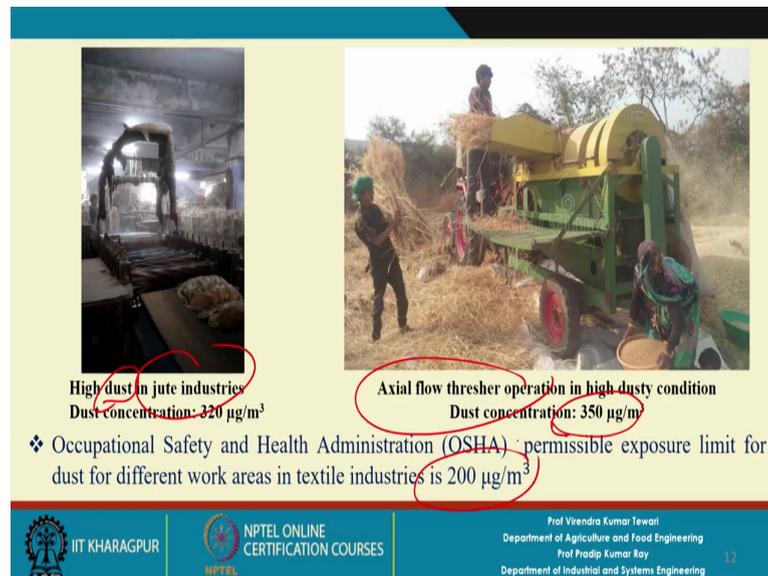
When we talk of the environment, the immediate environment and the outside environment. In the outside environment components, we are talking of high illumination level at workstation. If it is very high what will happen, if the illumination level is low at the workstation what will happen? The person will not be able to visualize the exact information which is displayed in front of him, whether it is a digital information or the analog information or anything that is in the form of written.

He has to have the proper illumination level, it should not be very high, it should not be very low. Similarly, if it is low what is the condition you feel and if it is very high what you get here. So therefore, some of these data are recommended and one must definitely take cognizance of this data which has been prescribed while designing an appropriate workstation which is serving a large number of people or large number of processing station.

For example, National Optical Astronomy Observatory, US, recommended light level in different workspaces where visual task is occasionally performed is 100 to 150 lux. So, you must keep this in mind while you are designing a workstation, irrespective of whether the size of the workstation.

The parameters have to be considered, enough level of illumination has to be there, the postures which the person assumes while operating some of the controls or the buttons or the levers or try to understand the data which has appeared in front of him.

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Highly dust in jute industries  
Dust concentration: 320  $\mu\text{g}/\text{m}^3$

Axial flow thresher operation in high dusty condition  
Dust concentration: 350  $\mu\text{g}/\text{m}^3$

❖ Occupational Safety and Health Administration (OSHA) permissible exposure limit for dust for different work areas in textile industries is 200  $\mu\text{g}/\text{m}^3$

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Now we talk about dusty environment. Here in a jute industry, you will find lot of dust comes up which is very dangerous for the operators. They inhale this and it has been seen that in next 15 years or so they get all lungs problems and it is very complicated and sometime terminal.

So, therefore, the dust is another environment which should be avoided. The dust concentration what is shown here 350 microgram per meter cube. What the Occupational Safety and Health Administration (OSHA) USA have recommended is only 200 microgram per meter cube.

If these are the two environments of dust, what will be the performance of the person? Definitely it will toll upon his health or her health and the you will not get the maximum even from his or him for a longer duration of time.

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**Spade operation in Agricultural field**                      **Blast furnace at TATA Steel**

- High temperature reduces the efficiency and productivity of worker.
- It increases fatigue, heart rate, blood pressure, reduces activity of digestive organs.

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Similarly, in blast furnace.

(Refer Slide Time: 29:25)



**Noise level measurement during tractor operation in field**  
Sound pressure level: 91 dBA

**High noise level in jute industries**  
Sound pressure level: 97 dBA

- ❖ High noise level affects human performance, causes hearing impairment or permanent hearing loss.
- ❖ Occupational Safety and Health Administration (OSHA) permissible exposure time limit at 90 dB is 8 hours.

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The noise environment in both locations is 97 dBA. The level which is acceptable to us is about 72 to 80 dBA as per the OSHA recommendations, but this is very high.

(Refer Slide Time: 29:45)



**Hand arm vibration during cutting wheel operation**

- Resonance occur at 100–250 Hz.
- Causes white finger disease at vibration frequencies of 50–100 Hz.
- Causes Dart's disease at 100 Hz.

**Whole body vibration during tractor operation**

- Resonance band 4–8 Hz.
- Causes various spinal, anal-rectal, gastrointestinal disorders.
- Induces physiological responses.

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Similarly, vibrations, this is another factor. Vibration also has to be there and it will take resonance shape at the edge of 4 to 8 hertz in case of a driver's seated posture.

These are some of the data which will help you to understand how best a person can use this activity, you do work in these activities at the same time keep track of his health.

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Work has to be properly organized if you get maximum out of that. Work organization talks of how the task to be allocated, what is the job, which has been properly designed? We must

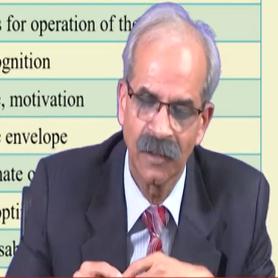
take care of the health and safety of the person, while managing human reliability because, in a human being 100 % is not possible.

In a chain, the weakest link is the human being; maybe the machine is in working capacity, other components are working, but the human component is not the external liabilities- 18 to 20% only. So, the decision making has to be proper, the responsibilities have to be properly given. When you are allotting a job to a person you must know about his capabilities, limitations and the training that he has been given. Otherwise, the job or the work is not properly organized to get maximum out of this.

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**Interaction between components**

Interactions	Design issues
Display : Workspace	Location, size and contrast of displays
Display : Environment	Illumination level, vibration, noise, legibility for display design
Senses : Environment	Environmental requirements for operation of the
Processing : Environment	Effects on perception and cognition
Processing : Organisation	Skill levels, training, fatigue, motivation
Effectors : Workspace	Determination of workspace envelope
Effectors : Environment	Effects of vibration and climate on
Controls : Workspace	Task description needed to opti
Controls : Environment	Effects of environment on usa



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(Refer Slide Time: 31:41)

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2. Bridger, R. S., Introduction to Ergonomics, Taylor and Francis Group, Third Edition
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18