Human Factors Engineering

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Lecture - 60
Epilogue

Welcome friends to this last lecture on Human Factors Engineering. This course was started by myself Professor VK Tiwari and currently the Director of the Institute of IIT Kharagpur, with my friend Professor PK Ray who was the Dean of Vinod Gupta School of Management and a senior professor of the Department of Industrial and Systems Engineering.

We came together and we wanted to start a human factor engineering course. Because we thought that this is an essential requirement and today in the age of automation lot of problems are coming up because of the mismatch of various designs of equipment etcetera, which have taken place over the years.

We know that right from the beginning of our day when we are talking of the size of the bed and the height of the bed, we are talking of the tooth brush, you see that ergonomical design. When you go to the office, we have the chairs which are ergonomically designed.

And then the various other factors in the illumination level, noise level etc. are maintained properly because these are the factors which will maximize the output of the worker. Even in the corporate houses, we are thinking of how best we can utilize the services and the capacity of all our executives. For those various sessions of yoga and meditation and also of taking rest at various intervals and changing the mood of these people so that they are always fresh and take good decisions.

This has been the case throughout and particularly in the production industries where manufacturing is going on. We have seen over the years lot of accidents have taken place and because of which the companies have to incur a lot of loss from the point of view of the money, but at the same time loss of life.

Then the worker or the person who is involved have a miserable life. Therefore, the aim of every company is now or any production system or any construction system is to see that we should have enough ergonomic provisions given to the workers or the people so that they are very safe.

Once they are safe, it is expected that they will be able to perform to their maximum and give maximum to the system, that is the aim. So, when we are talking of this, we always see that central part of the human being and that is why we call human factors. What are the factors which require the capabilities limitations and other attributes, which are connected to the human being and what are the attributes of the machine?

Machines have started from Industry 1.0 to now Industry 4.0 and we have lot of transformations over the last 30-40 years. Accordingly, there has to be a match between the interventions of how best the persons capabilities and limitations could be utilized, how the environment is created.

Now, we can see the offices which are created; there these are very good offices even in the hospitals, we have seen those good hospitals, they do not exactly look like hospitals. It is only to create an atmosphere by which the patient who comes gets an open atmosphere; he gets a very relaxed attitude of the people around and does not get bogged down or does not get deserted because of the environment prevailing over there.

Therefore, all these infrastructures which are being created has only one central theme in mind and that is the human factors, because whatever may be the automation level of any industry, there is a human being involved. The higher the level of automation higher is the level of requirement of the intellect of the person.

The production industries are there where in steel manufacturing, car manufacturing or car assembly line or motorcycles or whatever lot of infrastructure development has taken over the last 30-40 years across the globe and in this country as well.

We have seen that various road constructions are going on, only to see that the people can move faster and the vibration etc. which come to the mind of the occupants particularly in those vehicles are minimum. They do not get hurt because of the type of the surface which is provided. These are only to see that the convenience is created while the maximum output is in the mind of the people.

So, we wanted such a course which will be beneficial to the undergraduates, the postgraduates, the researchers and the practitioners in the various industries, the corporate houses.

All sorts of information which you can think of including what we have developed ourselves by working at IIT, Kharagpur and our expertise which we have acquired over the years; we have put in lot of strength into the pedagogy of this, as well as the whole course content.

We started with human being at the factor and central factor or the central theme of these ergonomics. Then we are talking of human engineering anthropometry because we know that human being is of different sizes and the equipment which are manufactured in Germany and other places thinking that the people will be tall people. Now, how do that equipment be utilized by our persons?

Therefore, some sort of intervention has to be created so that equipment which are high ended equipment can be also used by people who are shorter in length, shorter in height as well as women. Because we know that the strength of women and strength of men are slightly varying.

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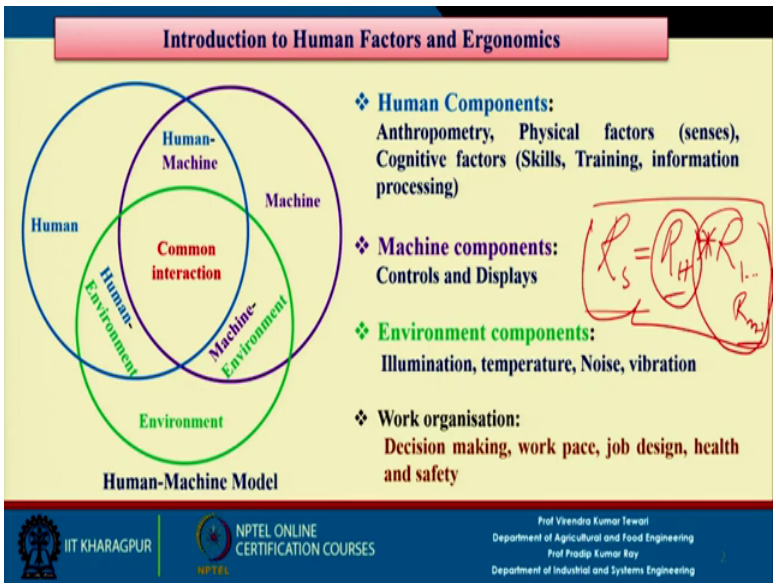

So, accordingly we have to create these opportunities and interventions in such a way that everybody gets more no more information and he is better placed to do the job.

These has been the central theme. We have started bridge engineering anthropometry then we are talking of interventions.

Here, three circles you can see, one circle talks of the human, the other circle talks of the machine, the third circle talks of the environment. Now, you see the interactions here, when you talk of the human machine- there is one level of interaction, when you talk of the human and environment, there is one level of interaction and we talk of all the three- you can see that where we are coming to a common location.

And we find that is not very much and therefore, whenever we are talking of the reliability of any system, we are saying that human being which has the central part. Suppose, we talk of the reliability of a system then this comes R_H and the rest are R_1 ….. R_{n-1} if you talk of the overall n systems which include also this.

Therefore, the R_H has to be taken because we say that the human being has certain capacity because of the food habits, because of the fuel that he takes.

The energies are employed for his mental strength, for the physical strength and for his interventions and of the cognitive strength. Therefore, irrespective of the type of job that we are providing, we have to take the central part as human being and all sorts of interventions that you are thinking of today in all industries considered with these factors only.

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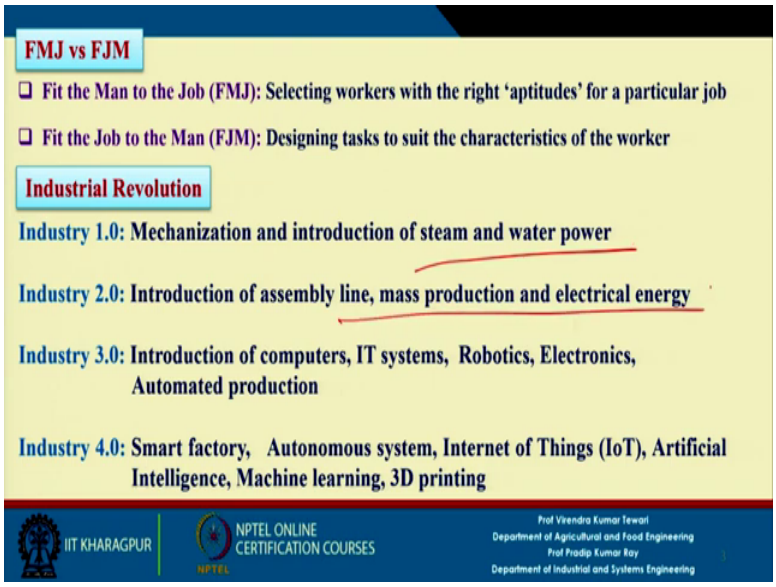

Sometimes we say how do we fit, because sometimes the equipment is already designed and we have imported the equipment, but we do not have people. Say, example of that is the engineering anthropometry that I was talking of. Fitting the man to the job, this is one portion of fitting the man to the job in some cases; we should have some cases we have to fit the job to the man depending upon the strength required, depending upon the mass.

May be some of these equipment where it is possible to fit the man to the job, but otherwise it is not possible. Majority of these will go for fitting the job to the man whereas, fitting the man to the job is as less as possible. Now, industrial revolutions. Industry 1.0, 2.0 where 1.0 we have steam and water power. Then we came to Industry 2.0, where mass production and use of electrical energy came up.

Industry 3.0, where IT system, robotics, electronics and automated production came up because, wherever hazardous situations are there, robotic robots have been used. Then IT system has been introduced to simplify the task and to minimize the paperwork and to get the data at one go immediately online.

Now, we are talking Industry 4.0, where we are talking of a smart factory, we are talking of autonomous system, we are talking of internet of things, we are talking of artificial intelligence, machine learning and we are talking of 3D printing.

At this age of Industry 4.0, manufacturing has to be at the highest level. Therefore, people must be prepared for that, people must be geared for that, people must be trained for such situations. We have Industry 4.0 and advanced system of manufacturing; we are talking of manufacturing across the equipment across the components. But that is not possible until and unless you have the manpower to do that and if you have enough manpower, you need to train the manpower.

Because manpower cannot be generated overnight; therefore, we need to train that manpower. For training, you have to consider ergonomics, you have to consider the safety of the person, while he is in job Industry 4.0, may be Industry 5.0 and all that which will come up with the advent of 4G, 5G and 6G beyond.

We can think of how Industry 4.0 is affecting the health of the person and what sort of interventions are required in the current level of 5.0, Industry 5.0 and beyond.

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The modern work systems user centered design. Risk assessment. We need to assess the risk, cognitive assessment of the worker which has been right from the beginning.

Now, everything that we are talking today of artificial intelligence and machine learning is a data driven technology which has to be picked up. We have lot of course and cases.

We need to have data and we need to digitize the information which is already available. We are talking of green ergonomics, we are thinking that we should have all these factors taken in such a way that we are not talking of only ergonomics; we are talking of green ergonomics, we are talking of the way we are talking of food materials we are talking of not having the chemicals etc. and we are talking of organic food. Accordingly, we are talking of organic ergonomics.

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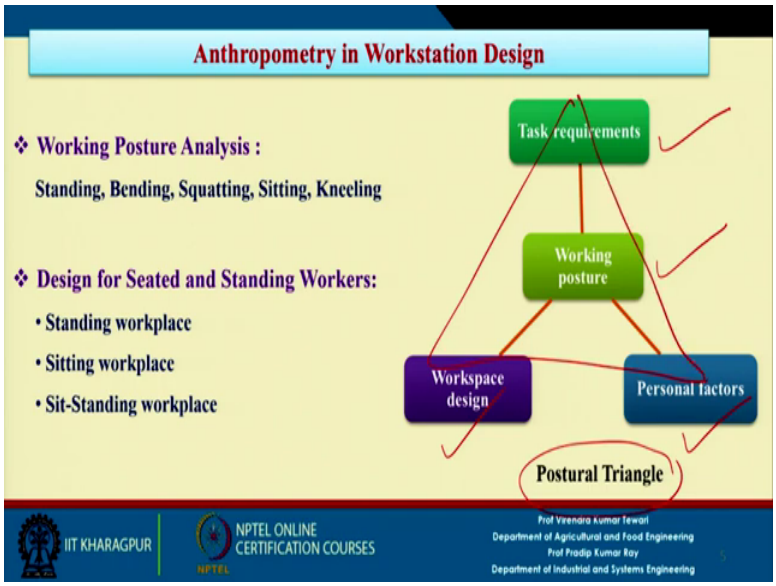

Working posture. We have discussed about different postures of the person as task requirement depending on personal factors and workspace design. The postural triangle. We needed to understand how best we can utilize this while the work is being done either in a standing posture, bending posture, squatting posture or standing workplace, sitting workplace or sit and stand workplace.

These are required depending upon the condition of the task while anthropometry and workstation design you consider.

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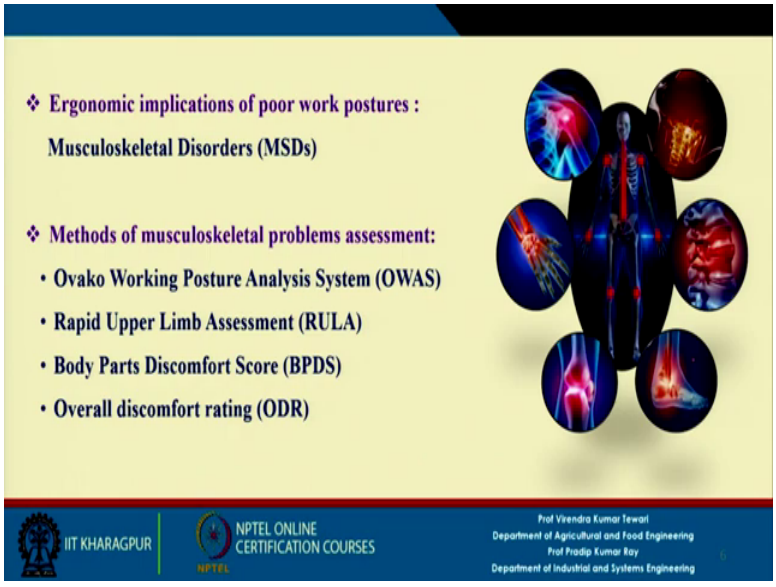

What are the effects of these if you are not designing? While you are talking of workers or people even the executives, lot of IT professionals are there. Those professionals are maintaining such a body posture for hours together. Many of them have problem of the back and hence this also results in many other biological systems and it goes back into their family.

We have talked of the methodologically, we have talked of various ways to assess them. There is a need for finding out and taking into consideration these MSDs which will happen if you do not go into details of proper design of the equipment, with regard to the interventions and the environment in which the task is being done.

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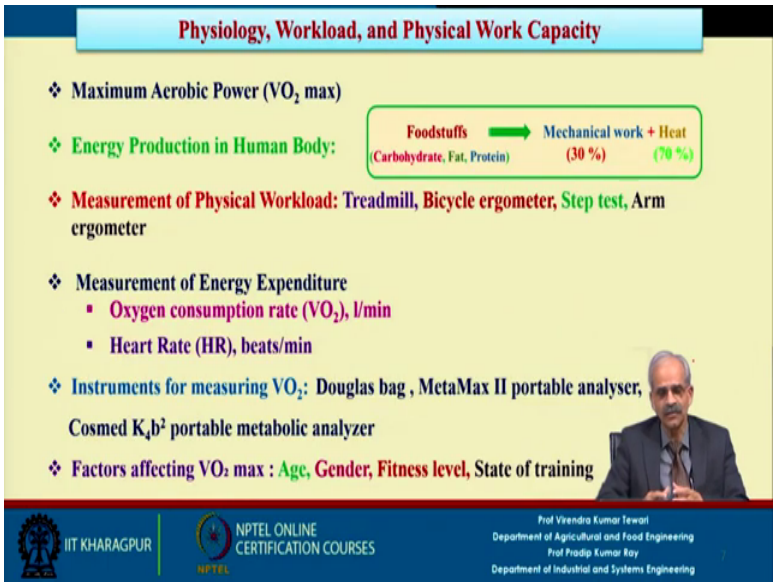

We have seen that the total about 1900 to 2300 kcal food is required male or female and this energy must be reserved with them. If they are not fed properly, if they do not have that energy, it will be difficult.

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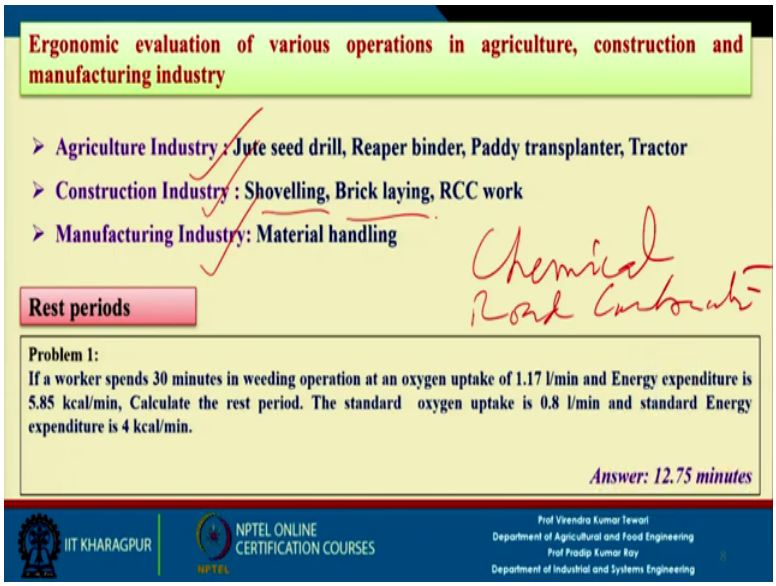

Anything goes beyond that; you require rest and you require various other factors to be considered in case of the industry work. When we talked of the different industries or different organizations in which this can be employed, where we are talking of agriculture industries, we are talking of construction industry, we are talking of manufacturing industries, we can talk of the chemical industries.

In the road construction, where lot of people are involved. Even we are talking earthmoving machinery where land reclamation is going on. Those machines where we are lifting the soil and putting at several locations, you will find that the shoveling work, brick laying work, these are all tough work.

We have to give instruction description that can be extended to these different types of industries. You can use your brain; you can see how a person seated in the bulldozer or in the earth moving machinery for hours together and he has to be careful because at any time the whole thing can topple, some of the slopes at which they work. Therefore, it is a very tough task and the people who are there must be a rest and work cycle created for those people.

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Hand tool design: Many times, when we are handling certain tools and devices, we need to look into these devices, we look into the requirement of the people, we look into the hands and their capacities of their leg, hand. Some of the work which we have done where the person is not in a position to use his leg at all and lower limbs are not in working.

Only upper limbs are being utilized and accordingly you can make a change in the workplace design of a person. Redesigning the workplace is more important. Then the training. What are the factors affecting tool design? We talked of the anthropometry, we talked of hand movements, we have talked of body movements and so on and so forth.

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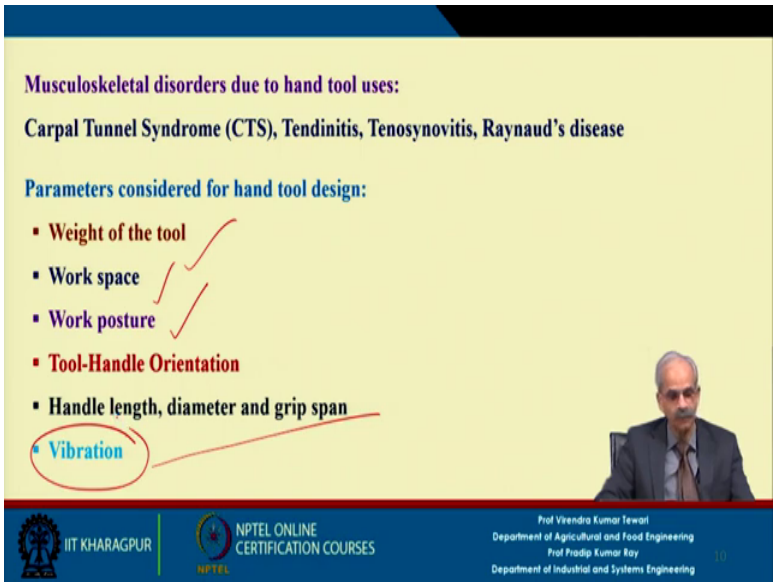

Now, we have talked of the carpal tunnel syndrome. These are some of the affects we have talked of. If proper interventions are not there in any task, they will result into these difficulties and hence the person will be affected. He will not be able to come to the office or to the work and he will have to be compensated.

Sometimes if it is not fatal, then also could be compensated. Lot of downtime of the machine could be there if the person is the only person working. In the hand tool design we must consider the weight of the tool, the workplace, work posture and other portions. Now, we are talking of the vibration and noise is an integral part of it.

How do we take care of that and therefore, these factors have been discussed with you. You are only to create a conceptual idea about ergonomics and shift engineering wherever you talk of. Irrespective of where it is an office work situation or a production steel manufacturing or any manufacturing industry that you can think of, these have to be incorporated.

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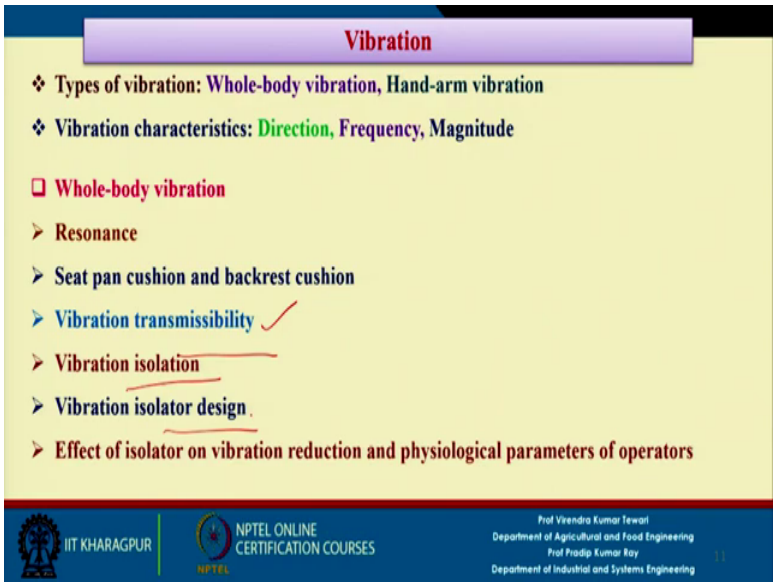

While we were discussing this vibration, we have talked of hand-arm vibration, we have talked of vertical vibration or the whole-body vibration. In a seated posture, whole body vibration is important one.

If you want to quantify this you should be able to quantify the vibration transmissibility, how to isolate vibration, what are the isolated designs.

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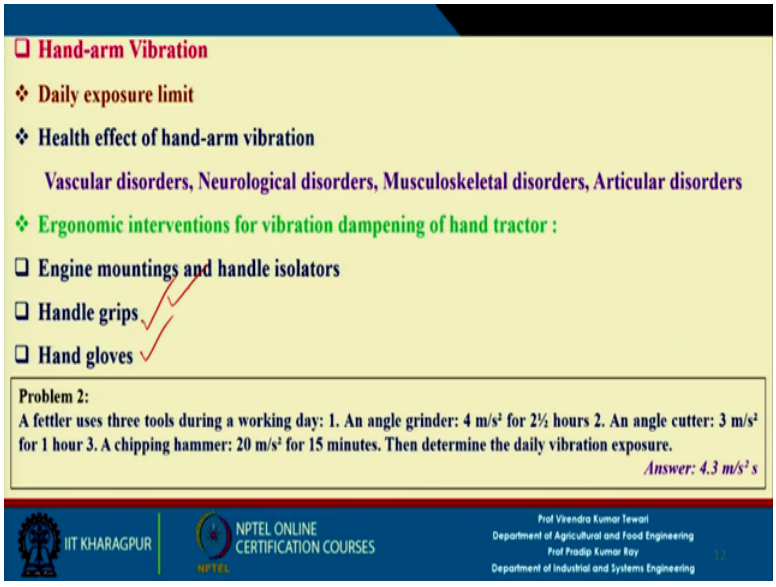

These are the different types of interventions like engine mountings, handle grips and then hand gloves.

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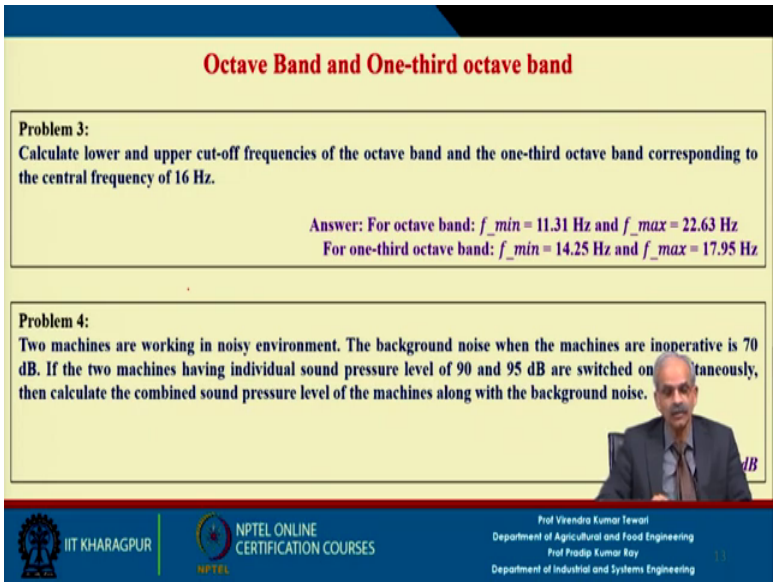

When we are talking of vibration level, we are talking of the octave band and one-third octave band.

Because at the frequency at which the vibration is taking place and you want to analyze and quantify, you need certain basis. Because these are vibration or random vibrations, we needed to have a time series data of that vibration. And when you get those data how do we analyze that?

So, we go into some of the bands which are to be taken. We talk octave band where we have discussed that octave band is between two frequencies, where the final frequency is twice that of the initial frequency and then we talk of the center frequency of that.

But even beyond, if you want to have more detailed information, we go to the one third octave band where we are talking of in the octave band. Then accordingly we should get the one-third octave band frequency, what is the central frequency, what are the initial and the final frequency that will give us more idea about the type of vibration.

Then we can take care of that vibration in the design of the equipment.

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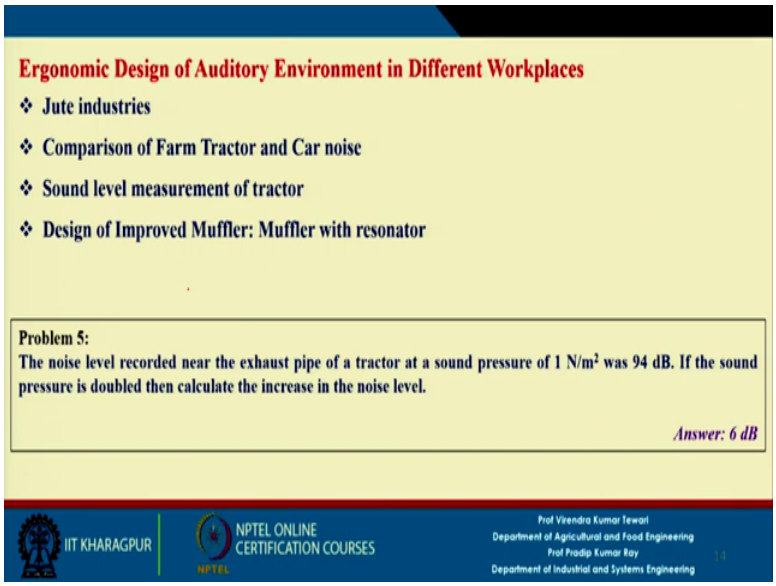

We have given certain examples of some of the auditory or different workplaces.

Many people after working for 15-20 years when they are really old, even at the age of 50-55 they have lungs problem particularly in the jute industry, where we find that lot of dust inhalation. Then the heat is there, noise is the problem, many problems which come into that.

We gave the example of the various factors which are coming up. We also said which are the ones where the noise level or the auditory environment should be there and what is there in those places. The dust levels. We gave picks up examples of some of the tractor and power tiller design of mufflers.

Because you might have seen that when a tractor goes there is hardly any intervention made for arresting the noise which is there. In case of a car, we get about 40 to 50 dB only inside the car. Whereas, in case of a tractor we get about 90 85 to 90 dB value.

So, we have made some sort of designs which we explained.

When you talk of industry 5.0 and beyond, all these things will be taken care of and you will have a tractor with only say 75 to 80 dB auditory value which the operator will be able to listen.

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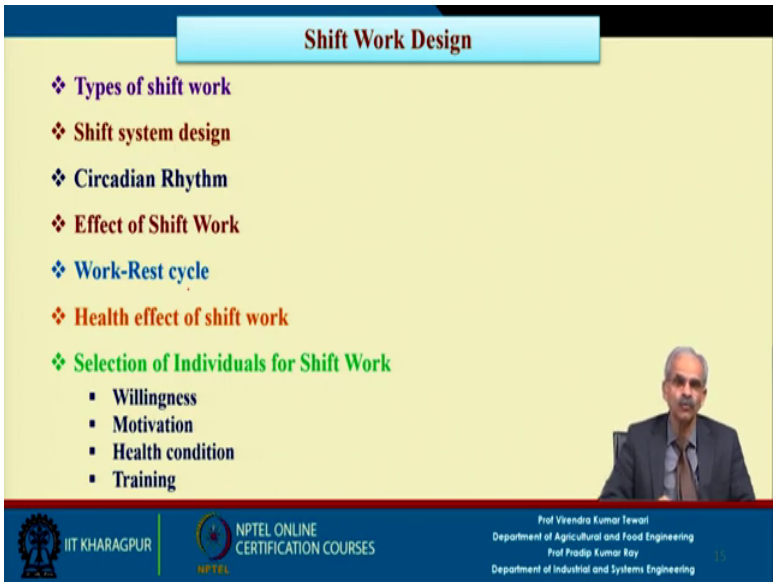

Type of shift work. Why shifts are required?

We know that shifts are required because some of the manufacturing which is going on industry has to go on 24*7 and therefore, it is not possible for one person to be there working for all 24*7, and therefore, we have designed shifts, morning shifts, afternoon shifts, and night shifts.

Sometimes we talk of day shifts, sometime we talk of night shifts depending upon whether it is an office work, it is a manufacturing task or a security work and so on and so forth. In the manufacturing industry, it is also not possible to keep one person in only one shift and hence shifting is essential. Therefore, the shift design has to be there, people have to be motivated to go from one shift to another shift and there should be newness in that.

Instead of the monotony of a particular type of task, the persons brain is fresh and sometimes he can contribute well and he will have a live frame of mind always when he is on the job. We had talked of certain level of selection of these shift work. Our own way of looking at the whole thing may be when you are involved in this; you should look at these parameters and check whether how far we are correct and how far we have made a good assessment of all these things.

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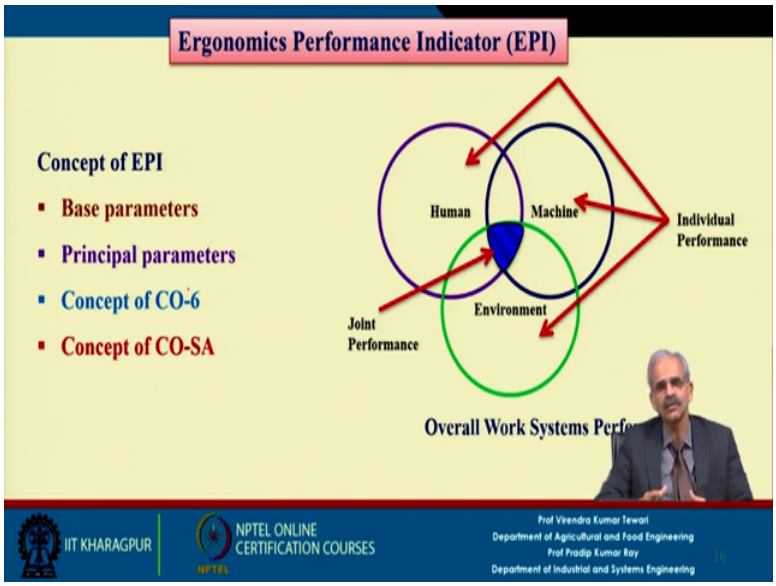

When we were talking of the chemical industries where hazardous situations are there, we found that the interventions between the human machine and environment have to be quantified.

We came out with a factor which is called ergonomic performance indicator which talks of the ergonomic maturity of any system. In my earlier lectures, we have also given the case studies as to how do we quantify the ergonomic performance indicator, how do you say that the ergonomic maturity of a particular place is good, very good or excellent or poor?

Because this arrangement, if it is there, the persons will be able to make some sort of interventions and see that their workshop people are happy and they are contributing maximum. Because the compensations which the industry has to give are minimum and people prefer their industries to work with. So, therefore, we talked of the concept of EPI, where we consider several factors like base parameters, principal parameters. We created a concept of 6. We created a concept of safety awareness.

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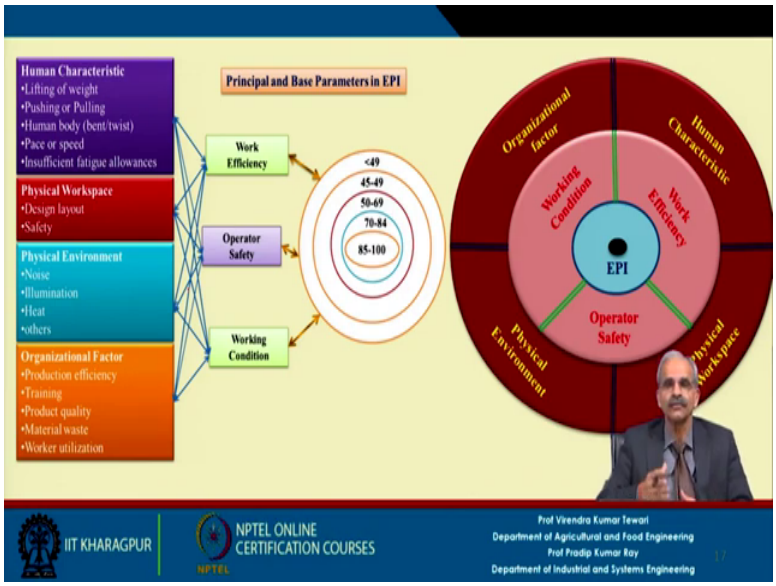

We had given you a model which is in front of you. We always saw that we are targeting the bullseye. We should be targeting the maturity of the system close to 100.

But it is not possible because of certain factors.

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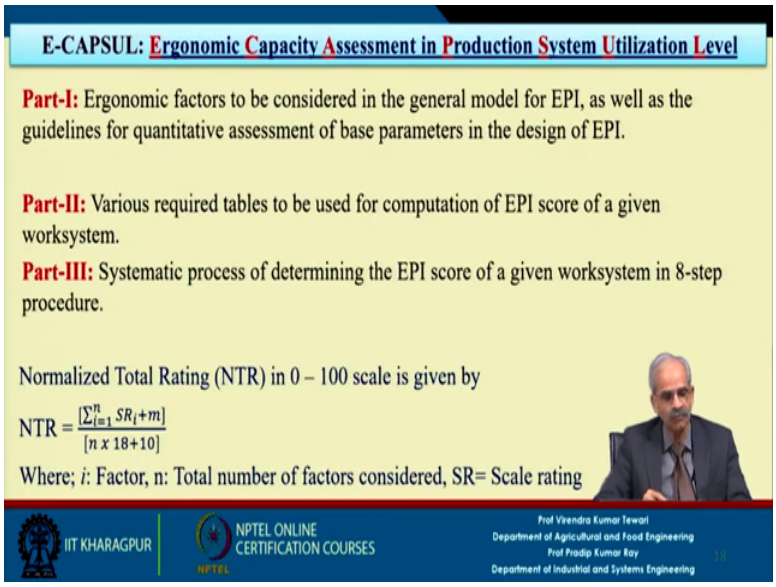

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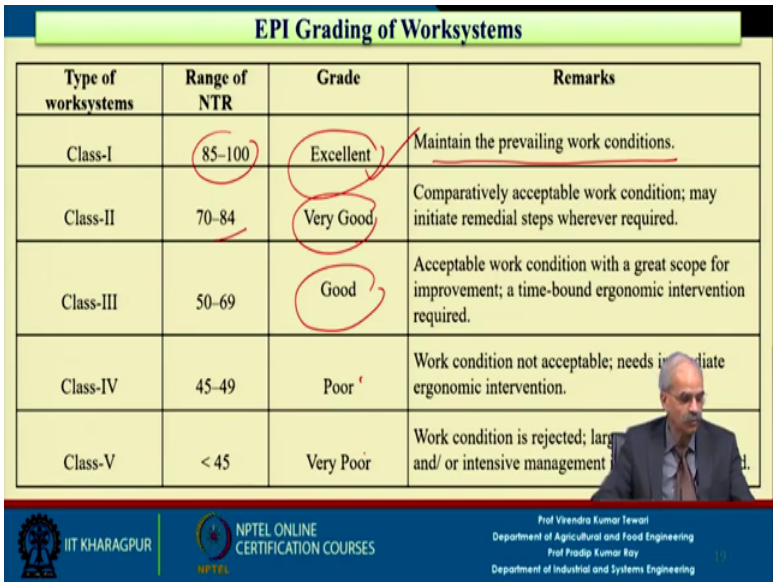

Then we must consider this principle and base parameters and consider the whole thing and come out with the formula where we have designed this NTR and which will talk of whether the system is good or bad. You can see here where the system if the value is this, the system is excellent and there we need to maintain the condition.

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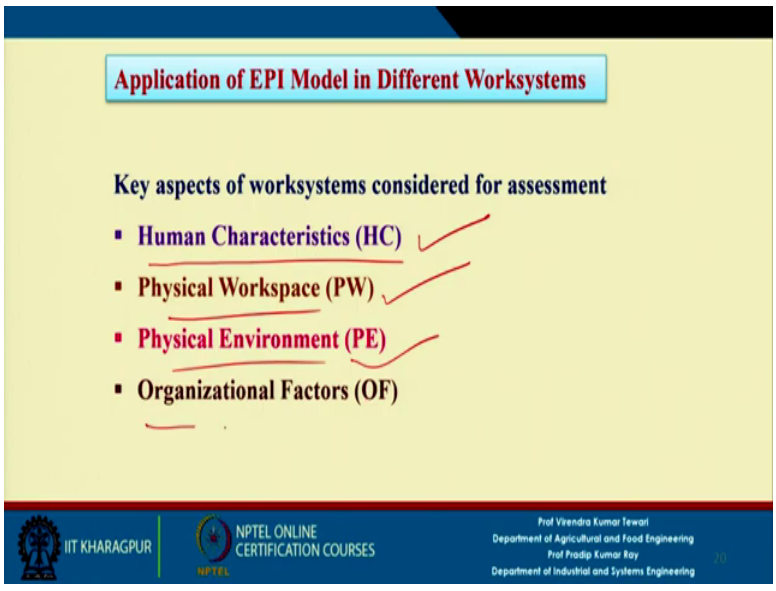

We were talking of the various characteristics of the data collection. While we were discussing the items and the detailing of the task which was there, while we are assigning a particular factor out of the 15 factors that we had designed, we need to quantify that.

We talked of human characteristics (HC), physical workspace (PW) and physical environment (PE) as well as organizational factors (OF).

Once you get the data collection, you will be in a position to connect this to the particular factor. We also said that all the 15 factors will not be applicable to all situations. A few of them will be applicable. We have given you the steps by which you can create the API and find out the NTR normalized total rating and on the basis of that you can say whether the ergonomically matured system is there or not.