Human Factors Engineering

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Ergonomic Design for Manufacturing and Assembly
Lecture - 50
Maintenance in Manufacturing/Production System Important Ergonomic Design Issues: Part-I1; Job Design and Job Satisfaction

Ergonomic design for manufacturing and assembly we have already the taken in four lecture sessions. Now, the fifth lecture session remaining.

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In the 5th lecture session, we are going to discuss the maintenance in manufacturing production systems and related important ergonomic design issues. Already if you remember in the last the lecture sessions, we have highlighted a number of the design issues and the details we have referred to, against each issue, we discussed certain other design i

one important the topic we are going to discuss in the last lecture session plus job design and job satisfaction.

The last important is the design for job satisfaction.

We will be referring to job design relevant for maintenance and servicing work. So, this will be your coverage in the 5th lecture session.

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Design for the fault identification. There are four aspects. The second important aspect is design for the testability followed by the troubleshooting or the actual repair work that you carry out.

For fault identification, a maintenance person has to carry out a number of tests for certain simple design by the looking at the state or the condition of the components.

So, immediately you can decide that if it is feasible physically then, you find that this sort of the damage has occurred and the kind of repair work you can do or repair work cannot be done. But what you find that almost all these components or all the parts of the subsystems are not visible.

So, you have to use some indirect means. What is this indirect means? A number of tests you can carry out and given a particular machine tool, given a particular workstation, the designers may identify all these tests, they are aware of the kinds of failure related the problems you may face and what kind of the test to carry out for fault identification as well as the types of tests to be carried out manually or without test equipment.

Test equipment or the class of equipment you also must know. What are the test equipment you may use for indicating of different types of failures? However, there is no

standard method that may be followed for fault finding in most cases, even if you have knowledge in pneumatics or hydraulics electronics, but when you face the actual situation.

So, you say given a particular machine tool which method I should follow for fault identification? Tests are done at visible testing points in almost all kinds of the machine tools we use these days.

The test points are marked and this will help you in carrying out the tests at open or closed space, at overground or underground and with working postures for short or long duration. If the working posture is good, it will directly affect your productivity, your performance. Suppose the fault identification is your objective. If the working posture is acceptable then in all likelihood that the fault identification will be perfect. But you have to consider whether the person working underground is carrying the maintenance related repair work.

The kinds of actions to be taken are known to them and they are taking actions, they are doing repair. The working postures- there are many cases, it could be short duration or long duration. In a long duration working posture, the person may be lying on the floor, and they are trying to find out that where it has gone wrong.

We are not getting any function from the product. So, the test sequence to be followed is individual dependent and that is why the design should match with individual anthropometry. For certain persons, even if it is a cramp posture for say one hour or half an hour, the person may not feel uncomfortable. But there are persons where their anthropometry is such that they cannot work comfortably a lot of complaints if they work in a cramp posture for more than 15 minutes.

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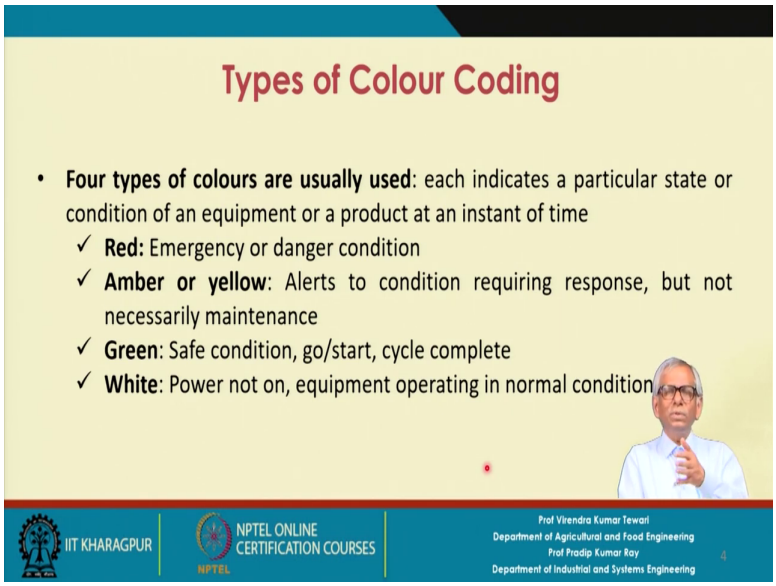

Now, as far as the colour coding is concerned, there four types of colors are usually used. Each indicates a particular state or condition of an equipment or a product at an instant of time. Like say the Japanese system is very popular, they have been using a system called autonomation.

It means that as soon as you start producing a defective item, another system they use that is in on condition. So, in a typical autonomation system, as soon as you start producing the defective output, the machine stops functioning and there will be red signal.

So, immediately you have to check the something has gone wrong, it is a maintenance problem; that means, it has broken down. You have to stop and you have to check. The level of the control you must have. If you allow even the defective product coming out from the system and you are saying that it is in perfect condition, then there is a another aspect we are talking about.

So, maintenance is required, repair is required, resetting are required of different parameters with respect to a product specifications. Then you have to search for reasons or the causes. So, that is basically one kind of fault identification.

Colour coding is used for this purpose. The state of the system we will come to know; first one is the red; that means, emergency or danger condition, it is just producing

defective outputs and the next point in time suppose you allow, then there could be a severe damage and it may break down in such a way or in such a manner that it becomes non repairable and maintenance is not possible.

It is the danger condition, emergency situation; everybody knows red means what. Second one is amber or yellow. It means what? Alerts to condition requiring response, but not necessarily maintenance. Right now it is not an emergency condition dangerous condition, but very soon you may have this danger condition. So, you have to take some corrective measures.

It starts producing defective units. The settings might have changed. So, you have to change the settings once. Otherwise, if you cannot change the setting then it is a problem of the maintenance.

In certain cases, maintenance could be the solution. In certain other cases, resetting could be the solutions. Green color means safe condition, go or start cycle complete; that means, entire work is over and you got the output. White means, power not on, but the operating conditions is normal. As soon as you power is on, the white becomes green.

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Now there are two important aspects, aspect 3 and aspect 4 designed for maintainability. If you remember that is design for accessibility that is the third one and the fourth one is

ease of manipulation. You design this system in such a way that the condition of ease of manipulation is guaranteed.

There are two types of access visual and reach. Certain things you observe with your eye, that is called visual. Whether you can see this red color, green color and all those and you conclude regarding the state of the system, then it is a visual access and suppose you want to carry out the repair work then you must have the reach access also.

Suppose you have to go underground to carry out the repair work for maintenance. Many times, you have to use the lamp fixtures. These are installed inside an equipment for improving visibility. The fault identification becomes easier as well as carrying out maintenance work or the repair work also becomes easy.

Visibility has to be there. How to the design a visual environment? In the underground work, in a closed space, make sure that for the kind of maintenance work, the visual environment is acceptable.

The maintenance work is basically an exacting work exacting job. As you may be knowing that there are two kinds of work you have. The jobs may be classified from a number of perspectives.

From one perspective you say whether the job is exacting type or non-exacting type. When you are carrying out the maintenance work, it is an exacting job. Make sure that the work posture is acceptable; that kind of work posture you have to ensure and the second one is the visibility. Right kind of visibility is to be guaranteed.

Service components should be easily located because already it is known that at periodic interval you go for servicing it and for carrying out the servicing work, you need different types of equipment, different types of mechanical aids, different types of test equipment etc. depending on the type of the system you are dealing with. This service component should be easily located. The design for spatial compatibility should be ensured.

Access ports should be provided. In any workstations or say in any machine tool you observe, in any kinds of manufacturing systems or production systems, the access ports

are given. Accessibility determines significantly completion time or the work time of a maintenance work. Any access port you have, one is the depth and the width.

The work time depends on the depth as well as the width of the access port and this is physical axis or the manual axis. We will discuss the relationships for different sizes of access port. Sufficient clearance for hands should be provided to prevent injuries.

Any work you do, make sure that your body parts should not touch with the equipment in working conditions. So, that condition is to be ensured and that is why certain clearance dimension you should consider.

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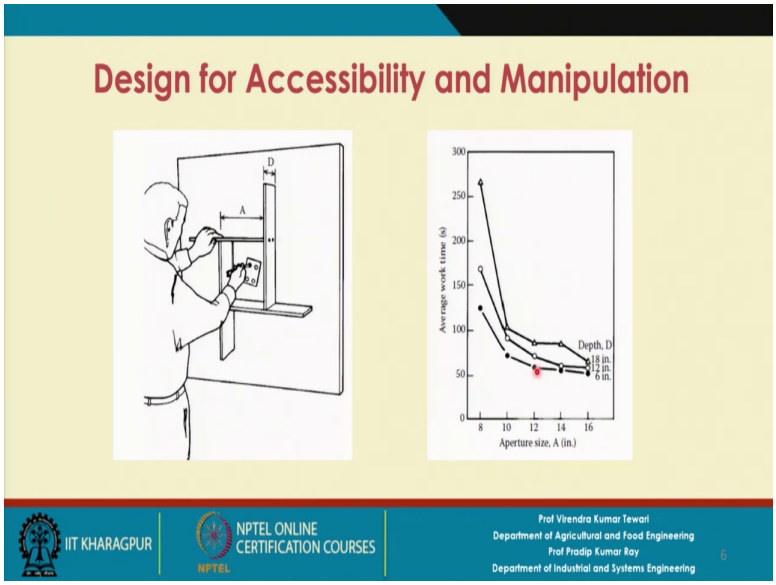

This is just one access- the design for accessibility and manipulation. In the first figure you find that, A is basically access port and you have to carry out certain repair work. So, the person is standing in front of the port and he has to insert his arm or the hand to the access port to repair the kinds of work, whether it is a screwing or unscrewing whatever it is.

He has to use some spanners. There could be different types of the mechanical aids he has to use and then he is doing this repair work. Now, physically he has to get the access, A is basically the width of the access port and the D is the depth. Depth could be large; could be very small.

Now you have to check that, for a specific value of A and for a specific value of D, you have the least work time. Here, one experiment they have conducted. Here, you will find that the A is the aperture size, the width of the port- you call it aperture and y axis representing average work time.

Several sample data you collect and then you will find that as you increase the aperture size whatever may be the depth, the depth could be very high.

The depth is more and the aperture size is also more. You find that the work time is becoming less. But if it is 12 inch and beyond, there is hardly any effect on the work time.

The work time is almost remaining constant whereas, if you consider a depth of 18 inch, you will find that you reach to the maximum level of maximum aperture size and you reached the minimum point that means the minimum work time.

The two factors you consider and for each factor there could be several levels. You carry out the experiment and you try to find out that for which combination you get the minimum work time.

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Now there are certain other issues we should mention like DFM, DHA. Design for Human Assembly and Design for Maintainability are a part of concurrent engineering approach for product development. Design for serviceability is a precondition to set for

many products and equipment for which breakdown and downtime cost is very high like the computer workstation, the vehicle automobile, crane, etc.

There are some many such work systems where servicing is a must. Otherwise if you wait for its failure and then you go for maintenance, the failure could be very expensive, with the loss of life in many cases. The safety will be a big issue.

The design for serviceability is well accepted and operator comfort, convenience and performance are assured; if design for manufacturability and design for maintainability are done simultaneously because we believe in the concept of concurrent engineering.

The manufacturability part or the producibility part we will consider. What are the features in produceability? The system is designed keeping in mind the maintainability aspect.

We are considering a product or an equipment or a workstation or the work system whatever it is- simple or complex, you have to use, you have to check, you have to verify whether the design is certified for maintainability also or not. A natural work posture is recommended for maintenance and servicing works.

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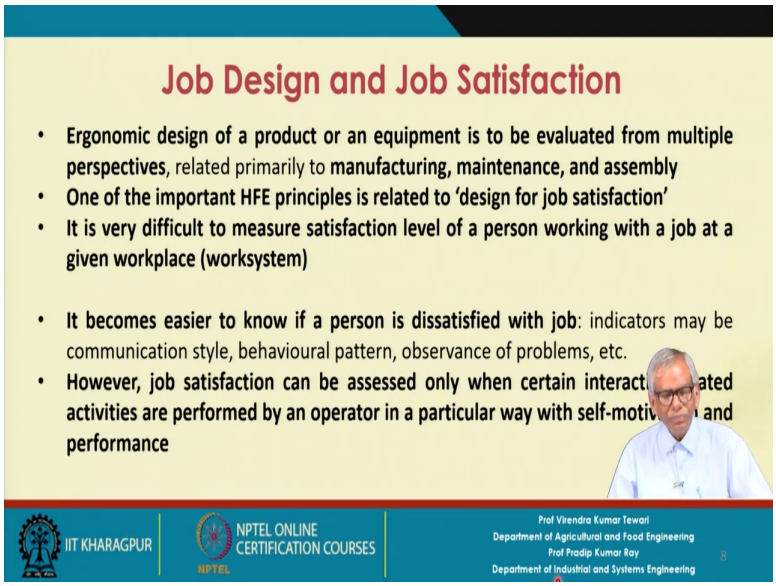

Ergonomic design of a product or an equipment or a workstation is to be evaluated from multiple perspectives related primarily to manufacturing maintenance and assembly. In all aspects, all these the issues, you have to check whether you can go for automation or

not. First these are the necessary condition and the sufficient condition could be design for automation in certain work systems only.

One of the important human factors engineering principles is related to design for job satisfaction along with six others. It is very difficult to measure satisfaction level.

If the person the remains satisfied, he or she will not express because this is a natural expectation from a person.

This is also one of the reasons. Measuring satisfaction level of a person is a very difficult job. It becomes easier to know if a person is dissatisfied with job, indicators may be communication style changes, then behavioural pattern and observance of problem etc.

However, job satisfaction can be assessed only when certain interaction related activities are performed by an operator in a particular way with self motivation and performance. Many a time what happened that a person may be intrinsically motivated, but the performance is not guaranteed. He is highly satisfied, but he becomes slow this is not acceptable in an organized system.

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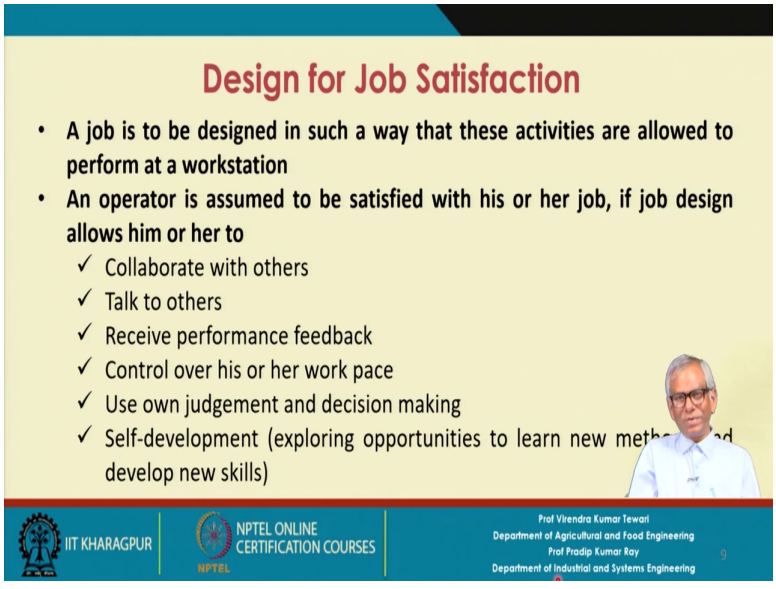

A job is to be designed in such a way that these activities are allowed to perform at a workstation freely and quite comfortably, that sort of environment you have to create. An operator is assumed to be satisfied with his or her job. If job design allows him or her to the following:

You closely observe the interface and do you find that, there is collaboration with others because most of the jobs you though at this point in time you are working individually, but it is a group work. Talk to others freely and frankly, receive performance feedback.

That way you have to create the system to know that whether performance is acceptable or not or what kind of error I am making, what kind of the defectives I create and what are the possible reasons. It is not that the system will blame you; but always there could be some error.

The two varies- human cannot avoid. That is why the receiving performance feedback is a very important issue. So, he or she feels satisfied. Control over his or her own pace like whether if it is a labour intensive, normally the work space is at your hands, you can have work space, the rate of work.

You can run the system very fast; you change the rpm; the spindle speed is changed and the work rate is changed. But, if it is a capital-intensive plant, the work rate you have to adopt where the system is prescribing. Use own judgment and decision making, whether you are allowed to use your own judgment and self-development.

Exploring opportunities to learn new methods and develop new skills like when we refer to the law of practice or learning curve, you yourself are trying to assess your method and you have many ideas inside and the system is allowing you to use those ideas.

Ultimately, you are changing learning curve, you are proceeding with your learning curve. So, the learning rate is very high. If you are job satisfied you will find, given a particular task, the learning rate is very high.

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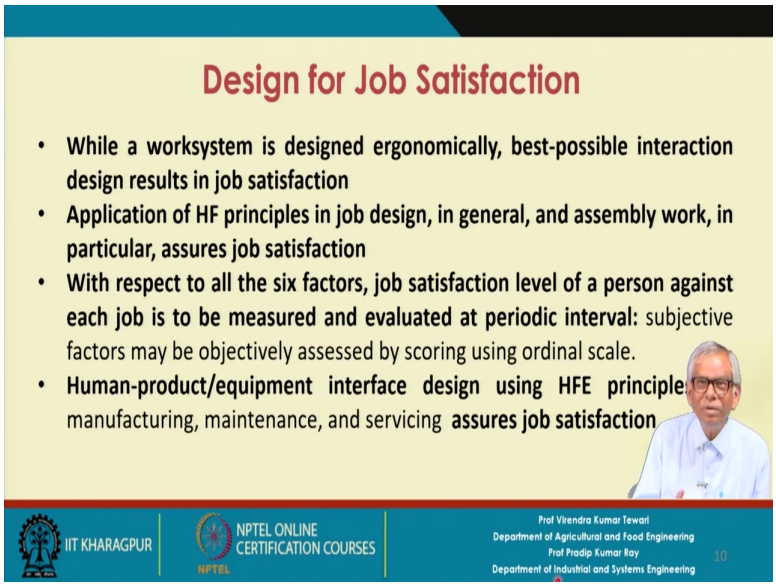

While a work system is designed ergonomically, best possible interaction design results in job satisfaction. Application of HF principles in job design in general and assembly work in particular assume job satisfaction. Why we have identified assembly work? Because the assembly work involves manual work and wherever there is a manual work or human labour, you will find there is a lot of scope for applying human factors related concepts or ergonomic concepts.

With respect to all the six factors, job satisfaction level of level of a person against each job is to be measured. You can build up a framework and you have to evaluate, at periodic interval, subjective factors may be objectively accessed using ordinal scale.

Human product or equipment interface design using HFE principles for manufacturing, maintenance or servicing assures job satisfaction.

All these are interrelated and the main the approach is concurrent engineering for product development.

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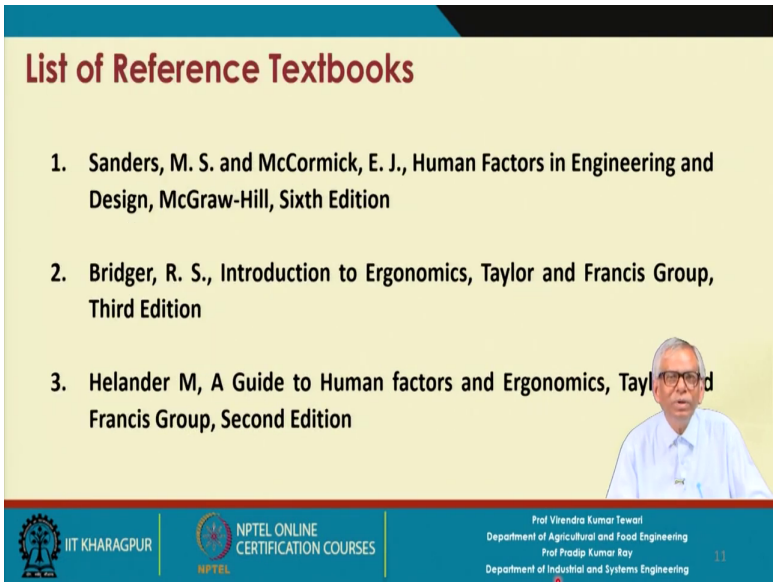

So, in week 10 we have discussed in detail a very important issues related to say ergonomic design of work system.