Work System Design

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Lecture – 60
Case Study: Assembly Line

Namaskar friends, welcome to the last session of our course on work system design and today we are going to finish the course, we are going to conclude the course with a case study about the assembly line, as you are well aware during the last week, we are trying to cover the various application part of the concepts that we have studied and more focus is on the ergonomic design of the workplace.

And if you can refer back to the previous sessions that we have already covered, you will see that we have taken examples which are relevant to each one of us, we have taken an example of a chair or an ergonomic design of a chair, each one of us use the chair, then we have taken car seat, we have taken an example from industry that is the tower crane cabin, we have taken an example of a computer system and a man or a computer workplace or a software based industry where a person is working on a computer system.

Today, our target is to study about the assembly line, so overall if we summarise what we have covered in this course we have covered 3 important aspects; the first one is the productivity, the second one is the method study and third one is the work measurement and the last part that we are focusing which is more general in nature, more wide in its application that is the concept of ergonomics.

In method study, we focus on a specific area, in work measurement also use simple mathematics to do the calculations and find out that how much time will be required by experienced skilful worker to perform a specific task, so in case of work measurement, in case of method study our approach is very, very focused, in case of ergonomics, we take the complete system as a whole and try to improvise it, try to improve the comfort of the worker who is performing the task.

And in that context, we will see today that how we can try to improve or what are the factors that we can take into account, when we try to improve the assembly line or the man machine interaction during the assembly line operations. So, let us see now how the workers perform their task in the assembly line.

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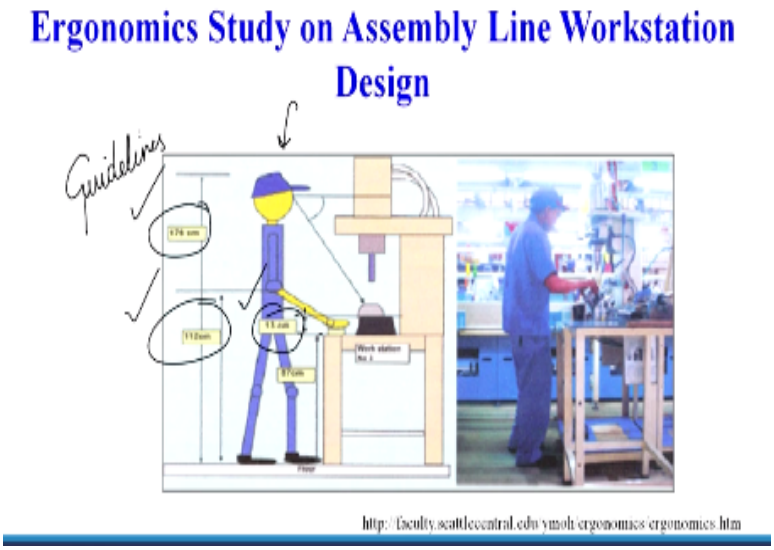

So, this is a very common scenario in an assembly line, we can see a worker is performing a task and there may be a conveyor belt on which the material is moving and this is one schematic diagram which is been shown, so we will try to see the exact dimensions also, we can try to see here also, this is written 176 cm, it is written 112 cm, so this height from elbow to the workplace is also mention.

So, basically we can design the system in such a way that the person who is performing the task feels comfortable and is productive at the same instance also, his comfort may not lead to loss of productivity, so we have to maintain or ensure that there is a balance between the worker who is performing the task, balance between his productivity and as well as the comfort, the safety and other aspects related to fatigue and his tiredness.

So, we can see that when we design our system in a most logical manner with the anthropometric data with the ergonomic principles, our system will be such that we will feel quite satisfied that we are providing a very good working environment, safe environment or comfortable

environment for our worker and for that we need to take into account all these guidelines, we cannot ignore these guidelines, when we are designing a system for our worker.

Similarly, this is the actual worker who is performing the task, so when we follow these guidelines our system will be perfect or I can say near perfect, so we will try to see that what are the various steps which we must follow or what are the various factors that we must take into account, when we are designing the workplace for a system or for a sorry, the work system for a worker, who is performing the assembly line operations.

So, what you can see in both the cases, the worker is standing, so it can be very safely concluded that in case of assembly line, most of the time the worker will be in the standing position only, so according to that we have to see that what must be the height of this table, what must be the distance between the body as well as the place where the person is doing the task, what can be this angle, which is clearly depicted in this case also.

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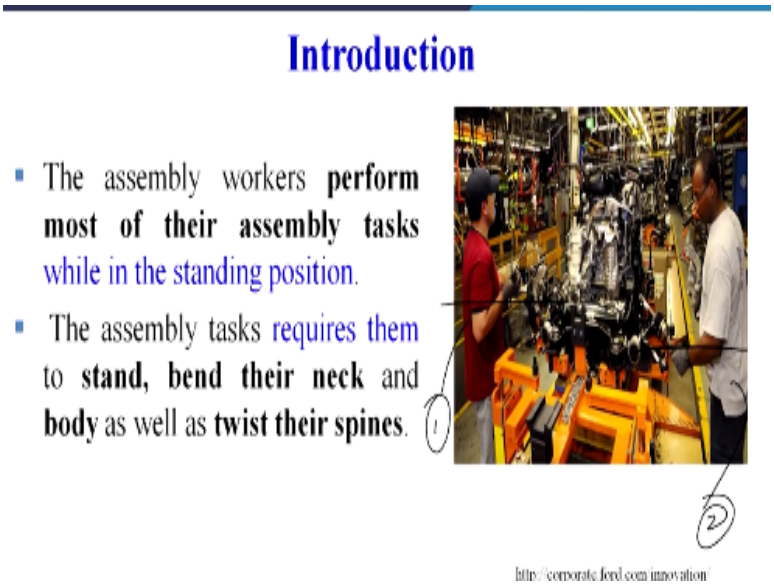

So, all these parameters we will try to see in today's session, this is another complicated assembly operation, 2 workers are performing; the worker number 1 and here we can see worker number 2, so on the equipment or the machine which is getting assembled, 2 workers are simultaneously performing the task and you can see the table or the height at which the work is being done in his case also.

So, we can see that there has to be standard guidelines where the work must be placed when the person is performing the task, in my case also suppose this table is at a slightly higher position, it is at this height, I may not feel comfortable speaking, standing on that dice and if it is too low, I may have to bend to change the slides, which is also not a comfortable posture for a speaker, so now I feel it is at a comfortable height for a person of my height.

So, this is a; you can say relative adjustment, a person who is much taller than me may feel it slightly at a lower height or a person who is shorter than me may feel it slightly add up higher height, so this can be as an ergonomic design we can design it in an adjustable manner, so that a person can adjust the table as per his or her height, so therefore there are standard guidelines and here, what I believe most of the faculty members who come to record the session, feel this table as an adequate or this dice as an adequate height.

And they feel comfortable while recording the sessions, so we can say that the design must be such that the worker feels comfortable in performing the task, as well as he is productive, efficient, effective in the discharging of his duties. So, let us see now what is the text; the assembly workers perform most of their assembly task while in the standing position, which I have already told.

Previous slide also we have seen the workers were standing, here also he is standing and the other worker is also standing, the assembly tasks require them to stand, sometimes they have to bend their neck or sometimes you may have to bend your neck or you may have the bend sideways also as well as their body, sometimes they have twist their spines also, sometimes they need to pick something from behind, so they need to twist the spine.

Or sometime you have to pick something from the bottom again, you have to twist your spine, so you can see now there are few guidelines which are coming here that a person who is performing the work on the assembly line, he will be in the standing position most of the time, he may have to bend sideways, he may have to twist his spine, he may have to bend his neck, so basically the

spine, the neck, the legs all are may be an important body parts, which need to be taken care of when the person is performing the assembly operation.

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Now, manufactures can create a more ergonomic and productive assembly line, so we can see ergonomic and productive, so it cannot be only ergonomic or we say that the person is very, very comfortable while performing the task but he is not producing the things as per mandated to him as per told to him as per assigned to him based on the calculations that we have done, we have already studied.

Work measurement study or work measurement will help us to find out how much time must be assigned to a worker for performing a specific task and how many jobs must be assigned to him during the day, so all that has been already discussed in this course, so in work measurement we can easily find out how much work has to be assigned to a worker or work in terms of number of jobs has to be assigned to a worker, all that we know.

So, that must also be achieved, it is not only that we are making the work comfortable or the work environment comfortable for the worker, we also need to ensure the output that has to be delivered is also ensure, so the manufacturers can create such an environment in which the worker feels both, he feels both comfortable also, safe also, at the same time he is able to

produce as per requirement or his productivity is good, his efficiency is better, his effectiveness is the best.

So, if he is able to do that then, we will say, yes the environment that we are providing or the assembly line that we have design is designed in the best possible manner, now how we can design an assembly line, so we can design the assembly line by taking 4 simple steps.

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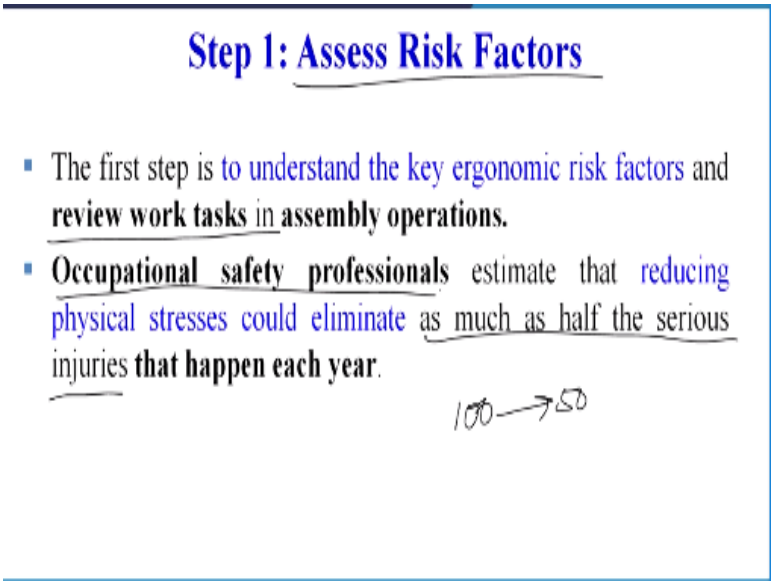

So, step number 1 is assess the risk factors, so first we need to find out that what are the most important risk factors, the first step is to understand the key ergonomic risk factors and review work tasks and assembly operation. So, if you remember in the method study, we have already seen that we go to the Micro motion level also and try to understand and divide the work that our operator or a worker is doing into therbligs and try to see the motion of his body parts.

And how he is reaching to a particular component, how he is taking the component, how he is grasping the component, what is the travel empty, what is the travel loaded, so we can do the micro analysis or we can see the micro motion analysis and see that how the operator is performing the task, so we can find out very easily that where the risk factors are, what are the most repetitive type of work elements being done by the operator.

So, the first step is to understand the key ergonomic risk factors and to review the work task whatever the worker is performing in the assembly operations, so occupational safety professionals estimate that reducing physical stresses could eliminate as much as half the serious injuries that happen each year, so you can see half the serious injuries, so if suppose we have 100 injuries in a year can easily be reduced to 50.

But how; how these can be reduced? Occupational safety professionals can help or estimate that reducing the physical stresses could eliminate, so we need to reduce the physical stresses that are happening or that are occurring when the operator is performing the task, so basically in this slide, we understand that we have to assess the risk factors, we have to see that what are the repetitive type of work being done by the operator.

What are the body parts that are involved in that repetitive type of work? whether the load the person is lifting is beyond the natural limit or beyond the natural load that must be lifted by able bodied workers, so we can try to assess that these are the problem areas where workers can be at risk and we can try, we can easily try to help the worker with certain assistive devices. For example, suppose a worker is lifting a very heavy load, may be 30 times in a 3-hour shift.

So, when we see that this heavy load is being lifted frequently by the worker, his backbone may be under a lot of physical stress, how we can avoid that, so as a, engineer, as an industrial engineer, as a mechanical engineer, I will try to find out that what can be the assistive device which once designed can easily help the worker and reduce the physical load that is coming on his body.

And the; I believe that the cost of designing and developing that equipment will easily be offset when we will use it in a long run or the life cycle cost of the equipment will be much, much, much, much less as compared to the comfort that we are offering or providing to our workers, so therefore the occupational safety professionals can do the analysis, can do the assessment of the risk factors and try to indicate that these are the areas, where the improvement is needed.

So, first thing is the identification and assessing or assessment of the risk factors, next is the; we have to control these risk factors, how we can control? One example before coming to this slide already, I have shared with you that once we assess that a person is a lifting lot of load, we can try to invent, we can try to innovate, we can try to create a new device which can help him to lift that load, so that is kind of a control which we are going to see in this slide.

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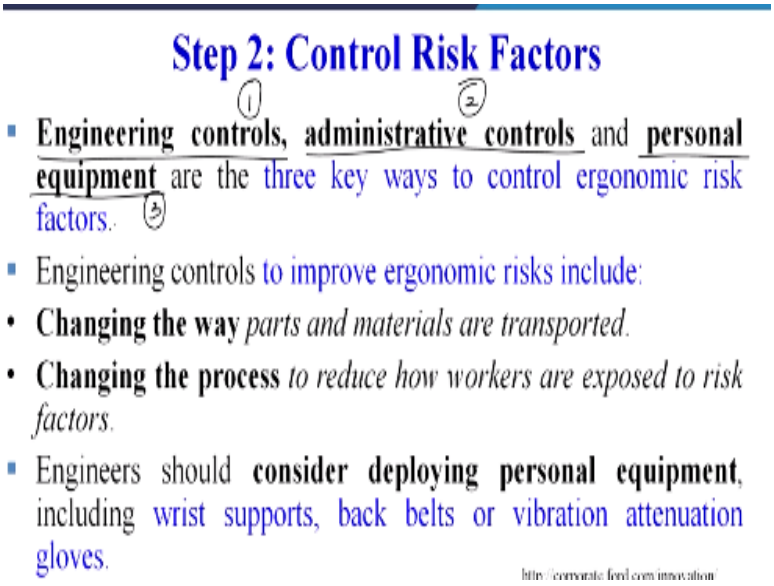

So, the engineering controls, administrative controls and personal equipment are the 3 key ways to control the ergonomic risk factors. So, in step 1, we have assessed, we have identified the risk factors, so here we will try to control. Now, what are the 3 types of controls which is clearly given on your screen. First one is the engineering control, the second one is the administrative control, third one is the personal protection equipment or a personal equipment.

Now, let us see one by one, engineering controls to improve ergonomic risks include, now, what are the engineering controls which can help us to improve the ergonomic risk or we can say reduce the ergonomic risks, instead of we can say, improving may not be the right word, so engineering controls to reduce the ergonomic risks include changing the way parts and materials are transported.

So, we can change the way in which the material or the parts or equipment or the finished product or the raw material is getting transported inside the shop floor or inside the factory, so

we can change the way, then changing the process to reduce how workers are exposed to the risk factors. Now, example that I have given to you is changing the process only, initially the process of lifting the load was manual.

So, with the help of the assistive device we have changed the process of lifting the load by the worker, now the engineers must consider deploying personal equipment including wrist supports, simple being a sportsman usually I give examples from sports only, so whenever a person is doing weightlifting, you will see your whenever he or she goes to lift a weight, there we will see certain protective equipment on the wrist, they will always be wearing a belt.

So that kind of belts again, back belts are given, wrist supports, vibration attenuation gloves and sometimes the gloves must also be used when you are doing the welding operation, when you are visiting a particular company you must wear a helmet, so all these are protection equipment which will mitigate the effect of the risks, so all these have to be taken into account and these are general guidelines, not very, very specific we can say to the shop floor or the line type of layout or the assembly line.

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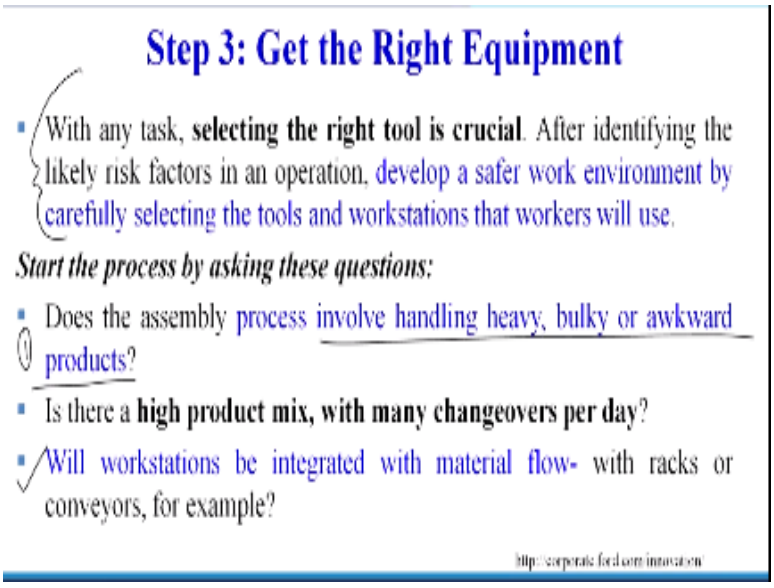

So, in any industry we must follow these type of guidelines, now get the right equipment that is the third thing, how to identify? With any task selecting the right tool is very, very crucial, after identifying the likely risk factors in an operation, develop a safer work environment by carefully

selecting the tools and workstations that the workers will use and this is again relevant to what we have already studied.

If you remember the computer system in which we have seen a person is operating the computer how this interaction has to be controlled and how this interaction has to be designed in that case also we have seen that we must select our equipment or the computer system in such a way that it is comfortable for us to perform work on that computer or that system for long or maybe for longer duration of time.

So, you start the process by asking these questions, so this is related to selection of equipment carefully selecting the tools and workstations that the workers are going to use, now start the process by asking these questions; does the assembly process involve heavy bulky or awkward products? Now, this is specifically related to assembly, when you are selecting the equipment to be used by your workers who are performing the assembly operations, first question that we must ask is that whether the process involves handling heavy bulky or awkward products, so that is first question, question number 1.

Second question is; is there a high product mix with many changeovers per day? So, sometimes it may happen that the same product is being produced on the assembly line, so the operator become habitually become skilful also in performing his tasks but suppose, every other day or every other hour, there is a change in the product which has to be handled by the operator definitely, he is at more risk as compared to a single product assembly lines.

So that also has to be assessed when the equipment has to be selected which is to be used by the operator, then will the workstations be integrated with the material flow with racks or conveyors for example, so sometimes it may so happen, we will see one diagrams in the subsequent slides where a worker is working on a particular machine and then there is an adjacent conveyer belt which is carrying the finished product to the next station.

So that must also be taken into account that whether the work person who is performing the task is; workstation is integrated with a material management system or a material handling system

also, so that also will dictate that what type of equipment must be selected, so these factors will help us to identify to select the equipment, which will make the work environment safe for the worker.

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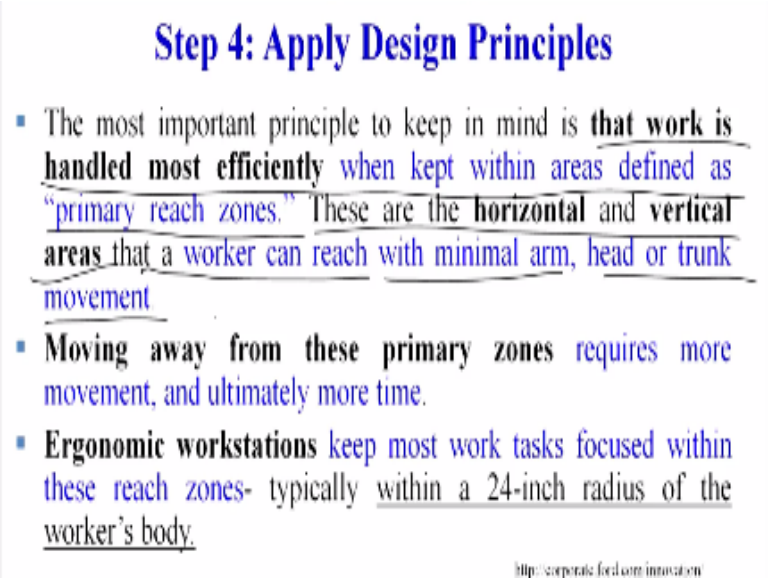

The last step is; we must apply the design principles, now what are the design principles? The most important principle is to keep in mind that work is handled most efficiently when kept within areas defined as the primary reach zones Now, we have seen that there is a primary working area there is a minimum; sorry, major working area, minor working area, so here the primary reach zones, what are these zones?

These are the horizontal and vertical areas that a worker can reach with minimal arm head or trunk movement, so maybe if I am standing here, the primary reach zones can be I can easily lift this span, I can easily lift this pointer, so this is a primary work area for me, so again I will read it for you. The most important principle is to keep in mind is that the work is handled most efficiently when kept within the areas defined as the primary reach zones, what are the primary reach zones?

These are the horizontal and vertical, for me I am talking of the vertical primary reach zone only, there can be a horizontal which can be, which must be at my shoulder height only, if I have to reach again and again above the shoulder height, it can also lead to physical stresses in the

shoulders and the neck, so that is also problematic, so the horizontal and working areas that a worker can reach with minimal arm head trunk movement.

So, minimum movement of arm head or trunk, so these are the 3 body parts which we must use when we are working but their movement must be natural movement, it must not be; it must not be a movement which we have to do beyond our physical limits, so moving away from these primary zones require more movement and ultimately more time. So, therefore the first point is a recommendation, second point is again being a deterrent that if we place the things away from the primary zones, it will require more movement.

And ultimately more time, to add to that I can say it will add to physical stresses also, so ergonomic workstations keep most work task focused within these reach zones only, so the primary reach zone is the range that is given here, within a 24-inch radius of the workers body, so if I am standing here, within 24 inch radius of the body, the things must be placed that may be the primary work zone or the primary reach zone.

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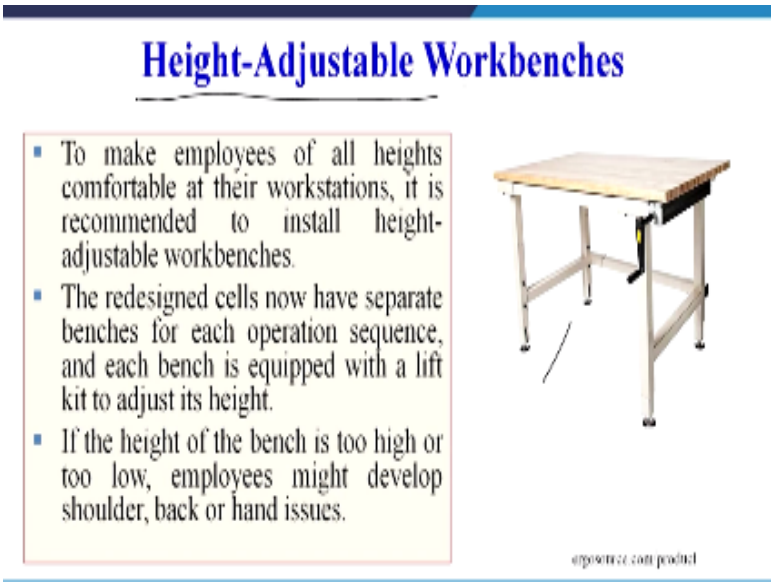

So, let us see now about when a worker is working on the assembly line, what are the various types of components that needs to be used by the operator, so first thing as I have already highlighted is the workbenches, so this is one workbench, so let us quickly read as I have already highlighted a height adjustable workbenches. So, I think I will read the points for you; to make

employees of all heights comfortable at their workstations, it is recommended to install height adjustable work benches.

The redesigned cells now have separate benches for each operation sequence and each bench is equipped with a lift kit to adjust its height, if the height of the bench is too high or too low, employees might develop shoulder, back or hand issues or problems, so again this example I have taken, this is also a dice that we are using, the height must be adjustable as per the height of the speaker.

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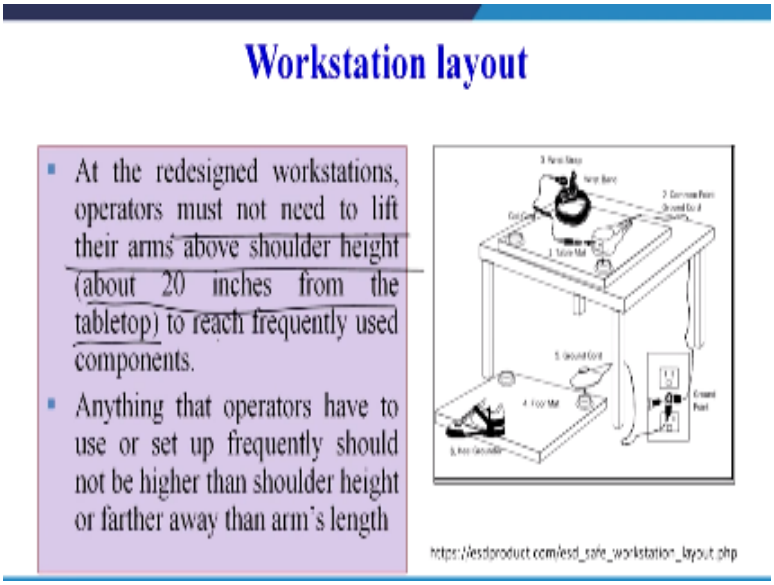

Similarly, the table which is being used in the assembly line, the height must be adjustable as per the comfort or as per the liking of the operator. Workstation layout; now this is we can see, so many different equipment the worker has to use, when he is doing some assembly operation, so as the redesigned workstations, operators must not need to lift their arms above the shoulder height, must not need to lift their arms above the shoulder height.

So that is approximately about 20 inches from the table top, now they must not raise their arms beyond the shoulder height or need to lift their arms beyond the shoulder height to reach frequently used components, so once in a while maybe I may have to lift something above my shoulder height but if I am doing some assembly operation frequently I have to work in the vertical space, the things must be in my primary reach zone only that is in vertical space also

So that while sitting or standing, if I am doing my work I must be able to get the things easily or I must not have to reach or move my body to reach to that particular point, so anything that operators have to use or set up frequently should be higher than the shoulder height or farther away from the arm's length, so anything that the operators have to use or set up frequently should not be.

So, whatever is to be used frequently is the keyword here, should not be higher than the shoulder height which is same as the top point or the first one or farther away from the arms lengths, so it must not be too far away from the arm's length. For example, I can easily lift something from here but if it is beyond that I will have to move my whole body to get that thing and that is not advisable from the ergonomic point of you.

So, if I have to frequently do this movement of the body may be 500 times in a day, it is not advisable or maybe it is going to have an ill effect on my body, so that is as a designer we must take into account all these points.

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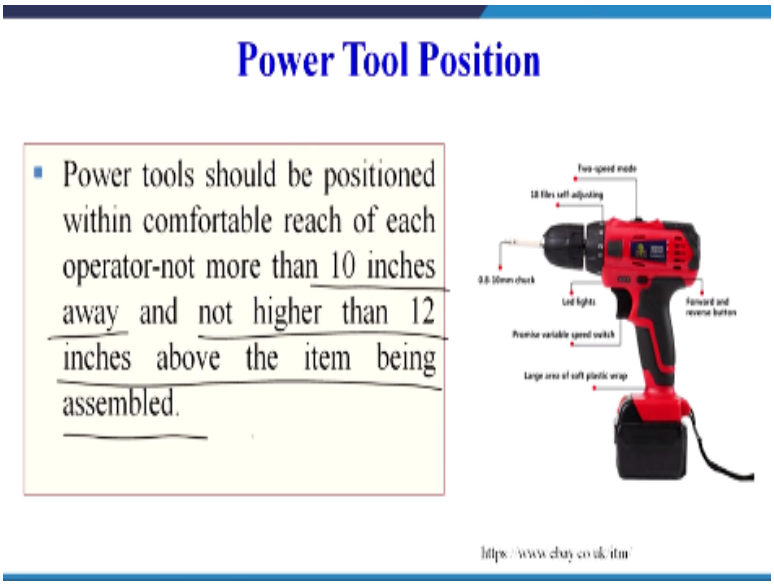

Then, power tool positions, so this is a power tool just a standard tool given, power tools must be positioned within comfortable reach of each operator not more than 10 inches away, so 10 inches away and not higher than 12 inches above the item being assembled, so if we are assembling

something and this power tool has to be used, so it must not be a too, too far away from the item being assembled, it must not be higher than 12 inches.

So, suppose, here I am assembling something or as per my height if I am assembling something here, so think this power tool must not be at a very, very large height or maybe it must be 12 inches approximately, this much height only, so that I can lift it and bring it down and use it, so it must not be 10 inches away and 12 inches higher, so this is the working range for the use of the power tools.

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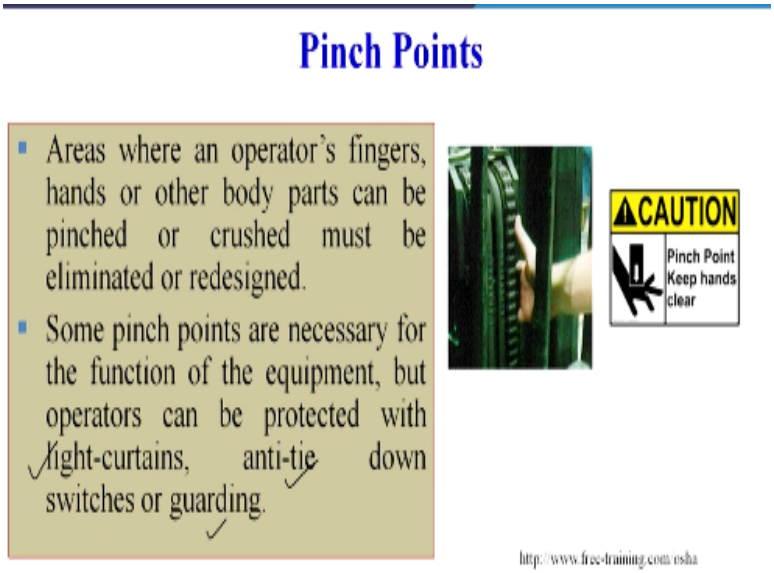

So, pinch points are very, very common in industrial scenario, so we must avoid the pinch points through guarding or through whatever mechanisms or equipment that we can use, so areas where an operator's fingers, hands or other body parts can be pinched or crushed must be eliminated or redesigned, some pinch points are necessary for the function of the equipment but operators can be protected with light curtains, anti-tie down switches or guarding.

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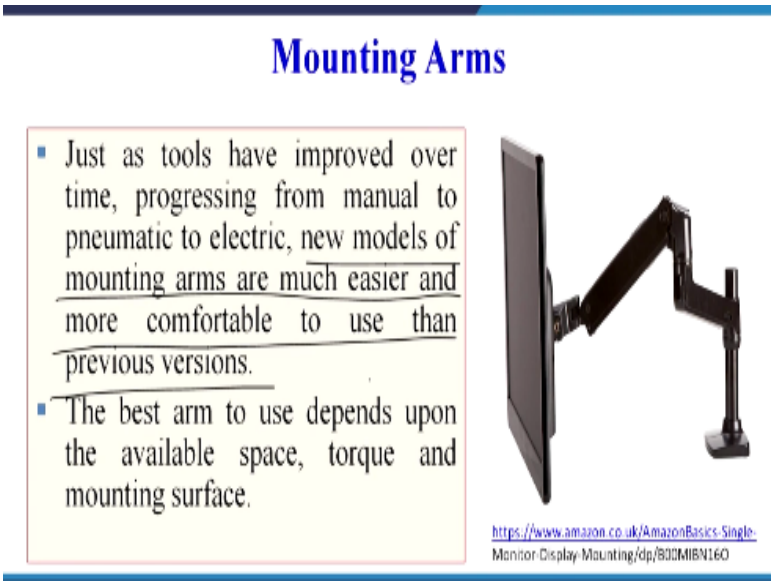

So, we must design the equipment in such a way that this pinch points are taken care of, then the mounting arms; the worker may have to look at the display when he is performing the assembly operation, so just as tools have improved over the time progressing from manual to pneumatic to electrical, new models of mounting arms are much easier and more comfortable to use than the previous version.

Sometimes, it will be mounted at a height again and again we have to bend our neck to look at that; look at that particular display or the arm, so what we can do; we can bring it forward, it can be flexible, we can adjust it just adjacent to the machine and just we can look it without having to bend our back sorry, neck again and again, so that neck rotation can easily be avoided, so the best arm to use depends upon the available space, torque and mounting surface.

Now, depending upon the work's space; workspace available with you in X, Y, and Z domain whatever is the space available according to that you can design your mounting arms, so that the workers need not bend the neck again and again, turned the neck again and again or bend his body, posture again and again, so that bending, twisting can easily be avoided if we have a flexible mounting arms for the displays.

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Anti-Fatigue Mats

- The redesigned cells also feature anti-fatigue mats.
- Many plants have concrete floors, so the mats provide cushioning to relieve the pressure on lower-body joints.

https://www.uline.com/Grp_36/Anti-Fatigue-Mats

Then, anti-fatigue mats can be used, the redesigned cells also feature anti fatigue mats; many plants have concrete floors, so the mats provide cushioning to relieve the pressure on the lower body joints, so this is very, very common these days, so with this we conclude the today's session and I think, we have tried to see that when the worker is performing his task on the assembly line, what are the things that we can design or we can take into account to help him in performing his task in the best possible manner.

So, with this we conclude our last session, I think I believe sincerely that we have tried to put all possible efforts in collecting different types of literature, different types of figures we have tried to collect different types of case studies and try to include them, try to incorporate them in our discussion, so that the things become more practical, more understandable, more comprehensible for the learners.

So, with this I wish all the learners who have registered for the course, all the best for the examination, may all of you pass with flying colours and we wish that in future also, we will keep on developing similar courses which will be relevant for the industry and will be beneficial for the learners in terms of enhancing their skills as well as their employability, wishing you all the best and thanks for joining the course on work system design. Thank you very much.