# Human Factors Engineering

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## Lecture - 29
## Hand tool design: Fitting the task, user and hand, Usage of hand tools and types of injuries and their prevention

Dear students and participants in the course of Human Factors Engineering we have been learning about the various aspects of human factors engineering when it comes to man machine interaction. Now, today's lecture will be on work posture for task and hand tool design.

Particularly because we know that various types of tools and devices as operated by hand and also sometimes by leg. And therefore, it is very essential to understand the biology of the hands at the same time or the biomechanics of the hand and the details of the interaction with the tool or the device.

And if this is taken care of properly in the design itself, then we will be able to maximize the output of the hand and the tool interaction or the hand and the device interaction. And the whole system will give us more output that is the aim of human factors engineering that while keeping the operator in good health and in better condition, get the maximum out of the system.

So, in this we will follow the details of Hand Tool Design, we will try to fit the task to the person, user and hand, usage of hand tools and types of injuries and their preventions. I think it is very essential to understand what sort of diseases will come across once these tools are not properly handled.

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Well to start with some of the hand tools we have given different types of examples which starts from agriculture engineering, which many of you know that these are the two devices which are used khurpi and sickle.

In fact, these are the two devices which are which are used for which are used for either cleaning of the grasses or sometimes even harvesting, sickle is used for even harvesting of some of the crops as well. And the different industrial tools you can see here that we have the wrenches, the pliers, the hammers as well as slide wrench and all that these are industrial tools which are very much used.

Now, these are all operated by hand and therefore, it is essential to see how hand is used in its operation, what principles must be used in these operations, until unless we follow a certain guideline or principle because these tools are not meant for a single person, they are meant for large population. And therefore, there has to be proper design keeping in view the biomechanics of the hand and the comfort of the hand being used for the operation of that device.

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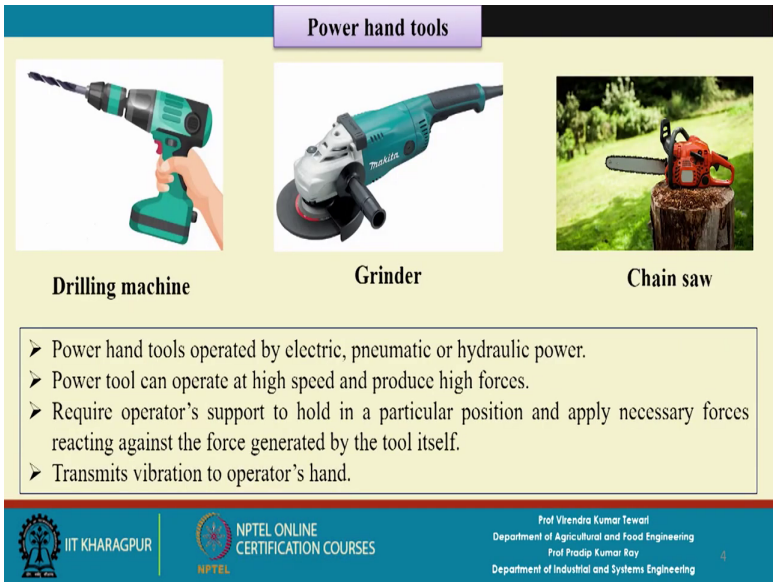


Well, there are of the power hand tools where the power is given by the electric power, electrical energy as well as grinder and chains saw. You are giving the energy for operation of these separately, but then you are holding the hand, holding the tool in your hand and see the posture in which you have to hand these tools.

Generally power hand tools are operated by electric pneumatic or hydraulic power tool depending upon the condition that he has. It requires support to hold in a particular position and apply necessary forces reacting against the force, reacting against the force generated by the local by the tool itself.

Yes, there will be certain forces, certain vibrations coming out while we are operating these tools. Therefore, you must be having the correct way of holding these tools while you are utilizing these tools in the operation.

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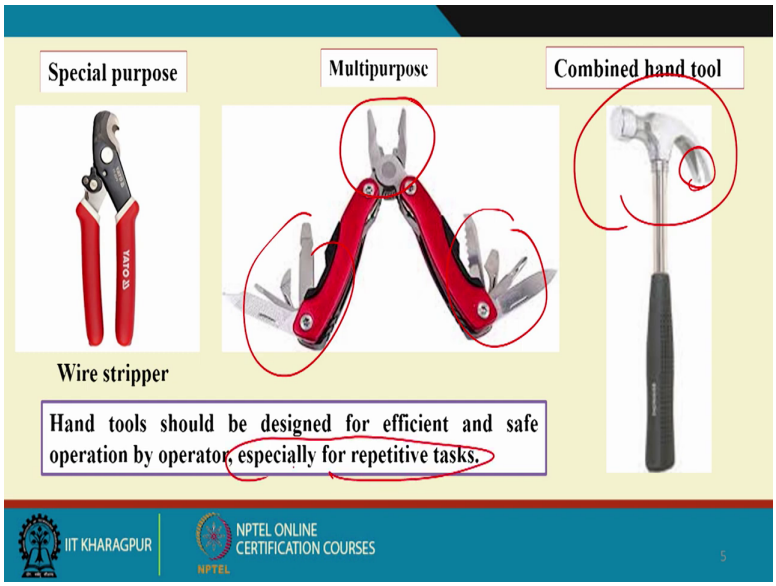


There are some other special and multi-purpose tools. It is definitely true that the hand tool should be designed for efficient and safe operation, the aim of this exercise or discussion today is only to see how best the different tools and devices are used efficiently, while keeping in view the correct biomechanical posture of the hand in operation.

Sometimes you can have special purpose tools as it is shown in wire stripper, multi-purpose tool where several of the items are there, you can have a look at these details and visualize that how many different types of tasks could be done. There could be combined hand tool where it can work as a hammer as well as this can be utilized for removing the nails etcetera from the boxes.

So, the idea is that when we are using, they our hand our hand for different operations and specially for repetitive task, repetitive tasks because the muscles of the hand are going to be under the similar stress for a long duration of time when you use, when you do this task repeatedly holding that instrument or the power tool for a long duration of time. And therefore, it is essential that the biomechanics of the hand has to be taken care of.

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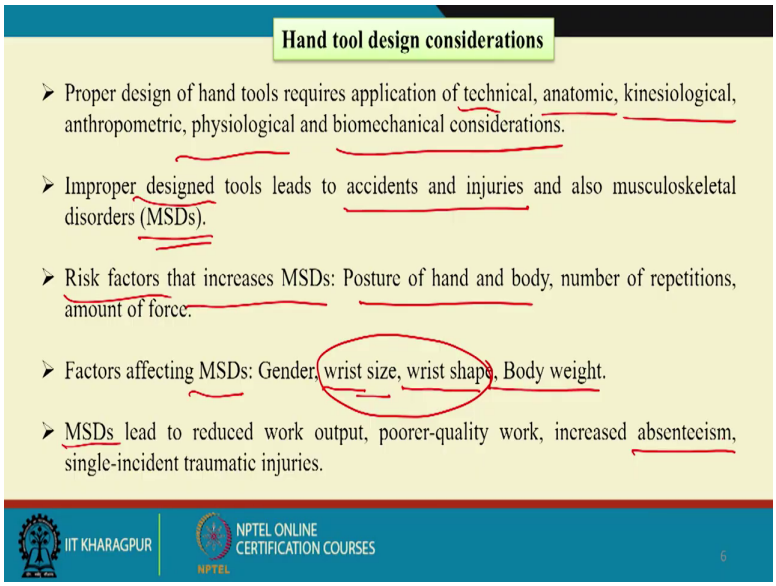


Well, hand tool design, what so therefore, what sort of consideration should be there? A proper hand tool design requires application of technical anatomic and kinesiological anthropometric or physiological and biomechanical considerations which I told earlier.

It is essential, because until unless you consider these technical and the biomechanics of the hand or the construction of the hand in such a way that it takes care of the physiology of the hand and the various dimensions of the hand and its other locations.

Improper design tool, what will happen if you do not have these considerations, then improper design will definitely lead to accidents and injuries and also to musculoskeletal disorder. Because various bones are in consideration, various muscles are in consideration while operation of these tools.

The risk factor that increases MSD posture of hand and body true, because if the posture of the hand and body is not correct then definitely there will be higher risk of musculoskeletal disorder. And of course, you know that once the risk of MSDs is higher, they will lead to lot of absenteeism more of sickness and then maybe a longer duration of stay in hospital and things like that.

And what are the things which affect these MSDs? Well, of course, from the gender right, because depending upon the male and female it could be a one which is you can use a stronger strength. May be female could not be utilized or could not have so much

of strength at the same age, but what is more important is this part, the wrist, wrist size, wrist shape and body weight. So, these two are more important along with body weight.

The wrist size and the shape wrist shape and what are the muscles which are coming into consideration, see this MSDs as I said it will definitely lead to reduced work output, because when you will not have good quality work and definitely you will be having increased absenteeism and all that as I said earlier.

So, while hand tool design considerations, the considerations must talk of how best we can utilize the tool, what are the biomechanics of the hand that is going to be utilized in operation of this tool, how long this tool is to be operated, what is the position of the wrist to when we are holding it, what sort of force we have to apply, what sort of vibration or otherwise which is affecting the hand as well. So, while considering all these things and the limitations of the human being that we one cannot do for long time.

For example, if the hammer is very heavy, then it will not be possible for you to operate it for long time. Therefore, even the size of the size and weight of the tool is also important, if it is to be handled and then do some operation by repeated motion.

And as I said earlier repeated motions are very important because that time the hand muscles are repeatedly being stressed, if they are not being properly utilized, they will have MSDs and I think we must avoid MSDs, because they will create reduction in the output and the other biological problems or the medical problems which will come to you.

And therefore, we must have strong tool design considerations and then we will come to the principles as to what are the principles to be followed while we are designing this.

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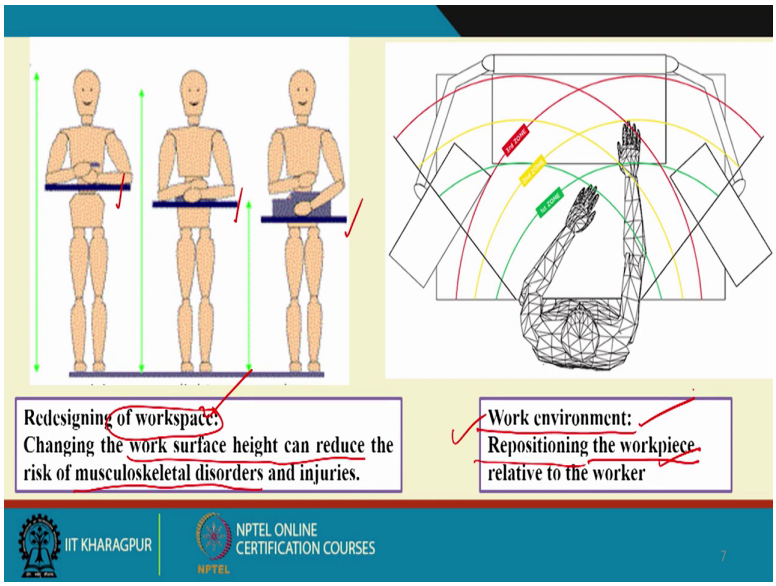


We know that how best we can redesign or design the tools, it is also possible that you can think of the space sometimes, it is not possible to each time to have the change in the design. Because these tools and devices are not meant for individual persons, but a larger category of persons and enough design considerations have been taken care of so that larger population is in a position to handle that.

So, sometimes in order, depending on the height and weight of the person accordingly you have to adjust the person in such a way that he is in a position to operate that. For example, the redesigning of that tool and the workspace could be, that redesign the work space itself. Because once you redesign this workspace maybe he is suiting to his requirement although he is not in a position to either reach to that or properly operate if the person is shorter.

Now, in these three cases you can see that the persons height has been different and accordingly, they wanted that the work surface height can be reduced to avoid the muscular skeletal disorders and any injuries. Yes, it is possible because instead of touching the tool you can just have redesigning of the work space.

So, this is also important that while we are thinking of redesigning or designing the tool from all considerations, we must also think that sometimes by small interventions of the workspace itself you can take care of the slight ambiguities or slight weaknesses of the tool design.

It is possible that you can cover those weaknesses if you design the work space itself and it serve the purpose. Similarly, when you can think of the work environment were repositioning the workpiece relative to the worker; yes, why not. Work environment when you change the work environment, when you make certain changes in the work environment apart work space work environment, that will also solve the problem of redesign or refitting of the equipment or the tool to the operator.

So, these are standard things which must be taken into with an open mind, you can think of each time if you there is a mismatch of the tool and the person, while you think of the redesigning with regard to weight, with regard to size, with regard to shape, but you should also think of redesigning the space itself.

Many a times as it is said in these two examples that environment could be the workspace, changing the height of the work surface, you can still feel that they are in a position to utilize efficiently. And even repositioning as environment is taken care of, repositioning the task or repositioning the tool with regard to the task being performed in the ecosystem.

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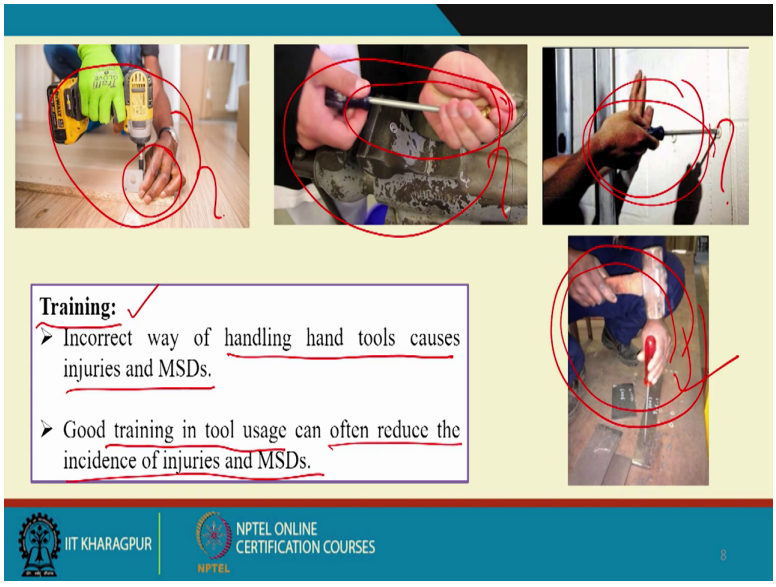


We will go to some other examples, there is another important thing which comes into play and that is the training part of it.

Because it so happens that while we are thinking of the tool design and it is not possible to have always redesigning tool for each and every person. But there has to be some adjustments as it was said in case of the workspace or the environment or positioning repositioning of the device or the tool, with regard to the person concerned, with regard to his position with regard to with reference to the ground or the workspace where he is sitting.

Could be the one example of taking care of some of the weaknesses or some of the disadvantages, why the person is feeling. And that has been the case because we are trying to fit the task to the man's capabilities and limitations. And therefore, another thing which comes into play is the training.

Sometimes we feel that no its possible I can operate a tractor, I can operate a car, I can operate a may be power tiller or I can operate any tool like saw or hand saw or power saw we can say that yes, we can operate. But the question is training if you have enough training then you would be able to readjust yourself to set the tool in such a way that you get maximum.

For example, have a look at figure given, see the task which he is doing over here and look at the task over here, look at the task over here. See these are some of the things good training handling hand tools causes injuries and MSD with tool. So, good training in tool usage can often reduce the incidence of injury and MSD. Yes, we should be advising as to how best you should be utilized a particular tool for a particular task yes that is an important.

If you do that it is very much possible that you could be in a position to design the tools, still without touching it, you can still get maximum out of the person as well as the tool without even touching the design of the tool or without making any modification in that. And can still avoid incidence of injuries and MSD. As you can see here how the tools are how the hand is being used here, how the both the hands are being used here, you can see how these are.

So, it is very important to consider the task and accordingly adjust your environment, at the same time have sufficient training of that particular task being performed. Otherwise, you will have a wrong way of operating and you will continue and you will have ailments over a period of time and therefore, it must be taken care of.

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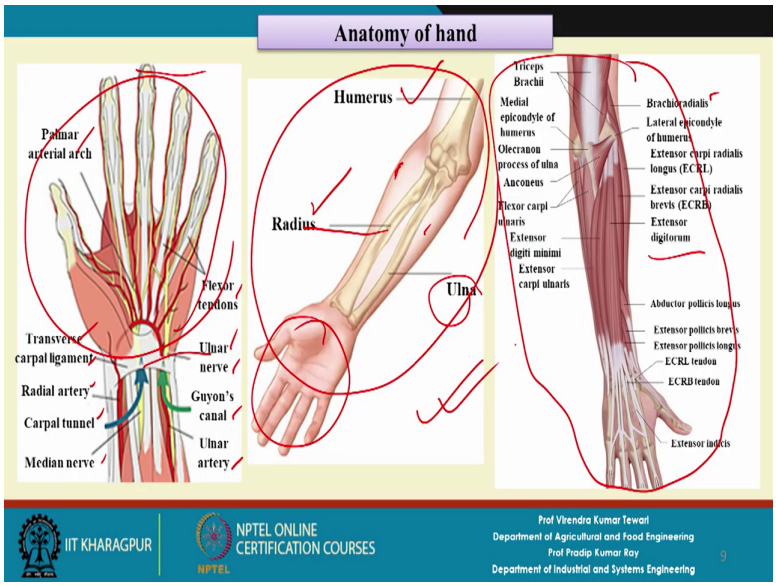


Well, good once we know that it is the hand which comes into play with the various types of devices and tools, how you we must also have although you may say that why should I be bothered about the anatomy of hand or the biology of the hand.

Yes, you may not be to the extent, but I think since you are engineering, you would like to know some of the details of how the hand muscles and bones are in action, while you are applying force or while you are twisting the hand or while you are addressing a particular task with regard to a vibrating element, things like that.

And therefore, it is essential that you must have some idea about the anatomy of the hand. You can just see this part of it, you see here that these are the bones, this is what the radius, this humerus and then this is the ulna. Now, these and then these are your have muscles and the other veins etcetera.

You have this is the palm part of it, the details of this are given over here. You need not memorize these, but just have an idea as to these are some of the details which are there in everybody's hand, irrespective of the hand is smaller and shorter or longer of course, that depends on the complete height of the person.

So, depending on the height of the person, these lengths etcetera are accordingly changing. So, we will not talk of that, but we will talk what are the details of the constituents of the muscles and other bones which are there in the hand are essential.

Now, here you can see other details of how the various veins and other things are given, you need not worry about the details of names, but what is important is you must know that so many of the muscles and the bones and the arteries are involved, while the person is at that at that particular job.

And that is why it is very essential that you give him a proper design, you give him an efficient design, you give him a design which is readjusted or made in such a way that he can perform for a longer duration without causing any injury or MSD to his own body and still fresh to do the next time. Of course, we do give rest and that rest is essential, that rest varies from task to task, but then until unless you know the details of it you will not appreciate the concentration of the hand with regard to the tool.

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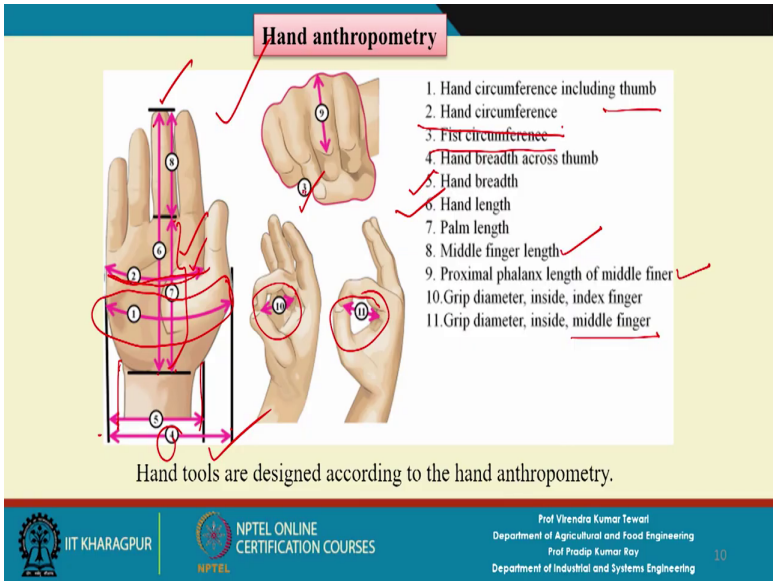


Well, how the hand anthropometry comes into play while you are holding the tools because until unless you hold the tools properly you will not be operated, you will not be able to operate this either through the thumb or through the fist or through your wrist etc.

1. Hand circumference including thumb.

2. Hand circumference.

3. Fist circumference.

4. Hand breadth across thumb.

5. Hand breadth.

6. Hand length.

7. Palm length.

8. Middle finger length.

9. Proximal phalanx length of middle finger.

10. Grip diameter, inside, index finger.

11. Grip diameter, inside, middle finger.

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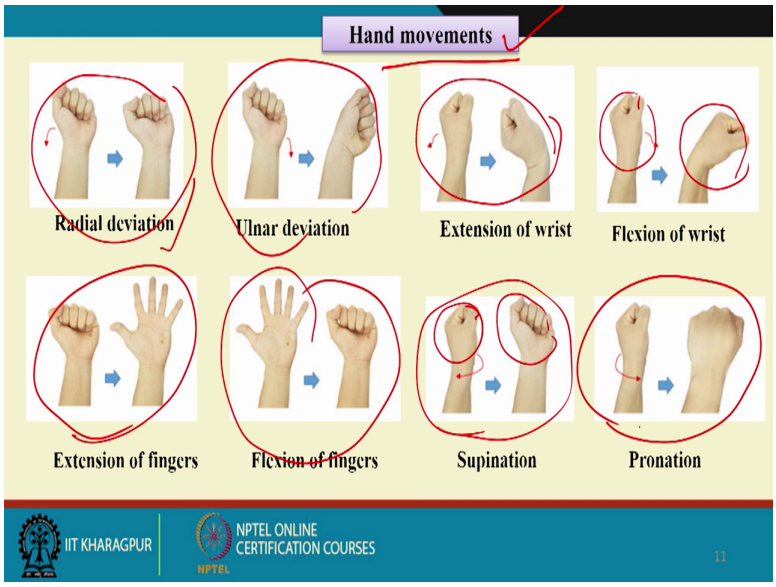


Well various movements this is very important, I mean that you must know what are the various movements that the hand has to make while doing the task. There are different types of movement of hand and they are as follow:

1. Radial deviation
2. Ulnar deviation
3. Extension of wrist
4. Flexion of wrist
5. Extension of fingers

6. Flexion of fingers
7. Supination
8. Pronation

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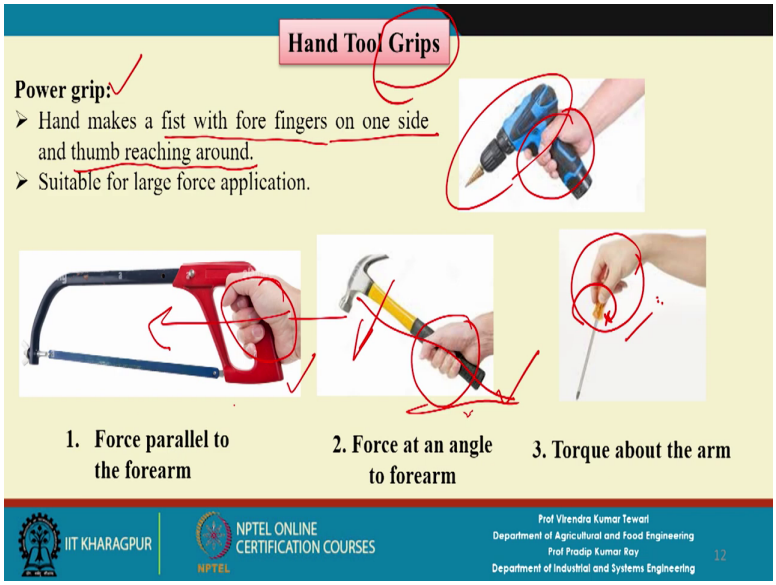


Power grip: Hand makes a fist with fore fingers on one side and thumb reaching around. Suitable for large force application.

Force parallel to the forearm is generally used for hack saw.

The force at an angle with respect to the use of hammer then the torque about the arm.

And therefore, the applications as smooth as possible and as convenient as possible will lead to efficient operation and more output.

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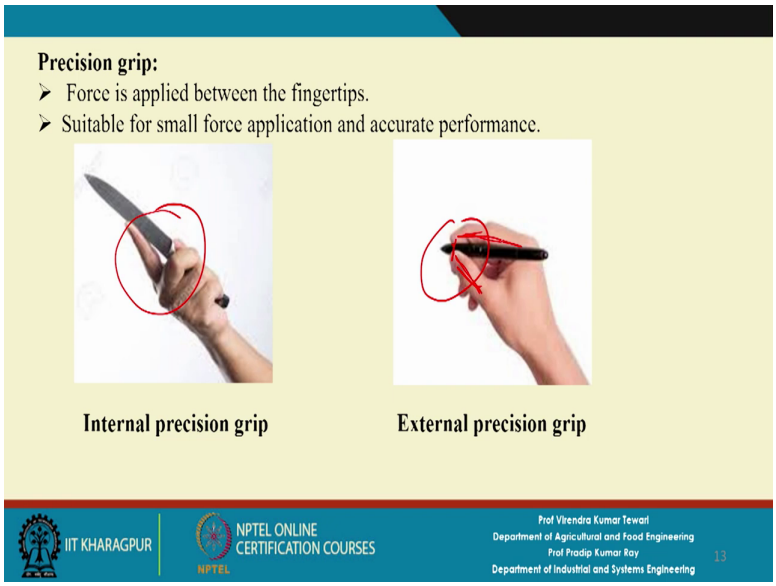


Precision grip: sometimes we need to go for some of the grips where force application between the fingertips and suitable for small force application and accurate performance when we are talking of precision grips.

We need because we need to apply certain amount of force through the fingertips or we want application in accurate performance and there you can see that how best we are trying to either draw something or you are trying to write something here and then we are trying to operate something or use certain portion of the internal precision grip here.

So, in that cases you will have to be very careful that what sort of application, although you see here if these are very tight it will give pain to your fingers over here and for long duration you will not be able to operate this.

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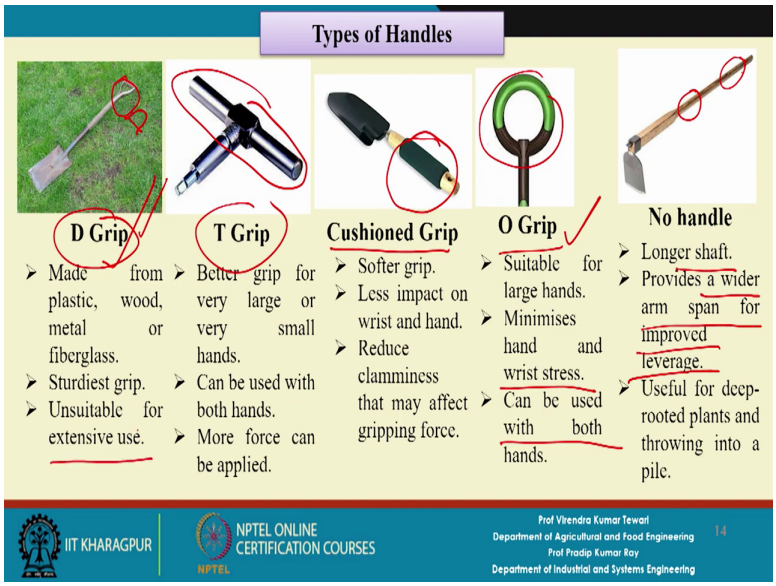


Types of hand tools

1. D Grip-Made from plastic, wood, metal or fiberglass. Sturdiest grip. Unsuitable for extensive use.

2. T Grip-Better grip for very large or very small hands. Can be used with both hands. More force can be applied.

3. Cushioned Grip- Softer grip. Less impact on wrist and hand. Reduce clamminess that may affect gripping force.

4. O Grip- Suitable for large hands. Minimises hand and wrist stress. Can be used with both hands.

5. No handle- longer shaft. Provides a wider arm span for improved leverage. Useful for deep-rooted plants and throwing into a pile.

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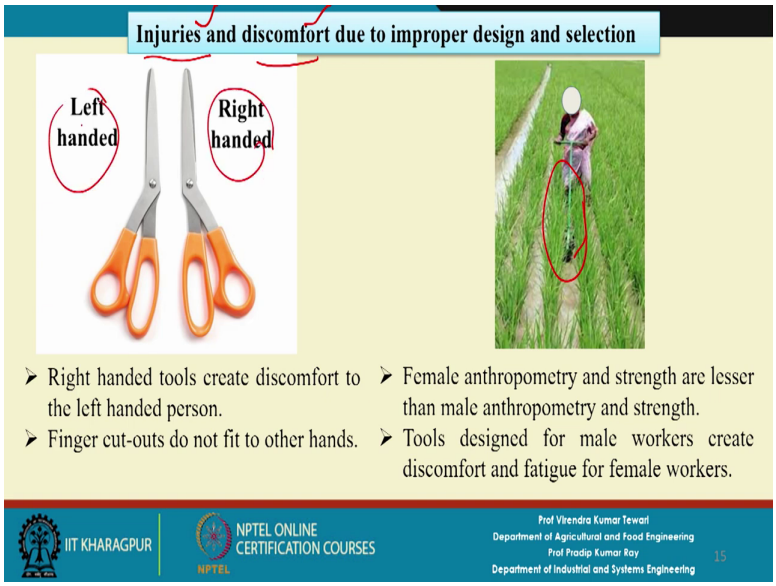


Injuries and discomfort due to improper design and selection: that will definitely take place as if you do not have proper design, then it will lead to injuries as well lead to discomfort.

And then ultimately the less efficiency less work output, that is going to happen. You can see that the posture if it is not properly made if the right-handed one is here, left-handed one is here and depending upon the use that you make it, if these are not proper then they are going to create problem for you and have the injuries as such.

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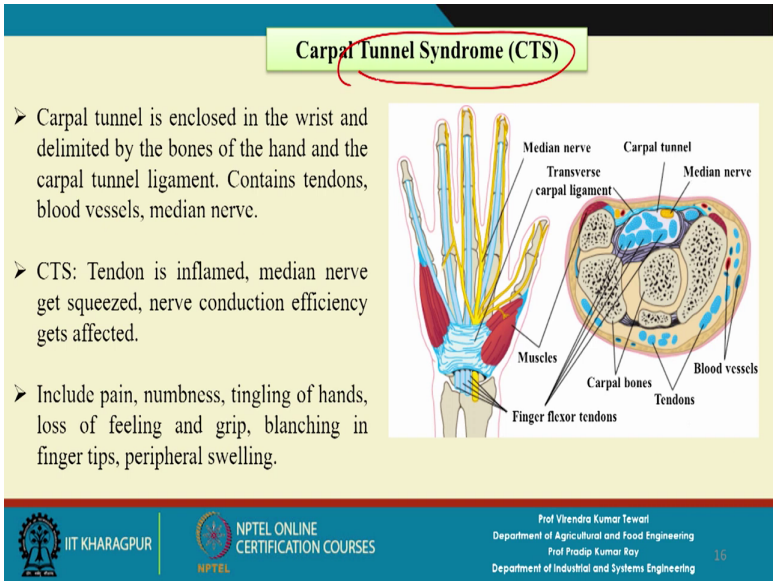

Carpal tunnel is enclosed in the wrist and delimited by the bones of the hand and the carpal tunnel ligament. Contains tendons, blood vessels, median nerve. CTS: Tendon is inflamed, median nerve get squeezed, nerve conduction efficiency gets affected. Include pain, numbness, tingling of hands, loss of feeling and grip, blanching in finger tips, peripheral swelling.

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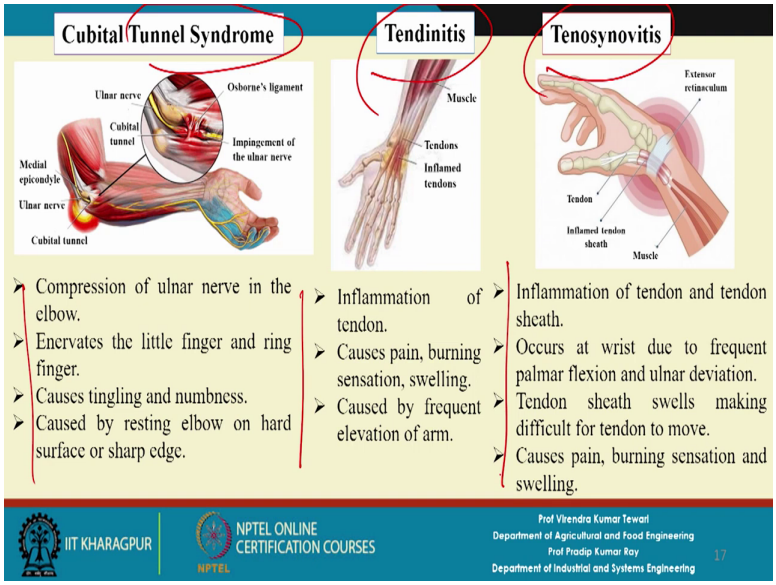


Well, the various other types of syndromes which are talked here, which are shown here, they are shown here these are how they behave and what are the details of that has been written over here. I think you just go through this only for your understanding, because at the back of the mind as an engineer you would be interested to have, the proper design.

And while argument of that why should you have a proper design, why should you have a proper weight of the tool which is being repetitively lifted and lowered.

Because it will create other problems to the hand and other diseases and syndromes which will come, and then they will continue for a long time and that is not the aim of the designer. The aim of the designer when we are talking of human factors engineering is to make these things together, bring them together as much as possible. Of course, it is not possible to have one design fit for all, but definitely we can make to the best possible extent where the people can utilize to a larger extent, larger people can utilize and have better designs utilized for more output etcetera.

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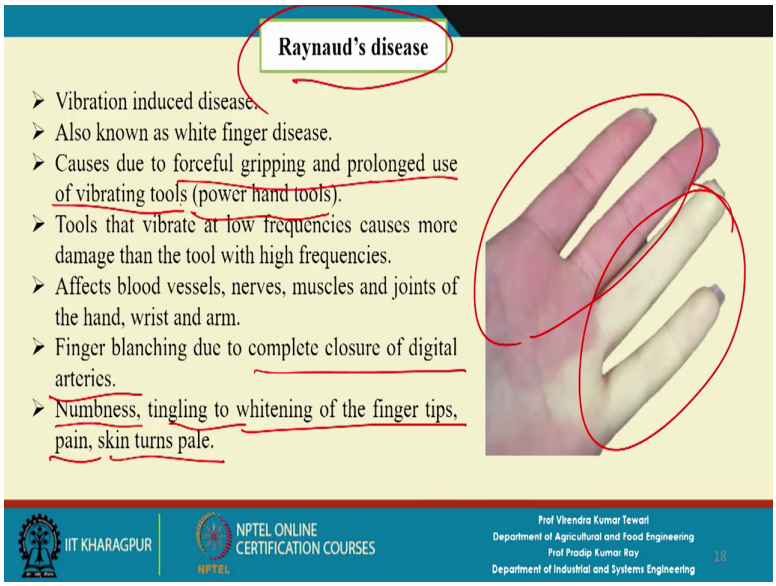


Raynaud's disease, Vibration induced disease.

Also known as white finger disease.

Causes due to forceful gripping and prolonged use of vibrating tools (power hand tools).

Tools that vibrate at low frequencies causes more damage than the tool with high frequencies.

Affects blood vessels, nerves, muscles and joints of the hand, wrist and arm.

Finger blanching due to complete closure of digital arteries.

Numbness, tingling to whitening of the finger tips, pain, skin turns pale.

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Injuries due to hand tool operations. If you do not handle hand toll properly you will hurt yourself and hence various injuries may occur.

See the diagram, see the what all sort of problems you may have if you are not protecting your body, your hand from the tool or the operation or the task at hand. So, it is very important for you that when you do the task, you take care of the proper PPE, which is given to you or the shield if you are doing welding.

If you are holding the handle of the torch, you should be properly holding the torch, you should see that you do not unnecessary burn your finger or hit your thumb here as it is shown here. It is possible because maybe we took slightly extra risk while thinking or may be over confidence sometimes leads to some of these injuries.

Therefore, you should be very careful in seeing that you do not get hurt, because those are ultimately going to create problem for you.

I have tried to give you a plethora of information with regard to various types of tools and devices which are used mostly by the hand and what are the difficulties, what are the problems which you will face if you do not have a proper tool design interaction in during the task.

And as I said that it has to be not only some many a times the tool design, sometimes proper adjustment of the environment, proper adjustment of the work space can also help

you, even proper training to the person that this is the right way of doing could also help you in redesigning the tool.

Thank you very much.