Industrial Engineering
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Module - 03
Lecture - 15
Metabolism and Organization at Work

Dear students in this presentation, I shall be talking about the Metabolism and its relationship in the organization of the human work, we know that the productivity of any organization to a great extent depends upon how effectively the different resources are being used in getting the desired job done. These resources are mainly the man material, machines and the capital power which is available with the organization.

In method study we to a great extent focus on the effective utilization of the manpower in such a way that a given job is completed in the less time and so that an operator is able to complete the job earlier and able to give the higher output for increased productivity of the organization. The output of the worker depends upon how much energy he is consuming in a given job and how long he can work without need of any break.

Whenever, work is carried out by the worker, some of amount of the energy is consumed in carrying out the work, the energy consumed in carrying out the work or energy delivered by the worker to carry out a given job is known as work cost. And, which energy is continuously delivered by the worker in while carrying out the job and we know that, this energy for a human body is obtained by an important process of the human body called metabolism.

Metabolism is a process, in which energy chemical energy of the food which human beings take is converted into the mechanical energy and the heat, so if we have to see that in which way a given work can be organized. So, that worker can continue to do the job and is able to carry out the job without need of much break, and even if the break is required how long break should be given, but all that will depend upon in which way the chemical energy of the food available to the operator is a converted into the mechanical energy and the heat and this achieved by the metabolism process.

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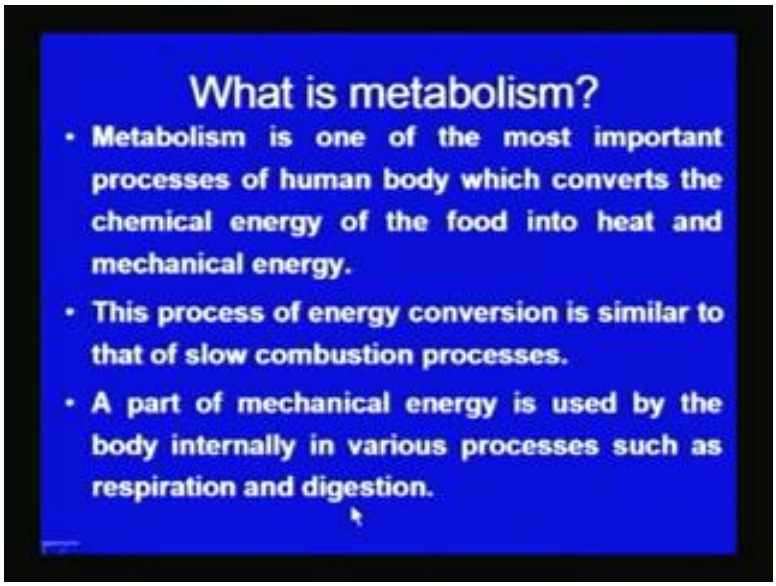

This process, this is the process in which the chemical energy of the food is converted into the heat and the mechanical energy and part of the energy, which is being generated is a used in some of the internal activities and the some of the external activities which are done by the human body. This process of the metabolism is similar to slow combustion process, where the chemical energy is converted into the heat energy and various other gases are also released. A part of the energy generated as a result of the metabolism is used by the body in carrying out some of the internal activities, such as the respiration and digestion.

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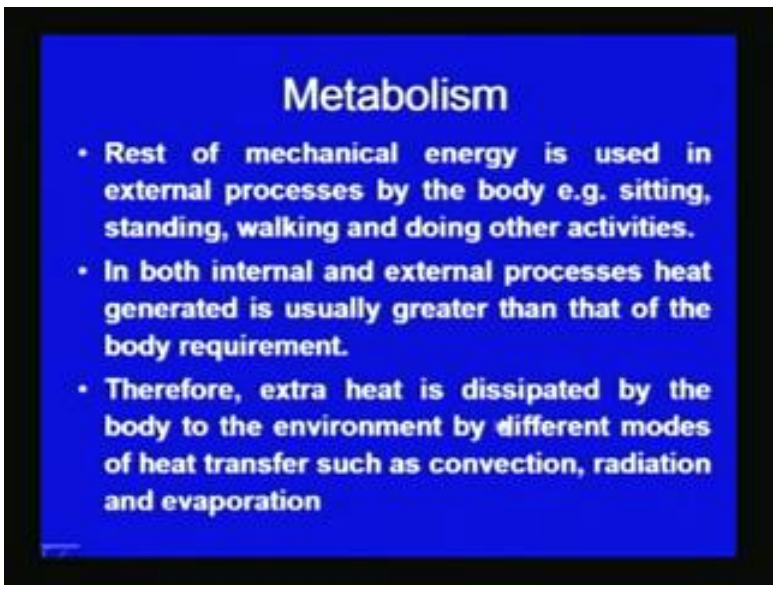

And, the part of the energy is also used in carrying out the external activities like, standing, walking or doing other activities related with the job, so if a energy consumption for the work is more he will be requiring a very fast this energy convergent process. So, that whatever energy is being generated can be consumed in carrying out the given job, both internal and external processes, the heat energy is generated and which is usually found greater than the heat of the body requirement.

As we have seen, that in metabolism the chemical energy is converted into the mechanical energy and the heat, so whatever heat is generated that amount of heat that heat generated is generally from greater than that of body requirement, and that is why the heat generated by the metabolism process should be dissipated to the surrounding to the environment. And therefore, extra heat is dissipated by the body to the environment by the different modes of the heat transfers such as convection, radiation and evaporation.

So, the heat loss by the different modes of the heat transfers help the body to maintain its temperature constant when work is carried out, since the different amount of the energy is required in carrying out the different types of the job. Therefore while job is the done the amount of heat generated also varies with the nature of work which is to be done.

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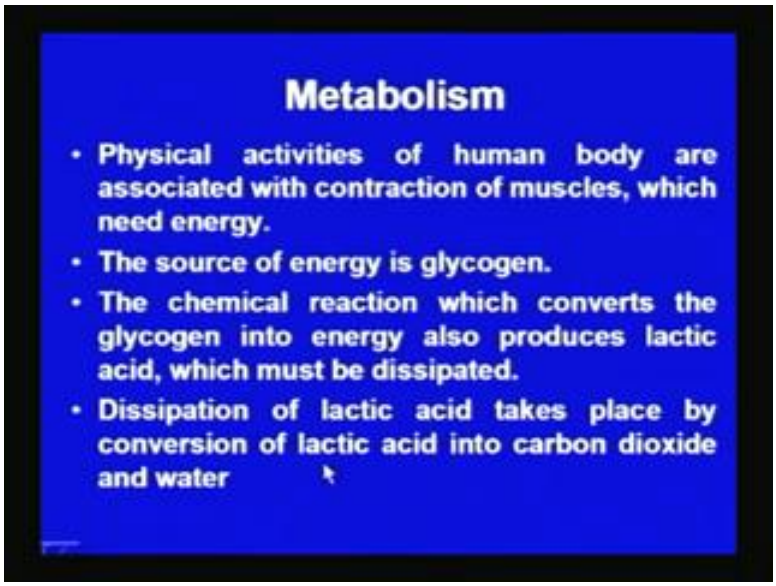

The physical activities of the human body which are associated with the contraction of the muscles need energy, whenever job is carried out that and the forces are apply to

carry out the job, those forces are applied with the contraction of the muscles. And for the contraction of the muscles, energy is required and this required energy is supplied by the glycogen.

This glycogen is a used to produce the energy through a chemical process and when this process is carried out, it results in the lactic acid also. So, this lactic acid is considered to be harmful for the blood and this lactic acid must be dissipated regularly while job is being done, so dissipation of the lactic acid also takes place through a chemical process in which, carbon dioxide is generated and the water is produced.

So, for conversion of the lactic acid continuously during the work, oxygen is required and when oxygen reacts with the lactic acid it produces carbon dioxide and the water. So, for continuous consumption of the lactic acid and to avoided accumulation in the blood it is necessary, that it is dissipated continuously when work is done, and for that lot of a oxygen is required which should be supplied continuously by the blood to the lactic acid, so that it is dissipated continuously.

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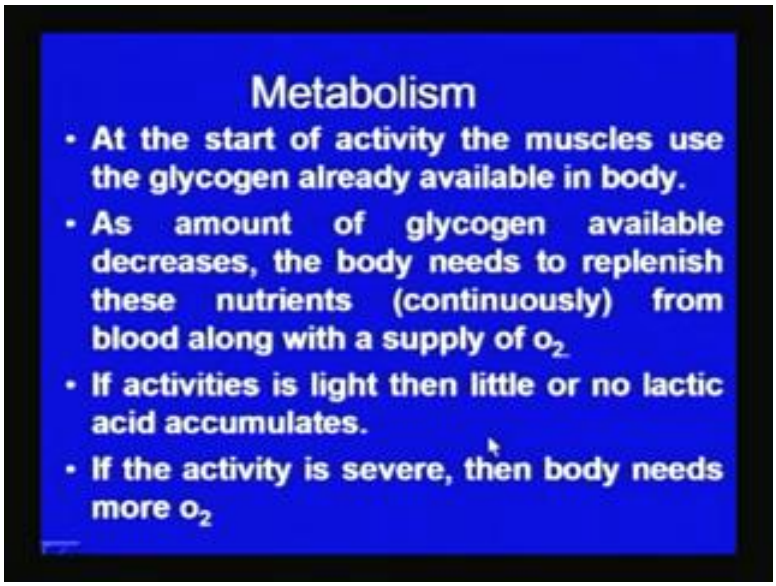

The start of any activity muscles use the glycogen, which is already available in the blood, but over a period of time when the glycogen is consumed the, these nutrients are depleted in the body and the in that case, the body needs to replenish of these nutrients. These nutrients which has been consumed, while work during the work, these should be

replenished gained and the amount of the glycogen available initially decreases gradually and the decreased amount of the glycogen should be replaced also.

And, when this reaction is carried out it results in energy by and at the same time lactic acid is produces and for which for the continuous dissipation, oxygen supply is needed. When there is a little or very light work is carried out whatever lactic acid is generated that is continuously consumed and therefore no major amount of the lactic acid is accumulated in the blood.

So, while doing the light jobs the amount of the lactic acid generated in the blood is not found much and it is consumed continuously or dissipated continuously with the available amount of the oxygen in the blood. If the activity is severe it will require more amount of the oxygen for continuous consumption of the lactic acid generated in the blood, if it is not consumed continuously the worker may start feeling fatigue and after sometime his sensations also may stop. So, while carrying out the extra heavy job the extra amount of the oxygen is normally supplied by the blood through.

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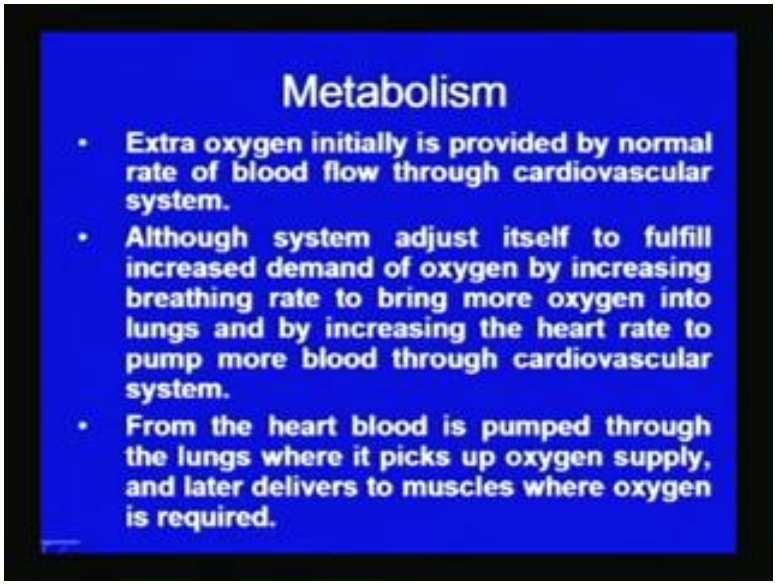

The flow of the through by the blood in which the blood flows through the cardiovascular system, so excess amount of the oxygen is required then, excess flow of the blood is also required through the cardiovascular system. Although, the body adjust itself to fulfill the increased demand of the oxygen by increasing the breath rate to bring

the more oxygen into the lungs and they by increase the heart rate and by increasing the heart rate to pump more blood through the cardiovascular system.

So, if the heavy work is carried out by the worker he will be requiring more amount of the oxygen for continuous consumption of the lactic acid which is generated in the process. So, this extra amount of the oxygen is supplied by the increased flow rate of the blood through the increased heart beat rate and the increased breath rate, when breath rate is increased more oxygen goes into the lungs and from the lungs, oxygen is picked up by the blood which is flowing at a higher rate due to the higher heart beat rate.

And, in this way the oxygen which is being picked up by the blood through the lungs, it is delivered to the muscles where it is a required, so from the heart, blood is pumped through the lungs where it picks up the oxygen supply and later it delivers to the muscles were oxygen is required. So, increased breath rate provides a lot of provides the increased amount of the oxygen to the lungs and where oxygen is picked up by the blood at lungs.

And, it goes into the muscles where it is required under the increased supply of the blood or increased flow rate of the blood due to the increased heart rate heart beat rate. It makes available the required amount of the oxygen to the muscles where it is a required.

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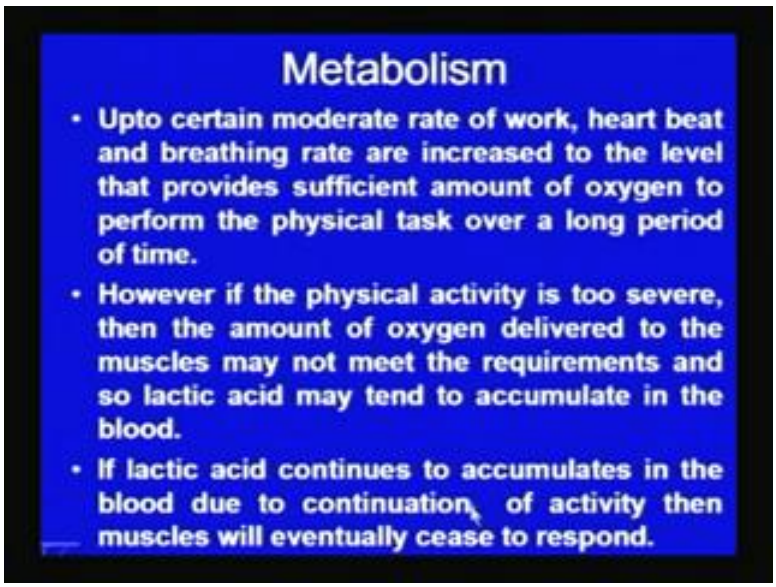

So, for the works which are which need is amount of energy in such a way that, whatever the lactic acid is generated during the work that is a continuously consumed by the available amount of the oxygen under the normal heart beat under the breath rates. Where up to certain moderate rate of the work, the heart beat rare and breath rate normally adjust in such a way that they provide the sufficient amount of the oxygen to perform the physical task over a long period of time.

So, up to certain amount of the energy consumption the breath rate and the heart beat rate provide the desired amount of the oxygen, so that whatever lactic acid is generated that is consumed continuously. However, if the physical activity is too severe then, the amount of oxygen delivered to the muscles may not meet the requirement which is required to consume the lactic acid which is being generated by the metabolism process.

And therefore, lactic acid may start to accumulate in the blood, so once the accumulation of the lactic is starts the operator may start feeling fatigue and after some time his sensations may also a stop. So, if the lactic acid continuous to accumulate in the blood due to the continuation of the activity then, muscles will eventually cease to respond and this is certainly not good condition, when the lot of well lactic acid is accumulate in the blood and which ultimately leads to the situation when body cease to respond to the activities which are desired.

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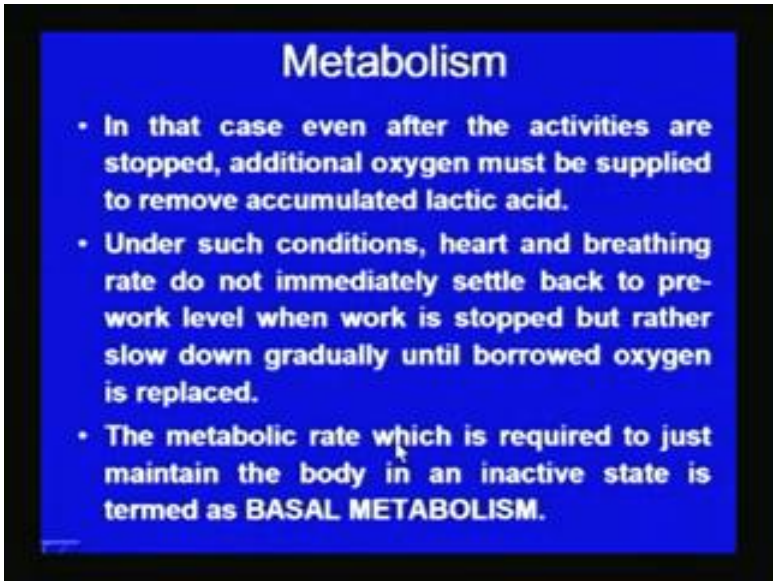

So, under such conditions the extra oxygen is require to be supplied in, such cases the activities are which are too severe and the body leads to situation where it a stop to respond. And then, under such conditions activity should be stopped and additional oxygen must be supplied to remove the accumulated lactic acid and under such a severe working conditions, heart beat rate and the breath rate are not normally able to supply the required oxygen.

So, that the heart beat rate and breath rate, breath rate can settle back to the pre work level, when work is a stopped, but rather it is slows down gradually until the borrowed oxygen is replaced. So, when the body responds to its body stops to respond, the extra oxygen must be supplied from the out outside, so that the accumulate lactic acid can be consumed and it will not be consumed automatically just by a stopping the work.

So, some amount of the extra oxygen must be supplied under such conditions, we know that the body always needs a energy for carrying out the internal and external activities. So, when there is no external activity is being done by the body is still some amount of energy is required by the body to carry out certain activities, internal activities such as breath and the digestion.

So, the metabolic rate which is required just to maintain the body in an inactive state is termed as basal metabolism, so this basal metabolism is corresponding to the process of the transformation were chemical energy is to be converted into the mechanical energy and the heat energy. And, the energy required is such that it is just sufficient to maintain the body in inactive state.

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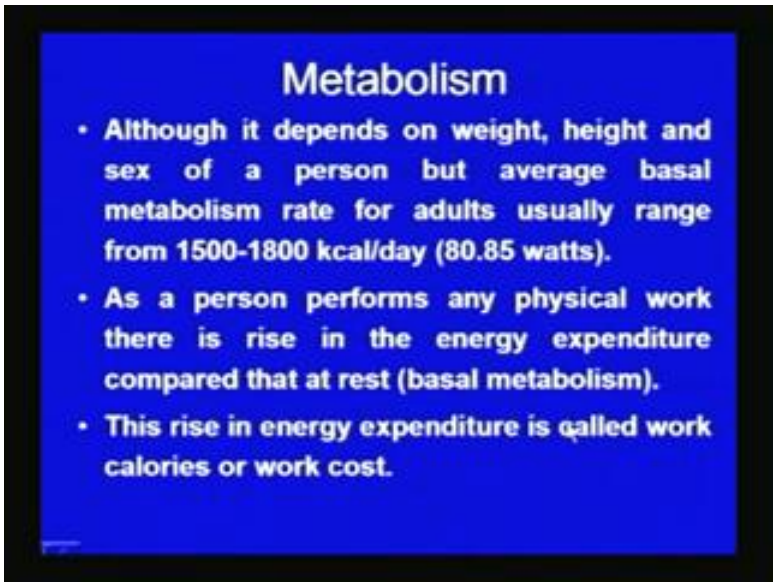

So, that the metabolism is termed as the basal metabolism although the rate of the basal metabolism depends upon the weight, height and the sex of the person. But, the average the basal metabolism rate for adults usually found in range of 1500 to 1800 kilo calorie per day that is found about 8.85 watts, so as a person performs any physical work, there is a rise in energy expenditure from the body as compared to that at the rest.

So, we know that whenever work is carried out additional energy is consumed in carrying out the external activities and that, the extra energy required for carrying out the job is termed as the work calorie or the work cost. It is also termed as energy cost of the work, what is the energy required for carrying out the given job, so now we will see that when different types of the jobs are carried out by the human body in which way and what amount of the energy is carried out by a amount of the energy is consumed from the body, when the job is done.

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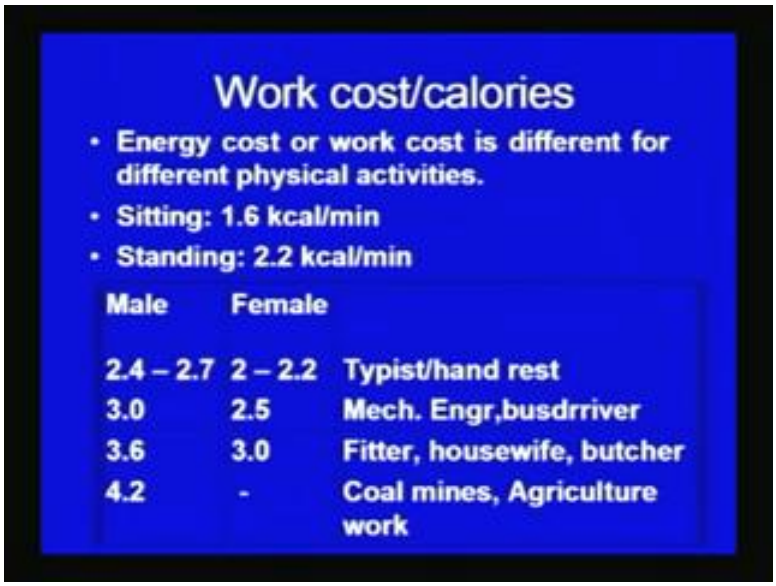

So, the energy cost or the work cost is different for the different physical activities because, the energy required for carrying out our a simple and light jobs will be less compared to the, compare to those jobs which will consume which will require lot of force and excessive amount of the energy in their performance. For example, when person is sitting he consumes about 1.6 kilo calorie per minute.

While in a standing position he consumes somewhat more amount of energy that is, about 2.2 kilo calorie per minute, likewise if you compare for male and female when work is a carried out of the different categories like for the energy consumption or energy cost for carrying out the light jobs like typist or hands at rest. The energy required is a about 2.4 to 2.7 for male, while for female it is 2 to 2.2, somewhat more the works which require somewhat more amount of energy like mechanical engineers moving around the shop floor or the bus driver controlling the vehicle as desired.

Here the male will be consuming energy about 3 kilo calorie while female will be consuming in a will be consuming energy at about 2.5 kilo calorie per minute, somewhat heavier work like fitter, housewives and butcher will be for male a for a males, it will be coming 3, will be about 3.6 kilo calorie per minute while that for female it is 3 kilo calorie per minute. So, if we see the workers were working in coal mines and agricultures fields, he will be consuming, the energy at the rate of about 4.2 kilo calorie per minute.

So, if severity of the work increases, the energy consumption also increases what depending upon the gender of the person, here the more energy is consumed by male compared to that of female counter parts. So, energy required for carrying out a job depends upon the nature of the job and the forces which are required, when the job is to be done by the worker at the same time the gender of the person, his height etcetera also will affect.

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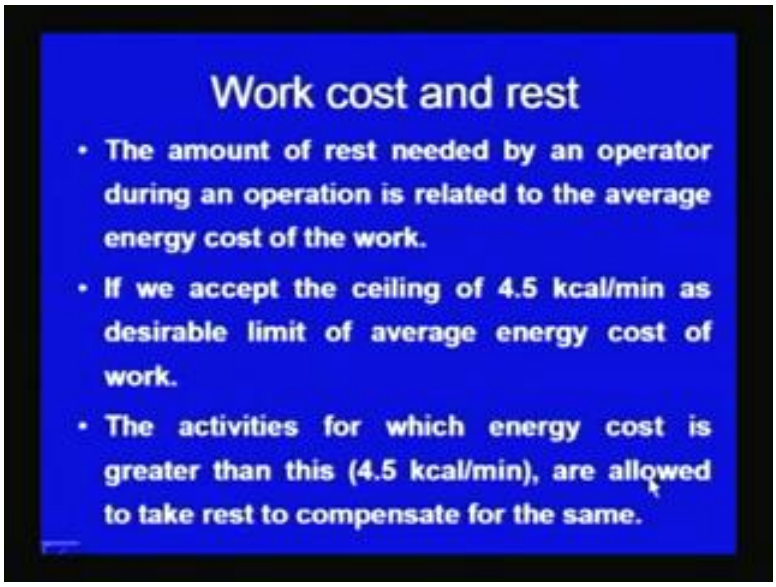

The amount of, the amount of the rest needed by an operator during an operation is related to the average energy cost of the work, we know that an operator can deliver the energy only up to certain rate without need of any rest. Because, if the work energy consumption is too high, then it will lead to the accumulation of the lactic acid in the body and in that case, body will require rest to dissipate and for dissipation of the accumulated lactic acid.

So, how long work should be continued and then, after that how long break should be given to the worker that to great extend depends upon the energy cost of the work. The therefore, the amount of rest needed by an operator largely depends upon the energy cost of the given work. Normally, the energy cost, the cost of the energy for a given work up to 4.5 kilo calorie per minute is consider as a upper limit of the energy consumption which worker can deliver without need of rest.

If we expect the ceiling of 4.5 kilo calorie per minute as a desirable limit of the average energy cost of the work and this is the limit which a worker this is the limit of the energy which a worker can deliver continuously without need of a break. Activities for which energy cost is found greater than this upper ceiling energy limit that is, 4.5 kilo calorie per minute the rests are allowed.

So, that the body can recover by consuming the accumulated lactic acid while doing the jobs which will require higher amount of the energy during their performance and then, to calculate the way by which the work should be organized how long work should be continued. And then when break should be given or how long break should be given to the worker, so that he can recover and he can restart the work, normally two methods are used to estimate the rest period.

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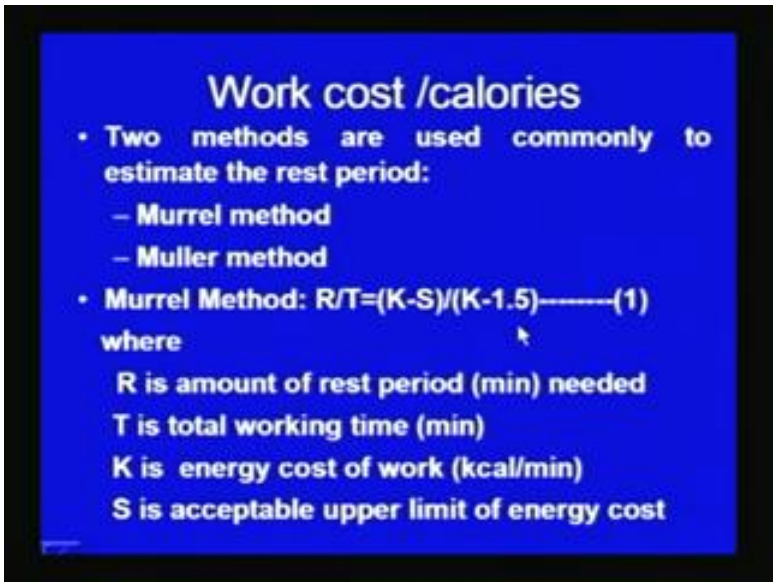

These are the Murrel methods and the Muller's method, if you see here, according to the Murrel method the rest R divide by T is equal to K minus S divide by K minus 1.5, this is one typical equation which has be proposed by the Muller for calculation of the rest period compared to the total time require. Where R is stands for the amount of the rest period needed by the operator, so that the accumulated lactic acid can be consumed and he can recover from the fatigue.

To start the work once again, T is the total working time in which work is done and there after I means it may be 1 hour it may be 4 hours depending upon the work period and K

is the energy cost of the work, the amount of energy which is it to be delivered by the worker for carrying out the given job, that is in kilo calorie per minute. If the energy cost of the work is more than obviously, the rest period will also be more.

S is the acceptable upper energy limit cost of the work, normally this acceptable upper energy limit cost of the work is found to be 4.5 kilo calorie per minute in this equation if we see the 1.5 refers to the basal metabolism rate. It is, it is the energy which is the required for carrying out the internal activities of the human body.

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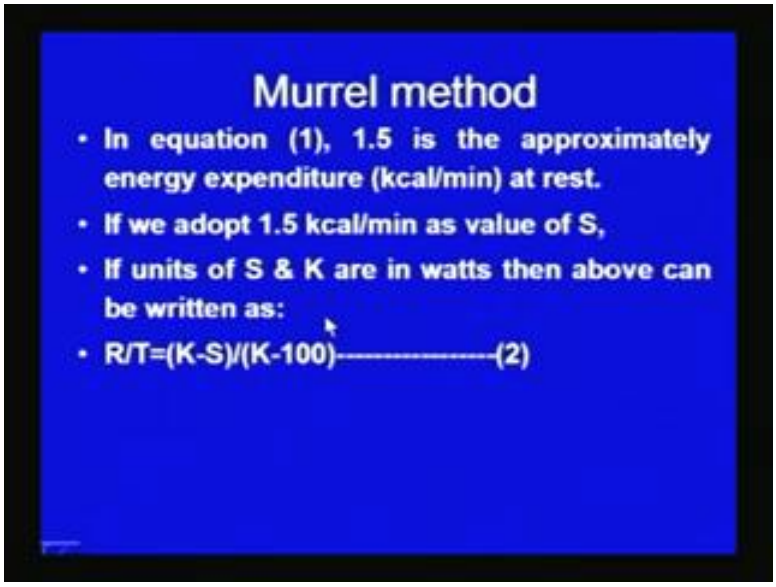

So, here it is the equation in this equation which we seen earlier the 1.5 is the approximate amount of the energy which is consumed by the worker during the rest and if we consider it as the, if we adopt 1.5 kilo calorie per minute as a value of S. Then the units then, if the units of S and K are put in watts then the side equation can written as following.

Whatever equation we have seen in the previous slide, that is corresponding to the case when the values for the energy cost and for the, that is a S that is a upper acceptable energy limit is and the basal metabolism rate is considered in kilo calorie per minute. And if the units of the S and K that is a the energy consumption while work is at, worker is at rest or while work is being done, so the energy cost of the work, if these two parameters are taken into the watts.

Then, the above equation can be also written as a R by T is equal to K minus S divide by K minus 100, where the significance of all other parameter all the parameters in this equation two is also same, except to the difference is that, that S and K are taken in watts while R and T are in minutes as before R refers to the rest period, T is a refers to the total work duration.

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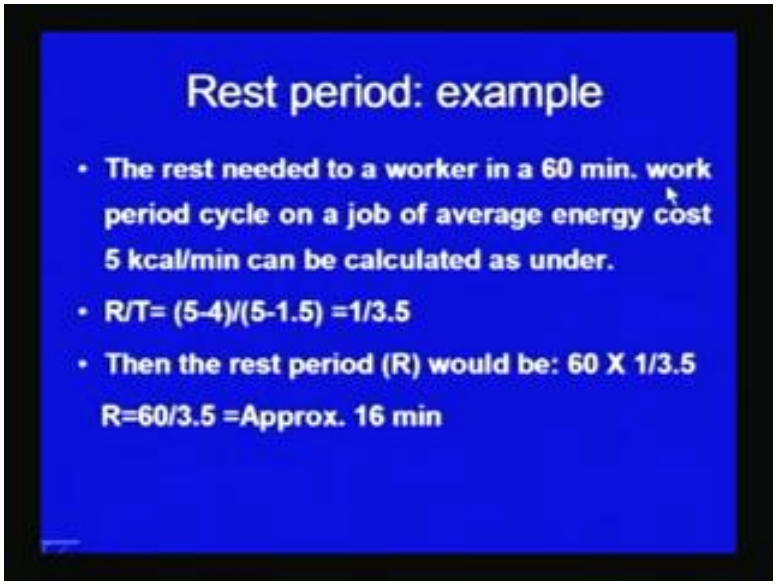

If we consider an example where the work cycle of the 60 minutes duration and the energy cost of the work is 5 kilo calorie per minute then, the time of the rest can be calculated using the said method in as following, here we can use the same equation like R by T is equal to here K refers to the 5. That is the energy cost of the work and 4 is the upper acceptable energy limit and the 5 minus 1.5 is the basal metabolism rate that is 1.5 kilo calorie per minute is the energy consumption of the worker.

When the body is at rest and using this equation if we see that it comes out to be one by 3.5, if we solve this equation for the duration of 60 minutes then, the rest period comes out be the 60 into 1 by 3.5. And which is approximately 16 minute it means, that is the energy cost of the work is 5 kilo calorie per minute and the expectable upper energy limit is 4 kilo calorie and the basal metabolism rate, that is the energy required by the worker at rest is 1.5 kilo calorie per minute. Then, the rest period for a work cycle of the 60 minute comes out to be the 16 minutes and the after the 16 minutes of the rest the worker should again start the work for 60 minute work cycle.

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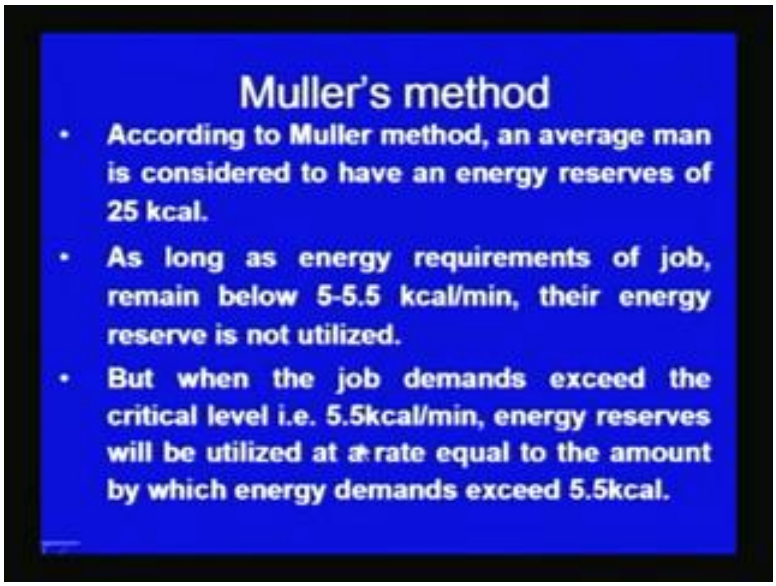

The Muller method is the another method for calculating the rest period and very effectively used in organization of the work, but there is difference in this method, this method is significantly different from the Murrel's method in which the energy cost of the work an upper expectable energy limit. And the basal metabolism rate is considered to calculate the rest period with the respect to the total a time of the cycle.

A Muller's method is the another method which is used to calculate the rest period into find out that how work effectively, so that worker can continue to do the job without excessive use of the body and a need of necessary rest. So, according to the Muller method it assumes that an average man is considered to have energy reserves of 25 kilo calorie.

And, these energy reserves are not used until the energy consumption of the work goes beyond a certain limit, so according this as long as energy requirement of the job is below 5.5 to 5.5 kilo calorie per minute. These energy reserves are not a used these are used only when the energy consumption of the work or energy cost of the work to be done by the worker goes above 5 to 5.5 kilo calorie per minute.

And, when the job demands exceed the critical level that is 5.5 kilo calorie per minute, energy reserves will be utilized at the rate equal to the amount by which energy demands exceed by the 5.5 kilocalorie. It means that energy reserves available with to the worker are used only when the energy requirement of the work is greater than the certain critical

limit that is 5.5 kilocalorie, if the light work is carried out by the worker which is consuming energy less than 5.5 kilo calorie per minute.

Then, it will not the then the energy reserves are not used and he can continue to carry out the job without need of a any rest, so according this the upper energy acceptable limit see is the 5 to 5.5 kilo calorie per minute. The value of this acceptable upper energy limit can vary from one organization to another but, depending upon the energy cost of the work which is to be carried out by the worker.

The energy will stored energy will be depleted and that the rate of depletion will depend upon, how much extra energy is required when the job is done. For example if the 7 is the kilo calorie the 7 energy cost of the work is 7 kilo calorie per minute then, the rate at which energy reserves will be depleted will be 7 minus 5.5, that is 1.5 kilo calorie per minute will be their rate at which energy reserves will be utilized.

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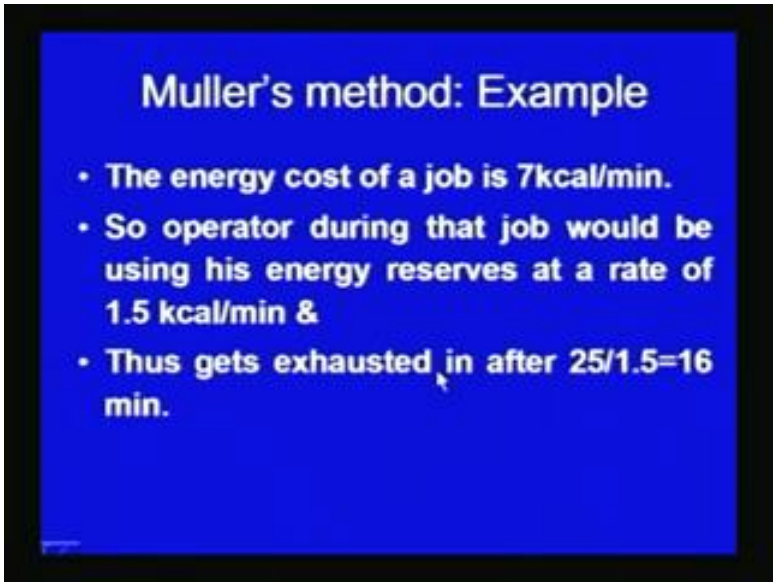

So, here if we see an example for example, energy cost of the job is 7 kilo calorie per minute and the operator during the job therefore, using his energy reserves at the rate of the 1.5 kilo calorie per minute. And, thus gets exhausted after 25 divide by the 1.5 equal to 16, 25 reference to the energy reserves available to the worker and these are used at the rate of 1.5 kilo calorie per minute, when the job having the energy cost of the 7 kilo calorie per minute is carried out

Then, the worker can continued to do the job only for 16 minutes and after 16 minutes of the duration, he should be given rest and the rest should be allowed for a period until his breath rate comes to the normal and his heart, heart beat rates also are also normalized.

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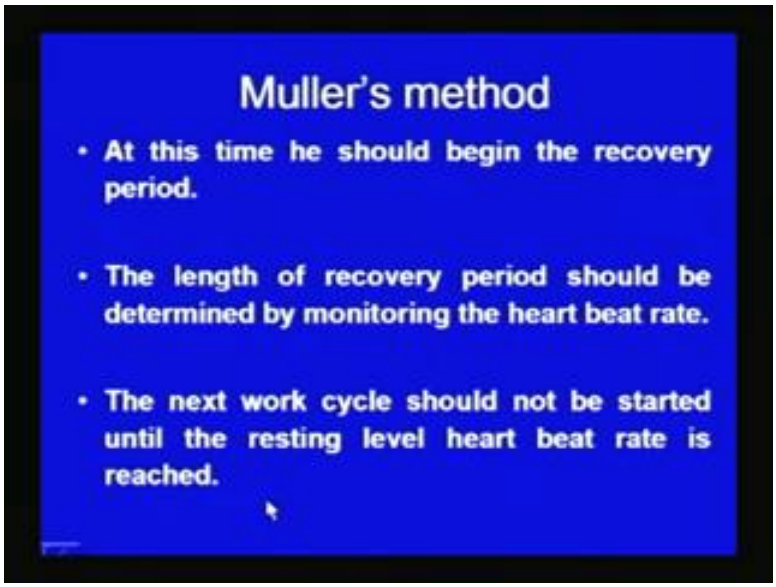

At this time, that is 16 minutes the worker should begin the recovery period and the length of the recovery period should be determined by the monitoring the heart beat rate. There are two ways for deciding that how long break should be given the time, which we have calculated above indicates the time for which the worker can continue to do the job and after that he needs rest, the how long rest should be given that for that the two methods are used. One is the checking the heart beat rate of the worker and he should be allowed to take the rest until his heart beat rates are normalized. Then, the next work cycle should not be started until the rest level heart beat rate is achieved.

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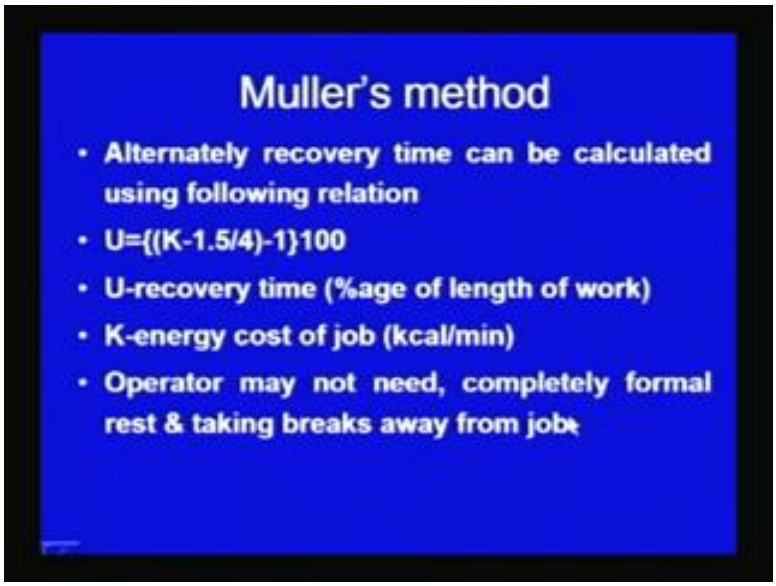

Alternatively the recovery time can also be calculated using the following equation which shows that U, that is the recovery time is equal to K minus 1.5 divided by 4 minus 1 into 100. It shows the recovery time in terms of the percentage of the length of the work, K is the energy cost of the job and the operator here 1.5 is the basal metabolism rate and 4 is the acceptable upper energy limit of the work, operator may not need the complete rest and he may be given some other job which is consuming some less amount of the energy. Operator may not be required to go completely of the work, but he may be ask to do certain other things which reconsuming less amount of the energy.

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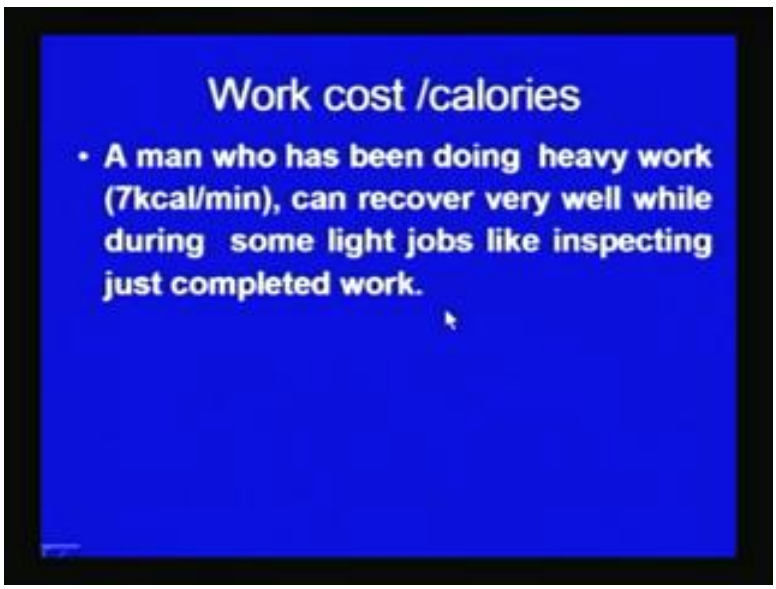

For example, the person who has been doing the heavy work and consuming the energy at the rate of 7 kilo calorie per minute can recover very well while doing some other light jobs. For example, inspecting or the checking the dimensions because, say the light work consuming energy less than 1.5 kilo calorie per minute or 3 kilo calorie per minute or less than the upper acceptable energy limit, those activities and jobs can be effectively done by the operator.

Instead of going for the complete rest from the work, so to organize the activities effectively the heavy work is done for the certain period and thereafter, during the rest period or recovery period some other light jobs are done. So, that the worker is able to recover at the same time other activities which are expected from him are also completed in the same period.

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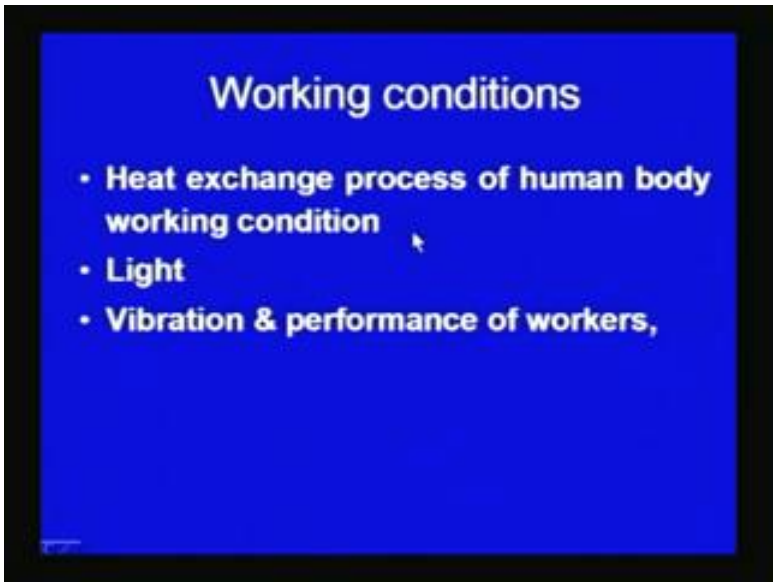

So, to get the best output it is necessary that the man machine system must be perfect and we know that, an efficient person can work nicely designed system effectively only when the man and machine both are installed or provided the proper working conditions or that is the environment in which they are working. So, to provide the proper working conditions, it is necessary that the, we are familiar with the conditions which can affect the performance of the worker.

And, we know that if during the work energy is consumed and at the same time heat is generated that heat, it is should be continuously dissipated from the body otherwise

temperature of the body will start to rise. So, the in which way the heat exchange from the body to the environment takes place and in which way the surrounding scan affect the body temperature and the performance of the work that should be looked into very carefully, the proper light should also be provided.

So, that operator can work continuously for long time without undue strain and fatigue while doing the job and the same time when the, this different systems work in a shop floor or in a work area, they frequently produce the vibrations due to the various causes. These vibrations should be isolated and should be checked and the systems would be design in such a way that operator performance is not very adversely affected. So, it is required to look into all these aspects in greater detail first of all will see the heat exchange process of the human body, and the way by which it can affect the performance of the human body.

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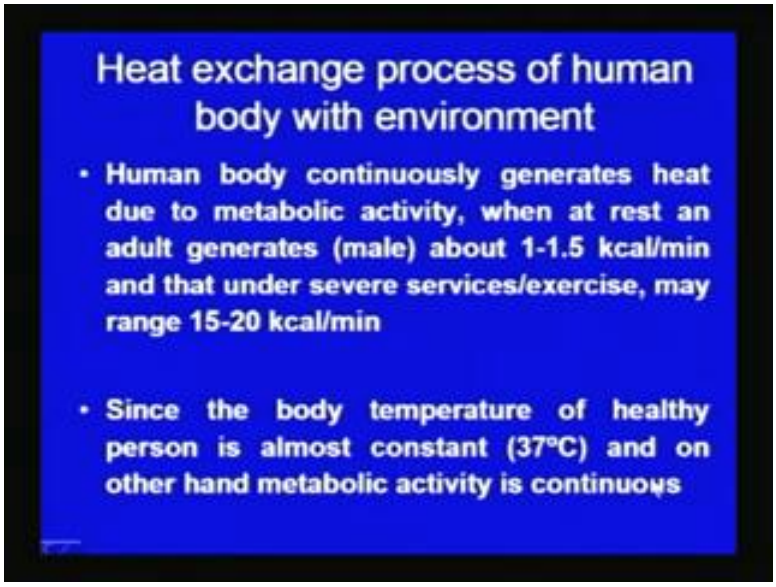

We know that during the metabolism process, heat is continuously generated in addition to the energy by the chemical process in which chemical energy is converted into the chemical energy of the food is converted into the mechanical energy and the heat. Whatever heat is generated that is found to be more than that is required by the body and that is why body temperature starts to go up, it is if the heat is not dissipated continuously during the work.

Human body therefore, continuously generates heat due to the metabolic activity when at rest, adult generates at about 1.5 kilo calorie per minute heat while the under the severe working conditions or during the exercise an adult can generate the heat as high as a 6, 15 to 20 kilo calorie per minute. Since the body temperature of the healthy person is almost constant that is around 37 per degree and the metabolic heat is generated continuously, so to maintain the temperature of the body constant, it is necessary that whatever metabolic heat is generated that is dissipated continuously.

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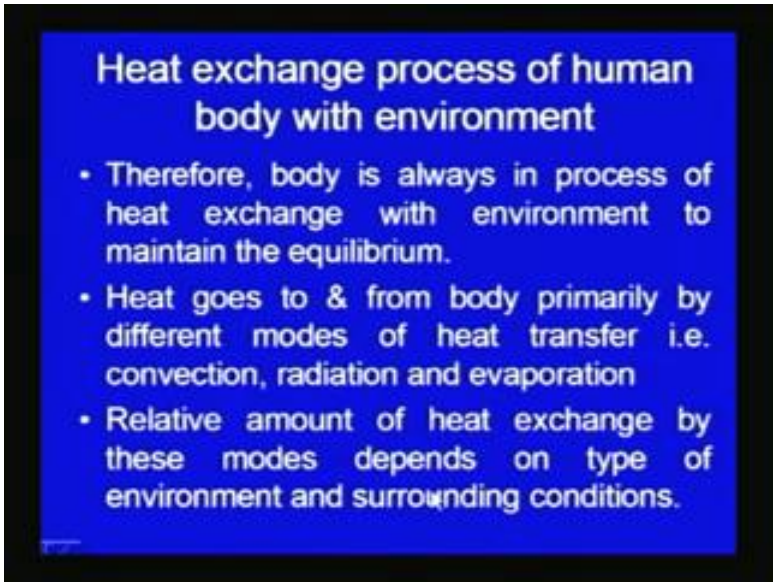

For dissipation of the heat continuously from the human body, the surrounding play a significant role then the heat the body is always in process of heat exchange with the environment to maintain its equilibrium temperature. Whenever heat is generated by the metabolic reactions and metabolic process that heat generated should be transfer to the environment or when that heat generated is less than the temperature less than the heat required to maintain the temperature of the body constant.

Then, the heat is a transferred from environment to the body itself to maintain the equilibrium, heat goes to and from the body primarily by the different modes of the heat transfers and these main modes of the heat transfers through which heat exchange between the body and the environment takes place or the convection radiation and the evaporation.

And the relative amount of the heat transfer by these three modes of the heat transfer depends upon the type of environment, surrounding and the temperature of the human body or the temperature of the surrounding conditions. The velocity of here humidity and many other factors related with the environment, so here the what amount of heat will be transferred by which mode of the heat transfer, it depends upon various factors and the main and important factors are the environment, surrounding conditions, air temperature, humidity and the flow of air in the, in the work space.

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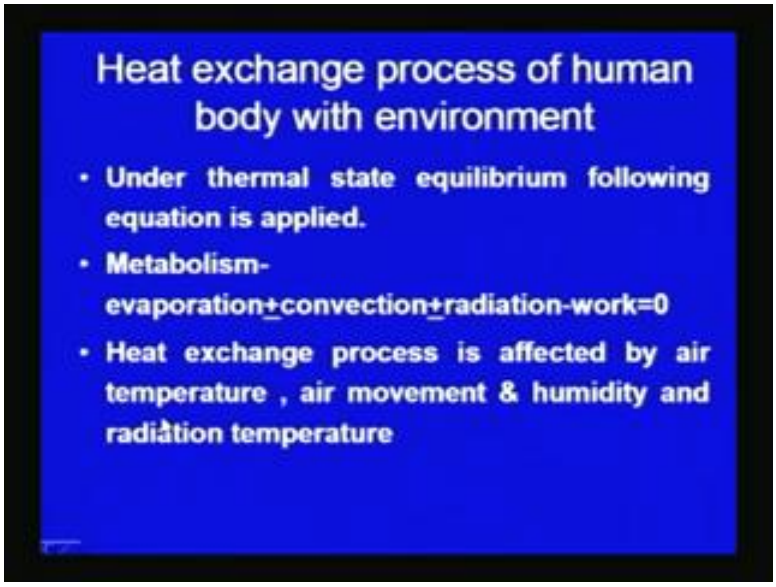

Under the normal equilibrium conditions of thermal conditions we can see that the whatever heat is generated by the metabolism, the metabolism minus the heat lost by evaporation then, heat can be added or lost by the convection to the body or from the body. And heat can be supply to the body or heat can be lost from the body by the radiation minus the energy which is consumed in the work.

Some algebraic some of all these is found to be equal to zero, if the energy cost of the work is less and the if we if we see here metabolism, whatever a heat is whatever energy is converted by the metabolism part of that is used in carrying out the work. And the rest of the heat generated is transferred through these three modes of the heat transfer in which the heat always lost by the evaporation while heat can be transferred to from the body the by the convection or the radiation. The heat exchange process is affected by the

air, air temperature, air movement, humidity and the radiation temperature of the surrounding.

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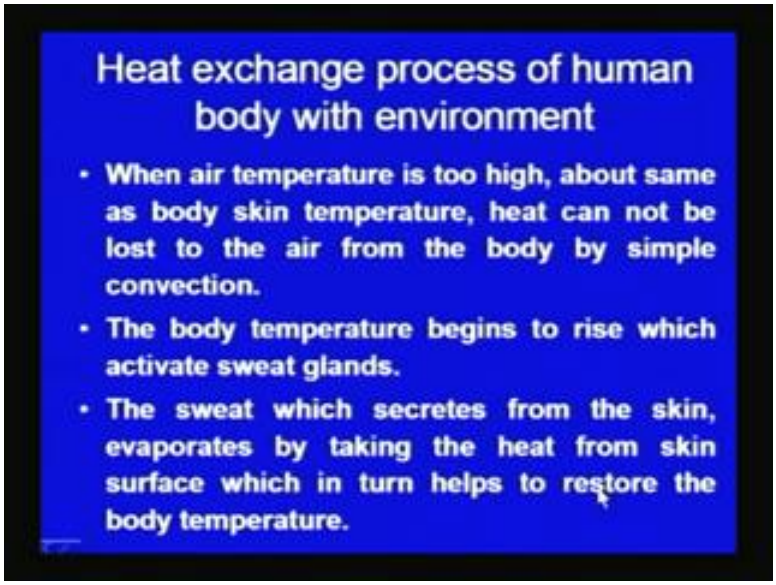

We can see here that when the air temperature is too high about the same as the skin temperature, heat cannot be lost to the air from the body by the simple air convection and therefore, body temperature begins to rise which activates the sweating glands. And the sweat which secretes from the skin and evaporates from the skin surface by taking the heat from the skin surface which in turn helps to restore the body temperature. So, if the temperature of the surrounding here is too high then, body will not be releasing the heat by the convection mode of the heat transfer and under such conditions the body temperature is starts to rises and with the increase in temperature rise activates the sweating glands.

And the activation of sweating gland leads to the secretion of the sweat from the skin and sweat when evaporates from the skin surface by consuming the heat presented the surface in turn leads to the restoration of the body temperature, and this rise in temperature is counter balanced by the heat lost by the evaporation of the sweat from the skin of the human being.

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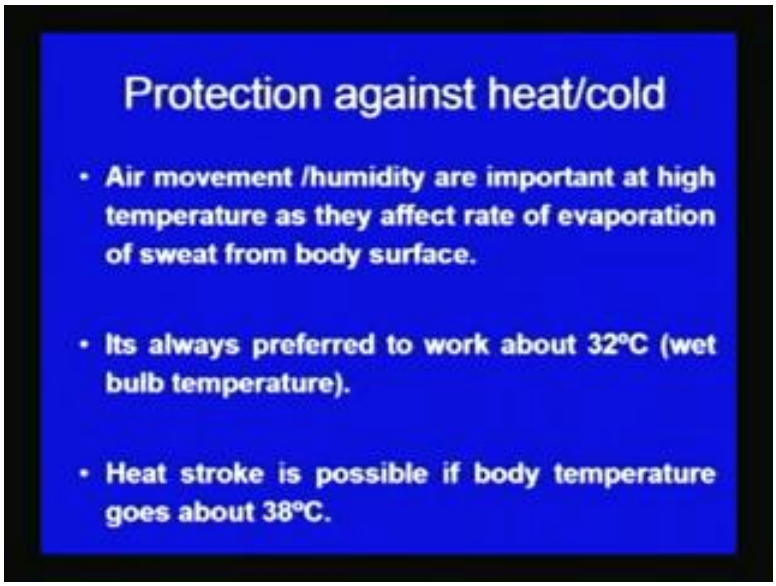

The air movement, the humidity of the, are the important factors that affect the heat transfer specially at high temperature, the air movement and humidity are important at high temperature because, they effect the evaporation of the sweat from the body surface. The higher will be the air movement greater will be the evaporation and therefore, the body will be able to lose the heat rapidly.

It is always preferred to work at about 32 degree centigrade wet bulb temperature and too high working in too high temperature around 38 or above the body may feel the heat is stroke, if the working conditions or too severe as far as the body high working temperature conditions are concerned.

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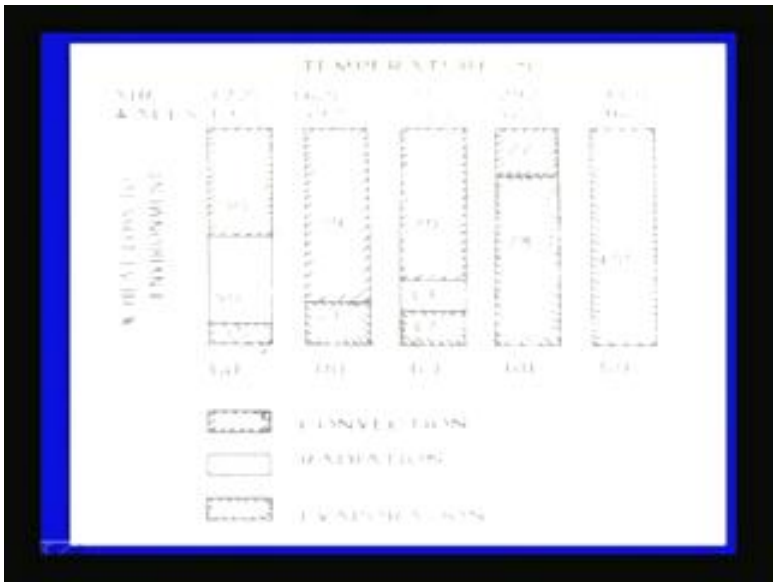

So, as we have seen that the heat transfer, relative heat transfer by three modes of the heat transfer from the body to the environment depends upon the air temperature, wall temperature, air velocity and humidity. In this diagram, we can see here the how the air temperature and the wall temperature can affect the mode of the heat transfer or the percentage of the heat transfer by three modes of the heat transfers.

So, here the percentage of the heat lost to the environment by these three modes of the heat transfer that is convection, radiation and the evaporation and the relative amount of the heat transfer by these three modes for the different, the air and the wall temperature conditions in centigrade has been shown here. You can see the air temperature for the different combinations of the air and wall temperature here we have first combination that is 17 degree air temperature and 19.5 degree wall temperature.

And, corresponding to this if we see when air and wall temperature both are low, here the 50 percent of the heat transfer to the environment takes place by the convection process 40 percent by, 40 percent by the radiation and only 10 percent by the evaporation. So, under low temperature conditions your, the 50 percent by the convection 40 by the radiation and only 10 percent by the evaporation.

While, if we see here when the temperature of both air and wall are too high that is 35 degree of the air temperature and 36 degree wall temperature, the heat transfer from the body to the environment mainly takes place by here, we can see the evaporation.

Evaporation is the main mode by which heat is lost to the environment and that is 100 percent approximately when the both air and wall temperatures are too high for reasonably low air and wall temperature that is 23 degree centigrade.

We can see that the 70 percent of the heat lost is by convection 13 percent of the heat lost by the radiation and about 17 percent of the heat lost by evaporation, if the conditions are just opposite in nature or you can see the air temperature is 29 and the wall temperature is 52 degree centigrade. Then, 22 percent of the heat lost takes place by the convection to the environment while 78 percent of the heat lost takes place by evaporation.

On the other hand, for 16 degree centigrade of the air temperature and a 14 degree 49 degree of the wall temperature, the 79 percent of the heat lost takes place by the convection and a 21 percent of the heat lost to the environment from the body takes place by the radiation by evaporation. And, the so here we can see the air temperature and wall temperature significantly affect the way by which heat lost to the environment takes place by the different modes of the heat transfer for the too high air and water air and wall temperature. The heat lost mainly takes place by the evaporation, while for the low temperature conditions it is the combination of all three where convection dominates and the evaporation is the minimum 1.

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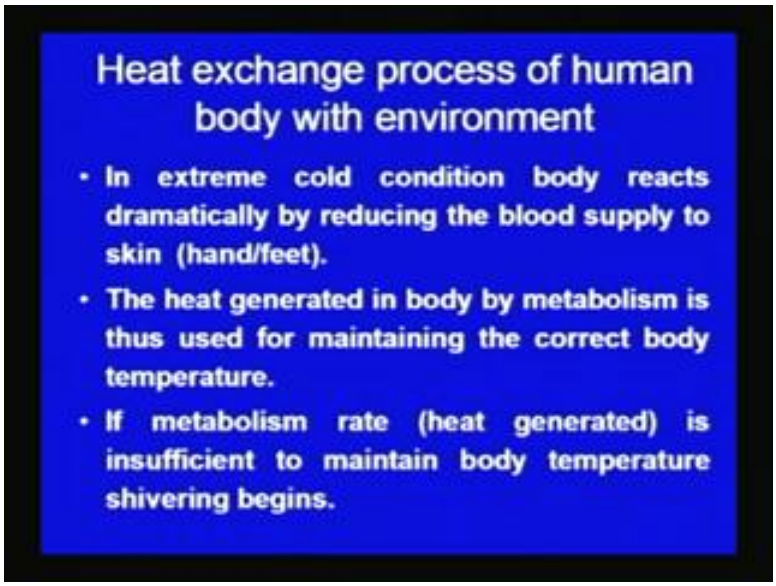

So, in extreme cold conditions to maintain the body temperature constant body reacts in different way, actually body reduces the supply of the blood especially to the hand and

feet, so that whatever heat is generated by the metabolism reaction can be conserved. Heat generated in the body by the metabolism process is thus used to maintain the body temperature constant, if the metabolic rate that is the heat generated is insufficient to maintain the body temperature then, the shivering begins and under such conditions the operator may lose the control over the movement of the body parts and that is why it effects his performance.

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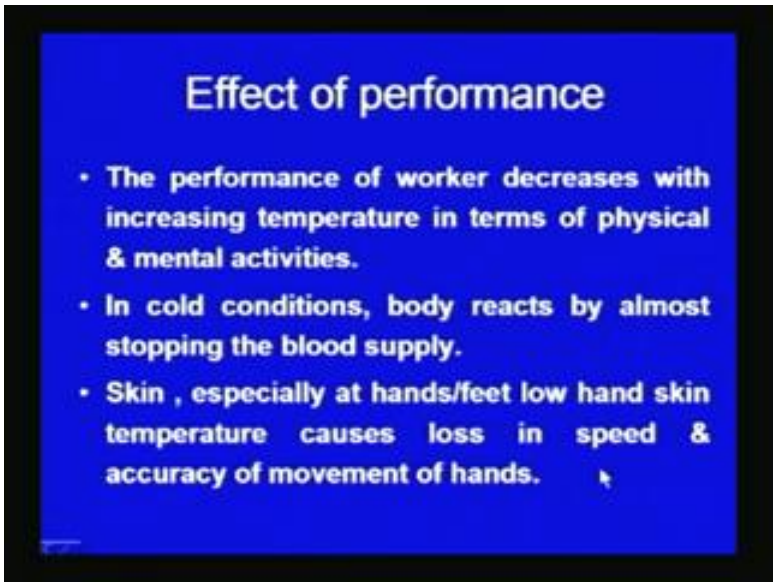

Performance of worker in general decreases with the increasing temperature in terms of the physical and mental activity, if the temperature is too high and very severe activities to be carried out that also adversely affects the performance of the worker. And, under cold condition if the body temperature is reduced significantly then, to maintain the body temperature constant the blood supply to the hand and skin is reduced which in turn leads to situation where at the control over the movement of hands and the feet in terms of the speed and accuracy decreases.

And, that is why the skin when the blood supply to the skin is reduced especially at hands and the feet on the skin temperature significant decrease in the skin temperature leads to the loss in a speed and the accuracy of the movement of the hands. So, those activities which require close control over the speed and movement of hands are adversely affected, especially under the low temperature conditions.

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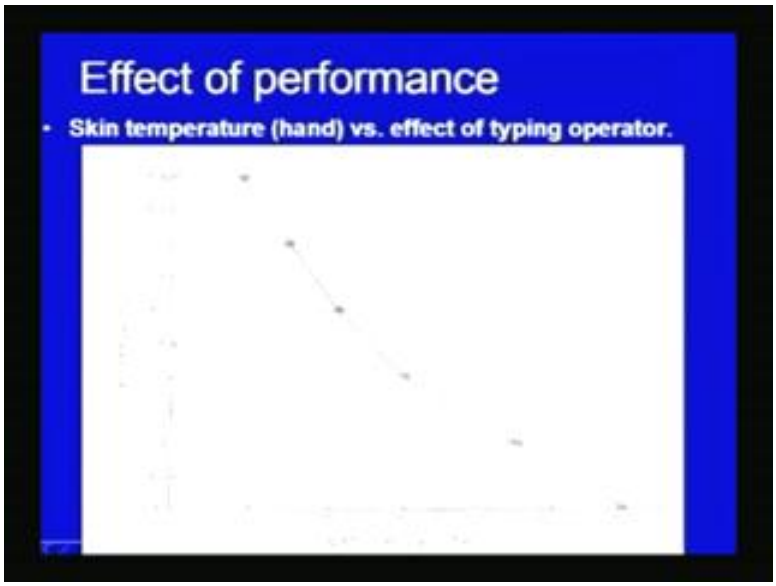

For example, an operator or the typist type typing efficiency is very adversely affected under the low temperature conditions, we can see here at the temperature around 30 to 34 degree centigrade is efficiency is typing efficiency is say 100 percent and then, with the reduction in temperature down to the 16 or 14 degree, it is reduce to the about 50 percent. So, here efficiency of worker for those activities were close control over the movement of the hands or the feet is required efficiency of the operator decreases rapidly with the reduction in the skin temperature.

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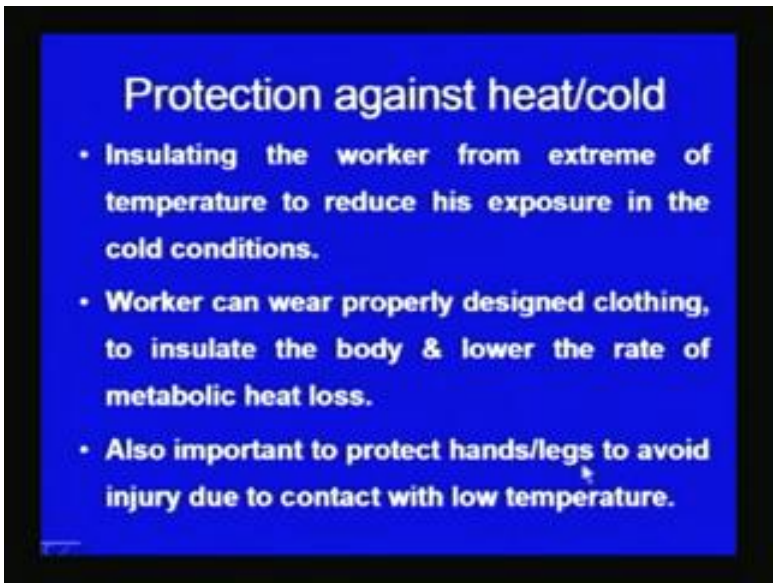

And therefore, to avoid the adverse affect of the high or low temperature, temperatures on the human body and his performance it is necessary that the operators are protected from the excessive heat or the cold conditions. And, for this purpose the workers are insulated from the extreme temperature conditions, so that their exposure to the extreme low or high temperature conditions can be reduced.

The best purpose means the best way to protect the worker under the cold conditions is to insulate the worker from the environmental condition, so whatever heat is generated by the metabolism process that is conserved and a retained within the, in close us which will be used by the worker inform of the clothing. The workers can wear properly designed clothing to insulate the body and lower them metabolic heat loss.

So, the metabolic heat is basically use to maintain the body temperature under the cold conditions by using especially designed clothing which will help to reduce the heat losses to environment the heat which is generated by the metabolic process. But, under such conditions it is also important that, hands and legs do not come in contact of the very low temperature conditions because, this can be harmful and this can very low temperature conditions can damage to the hands or the legs which can come across or which will come across the very low temperature conditions.

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To cope with the hot condition is for more difficult compared to the cold conditions because, hot conditions also come along with fire hazards, protective clothing should not

cover to protect the worker from the excessive hot conditions just by complete covering of the human body. If protective clothing should not cover the whole body until unless, it is very important and absolutely necessary.

Because, heat generated by the body is should also be dissipated and most of the heat is generated by the body is dissipated through the legs and hands, therefore effort should be made that the legs and hands are kept open unless, it is absolutely important to protect the whole of the body from the extreme hot conditions. So, now I shall conclude this presentation, this presentation we have seen the role of the metabolism in effective organization of the work.

So, that the time when worker should start the rest period and the time for which the rest should be given can be obtain very effectively, so that the work can be done by the operator without undue fatigue and he can continue the, new the job for long time. At the same time we have also covered that the, what is the role of the heat transfer from the body to the environment and how the workers should be protected from the excessive cold or hot conditions.

Thank you for your attention please.