Applied Ergonomics

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Module - 02
Lecture – 10

Hello and welcome to this lecture 10 of Applied Ergonomics. We were talking about manual systems in the last lecture. Particularly manual systems related to works study where there is the involvement from manual subjects and also hand tools. So, basically the power that goes in to any operations comes from a human subjects that is how you interpret the manual systems. We also talked about briefly about various other systems like man machine systems as well as fully automated systems all though we did not (Refer Time: 00:45) in to the details of it.

So, this particular lecture is intended to give you an idea of what we mean when we talk about man machine systems or automated systems, what are the different associated (Refer Time: 00:55) associated with these systems. So, let us look at what we mean by a Worker-Machine System or a man machine system.

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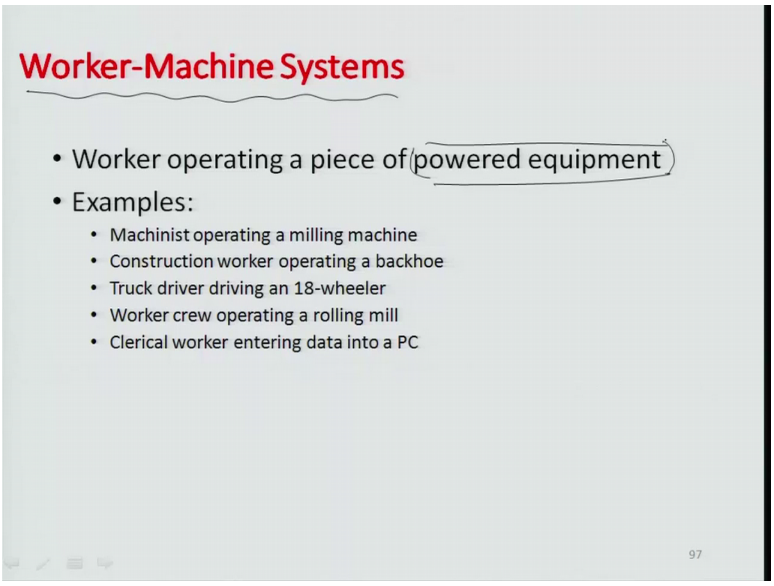

So, as from early definition it is quite clear that if we are using powered equipments where there is a scope of doing on own by the equipment concerned it is considered to be a work and machine system. Of course, the role of a worker there is completely related to loading unloading, you know changing the different condition of machining, or even the tools from time to time and the support system that in general needs to be done for an interrupted operation sequence on the machine is being provided by the workers.

So, he is an very important component in such complex systems, but once the loading unloading has been done on the basic operation this to be performed power does not come by the human subjects, but from the machine itself and power could come for example, in a transfer press which is mechanical from a big motor or for example, hydraulic on a big set of cylinders with different oil and other pneumatics circuitry associated oil circuitry associated.

So, these are classified in to worker machine system some examples could be Machinist operating a milling machine once the milling machine has been set up the indexing has been done the arbor as well as the tooling as well as the work pieces mounted, now it is left after switch on button you know it is left on to the motor of the milling machine to perform the power addition to the machine and drive the various stages in sequence.

So, that there can be gear cutting or something some operation which can happen or it is intended to happen. Similarly is the plight of a construction worker operating on a backhoe or a truck driver driving 18-wheeler. So, basically all the power that is needed to carry the load, push the vehicle is done by the engine, but the control on the engineers on the truck driver, who basically is the worker for such a worker machine system. There could be other examples like worker crew worker crew operating on rolling mill or a clerical worker entering data into a PC. So, all the data entries steps and preservation in to memory both you know random access memory and read only memory are done by the PC through a powered mode, but the clerical worker is helpful for just inserting relevant data. So, all the computation the processing is done by the processor

So, these are examples from daily life of worker machine systems now there are different relatives strengths and weaknesses that any system does have in case of strengths, for humans you know there are various strength components which might considered for example, human subjects can sense unexpected stimuli can respond to such changes in stimuli they can also solve problems quickly cope with abstract problems through knowledge as well as intuition adopt to change for example, there is a sudden change condition there is a quick adaptability generalized from observations.

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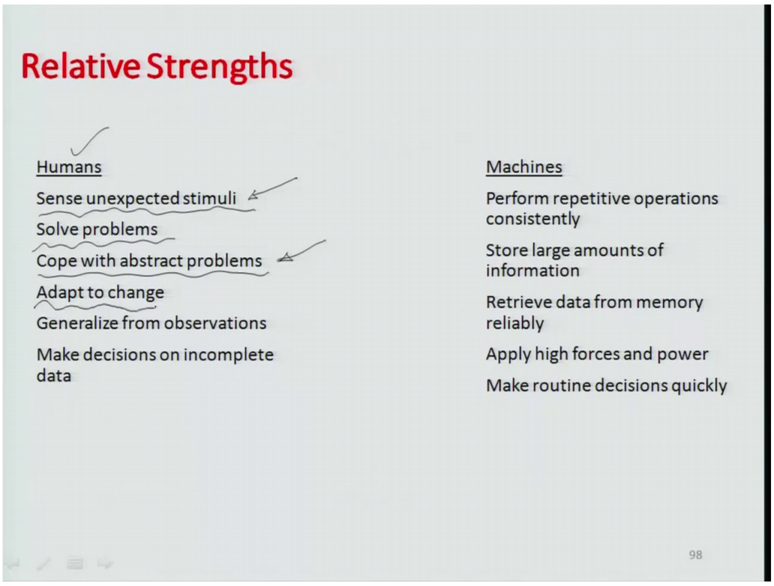

So if you have experiential observation then that is the best part which person can use knowledge (Refer Time: 04:14) from previous work sphere and apply as apply to the current work sphere for any changing situation or a problem which emerges. So, these are some of the relative strengths, also make decisions on incomplete data. So, these are some strengths related with the human subjects.

However, when we talk about strengths related to the machines, the biggest strength of the machine would have is the that the perform repetitive operation consistently there is the powered mode there is a distribution of power and all it needs to set up the power in a particular manner. So, that there is repetition of tasks and taken by the machine, it can store large amounts of information. So, there is the capability in nowadays of both storing as well as processing where you can retrieve the data from the memory reliably apply high forces and power based on some of the data which comes and make routine decisions quickly.

So, these are some very important strengths that machines would have and so basically the idea behind designing the worker machine system is to combined the relative strengths of each with respect to one other. So, that there can be a correct mapping h in that sense. So, when we talk about different powered equipments there are different Power Equipments available based on whether they are portable or mobile or stationary?

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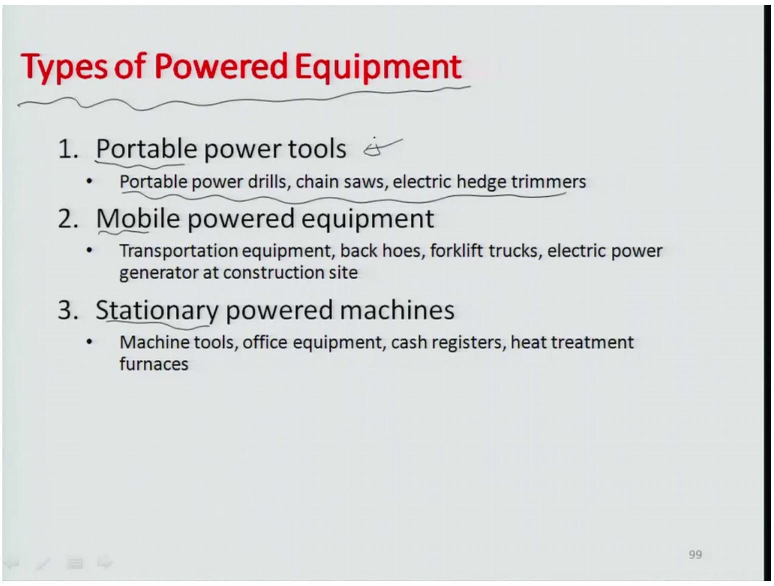

So, for example, let us look at portable power drills chain saws electric hedge trimmers these are some equipments which are power tools they are actually either having a weir weird orientation or even a battery operated orientation or in some cases for example, when we talk about chain saw etcetera there can also be you know or electric hedge; hedge trimmer they can also be engines associated with such tools. So, there is some source which emanates the power and it is mobile or it is portable not mobile really, but portable. So, basically you can lift from one place to another and you can do different operations through that such kind of tools, there are mobile power tools where there is you know certain mobility like for example, an engine mounted on the top of a Chasey moving ahead.

For example, in case of forklift trucks for example, or let say generators which are transported to the construction site, to generate electric power, transportation equipment as such all cars buses trucks all railway systems, railway engines, they are all associated with a power unit which is in form of an engine or which in form of a generator even some times gas turbines smaller in size which would actually be able to go from one place to another through.

You know in a in a Chasey driven carriage. So, those are mobile powered equipments. So, these equipments are typically used in a lot of heavy industry work then there are stationery powered machines for example, there are machine tools lathe milling, where there is need and necessity of somehow preventing vibration by creating a firm base and then grouting a machine to a certain area. So, it makes the equipment completely stationery at a certain place you have office equipment, cash registers, heat treatment furnaces, where if you station it at a place generally it is not advisable to move it out of that place.

So, these are sort of powered equipments in various industrial and other work machine systems which have different types based on how they perform what they are supposedly performing on sort of a classification into the different you know types of how they can be carried out or carried over or how power can be applied.

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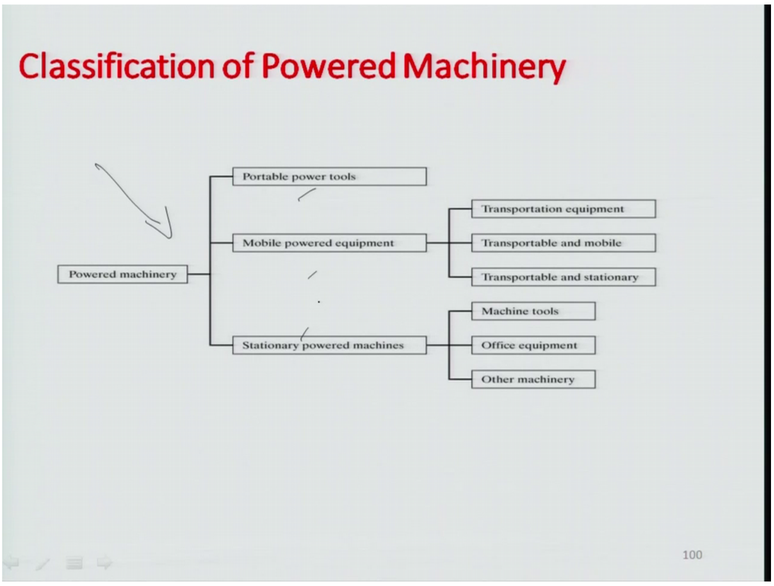

So, there can also be differences in terms of the numbers of workers and the number of machines associated with each other for example, there can be a case of one worker one machine let us look at the example of a taxi cab driver and taxi. So, this is something which is talking about the taxi being the machine and the taxi cab driver being the worker itself. So, this exactly one person controlling one machine, there can be a case were one worker controls multiple machines for example, sometimes there may be more than one machines in a machine cluster. So, let us say we are talking about an engine automotive engine shop and there are multiple machining centers on this engine shop.

Typically they are done on a s type layout on a u type layout where there a machines and inspections stations in between and such machining clusters are also referred to commonly as transfer lines, where there is a entry of the object or the work piece to the machine from one side and it goes through roller conveyors as it goes to the different machining stations, where there is a continuously loading unloading and also inspection carried out.

So, in such kind of systems there may be multiple machining centers all running on CNC capabilities of process which are fairly automatic in nature, but then there are sudden operators who are involved in loading the work piece checking the work piece for it is initial let say cylinder finish of the cylinder liner etcetera. And then later on as the equipment later on as the unit the work unit moves ahead it completely goes to the machine domain and then comes out back you know again when the operator can finally, inspect and take back and carry it or load it to another container.

So, this is one worker multiple machines kind of situation there can be also a case of multiple workers one machine for example, let say when we talk about running a big transportation unit like a ship or for example, an Airplane or even like you know a Train there are going to be multiple stake holders who will be associated with running this for example, typically an airplane as a pilot and a co pilot. So, there are more than one workers for this one machine to carry ahead or even in railway engines or in railway in trains.

There may be 3 4 operators 2 of them on the engine side one on the signaling side and so there is a way that they communicate with each other and run this whole systems. So, this again a example of multiple workers one machine. There can also be case of multiple workers multiple machines for example, when we talk about emergency repair crew responding to machine breakdowns, it is possible that you have to remove the problem or you have to start the facility in a relatively shorter amount of time and it may be worthwhile to put more than one skilled people on the job, who can actually go to multiple work centers and who can take corrective actions or measures. So, that quickly the system can be revamped or set initially back 0 conditions so that it can operate.

So, this is a case where you have multiple workers and multiple machines. So, there are numerous such examples where the number of workers and machine could vary with respect to one another when we talk about worker machine system design. So, then we talk about the level of operator attention which is involved in such systems. So, for example, there can be cases where the operator who is involved in performing on the work machine system may have to give attention for full amount of time that is involved with the machine.

Let us talk about a case of welder or welding operation performed by arc welding. So, the arc is generated whenever the operator itself the operator concerned is basically able to take the carbon electrode very near the take the electrode welding electrode very near the work piece and then suddenly shift back so that there is an arc created.

Now, once the arc is created then it is completely in the operators control and the gap needs to be maintained. So, that there is on one side molten flow of material, whether electrode size reduces in the gap needs to be continuously changed or gap needs to be continuously maintained by the worker by moving the molting melting electrode nearer and nearer to the work piece.

So, that you know you can ensure that the arc sustains itself. So, these kind of operation does involve almost full time attention for the person concerned person working on the system or if I talk about let say a slightly automated mode, where we are talking about let us say tungsten in a gas welding or some other process, where there is a feed stock which is actually giving a wire electrode and feeding it out away from the nozzle, but still there is always tendency of the concern unless it is fully automatic machine there is a tendency of the worker to actually guide the nozzle in to the area where welding has to be executed. Therefore, there is always a full scale attention of this worker till and until the welding process the actual process of molten metal reflowing into or flowing into the gap and joining to let us say parent metals that that process continues. So, these are all processes which would seek full time attention.

There are also part time attention during each work cycle kind of systems for example, I talk to you about a machine shop where the only work that could be done let us we are talking, but a CNC machine. So, only work which could be performed by a worker unless there is some in between in intervention needed because of programming error or some other issue during the cycle. So, it is at the beginning of the cycle and end of the cycle and the beginning of the cycle typically has work component like loading unloading even change of tooling inspection of tooling so on so forth.

And then towards the end of the cycle again these issues are revisited so that the next cycle can be started. So, in that kind of a set up you do not need to continuously attend to the machine once you have loaded unloaded the sample and then you know also checked about the tooling systems etcetera and you have also seen that all the 0 setting is being done, all the let say backless errors etcetera have been removed then you leave it on to the machine and let the work cycle continue on it is own.

So, during the time the work cycle is continuing even if you do not attend to the machine is going to do it is job properly. So, therefore, you need only part time attention during each work cycle in such cases. So, we say that worker loading and unloading a production machine on semi automatic cycle could be such an example, there can be other cases where the level of attention could be periodic with regular servicing. For example, when we operate a crane in a steel mill you need to be also very careful about probably at every shift end seeing all the joints and all the cables and inspecting the different.

Let us say components associated with the crane for snap age snap and breakage and also fatigue. So, that you know you do not have any accidents you know in the next cycle of operation. So, there is a preventive maintenance which is a needed probably at the end of every shift or end of every let us say work cycle sometimes work cycle period sometimes, because you need to make sure that the object after servicing is safe enough for the next cycle or it can get carried away in the next cycle without much of a problem.

So, such attention systems or such systems can be referred to as system where the worker is periodically attending to the to the concerned problem and then there could be another kind of system where there is periodic attention with random servicing

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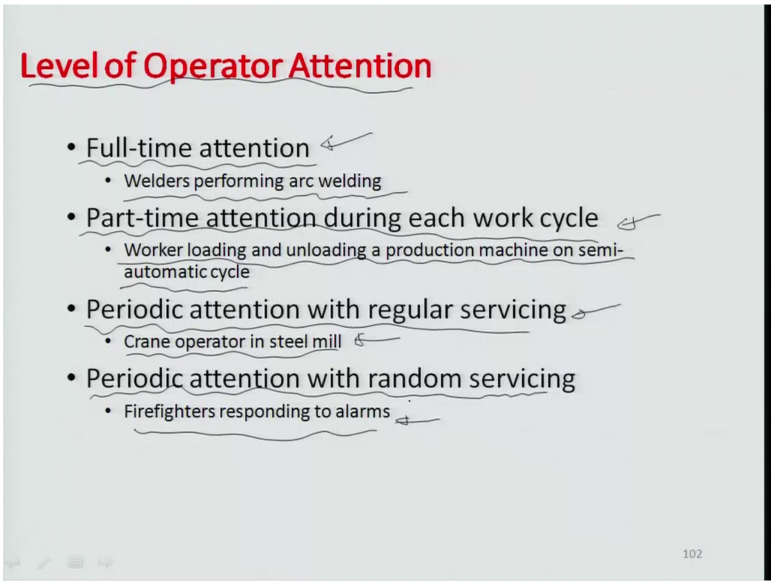

For example, there could be firefighters responding to alarms so these are some issues where the alarm can only be set in when there is one in a kind of incident of a smoke or fire coming out of a building, and in order to show the emergency preparedness there are also fire drills from time to time where the alarm is set off you know intentionally to see how prepared the team is to address the issue so, but then in this particular case the attention falls in a periodic manner, but you know on a random basis the demand comes up for such service or such attention and so you have to be prepared you have to have wing of you organization which is already prepared to meet any such kind of emergency level operations.

So, these are the different levels of operator attentions that could one could possibly think of when designing the worker machine system. We can then look at you know cycle time analysis for such systems, we have done same in case of manual systems. So, in case of worker machine systems, we also have is scope for analyzing how much time would be needed to execute a particular operation on such worker machine system.

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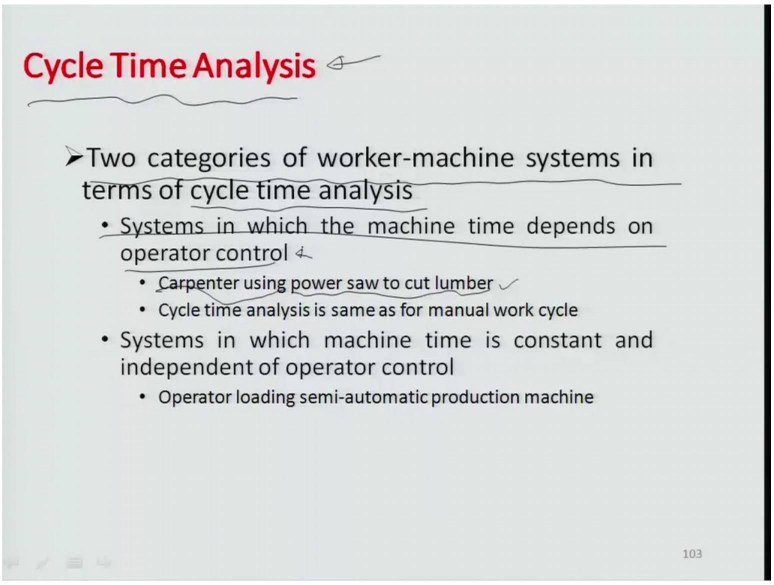

So, there are typically 2 categories in terms of cycle time analysis of such systems you know or what kind cycle time is related to those system in which machine time depends on operator control. In fact, if I looked at a power saw being operated or a let us say you know power saw used for cutting the lumber by a carpenter or. In fact, let us say we when we are talking about digging drills for concrete etcetera where section of the road is being excavated.

So, in these kind of situations whenever the operator initiates the work machine is barely an aid to give a power factor to his work, and those in those systems the you can say that machine time totally depends on the operator control, if today if you have operator who is actually let us say working for at 50 percent efficiency throughout a shift of about 4 hours it means that if he has or if he has been allocated to such a work centre where his operation is dependent on how much can be get how much can be done really with the power tool that he uses as a aid.

So, in that event the efficiency of the machine even though there is a capital investment will fall down. So, typically when do you do job alignments you have to look at the efficiency of individuals and those people who are more efficient to a job will typically be aligned to machines which are where the cycle time depends on the worker itself.

So, you are using the powered tool for all times to get more amount of work done that is the whole idea, while doing a work system designed for worker machine kind of systems. So, the cycle time analysis is same as manual work cycle because; obviously, whenever the effort is being done by the human being the power although coming from machine does not make much of a difference of the time you know. So, that amount of time that the human being does effort in terms of let us say thinking or pressing buttons or you know somehow controlling machine would typically be the work that is being rendered by the machine itself. There is no additional work in come done by the machine when it is come to finding out the total working time.

Now there may be another yet another class of machines where machine time is constant and independent of operator control for example, let us say system which is semi-automatic for example, we were talking about this transfer lines for machine shops which has a cluster of CNC machines.

So, here the loading unloading time is quote unquote the time which the operator needs apart from that whatever is being done is being carried out by a machine with a machine cycle time. So, once the machine has been loaded and it is being powered on then really everything is out of control of the operator and in control of the processor.

And so in such cases also the cycle time of the machine depends on the program or in the control the level of control that is there in the machine rather than on operator, but there is a small component of the operator contributing in terms of loading unloading which shifts that start point ahead in time and which may lead to an overall extension in the work cycle times so.

So, there we have to also see how much delay is be done by the operator for actually the productive cycle of the machine to sort of (Refer Time: 21:02) all portions of the working time cycle in totality. So, such analysis has to be carried out in terms of classifying systems in 2 where it depends totally on operator what is a machining time and in system to where depends on the machine, but subjected to the fact when the operator starts the machine. So, that is how you analyze for cycle time in these work machine systems.

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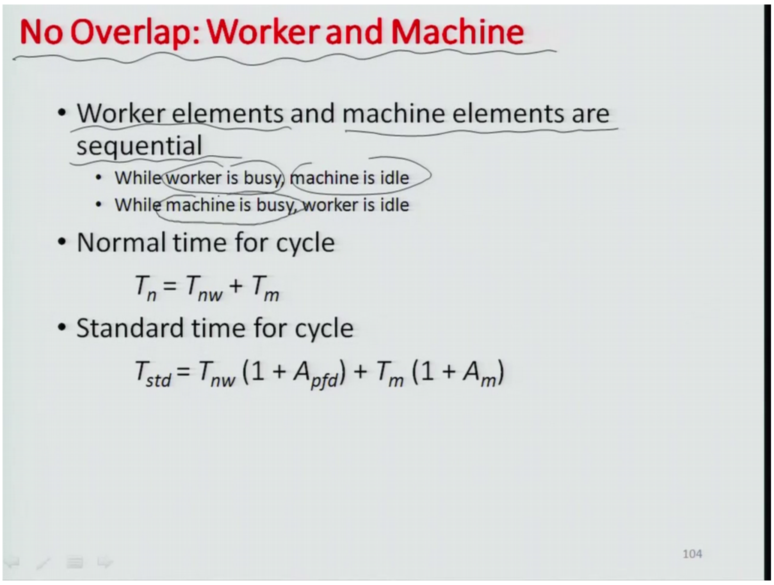

So there is typically no overlap between worker and machine typically worker to work elements and machine elements are sort of worker elements and machine elements are sequential in a nature for example, when the worker is busy and the machine is idle and vice versa.

So, therefore, while studying or while let us say demarcating into different elements of work it is important for one to estimate what is the total amount of time spent by the worker for the cycle to operate and the machine time in unison. So, in such a case the normal time of the cycle the work cycle can be refer to as the time which is needed for the worker to perform normally, where he initiates the machine or starts the machine plus the machine time. These are added together in sequence for estimating the normal time.

So, in this particular case if you wanted computed the standard time the standard time would really be related to the normal time of a worker times the allowance factor here due to various issues like delays or performs or fatigue kind of factors and I think we have extensively discussed this while doing manual work systems as well as work systems in general.

And then there is similar kind of idle time related to machining because; obviously, there are certain slacks in time which you cannot avoid for example, slack involved in co locating something to the origin or re setting back the machine, there is a stage movement which happens from the existing position particularly in CNC based controls from the existing position that the machine is an to the position which is refer is 0. These kind of motions are out of control and these kind of machine do consume time and so therefore, there has to been an allowance factor for calculating the even machining time with such kind of machining based you know idle components which are necessary evils.

Therefore, the standard time of the cycle now is obtained through this particular formulation here talks about the normal time of the worker plus times away 1 plus A pfd plus the normal the total time that the machine would be operating or the cycle time of machine times of 1 plus idle time or let us say the allowance factor given to the machine.

So, this is have you calculate the standard time for whole work cycle. So, mind you in the only worker or only manual system this was completely dependent on the worker and so this component was 0 or missing in this particular system because there is a sequence which is followed where the worker first works and then the machine starts operating. So, therefore, both the times are included for calculating the overall cycle time sequence.

So, that is how you calculate the worker machine with the assuming almost no overlap between the ending of one processor operation in starting of the other. So, then we can classify work elements into internal and external types generally it is probably a prudent idea to make work more and more work elements of the internal type and let us look at what they are. So, some of the worker elements are performed while the machine is working so you can say that the internal work elements are performed simultaneously with machine cycle and the external work elements are were work is performed outside the machining cycle.

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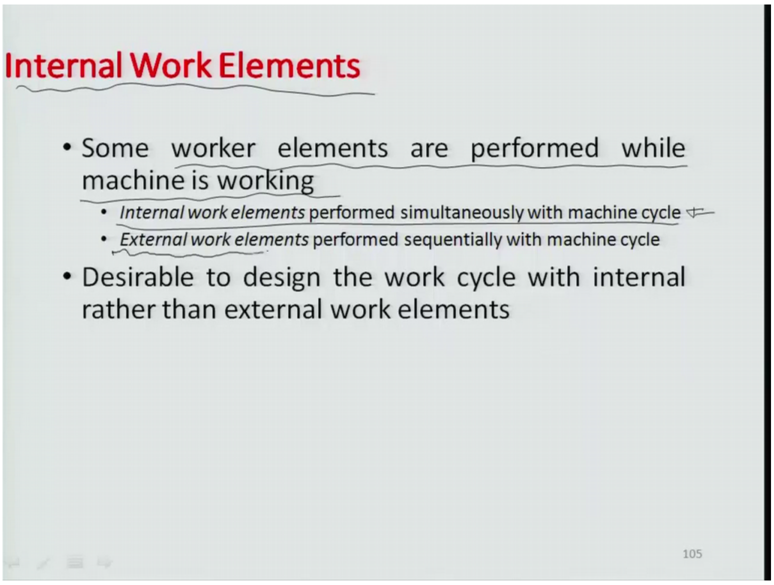

So, now, if the machining cycle includes loading unloading and the operation time something like rework, which may come because of inappropriate machining could be consider as the external work element because it is outside the cycle time it is happen one in a basis one let us say one in hundred cases or something where you need reworking, because probably tooling a got damaged in that particular machine cycle or something happened and it is quite random it is not that it will pop up in every cycle.

So, in such kind of cases these are the external work elements which are out of the machining cycle which otherwise includes on the loading unloading the inspection and the machining time.

So, we must in our whole design agenda try to put more emphasis on as much as internal work elements and reduce as much as external work elements from a system. So, if you can avoid non compliances where there are sudden pop ups of work elements which are outside the cycle and which are undesirable, they should be avoided as much as possible that is the whole idea behind designing.

So, when you are trying to look at work elements and you know it is always prudent for you to generate as much as internal work elements probably you take some more inspection measures within the machining operation. So, that such kind of non compliances sell the (Refer Time: 26:43) or the percentage reduces more may they become in p p m. So, try to avoid the external work elements which will perform sequentially with the machine cycle. So, while designing the work cycle.

So, now I think we will focus a little more on Automated Work Systems and what do you mean by this terminology.

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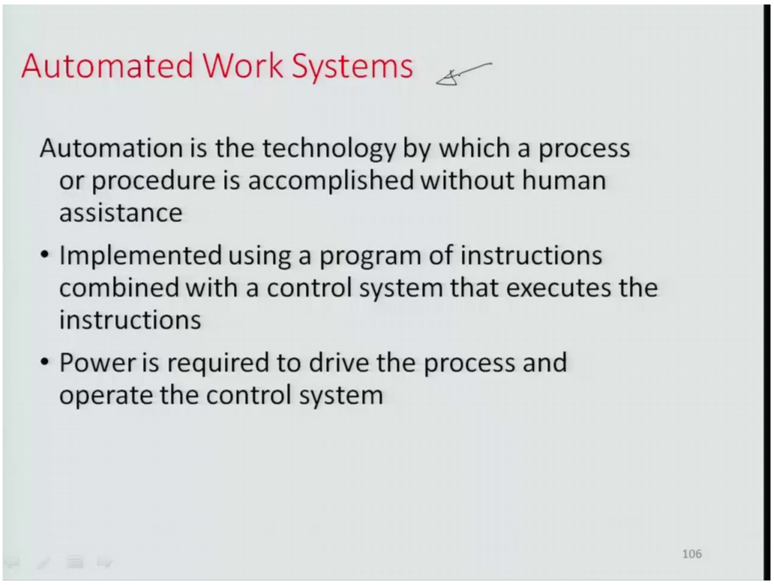

So, for we have looked at manual systems and manual or machine work systems, but we have not really looked at cases were everything is controlled by a set of Robos or a set of machines which are there on the line for example, we will talk about p c b assemblies or let us say electronic assemblies for different components like handy cams or video camera or let us say even you know record players or CD players. So, we are looking at assembly lines which are completely operated through a set of Robos and there is hardly any human intervention there. So, such kind of a work system where automation as a technology is used by a which process or a procedure is accomplished without any human assistance is known as automated work system.

So, an automated work system typically would then be implemented using a program of instructions, which are timed in a way and they are combined with the control system that executes such instruction in a proper manner in a and things related to cycle time etcetera are pre defined in the programs. So, what you are trying to establish is to standardize everything in terms of what you layout in terms of such program codes and now it all remains as to how the controller interprets it and implements it and how fast it is or rapid it is and there you have very less possibility of slag because all controllers are design to operator at quite a bit of speed. So, how much so it all depends on how much time the process takes to really process the data and implement the data.

And so therefore, you have everything more deterministic in nature and very less chances of miss occurrence or let say things which will create you know external elements work elements and everything can be within the cycle or planned within the cycle or cycle time accordingly. So, power is typically required to drive the process and operate such a control system there a many examples of semi automated and fully automated machines.

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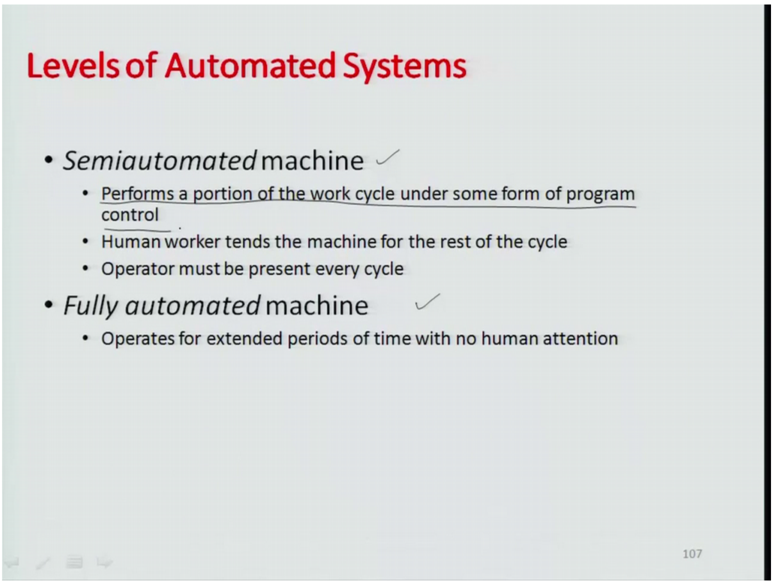

For example, if I looked at the levels of automated systems there can be Semiautomatic machines which perform a portion of the work cycle under some form of program control, there is a human subject or a worker who tends the machine for rest of the cycle for example, loading unloading or may be even checking the tooling quality as well as that of the you know the machine work piece operator has to be there in every cycle because unless his attention is there to start and stop the process the process would not work.

And then there is a fully automated machine which operates and extent for extended periods of time with no human attention. So, such systems are were all you need to do is to sort of press a button and everything else it taken care of by the system alone. So, this particular photograph shows automatic robotics spot welding cell on assembly line for you know the photo has been pulled from Ford Motor Corporation. So, you can see these welding Robos typically put spots.

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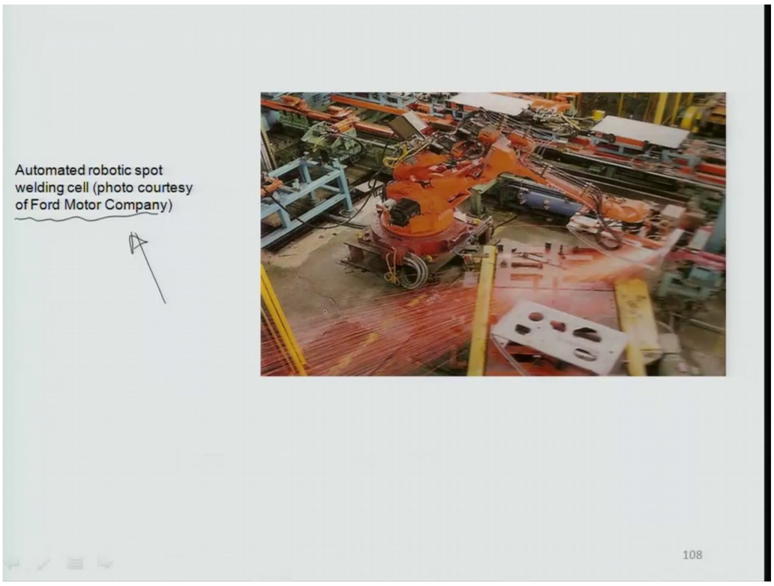

So, spot welding is mostly the most common means of welding carried out in automotive assemblies. So, here for example, the Robo is probably working on machine panel or a press panel which is a section of a car and trying to create some spot welds between 2 or more sheets and so such a system can be called fully automatic system because once you have switched on the press button it is pretty much out of control of your domain unless the whole cycle gets executed and the machine is ready for the next cycle.

So, I think will stop this lecture here, but in the next lecture we will talk a little more about industrial safety, hazards, some regulatory means and measures which are available and we will see how the factor of safety can be integrated with whatever we have set so far in terms of work system design. So, that it becomes you know overall a reasonable level of work environment for all sides including the human being as well as the work system side to work in harmony. So, we will finish this lecture as of now.

Thank you very much. Thanks.