Applied Ergonomics
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Module – 5
Lecture – 25

Hello everyone, welcome to the course Applied Ergonomics. And this is the last lecture module of this course and from the past two lecture module we are doing some problem solving examples on various topics, like in lecture 23, we did problems on productivity, in lecture 24, we did problems on cycle time analysis, manual work system. Now in this lecture module this is the last lecture module in this lecture module we will do some problems on cycle time analysis in worker machine system. Worker machine system it means it includes both systems workers as well as the machining time. So, this is a just you can say that this is the hybrid machining system and we will do problems on cycle time analysis how cycle time standard time calculated in this kind of hybrid systems.

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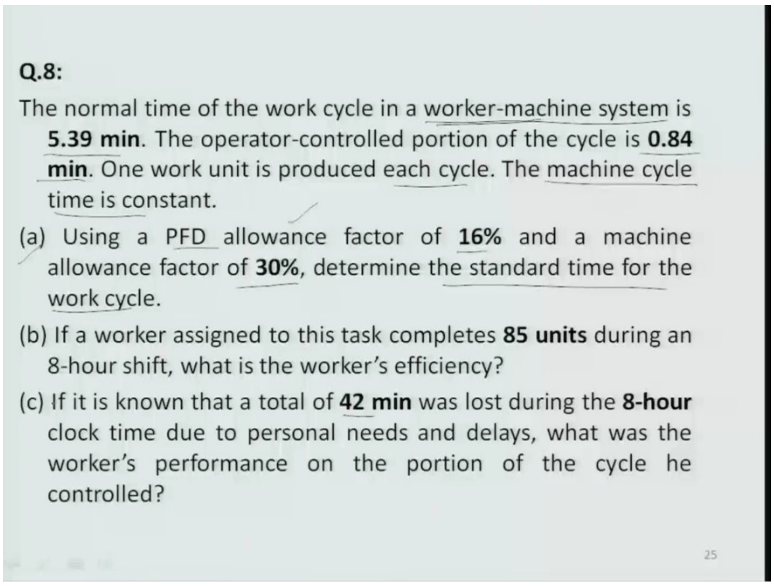

Now, come to the problem. now problem says that the normal time of the work cycle in a worker machine system is 5.39 minutes and the operator controlled portion of the cycle is 0.84 minute. One work unit is produced each cycle the machine cycle time is constant. These are some variables given in this problem and using these variables what will have to solve of in a using PFD allowance factor of 16 percent and a machine allowance factor of 30 percent determine the standard time for the work cycle.

It means first in part *a* we have to calculate the standard time for the work cycle given that allowance factor and machining factor and in part *b* first we will solve part *a* then we will come to the part *b* and part *c*.

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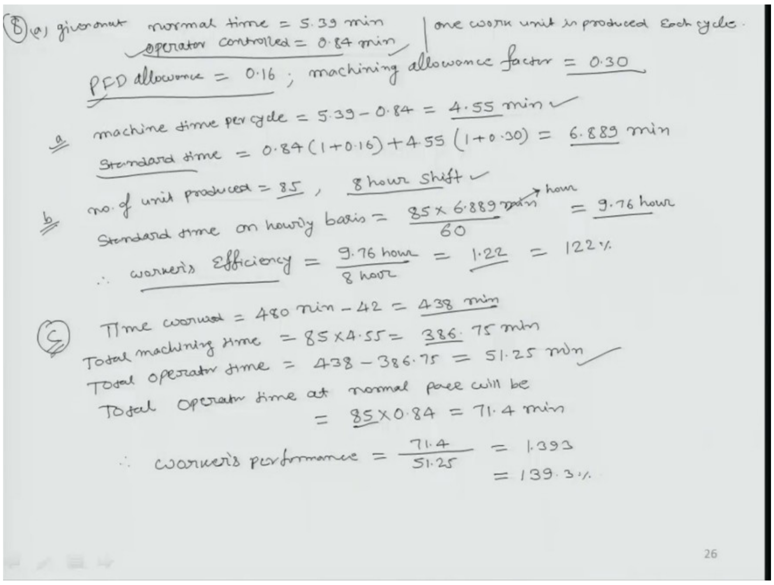

Given that normal time for the work cycle in the worker machine system what is the normal time? 5.39 minute and the operator control portion of the operator cycle time that is means operator controlled that is equal to 0.84 minute. And what other else is given? One work unit is produced each cycle, is produced each cycle and the machining cycle time is constant, other parameter are given allowance factor that is called PFD allowance that is equal to 0.16 and machining allowance factor that is given 30 percent means 0.30.

So, first we will calculate machine time per cycle machine, time per cycle. What will be the total normal time is 5.39 minute and operator controlled time is 0.84 minutes. So, we will subtract 5.39 with 0.89 minute that will be equal to 4.55 minutes. Now standard time that is equal to. first now operator controlled time is given 0.84 minute and associated with PFD allowance of PFD allowance is associated with operator controlled time that it means 0.84 minute multiplied by 1 plus 0.16 and because it is a hybrid process we have to include machine parameter also. So, what is the machine time that is 4.55 minute and machining allowance factor is given 0.30, 1 plus 0.30 that will be equal to 6.889 minute that is the standard time.

Now, we will come to the part b in part b what problem says if a worker assigned to this task completes 85 minute during an 8 hour shift what is the workers' efficiency, it means how many units they are produced 85 and standard shift is 8-hour shift, number of unit produced that is equal to 85 and 8-hour shift. And will have to calculate workers' efficiency. So, first what we will do? We will convert standard time in standard hour standard time on hourly basis what will be total unit is produced is 85 and standard time in minute is given as 6.889 minute and if we want to convert it in hour, so first what we will have to do? We will have to divide it by 60, so this will convert into hour. So, on calculation it will be 9.76 hour. Now what will be worker efficiency? Worker efficiency will be 9 standard time in hourly basis 9.76 hour and time standard time was allotted 8 hour so that is equal to 1.22, if you multiply it with hundred then it will be converted in percent so that will be 122 percent that is the workers efficiency.

Now, come to the part *c* if it is known that a total of 42 minute was lost during the 8 hour clock time due to the personal need and delay what was the workers performance on the portion of the cycle he controlled. There is an idle time of 42 minute so what we will do? We will calculate first how much time a worker worked time allotted was 8 hours it means 480 minute and idle time was 42 minute. So, net time will be 438 minute this is the time worked. Now total machining, time that is equal to number of unit produced 85 into machining time per cycle was the 4.55 minute. So, it will be equal to 386.75 minute.

Now total operator time this is will be equal to 438 minute was allotted work time minus this was the machine time. So, we have to subtract this one from 438. So, this will be the operator time and this is equal to 51.25 minute. So, total operator time at normal pace will be equal to 85 into this is the number of unit produced and the operator controlled time was 0.84 minute, so 0.84 that is equal to 71.4 minute. So, we will have to calculate workers performance, workers performance that will be equal to total operator time at normal pace that is 71.4 divided by total operator time allotted 51.25, that is equal to 1.393 and in percentage it will be 139.3 percent.

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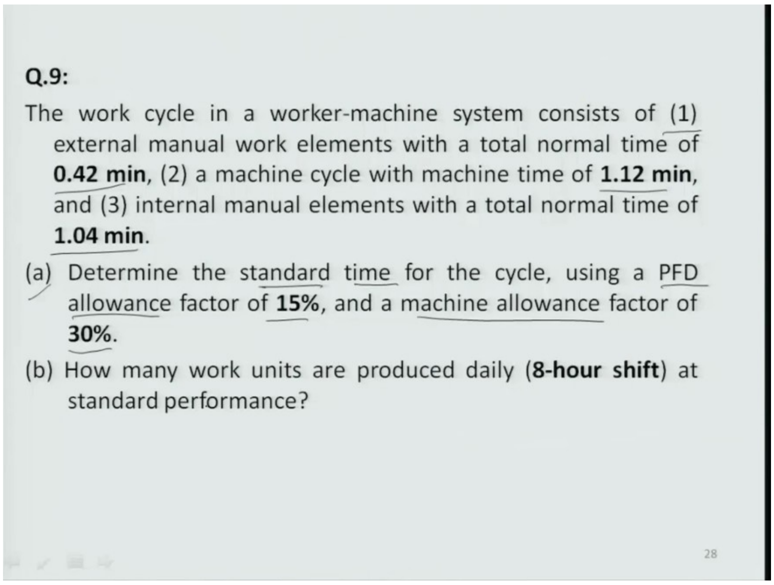

Now, we move to the question number 9 in this question this question is again based on to the worker machining system and we will have to calculate cycle time standard time this kind of things. So, what is the problem say the work cycle in a worker machine system consist of external first external manual work element with the total normal time of 0.42 minute and then machine cycle time with machine time of 1.12 minute and internal manual element with a total normal time of 1.04 minute and then determine the first part is saying determine the standard time for the cycle using a PFD allowance, personal fatigue delay allowance that is the PFD allowance factor of 15 percent and a machine allowance factor of 30 percent.

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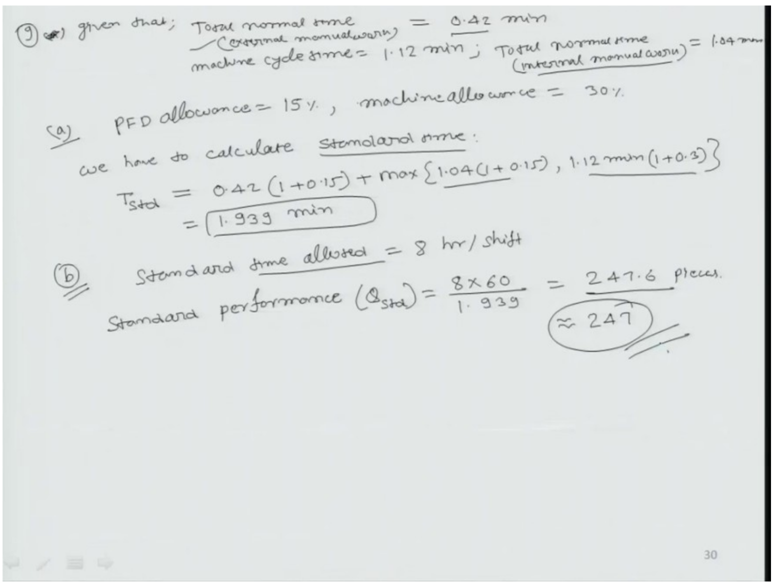

So, first we will have we will calculate standard time then we will come to the part b. In question number 9, given that sorry external manual work element with the total normal time that is the external manual work that is equal to 0.42 minute, machine cycle time with machining time hour that is equal to 1.12 minute and internal manual element with a total normal time total normal time that is the, this was the external manual work now this one is internal manual work that is equal to 1.04 minute. Now we will come to part a here PFD allowance what is there given that is equal to 15 percent and machining allowance factor that is equal to 30 percent. So, if you want to calculate the standard time we have to calculate standard time.

So, for standard time that is T_{std} that is equal to now see first will include total normal time for external manual work that is the 0.42 minute and this will be 0.42 and we are multiplied with PFD allowance means 1 plus 0.15. Then we will take maximum of maximum of total normal time that is the internal for with internal manual work that is the 1.04 multiplied with PFD allowance that is 0.15, 1 plus 0.15 and that is the another thing machine cycle time that is the 1.12 minute multiplied with 1 plus machining allowance means 0.3. So, if we will calculate you can see that there are a two things and we will consider n summation only maximum of two components and by on solving it we will get 1.939 minute that is the T standard time and by on solving it we will get 1.939 minute that is the T standard time.

Now, we will come to part b, part b is saying how many work unit are produced daily 8 hour shift at standard performance; that means, standard time allotted 8 hour per shift and on the basis of that we will calculate standard performance so what we will do? Standard performance we can signify it Q std that is equal to standard time allotted was the 8 hour per shift. So, 8 into and we will have to include since standard time we have calculated in minute, so will have to equalize the units, so will have to multiply it with 60 divided by standard time that is the 1.939. So, here it will come 247.6 pieces by rounding off by rounding off these term we; that means, that is equal to 247. It means the standard performance for 8 hour per shift that on given time that will be the number of pieces will be produced 247, that is this completes the question number 9.

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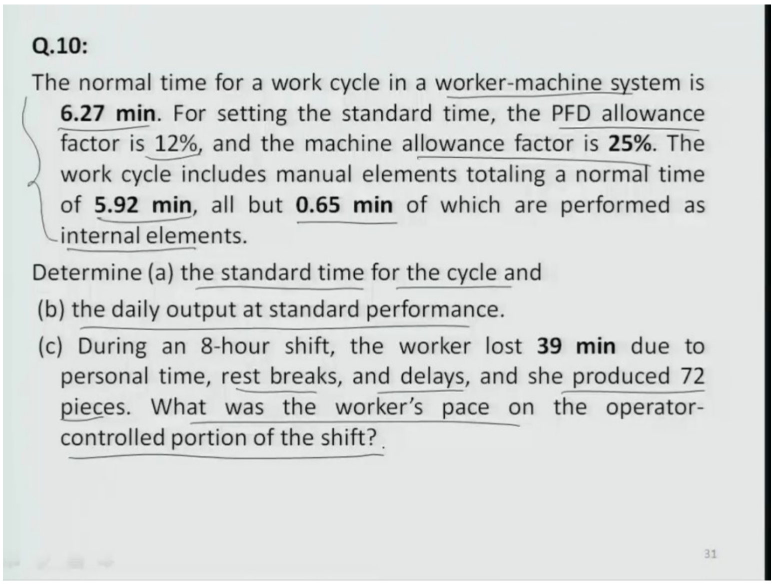

Now, now we will move to the next question. In this question problem what they are saying the normal time for a work cycle in a worker machine system again worker machine system is 6.27 minute. For setting the standard time the PFD allowance factor is 12 percent and the machine allowance factor is 25 percent. the work cycle includes manual elements totaling a normal time of 5.92 minute. All but 0.65 minute of which are performed as internal elements on basis of these statement will have to calculate determine the standard time for the cycle, then the daily output at standard performance, then part third is again this is the during an 8 hour shift the worker lost 39 minute due to personal time rest breaks and delays and produce 72 pieces what was the workers pace on the operator controlled portion of the shift.

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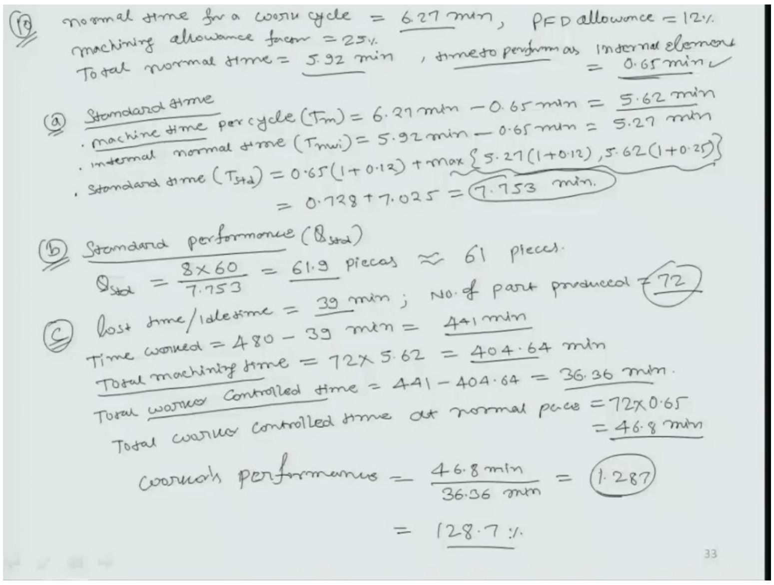

So, again we will first solve part one in part a and part b then we will come to the part c. In this question given that normal time for a work cycle is equal to 6.27 minute, PFD allowance that is equal to 12 percent and machining allowance factor that is equal to 25 percent. The work cycle includes manual element totaling a normal time of total normal time that is the 5.92 minute, total normal time that is equal to 5.92 minute and out of which 0.65 minute which are the performed as internal element time perform as internal element that is equal to 0.65 minute.

So, first we will calculate standard time. So, again this is the worker machine system. So, first we will have to separate out the machining time and worker time. So, we will do that machine time per cycle machine time per cycle that is equal to normal time for a work cycle was 6.27 minute, 6.27 minute minus and for internal element it was assigned 0.65 minute, so that will be the exact 5.62 minute. Now internal normal time T nwi is equal to total normal time was 5.92 minute and internal element 0.65 minute that is equal to 5.27 minute.

So, again we will use the formula for a standard time we will used in the question number 9. So, standard time that is equal to, first we will include our time to performed as a internal element 0.65 minute and 1 plus PFD allowance that is the one plus 0.12 plus maximum of 5.27 that is the internal normal time 1 plus 0.12 comma 5.62 multiplied by 1 plus 0.25 this one. So, from these expressions only maximum of either this one or this one will be included in this summation and then finally, what we will get 0.728 plus 7.025 that is equal to 7.753 minute that is the standard time.

Now, come to the part b, part b is saying the daily output at standard performance we have to calculate the standard performance for daily output then standard performance that is the Q std, Q std and standard time allotted for a worker we know that 8 hour and we will convert it into minutes, so it will have to multiplied with 60, then what was the standard time we calculated 7.753, so that will be equal to 61.9 pieces by rounding, rounding off these term it will it means approximately 61 pieces.

Now, come to the third part. Third part problem is saying during an 8 hour shift the worker lost 39 minutes means lost time or idle time that is equal to 39 minute due to the personal time rest break and delay and she produces 72 pieces', number of part equal to 72. So, what was the workers pace on the operator control portion of the shift we will have to calculate again workers performance workers standard performance. So, first we will do again we will have to calculate time worked exact because 39 minute was the standard idle time. So, for we will have to standard time allotted 8 hour. So, we will multiply it with 60 then it will be 480 minute minus 39 minute that is equal to 441 minute.

Then total machining time, we are talking about machining time. So, we have to considered how much part she has produced; that means, that is the 72 and how much time she has taken that is the machining time per cycle it is 5.62 minute and that is equal to 404.64 minute. Now total worker controlled time, this is the machining time now we will calculate total worker controlled time and in this case what is the exact time, time working time was 441 and machining time was this one, so will have to subtract 404.64 from 441. So, we will get 36.36 minute and this is the time worker has utilized or controlled.

So, now we will, because time to perform as internal element is given as 0.65 minute. So, we have to calculate total worker control time controlled time at normal pace time that is equal to number of parts he had produced 72 this one, multiplied by time allotted 0.65 minute and this was equal to 46.8 minute. So, this you can see that. So, workers performance what will be and this is equal to 46.8 minute this is the worker control time at normal pace divided by the worker control time allotted that is the 36.36. So, this is equal to 1.287. So, if you will multiply it with 100 then you can convert it in percentage 128.7 percentage; that means, you can say that workers' performance has been increased 28.7 percent.

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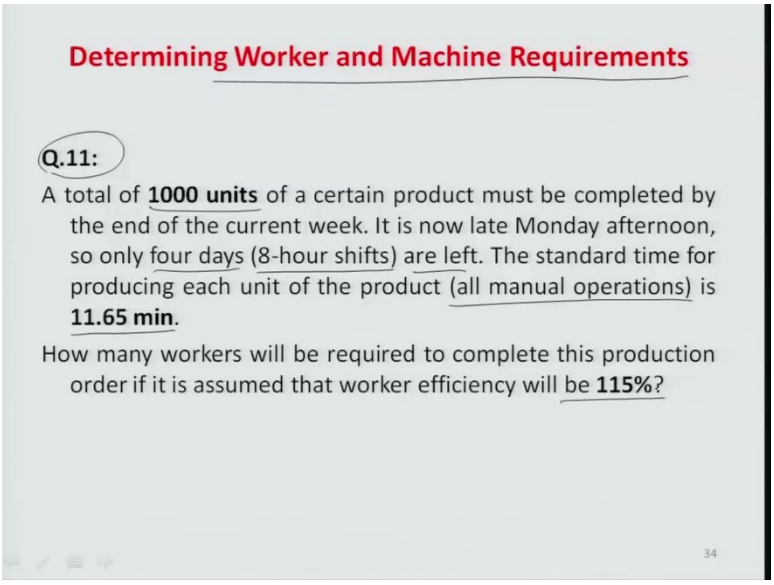

Now, now this is the third case we will solve that is the determine workers and machine requirements what are the requirements this is the different category of problems. Now in this one example you can see that problem is saying a total of 1000 units of certain must be completed by the end of the current week it is now late Monday afternoon. So, only 4 days 8 hour shifts are left it means the standard time for producing each unit of the product all manual operations is 11.65 minute. So, we have 1000 units of certain product and total producing standard time is 11.65 minute and we have 4 days then how many workers will be required to complete this production order if it is assumed that worker efficiency will be 115 percent.

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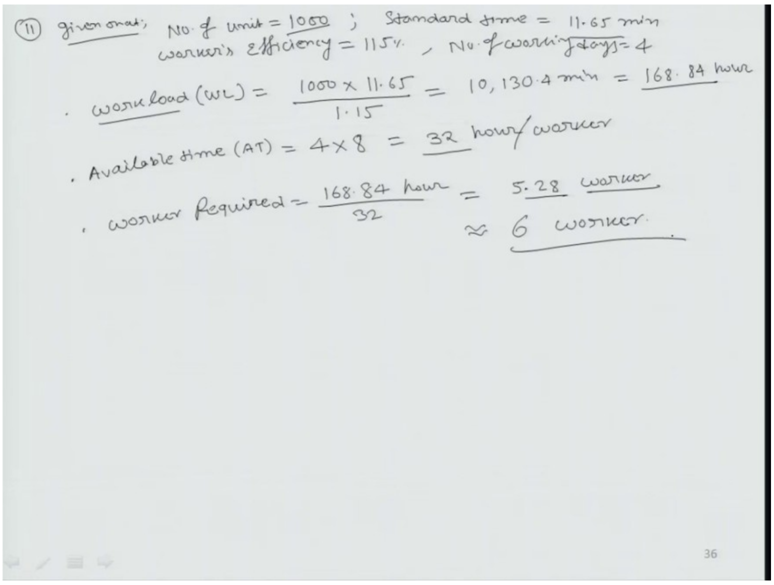

So, in this problem given that number of unit that is equal to 1000 and end of the time is saying standard time that is equal to 11.65 minute, workers' efficiency is equal to 115 percent and what else are given. So, now, we will have to calculate how many workers will be required to complete this production order means we will have to produce thousand pieces of work piece and standard time has given 11.65 minute and efficiency is 115 percent. So, first we will calculate work load that is equal to number of unit produced thousand that is to be produced into standard time 11.65 and what was the efficiency that is the 115 percent means 1.15. So, work load is that 10,130.4 minute if I will convert it into hour. So, we have to divide it by 60. So, it will get converted in 168.84 hour.

$$Work\,load=\frac{1000*11.65}{1.15}=10130.4\,min=168.84\,hr$$

Now, available time this is the work load. Now we have 4 working day we can mention here number of working days equal to 4, means four working day and in each day one worker will work for 8 hour. So, it will be 8 hour that is it means we have 32 hour per worker that is the available time now. So, what we will do worker required total work load is 168.84 hour and available time for one worker is 32 hours. So, if we divide by this one if you divide this 1 by 32 hour then we can get number of worker required. So, we will do that 168.84 hour divided by 32 means 5.28 worker since worker is a human being we cannot use this term. So, we have to round it and we will require 6 workers and so in this problem we saw that for a given number of production unit and standard time we can calculate how many workers will be required for to produce such amount of work.

$$Worker\ required = \frac{168.84}{32} = 5.28\ worker \approx 6\ worker$$

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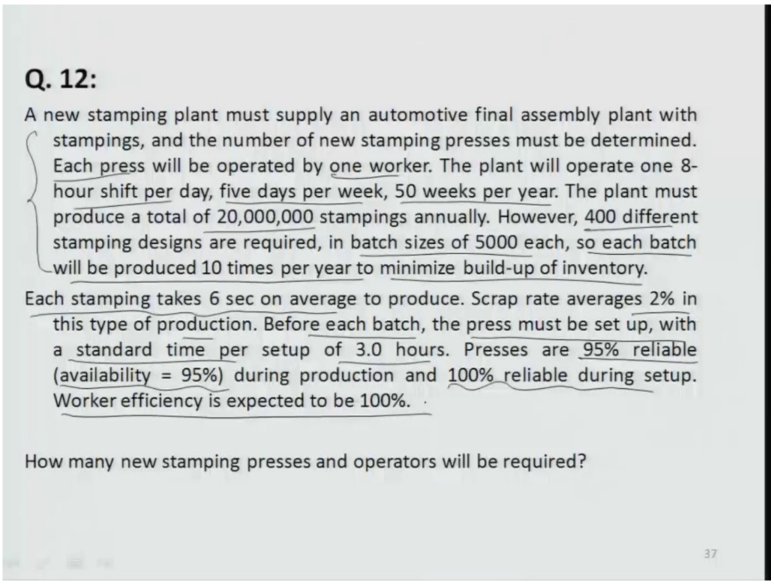

Now, in next problem and this problem says a new stamping plant must supply an auto motive final assembly plant with stampings and the number of new stamping presses must be determined. Each press will be operated by one worker, each press will be operated by one worker the plant will operate 8 hour shift per day 5 day per week Monday to Friday, 5th week per year and the plant must produce a two crore stampings annually. However, 400 different stamping designs are required in a batch size of 5000 each. So, each batch will be produced 10 times per year to minimize build up of inventory.

So, this is the problem statement and from this statement what we have to do an another with the statement is saying each stamping takes 6 seconds on average to produce scrap rate average 2 percent in this type of production before each batch the press must be set up with a standard time per setup of 3 hours. Presses are 95 percent reliable; that means, availability of press is 95 percent during production and 100 percent reliable during setup. So, worker efficiency is expected to be 100 percent. That is the expectation worker’s efficiency cannot be 100 percent, but that is the expectation how many new stamping. So, from these statements completes the statements what we will have to calculate how many new stamping presses and operators will be required means number of stamping presses and operator will be required.

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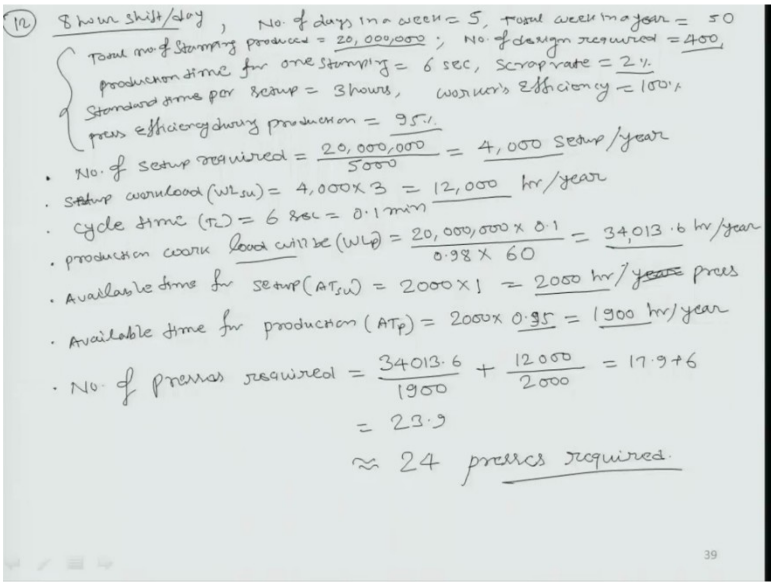

So, in this problem a statement is saying 8 hour shift per day number of days in a week that is the working day that is the 5 and total week in a year that is equal to 50 total stamping produced, number of 2 crores annually and however, 400 different stamping designs are required number of designs required. We have a variation in stamping and that is the number of variation is 400 and we have to produce 5000 each stamping for each design. So, each batch will be produced 10 times per year production time, production time for one stamping that is equal to 6 second and other things are given scrap rate average is two percent that is equal to two percent and standard time per setup is that is equal to 3 hour and workers efficiency expected 100 percent and presses are press efficiency during production that is equal to 95 percent.

From these variables we have to calculate number of new stamping press and number of operator required to complete this task. First we will calculate number of setup required we have to produce total two crore stamping and we have a 5000 variation 5000 for each batch number of production. So, how many setups will be required 4000 setups per year, now setup work load that is equal to work load is a what we have to make number of total number of setup required is 4000 setups per annum. So, we will multiply it with hour standard time per setup that is the 3 hour. So, it will equal to 12000 hours per year. So, cycle time also is given as 6 second. So, we have to convert it in minute, so 0.1 minute. So, production work load will be WLP that is equal to 2 crores into cycle time 0.1 minute divided by. So, scrap rate is 2 percent. So, we have to subtract this one by from 100.

So, it will be 0.98 into again you have to convert it in hour. So, we have to divide it by 60 so we will get 34013.6 hour per year that is the production workload time a work load.

$$Production\,work\;load = \frac{20{,}000{,}000 * 0.1}{0.98 * 60} = 34013.6\,hr/\,year$$

Now available time, available time for setup that is equal to 2000 into one, so it is equal to 2000 hour per press available time for production a Tp that is equal to 2000 into 0.95 this term come from the here efficiency. So, that will be equal to 1900 hour per year. So, number of presses required that is equal to; so what will have to do production work load we have to consider this one 34013.6 and will have to divided it by 19000 because available time for production was this one 19000 plus set of work load must 12000 hour per annum and available time for set up was 2000 hour. So, solving this we will get 17.9 plus 6 that is equal to 23.9 means equal to 24 required.

$$No.\,of\;presses\,required = \frac{34013.6}{1900} + \frac{12000}{2000} = 23.9 \approx 24\;presses$$

So, from this question this problem we solved the how many stamping presses are required and condition was given number of day in a week how much stamping on going to it produced, number of design required total week in a year 50 week. So, in this problem we can see that there is a lot of variables are given, but we utilize very few of them. So, do not confuse that every it is not necessary that every parameter has given in question is required to solve a problem.

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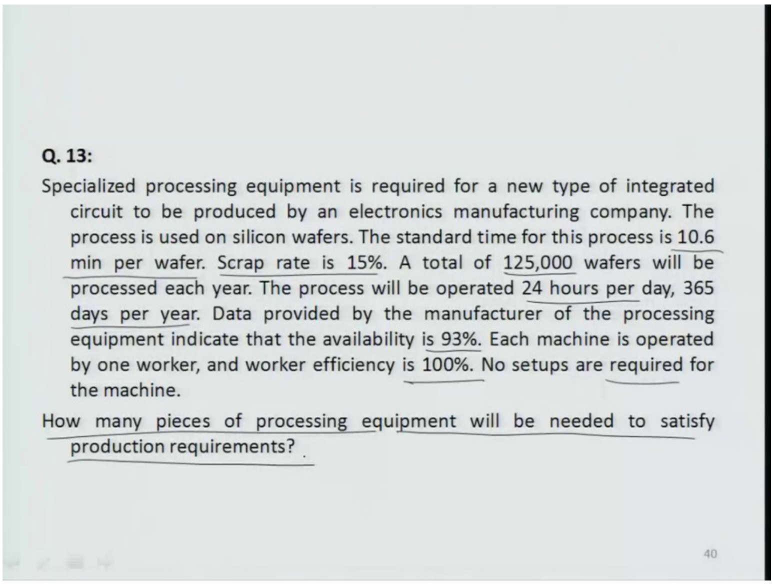

Now, again we are moving to a next question and this is the in next question problem is saying that like that a specialized processing equipment is required for a new type of integrated circuit to be produced by an electronics manufacturing company the process is used on silicon wafer wafers.

The standard time for this process is 10.6 minute per wafer scrap rate is 15 percent and a total of 1, 25,000 wafer will be processed each year. the process will be operated 24 hours per day, so 65 days per annum and data provided by the manufacturer of the processing equipment indicate that the availability is 93 percent. So, each machine is operated by 1 worker and worker efficiency is 100 percent. So, no setup is required for the machine that just like an automatic machine there is a no a set up time. So, how many pieces are of processing equipment will be needed to satisfy the production requirement.

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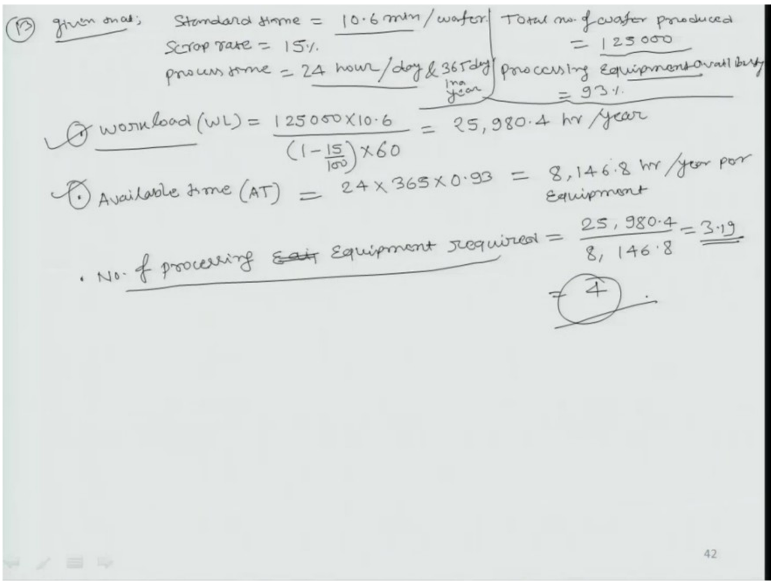

This is the similar kind of problem we solved in the previous question. So, again now we solved this question also in this what is given that standard time that is equal to 10.6 minute per wafer total number of wafer produced that is equal to 1, 25,000, scrap rate 15 percent, process will be operated 24 hours per day, process time 24 hour per day and it is like it will continuously it will work.

Then what else is given oh yeah equipment and indicate that availability is 93 percent availability processing equipment availability that is 93 percent, worker efficiency is 100 percent. So, will have to calculate again how many pieces of processing equipment will be needed to satisfy the product requirement; that means, processing equipment we will have to calculate. So, this is the very simple thing, first we will calculate workload, workload and what is that how we will calculate work load. So, first we will have to see how many total how many wafer will have to be we have to produce that is the 1, 25,000 and how much time it was given for that is the standard time that is in means 10.6 and divided by scrap rate was 15 percent.

So, we will have to take this thing by in account into account. So, 1 by 15 percent into we will have to convert it in hour. So, if we divided by whole expression by 60, so on solving this we will get 25980.4 hour per year. this is the work load total work load.

$$Work\,load\left(WL\right)=\frac{1,25,000\times 10.6}{\left(1-\frac{15}{100}\right)\times 60}=25,980.4\,hr/\,year$$

Now will have to check what is the available time again available time is 24 hours per day and 365 days in a year. So, 24 hours per day into 365 days per annum and what are the equipment availability that is the 93 percent. So, will have to take this thing again into account so, on solving it, that will be 8146.8 hour per year per equipment.

$$Avialable\,time\left(AT\right)=24*365*0.93=8146.8\,hr/\,year$$

So, basic 2 things we have calculated till now workload and available time. So, from the both of this things we can easily calculate how much equipment will be required, number of that is equal to 25980.4 divided by 8146.8 that is equal to 4 that is equal to actually it will be equal to 3.19. So, we have to round it because we have calculating number of processing equipment and it is having to be in whole number integer. So, that is the minimum equipment required is 4.

Now, we will solve some problem on time standard. Previously what we solved we solve cycle time based on the worker machine system now we are going to solved some problem on based on the time standards. Now in time standard problem we will solve question number 21, so, problem statement is as follow.

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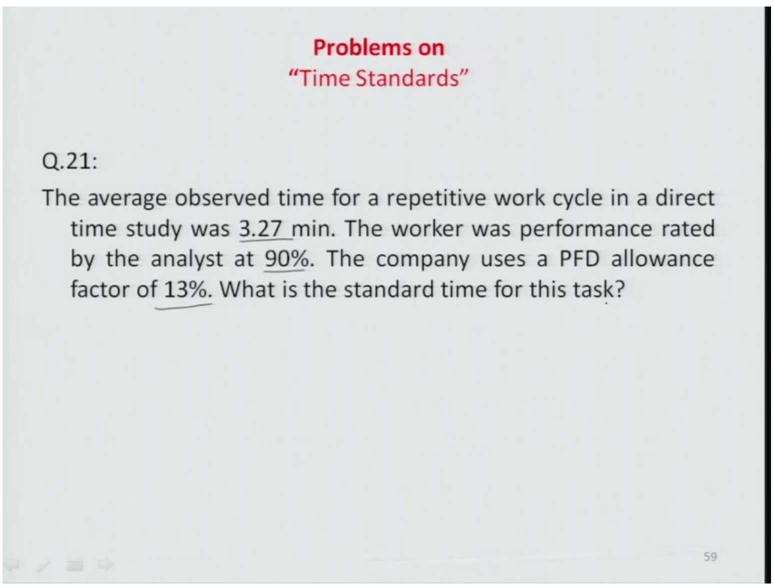

The average of observed time for a repetitive work cycle in a direct time study was 3.27 and the worker was performance rated by the analysis analyst 90 percent the company uses a PFD allowance factor of 13 percent. So, what is the standard time for this task?

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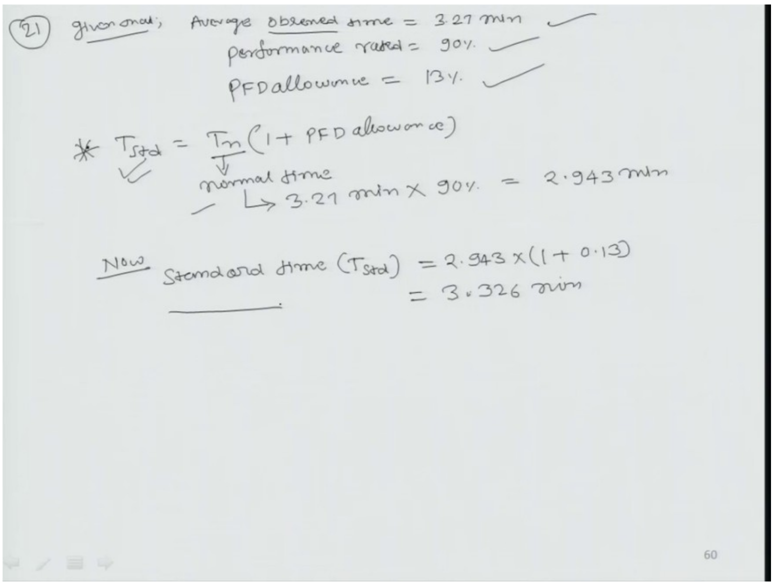

So, given that average observe time that is equal to 3.27-minute performance rated that was 90 percent it was done by analyst and the company uses a PFD allowance of 13 percent. So, that is equal to 13 percent. So, we will have to calculated standard time for this task. So, again first a start for calculation of standard time we know that a standard time T standard time is equal to T normal time multiplied by one plus PFD allowance factor.

So, for that we will calculate normal time and that is equal to average observe time was 3.27 minute and performance stated by analyst what was the 90 percent. So, we will take this into account 90 percent. So, what will be happen it will on calculating this we will get 2.943 minute. Now standard time that is equal to we will use this formula normal time is we calculated earlier 2.943 multiplied by one plus 0.13 and that will be equal to 3.326 minute.

$$T_{std}=T_n(1+PFD\,allowance)=2.943*(1+0.13)=3.326\,min$$

So, we got a standard time as a 3.326 minute. This problem was based on the time standard, everything was given process time was given performance related by analyst was 90 percent PFD allowance of 30 percent. So, what we did first we calculated normal time and then on basis using that that normal time we finally, calculated the standard time.

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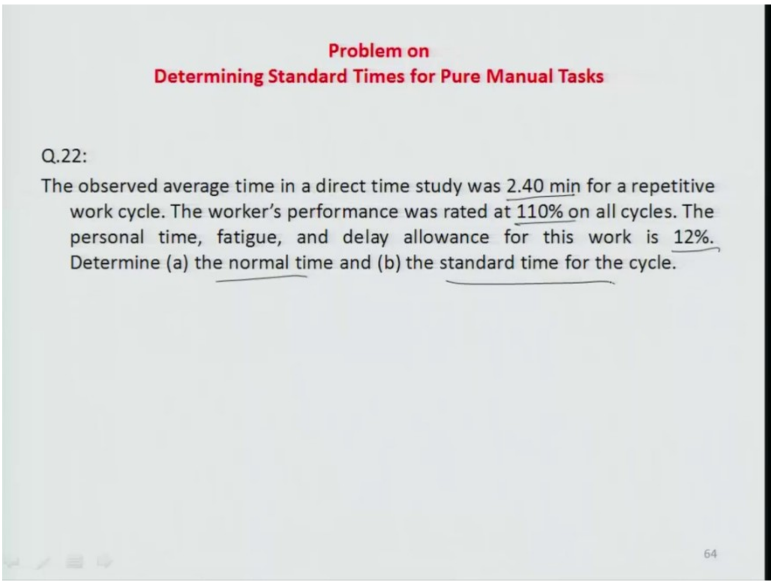

Now, we moving on its next problem and this program is based on the standard time for pure manual task and problem is saying that the observed average time in a direct time study was 2.4 minute for a repetitive work cycle and the workers' performance was rated at 110 percent on all cycle the personal time fatigue and delay allowance for this work is 12 percent. So, we will have to calculate normal time and standard time for the cycle.

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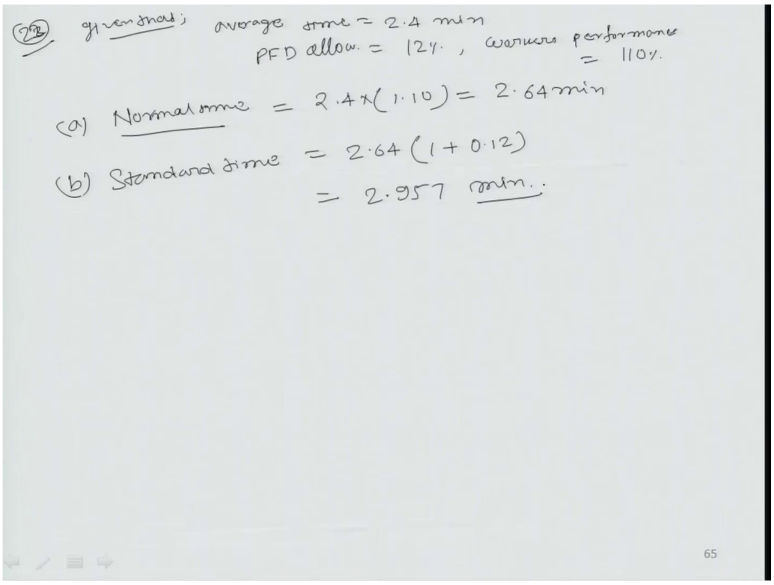

So, one given that 22, direct time study average time that was 2.4 minute PFD allowance that was 12 percent workers performance that is equal to 110 percent for all cycle. So, what will do normal? So, normal time first will have to calculate and normal time that is equal to average time to 24 into workers' performance, so 1.10 that is the. So, that will be equal to 2.64 minute.

So, on basis of basis of normal time first then we will calculate a standard time, that is equal to 2.64 that is the normal time 1 plus PFD allowances 0.12 that is equal to 2.957 minute.

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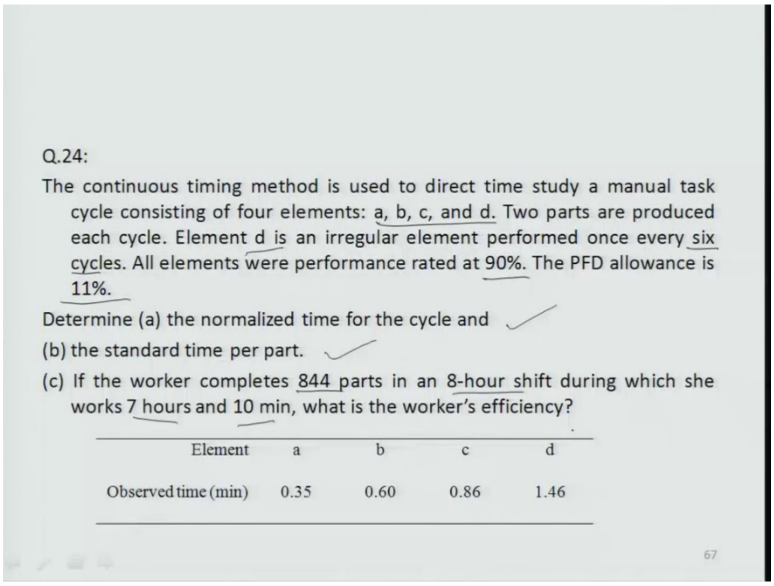

Now, next this is this is the final question we are going to solve today. So, this is the what problem is saying the continuous time method is used to direct time study a manual task cycle consist of four elements a, b, c, and d. Two parts are produced each cycle element d e is an irregular element, element d is an regular element performed once every 6 cycle every 6 cycle. All element we are performed rated at 90 percent and the PFD allowances eleven percent. So, what will have to calculate determine the normalized time for the cycle, a standard time for part and the third part is if the worker complete 844 part in an 8 hour shift during which she works 7 hours 10 minute what is the workers' efficiency.

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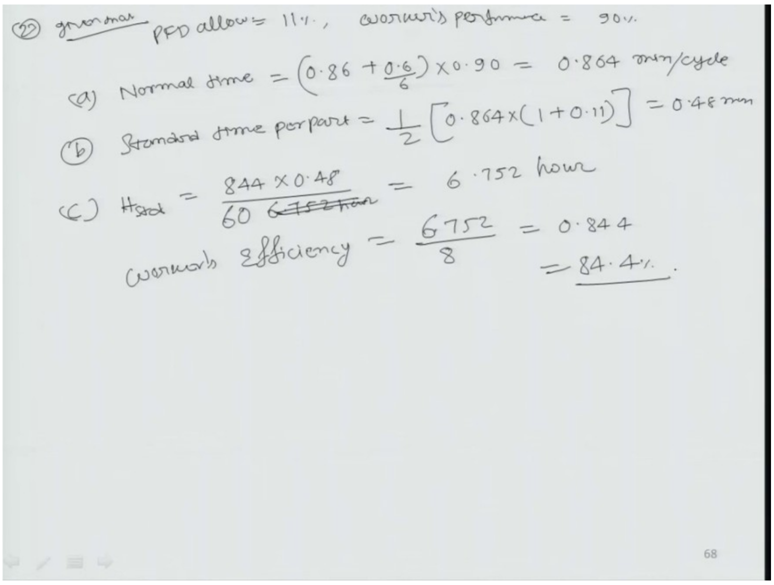

First we will have to we will calculate normalized time then we will calculate standard time. Given that, PFD allowance that is equal to 11 percent workers performance that is equal to 90 percent and 6 cycle you regular time element d is a irregular. So, what is the normalized time for cycle? So, normal time, normal time what will be the normal time. So, we have 4 kind of element a b c and d and observed time for each element is corresponding element is 0.35 for a, 0.6 minute for b, 0.86 minute for c and 1.46 minute for d. So, a in this thing we will we will take a b and c in take into account, so what is the time? 0.86 plus 0.6 and this is the irregular time, so will have to divided by it is 6 and again we will have to multiplied by 0.90 that is the workers performance and this will be equal to 0.864 minute per cycle.

$$Normal\,time = \left(0.86 + \frac{0.6}{6}\right) \times 0.9 = 0.864\,min/cycle$$

Now, since we have a two part per cycle though standard time per part will be per part that will be equal to one by 2.864 that is a normal time one plus 0.11 that is the PFD allowances and it will be equal to 0.48 minute.

$$Standard\,time\,per\;part = 0.5 * [0.864 * (1 + 0.11)] = 0.48\,min$$

So, on early basis what a standard time will be? That will be we have 84 minute total and into 0.48 divided by 6.752 hour, then sorry we have to divided by 60, because you are converting minute in a hour so that will be equal to 6.752 hour.

$$H_{std} = \frac{844 * 0.48}{60} = 6.752\, hour$$

Now, workers’ efficiency if you want to calculate that will be equal to 6.752 divided by 8. This completes the solution.

$$Worker' s\, efficiency = \frac{6.752}{8} = 0.844 = 84.4$$

Now, in this lecture module we have almost finished problems on cycle time productivity cycle time for manual system, for worker most machine system and time standard. And in week 8 to 11 we have already covered the method study, motion study, time study this kind of things and we did some pure problems on that. So, this almost completes every week’s numerical parts, so we are covered. So, thank you very much and this was the final lecture for this course.

Thank you.