Advanced Green Manufacturing Systems
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Lecture - 45
Green Factory Simulation - Part 3 of 3

Good morning, welcome back to the course; I am Doctor Amandeep Singh and I will take the plant simulation technomatix in this lecture.

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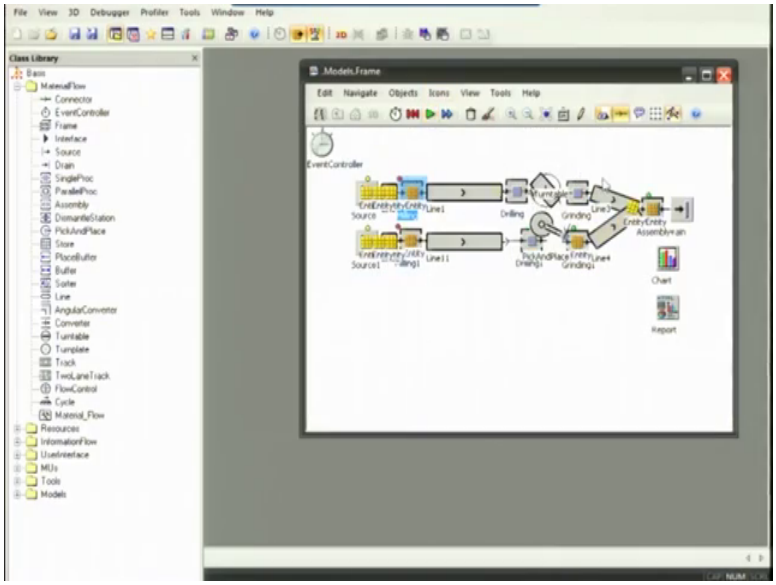

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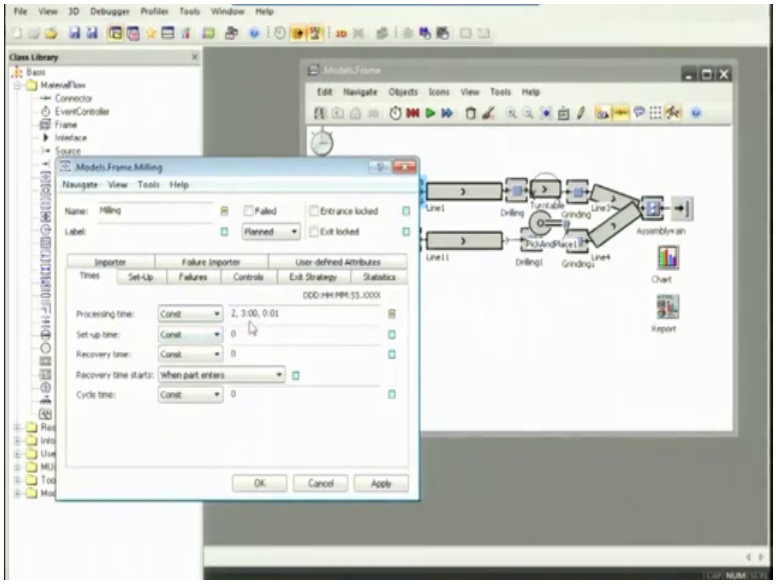

I like to talk about the distributions ok, I have just opened this milling process the processing time is 1 minute. If I open uniform distribution; uniform distribution you know that it is also known as rectangular distribution so, where we have just the start and stop we have the minimum and the maximum value and you know that the value would lie between these two values we do not have much information.

So, uniform distribution and triangular distribution and beta distribution these are sometimes known as the lack of information or lack of knowledge distributions because we do not have much past knowledge, we just have two or three or five or very few number of observation and we do not know what a distribution would it follow. We have just a minimum value and maximum value we do not know what is happening in between. So, we just pick this rectangular distribution, if you remember if you know the rectangular distribution is just we have a value and b value that is all.

So, it is showing if we have to put it in a this way stream, start and stop. So, I will just put start and stop, let me say the minimum time is 2 minutes and the maximum time is 3 minutes ok, so this is here. Now, I have just put start and stop I have not put any stream. What is stream? If you know about random numbers; stream is the seed of the random numbers.

So, when we when we talk about the simulations; simulation, what is simulation? Simulation we are trying to imitate the reality and what is representing the

reality, what is representing our actual real objects or subjects? It is the random numbers which we are working on.

So, where does our random number starts from of the specific? So that is the stream. So, if instance for there are two processes I put the same stream here, same stream means the random number will start from the same seed and the successive random numbers would be same. For instance if I put the seed value two here in one process and seed value two here in another process.

So, the 9th random number that is selected in this process and the 9th random number that is selected in this process that would be same 9, 5th because the seed is same, so the successive random numbers would be same. So, it is recommended to pick a random seed not I would say random seed at least a different seed for different processes to have the good simulation process.

So, if you do not put any stream value here the software would pick a stream value by itself. So, I am not picking any putting any stream value, so I have just put uniform distribution. So, we know that the minimum time would be 2 or let me say the time varies from 2 minutes 50 seconds to 3 minutes we know that this is the minimum, this is maximum first I will talk about triangle distribution.

Triangle distribution is actually sum of two uniform distributions, two uniform distributions are there, two uniform distribution to uniform distribution means, but just has have the smallest value and the largest value we do not know what would happen.

But in triangle distribution we have three values we have the smallest value, we have the largest value, but we have the one value that is in between, but repeating for the maximum number of times it is repeating to a maximum number of times that is the value is mode. What is mode? Like mean, median mode is there. Mean is the central value median mean is actually the average of the values median is the central location value, mode is the value that is having maximum frequency ok.

So, here we can put if I pick the triangle distribution it is showing stream c, a, b, here a is the smallest value, b is the largest value, c is the mode value that is repeating for maximum number of time, when it is repeating I am talking about the past data.

In the past data I have five or six observations and know this is the minimum value, this is the maximum value, but there is one value which is which is trying to repeat maximum number of times, so I can pick the triangle distribution. Based upon the past data if I have a lot of observations in the past, I can pick normal distribution if that fits good here.

In normal distribution it is asking for its parameters ok, the normal distribution I would say normal distribution statistic it is asking; it is asking for stream. Now it is asking for mu and sigma, mu is the mean or average sigma is the standardization, also it is calling for the lower bound and upper bound. Lower bound is the minimum value and upper bound is the maximum value within which our distribution would lie.

So, we should have the knowledge of the distribution as I said the softwares are GIGO Garbage In Garbage Out. So, if you put the right distribution and you have the right numbers and we having the results of the simulation very close to a realistic conditions. So, this is the work of a systems engineer to design it in a proper way.

So, if I change this time you can see I do not apply it because it is showing it is showing. You know if I do not put it in a proper way this is stream mu sigma. I am showing the value of stream it has just picked, I was showing the value that is 250 and 3, the value of mu was smaller than sigma.

So, that is why it said it is showing the negative value it is not accepting, would not accept any other format than is required. So, let me pick just constant time here and it was just to make you understand it properly it was 1 minute I will apply.

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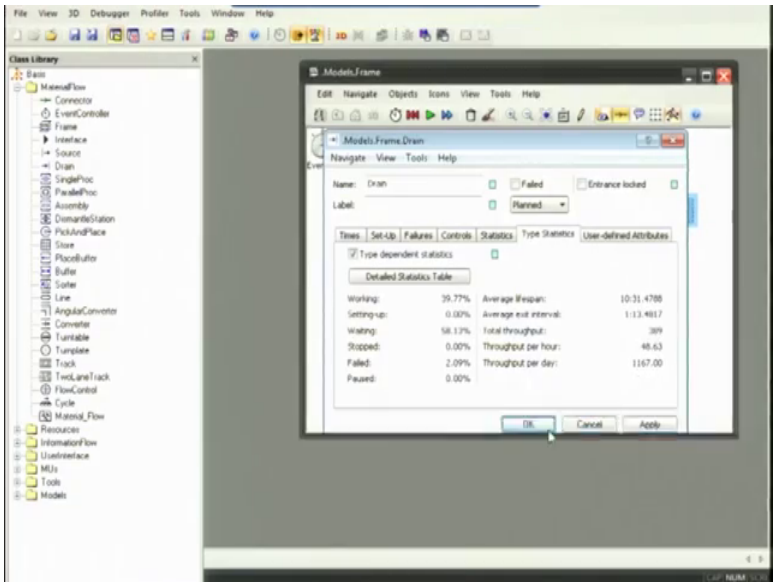

So, let me see if I run it for an 8 hour day and try to see the throughput; open it has to see throughput it is throughput per day is 1167 ok, per hour is 48 and the total throughput is 389 for an 8 hour day for 8 hours ok. Now if I change the processing times open, if I change this processing time to let me take 2 minutes and I change this processing time also to 2 minutes in actual conditions we cannot change the processing time processing that is as to take it would take.

The milling it has to if it has to take 2 minutes unless we change the tools, we change the machine or we have the CNC machines or advanced machines, we cannot, but work on more on the processing times. The processing times are fixed yes, in the plant stimulation or in the manufacturing simulation here we can think of working on the bottlenecks, the processing times are fixed. We can think of designing the lay out in a way that the material flow is minimum and that the total time taken is minimum total time taken would be minimum; that means, the total throughput would be the larger ok.

So, if I change this time now increase the time to 2 minutes, now I run the process and let me try to see the throughput here ,you can see the throughput was larger before so it has reduced now because the processing time is increased it is 582 pieces per day, 194 pieces in a 8 hour day ok.

So, also we can have the set up time as for the instance a work piece is to be manufactured it will take 2 minutes for processing and 1 minute for set up; 1 minute for set up means for instance some milling is happening if your milling process what do we do? We just rotate the tool and remove the material.

So, it is removing the material from one work piece this is 2 minute process after 2 minutes the machine stops, this work pieces taken off and a new work pieces brought in here that is the raw one and it will start process on this. Now, this set up this set up takes 1 minutes here, so this is set up time; so this is set up time, this is processing time. If I induce set up time as well and apply let us see what happens to my throughput now.

Only in one line I have put some set up time, so the throughput is further reduced here it was 197 pieces. So, it is 194 pieces now because the set up time is there now another 1 minute is being taken. So, total time taken in the milling process in the line one is 3 minutes now ok.

So, this was a brief introduction about the software the major or the main objects that we can use. Now I will pick some examples I have some examples for you to show you differential layouts and also the experiment manager we will use; we will try to see to see the simulation that we can do in the software.

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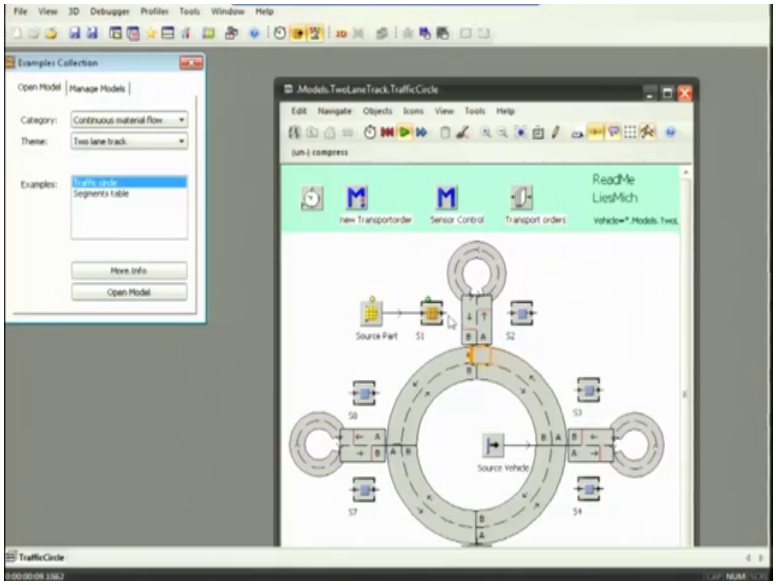

So, this is continuous material flow I will select two lane track here, so traffic circle or segment table traffic circle pick and open the model ok. So, this is the model it is already running. So, I will just run the model you can see this is the trolley that can pick our material from.

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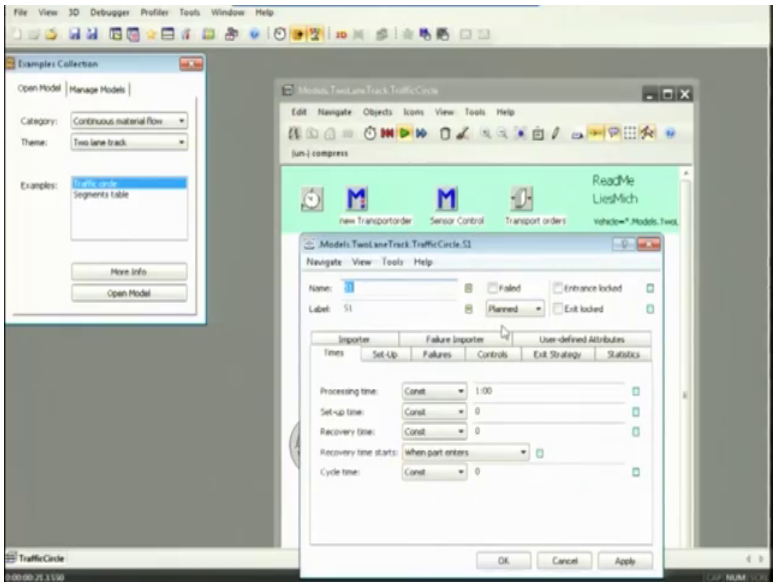

So, this is source part some processing is being done here I can see what is the time of the processing here, the time says it constant 1 minute. So, you can see it is happening I will make it a little faster, control panel I will make it a little faster and then run ok.

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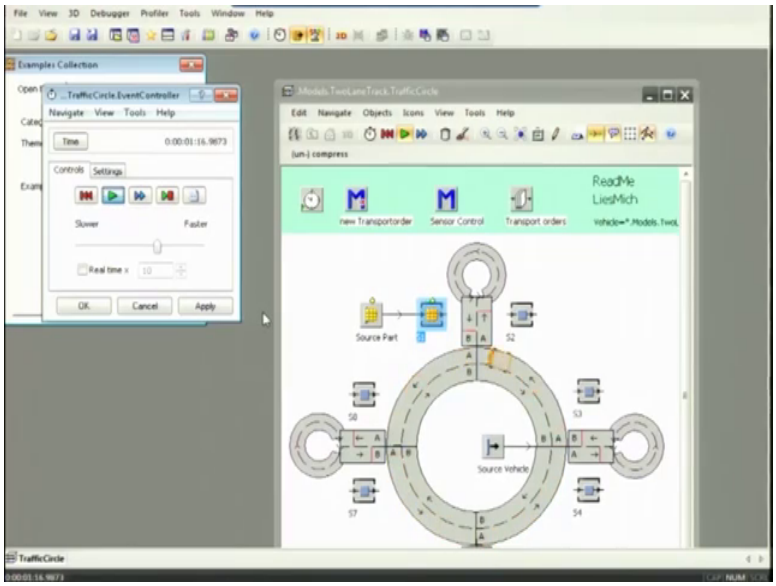

This trolley is running trolley is continuously running to a tracks this is actually about 20 times faster. So, the processing is happening it is happening for the 9 minutes, it is not stopping. So, what is the setting? So, there is no end time, so it continue for the infinite time. So, this is a kind of a just a cell an o cell ok. So, cancel; stop.

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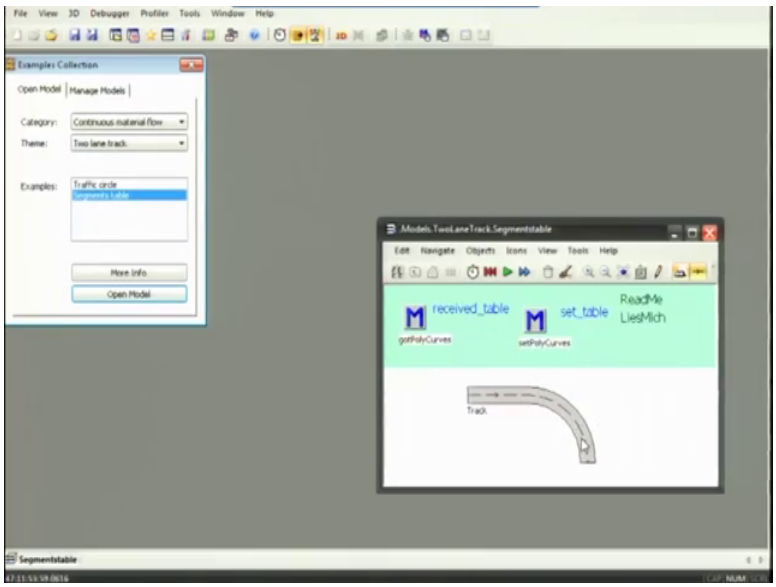

So, segment table open model, this is the showing a track; how the track is built? So, let me pick user interface; dynamic statistics; display panel; a chart; open.

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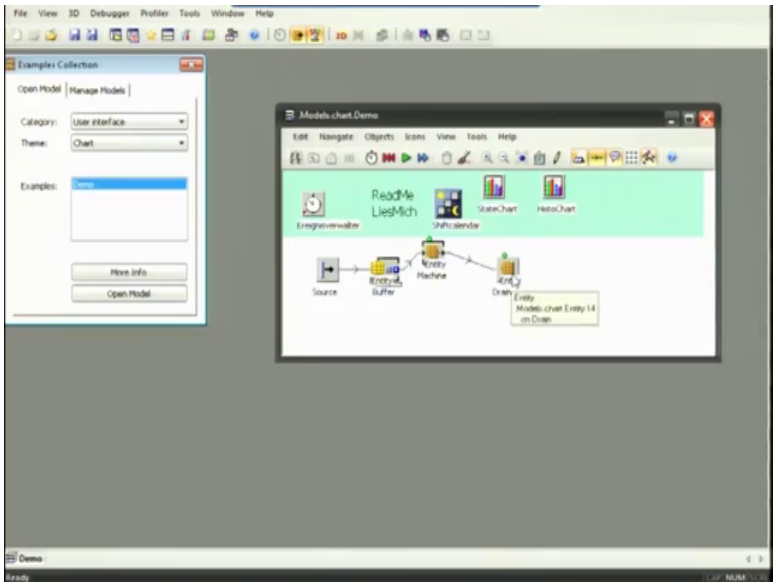

So, in this model we can see the chart what is the setting there is no end time I will put the end time here 08, 00, 00 apply; ok. Let me try to run this model, so it has run for 1 day. So, entity buffer is there, entity machine is there; this is similar to that, so we can see the charts here; show chart.

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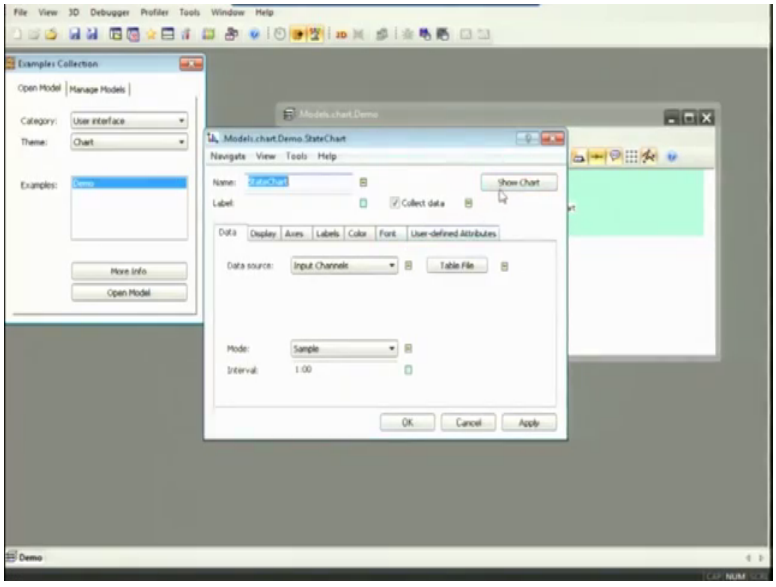

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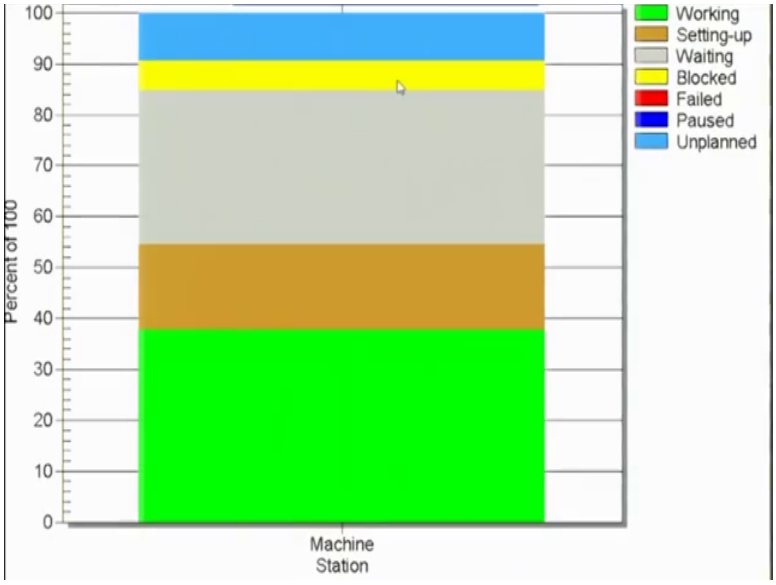

So, for only one machine it is showing the chart that this is something unplanned blue colour is unplanned, then we have blocked then we do not have any failure here. We have this waiting time for the about 37 percent of time it has been working, so this is another example ok. Then tools and optimization; ok important is experiment manager, I will just pick the buffer line optimization this is line comparison open model.

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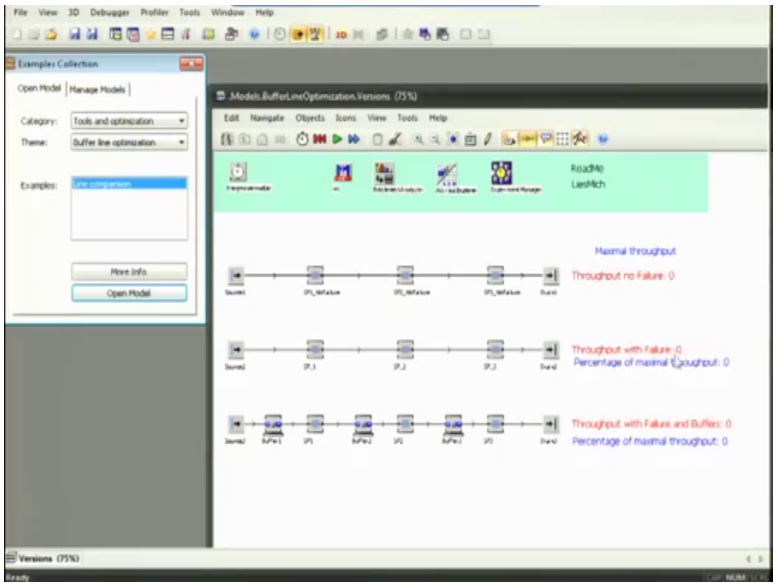

So, in this model what we have; we have three lines. In this line the throughput with no failure this is throughput with failure if throughput with failure and buffers. So, there is a they are buffers kept in between if I enlarge it, this is buffer, this is

another buffer. So, you back a buffers in between this is throughput we need to see throughput with no failure, another line is throughput we have put some failure rates here ok.

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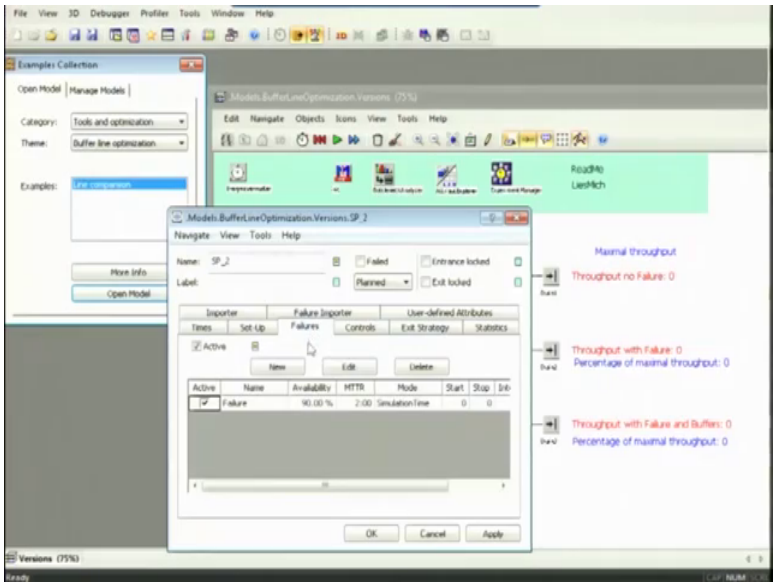

If I see the failures it has 90 percent failure, 90 percent availability, it is 10 percent failure in this case there is no, in the first case there is no failure ok.

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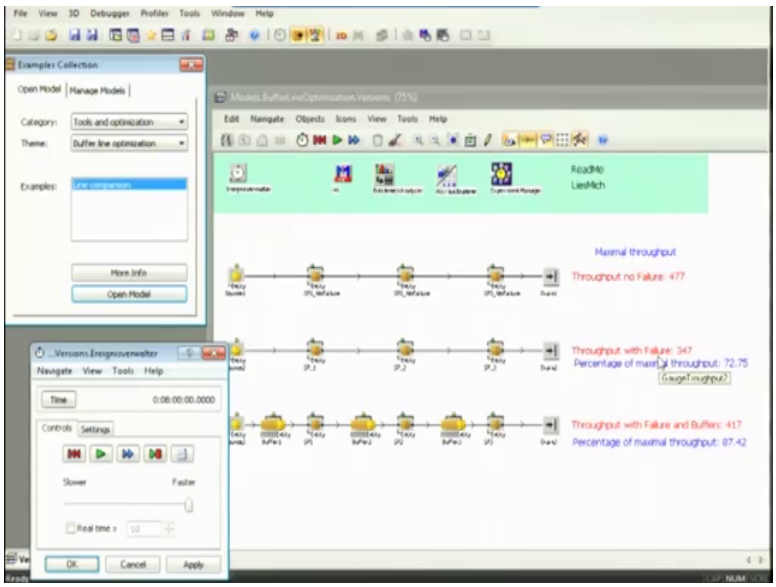

So, let me try to run this model. Yes, this model has the run for an 8 hour day. So, for with no failure, the pieces those were produced in a day work 477 with failure is

347, but because failure is there we have put the buffers in between that can store some of the material, so it is about 417. So, also it is giving the percentage of the maximum throughput maximal throughput is 477.

So, it is with failure we have 72 percent and with failure and buffers with 87 percent of the throughput of the maximal value. Then I can, then in resources I can see broker and animation, so shift calendar worker I will show you a worker introduction worker introduction model.

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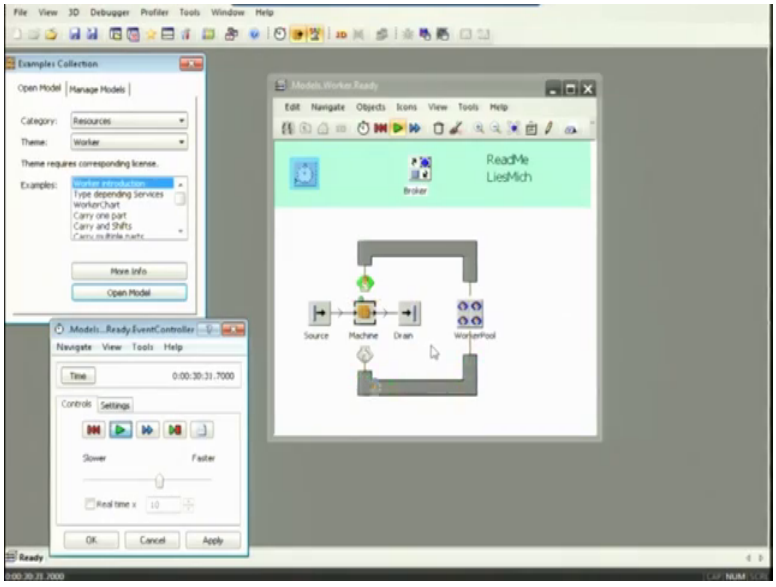

So, this is the worker introduction model, so in this case you can see the workers I just introduced into machine and if we run this let me try to make it a little slower, apply now run you can see the workers who are running it.

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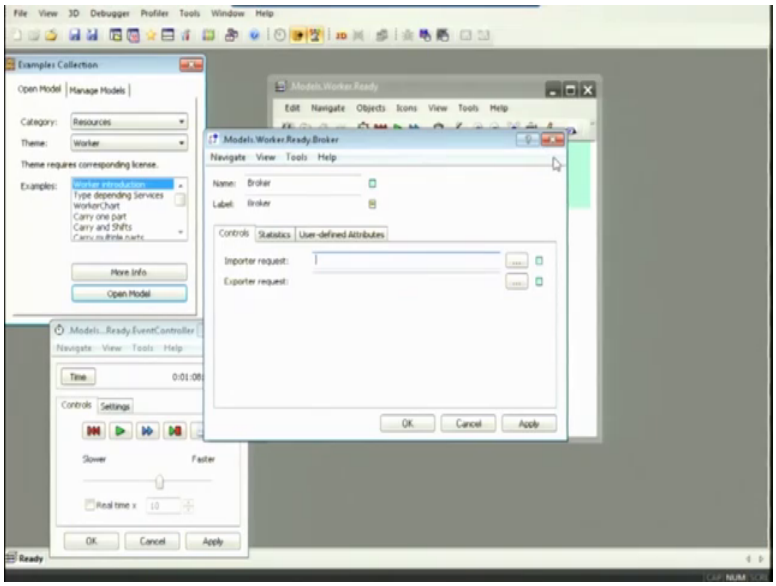

So, I can see the number of workers are two here and work pool is and a broker is there broker is trying to distribute the work to different workers, so this is one of the example. Then let me come to the major simulation thing that is the experiment manager tool and optimization experiment manager.

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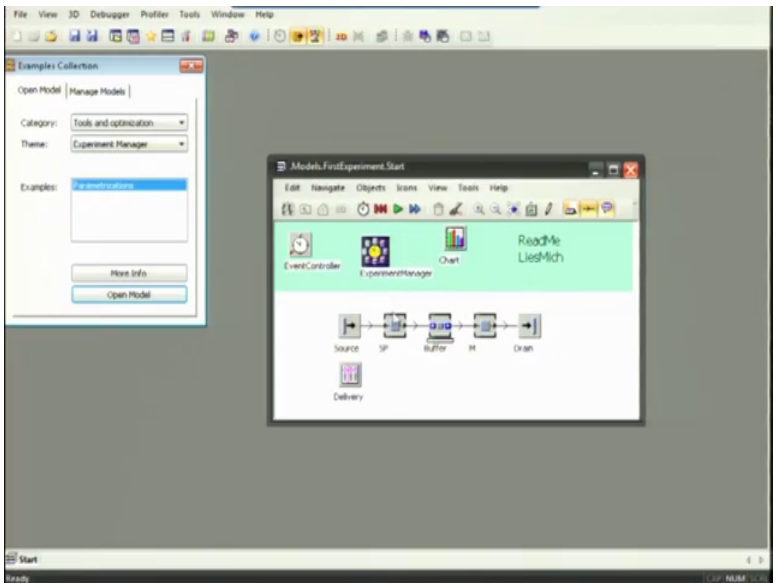

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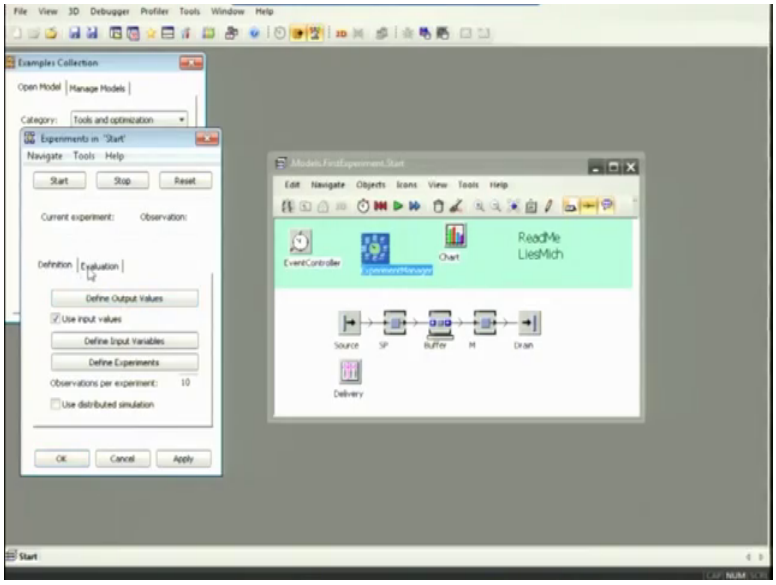

This is one of the models here we have experiment manager, this experiment manager can show this simulation; if I run this model or let me open this experiment manager first it said definition and evaluation.

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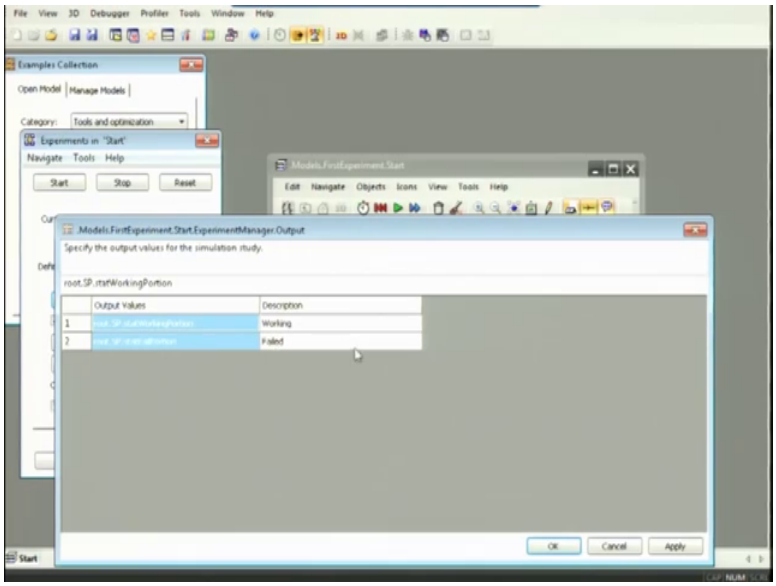

In definition you have defined the output value of the work station portion, start fail portion it is working and failed. So, what output do you need and what inputs do we have? Input is the root delivery and as mean time to repair.

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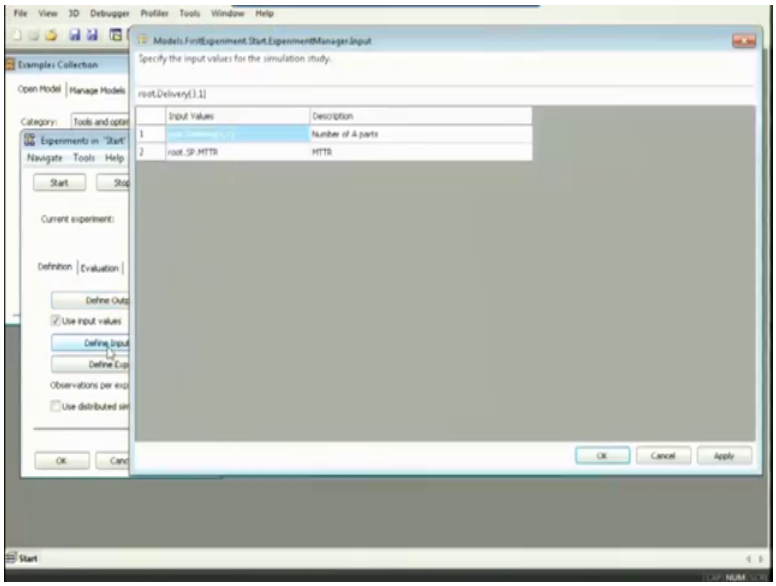

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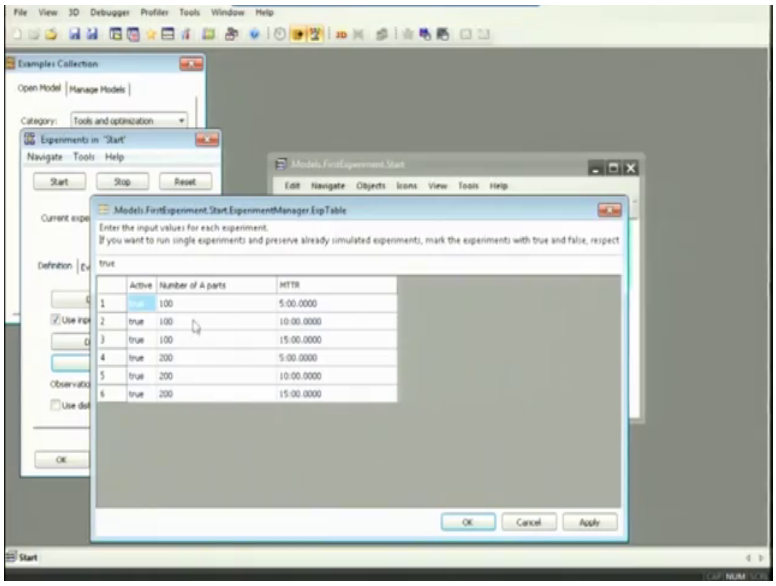

So, if I run this model, so also I can define the experiments that is for number of 100 number of parts mean time to repair is this much 5, 10, 15, then 5, 10, 15 this is for 100 parts this is of 200 parts again. So, these number of experiments would run if I run this experiment manager.

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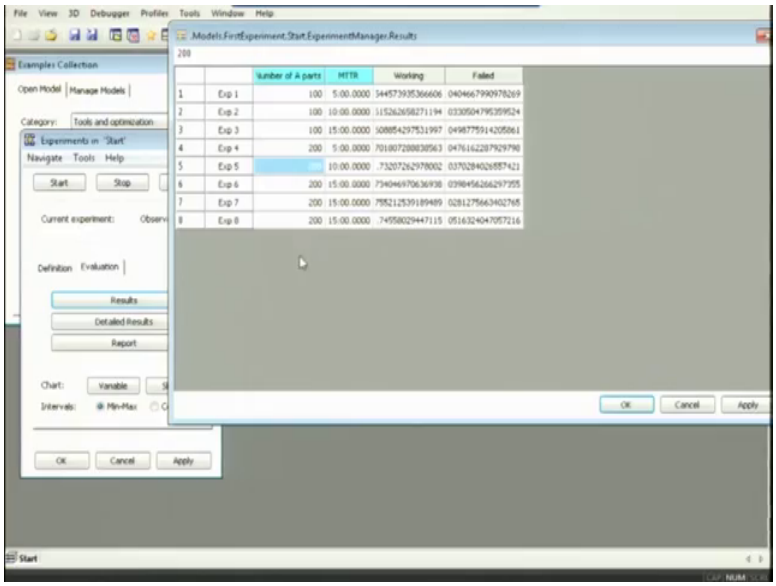

Let me try to run it has a run for 8 hours, now let me try to see experiment manager, now I like to see the results. It has shown the results that the mean time to failure if it is kept 5, so it is working for this much of time it is failed for this much number of time. So, for the simulation of 100 parts; for the simulation of 100 parts again this is of 200 parts, it has taken 8 experiments.

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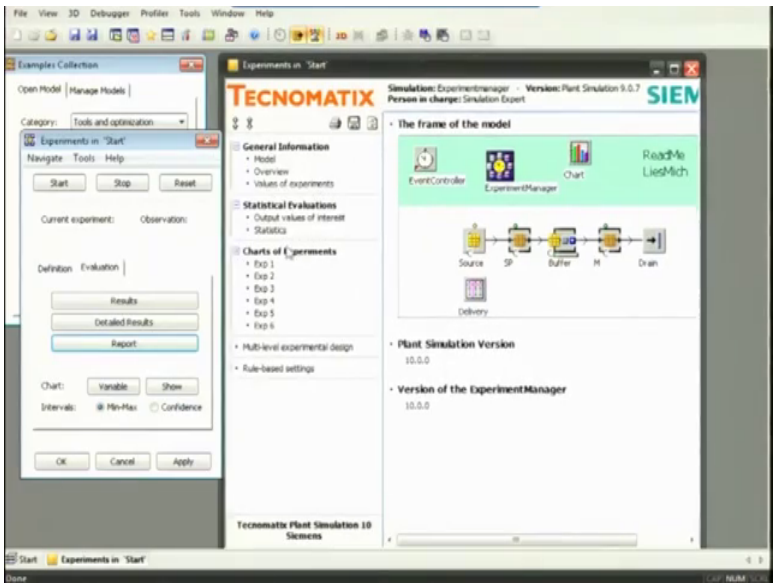

So, I can see the report as well here in the report it is telling that they are number of experiments in experiment one this happened, in experiment two this happened

this is the total failure this is what blocked time, then gray colour is waiting time; all these things it is telling in the report.

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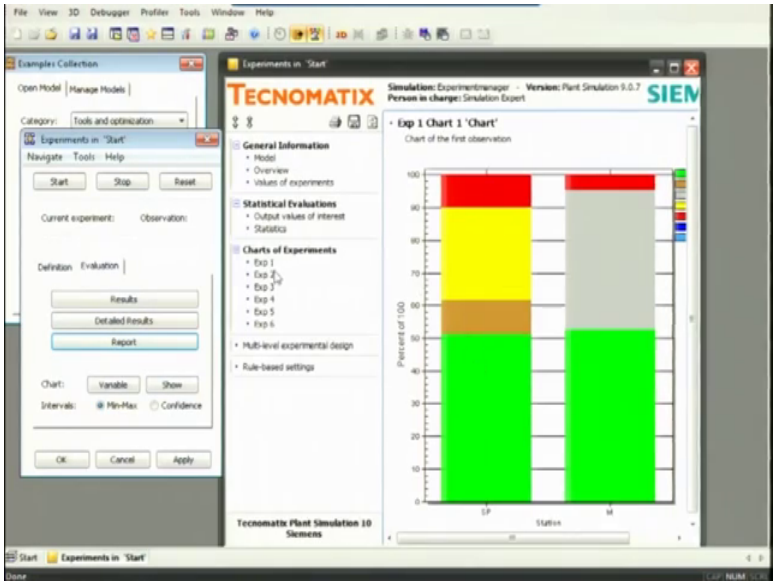

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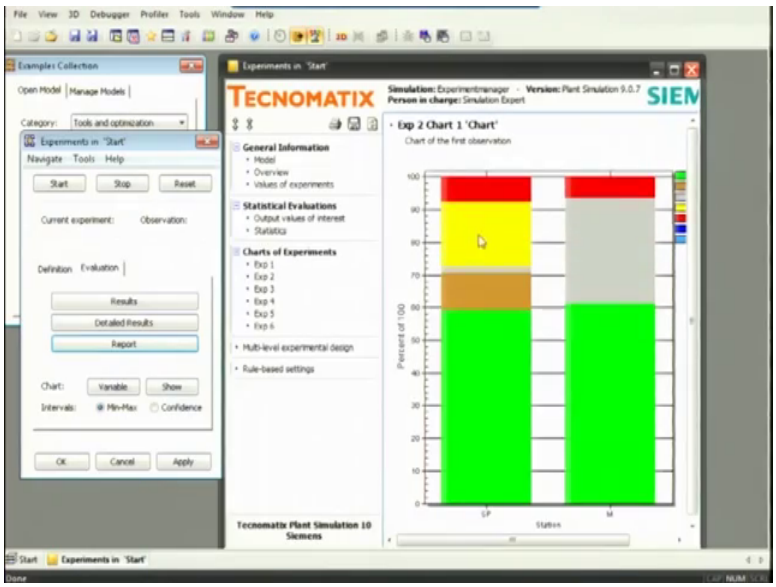

So, in experiments what has what is it taken? It has taken different random numbers, in experiment number 1 different numbers are random numbers are taken, in experiment number 2, different numbers are taken what is experiment number 1, it was given here the inputs that we give output values sorry output values are here in this results.

Experiment number 1 is 100 parts with mean time to failure as mean time to repair mean time to repair as 5 minutes, experiment number 2 is 100 parts with mean time to repair as 10 minutes, so it is showing these experiments here.

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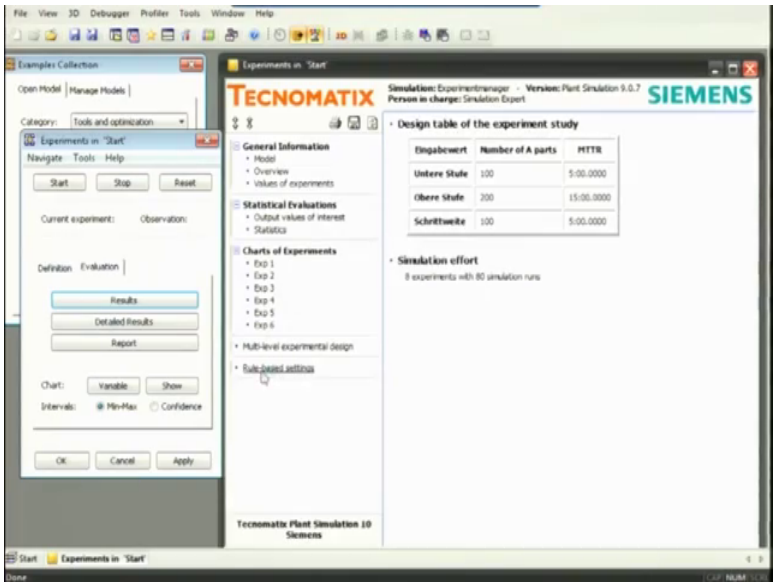

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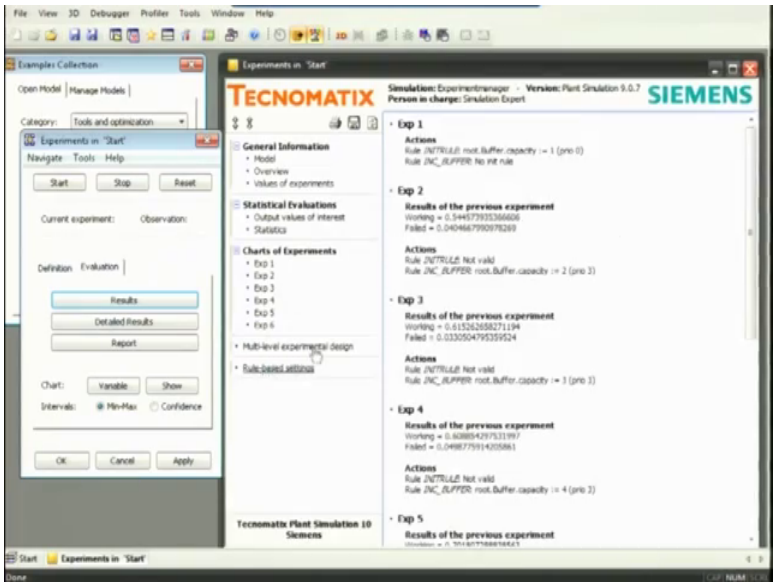

So, we can have all different kinds of designs, then rule you have not different any rule based setting can also be done this is in like if we go to the detail of the simulation these things are possible.

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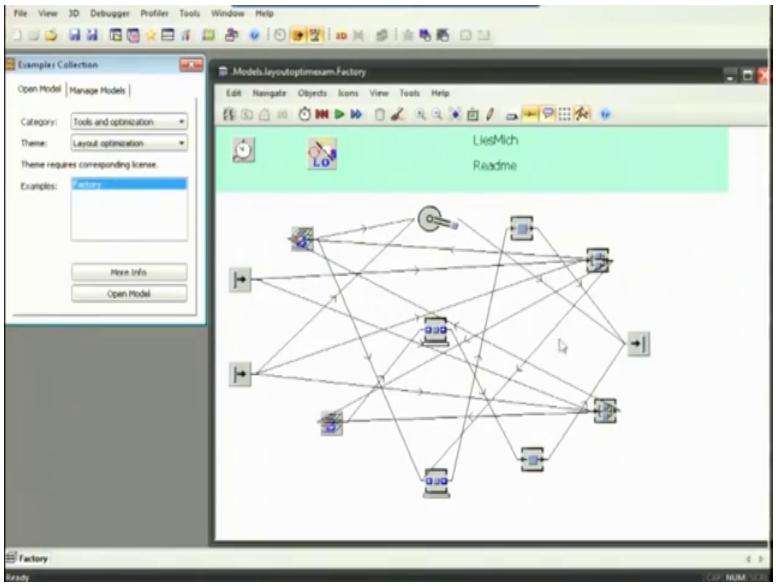

So, now, the layout optimization, factory optimization factory layout is there, this is the factory and we have weird kind of connections here. So, in fact, layout optimization can be done, for where to keep what machine, then what would be the overall what would be their maximum throughput if we do that. If this kind, this models can be also we can conclude through these things to find the optimization here.

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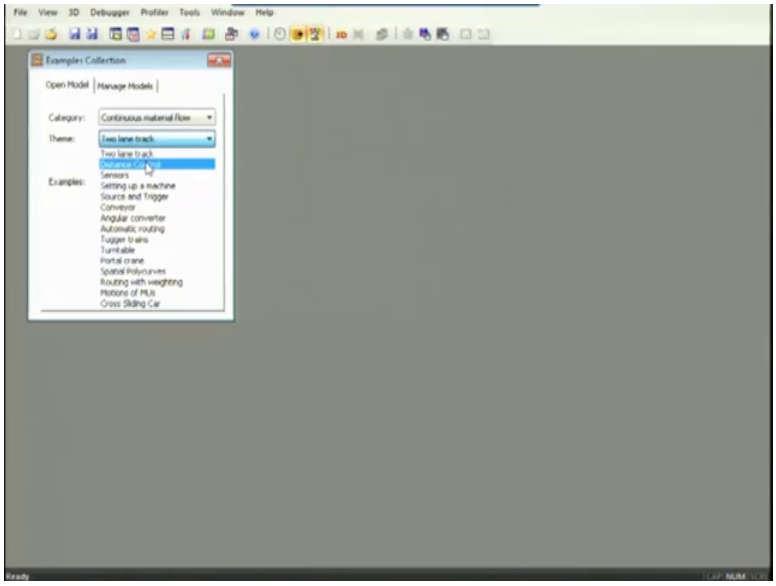

So, another model I can pick here is from continuous material flow two lane track distance control, sensors.

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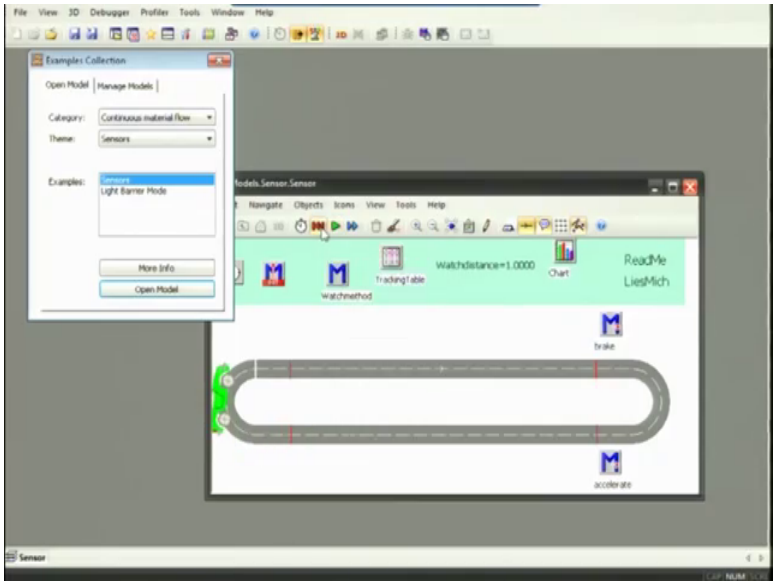

Sensors; sensors are like if we need to if instance, if we need to accelerate at some point or we need to put breaks or we need to put the occur this is our light and like we can do anything let me open this model yes this is an brake and accelerate model. So, I have defined the method here watch method; the method here is brake and accelerate.

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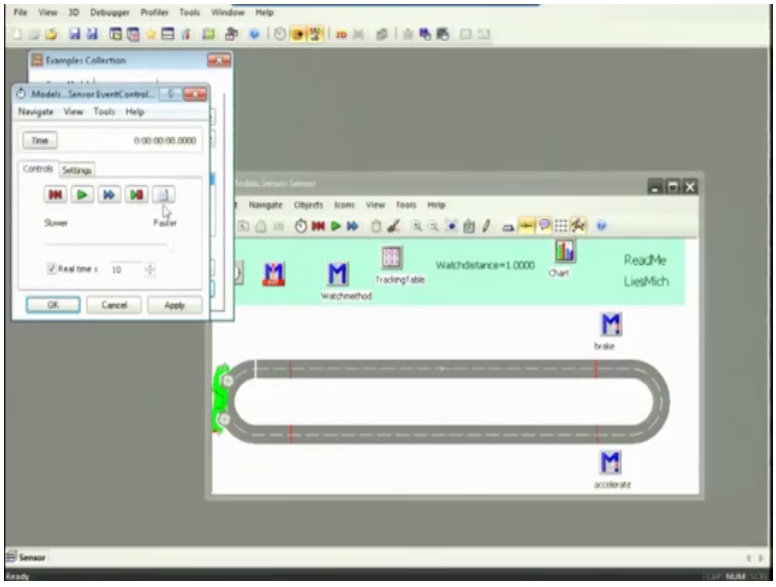

So, if I try to run this model first, let me see the even simulator it is end time of nothing, but just to see whether how it runs, you can see this is brake, after brake it will just slow down, after accelerate it will accelerate this is speed in this speed.

So, at this point brake would apply it is accelerate now, brake would apply it will take a turn accelerate it will accelerate from this point ok. So, this is a kind of entity; this car here we had just one kind of entity, this is another entity which is in the form of car the name is AutoSorter.

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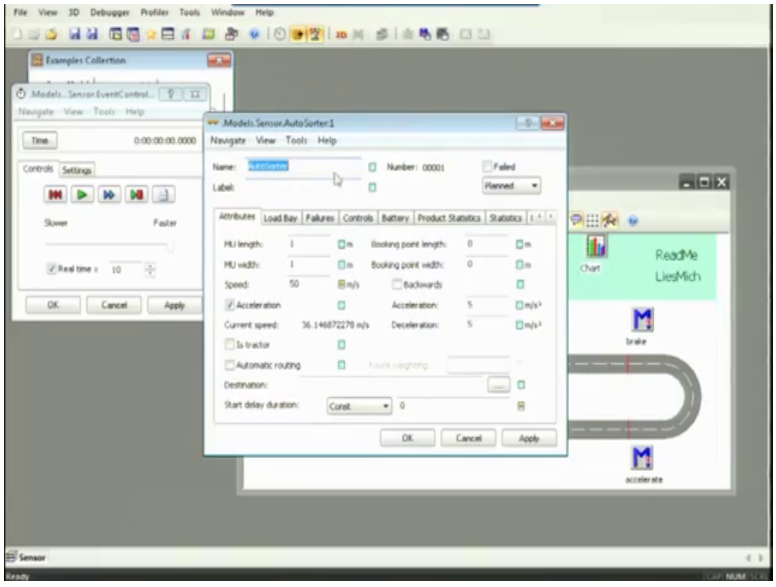

So, this was my sensor in continuous material flow, they are many models in this ok. So, I will just pick randomly something some tools and optimization I can pick experiment manager, then I have I will try to explain the a experiment manager in more detail I pick an example. So, before that let me pick something the transfer station ok transfer station I have a demonstration model here.

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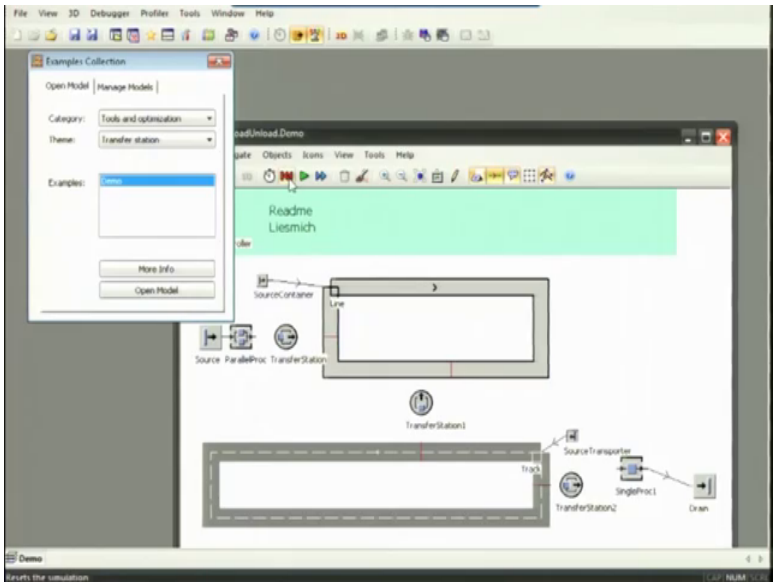

Transfer station is this is one cell; this o is one cell, this is another track here two way track ok. Transfer station it will just transfer the material from this cell to this track. Let me try to see the event simulator here.

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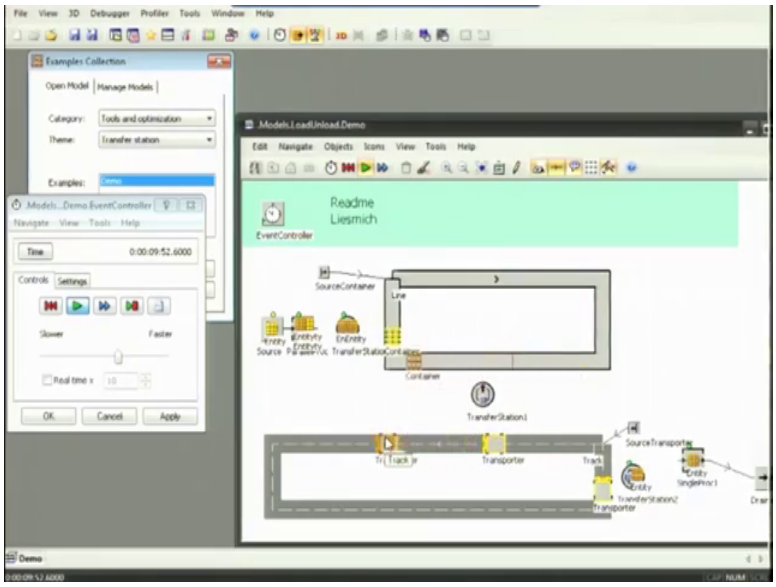

You can see the trolley where the container came here ok. So the container is coming the some machining is happening here, some machining is happening at this parallel process ok.

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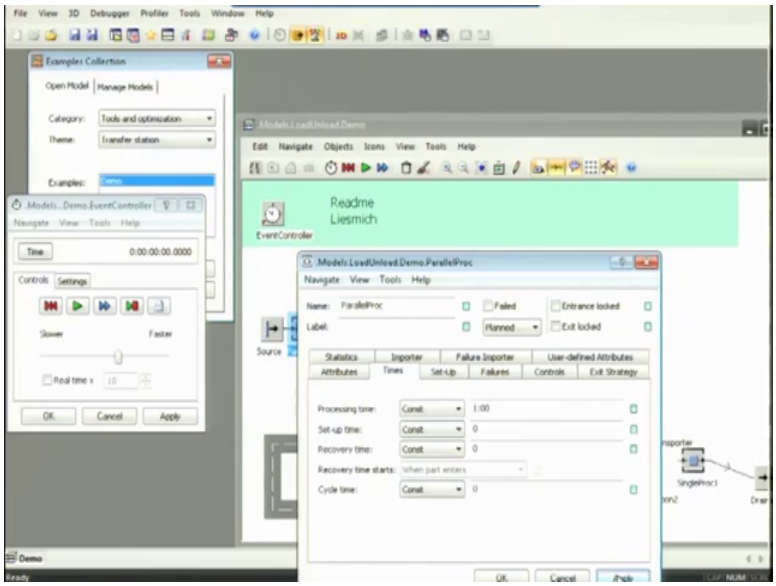

Let us first see what are the process parameters here, this is the parallel process in which 2 into 2 4 processes are there the times is again the default time 1 minute ok. So, it is from source it comes in transfer station is there will be need not to connect, transfer station; transfer station when we see the transfer station.

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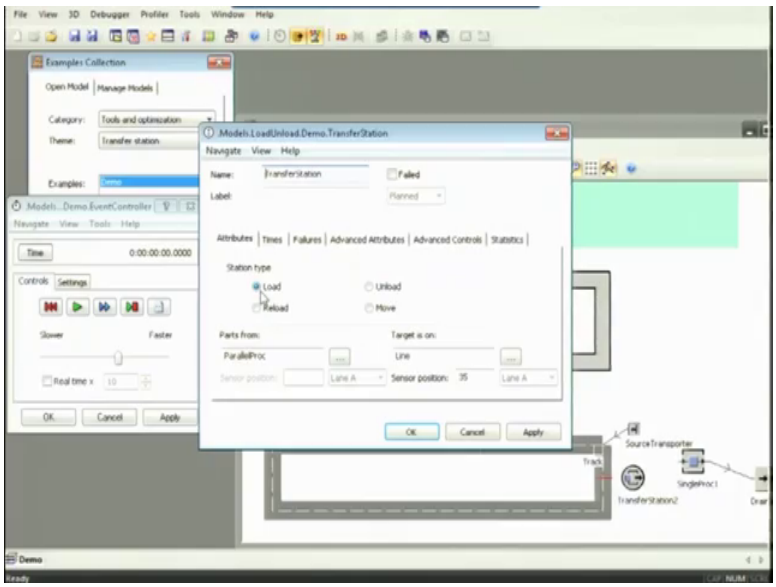

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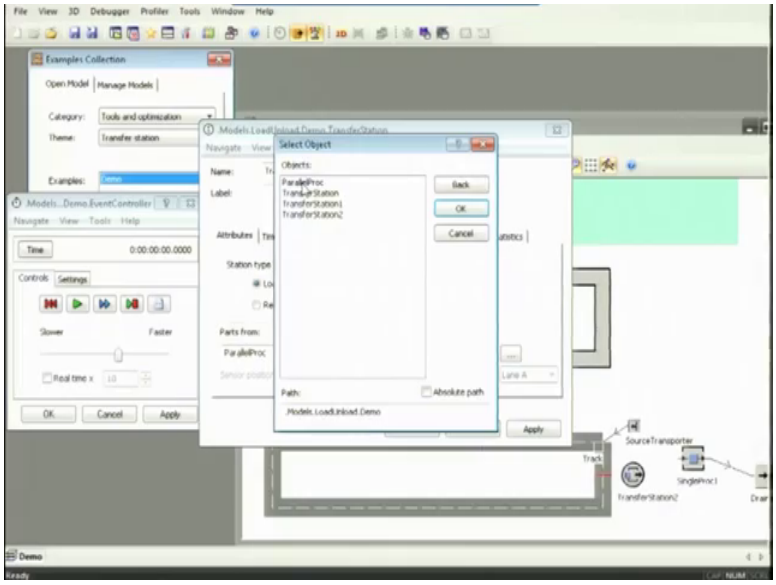

So, it will transfer into a load, it will just load the process it is corrected to correct parts from the parallel process we just need to put the name, of the process from which process it will pick the part from parallel process ok, then it will target or the transfer the parts to line ok.

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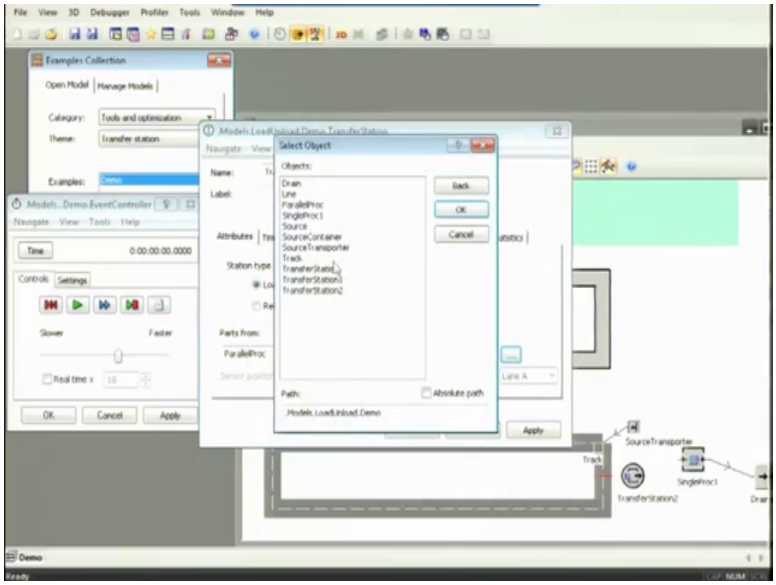

So, there is no connector required in between. We need to just mention the predecessor and the successor processes here. So, sensor position is this one, so all this. So, we can select load, unload, reload move, so, it is loading the parts. So, all this activities availability is 100 percent, we can select these I would not change anything and let me try to run the simulation.

So, these containers are running some processing is happening here it will taking 1 minute. So, transfer station is then transferring the part two this container, so this container results coming here and this transfer station it is collecting the part from this line 1 to the two way track. If I see its properties, it is from line to a track, the name of this track is track only.

So, again from this there is another transfer station ok, the source transporter as well the source transporter that is a source is there that is trying to transport material from some other frame or some other using some other interface which is trying to do that. So, this is one of the objects that can be used, so this is just a transfer station; now apply ok.

So, there are certain examples which are available for us to see how these things happened. So, I will just open the start page again and try to open this factory simulation that we had made once.

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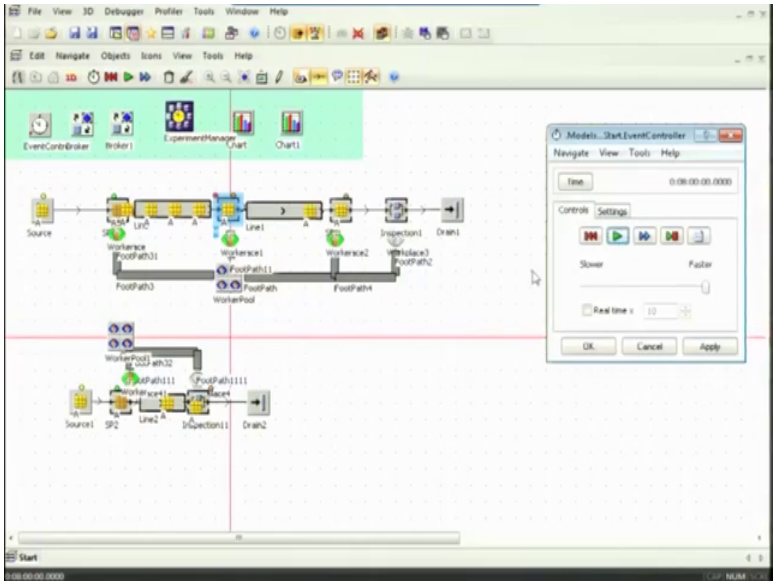

So, this is the factory simulation in which let me close these examples ok. This is a factory simulation in which these processes are there, this is the process if I put the names, this is the process single process 1 and a single process 2, single process 3 and the workers are working here, the times for the workers are put.

The speed of the worker which is defined by International Labor Organization is 80 meters per second and the times what the different machines are taken in a way that if it is a automated machine. So, the time is actual noted while doing live experiments. So, these live experiments were conducted.

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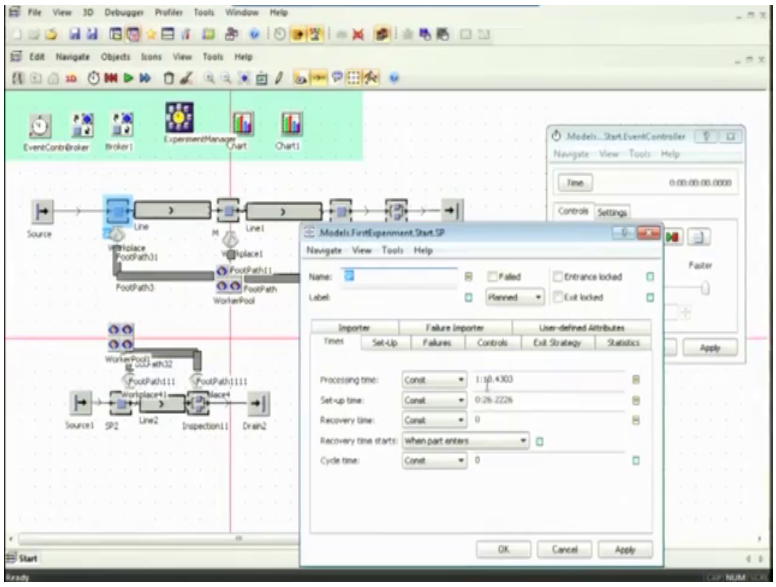

So, this is single process this is milling this is single process I have not change the name, but this is milling this time is kept constant here and this time is 1 minute and 10 seconds, like that is about 70 seconds it takes to do the machining then set up time is about 26 seconds.

So, for this machine these are actual times which are taken from the experiments live experiments are conducted. So, these times for the second machines this is the times the about 2 minutes; that means, 155 second 59 seconds for the processing and for set up it takes 33 seconds ok. So, these are all taken constant here. So, this is run for an 8 hour day ok.

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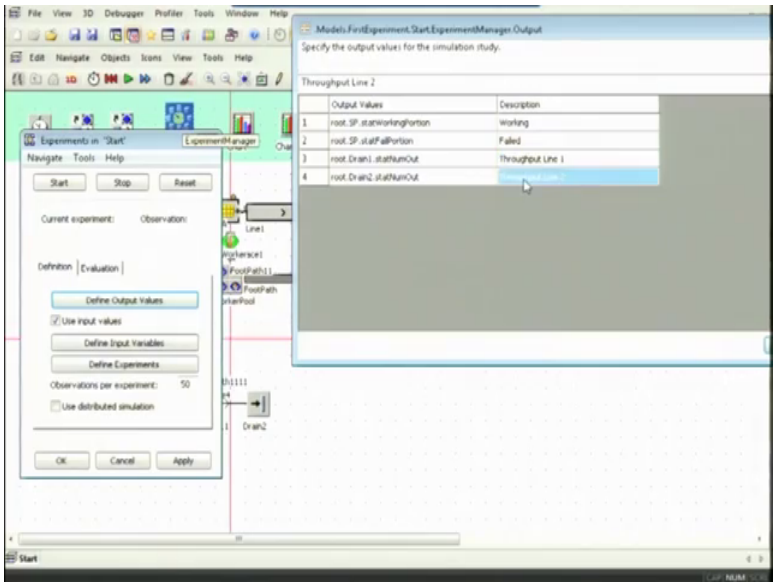

And also an experiment manager we have defined the output values; output values is one is working and failed and throughput of line one and throughput of line two we need to see.

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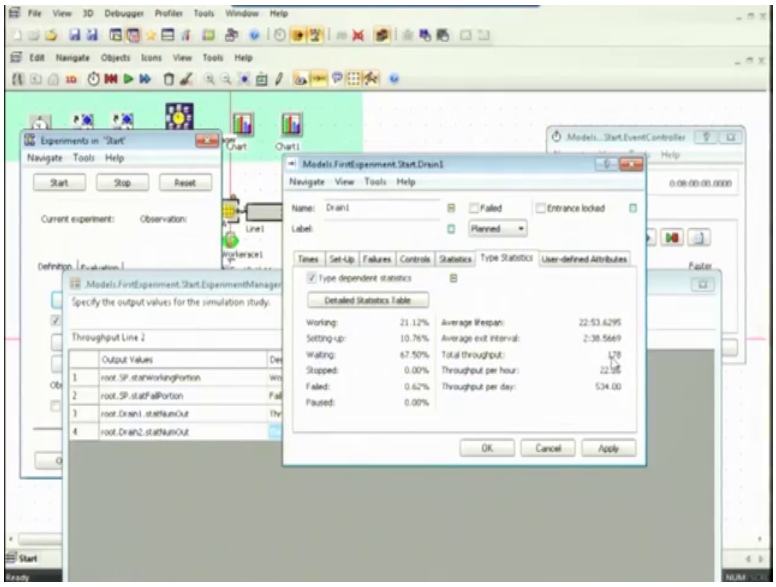

Like we can just see throughput here we can just see the throughput here in the previous way we did. So, we can just see the throughput of this run that we have done it is 534 pieces per day one seven 178 pieces in an 8 hour day; 178 but if I run my simulation using my experiment manager.

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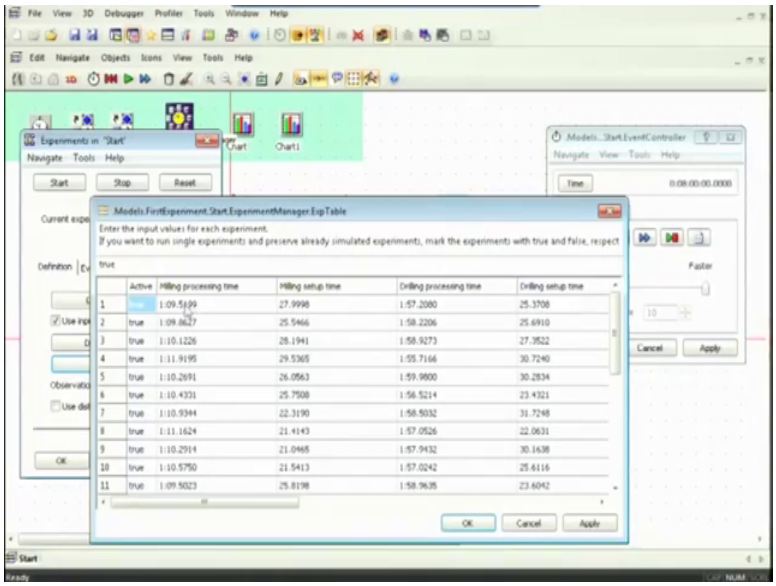

So, when I define the experiments I have defined 25 experiments here 25 experiments and these processing time is taken actually 59 seconds and this 59 seconds using random number table or using some random distribution; normal random distribution may be. So, we have selected a random times, those random times are put here 59 seconds was the mean and this is the these are random times not 50 not 59 actually 70 seconds is the time 70 seconds.

So, 70 it has 69 this is 69 1 minute 9 means 69, this is 70 71, so these are the random times set up times are also random. So, these times are putting time for milling processing, milling set up, drilling processing drilling set up, grinding processing grinding set up, then after grinding we have a inspection.

We have these machines here go back, this is my milling machine, this is drilling this is grinding, this is inspection one this is throughput through line one ok then workers certain pace of the worker footpath all those things are defined here, this is the model we made to I mean this is an hypothesized factory ok. So, defining observations per experiment, so their 25 experiments 25 experiments which are conducted using the random numbers and per experiments 50 applications would be taken, that is 50 times one experiment would repeat and of these 50 times, the box plot can be made for these 50 experiments this is one observation.

One observation means 50 experiments, the second observation is another 50 experiments. So, it is about the total number of experiments that that happen is 25 into 50. So, 25 experiments are made and 50 observations per experiment those are given here, this is 50 observations per experiment.

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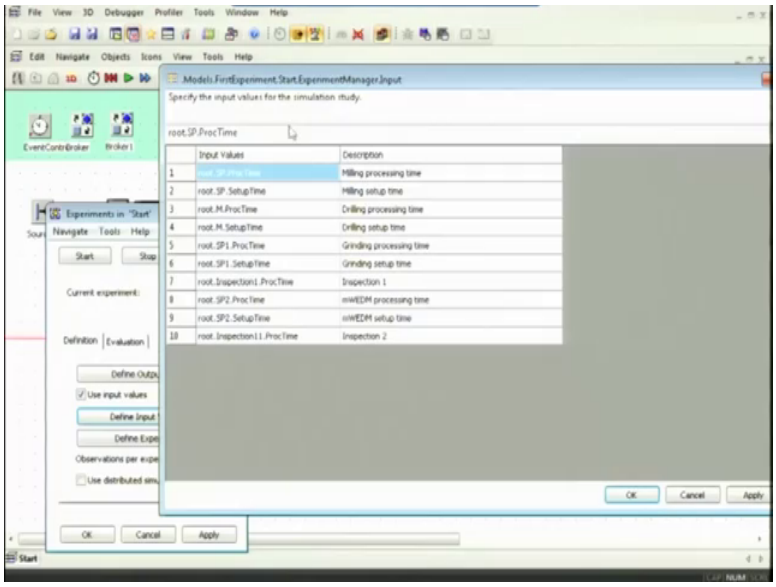

Then input variables are all these times milling, drilling, grinding processing and setup times inspection one. In the second line we have an model manufacturing machine which is micro wire EDM Electric Discharge Machine ok, so this is a model manufacturing machine. So, in this case also the time is put, so these three machine is inspection two is there.

So, the two lines you can see the two flow lines. First flow line is the conventional machines milling, drilling, grinding, second flow line is our model manufacturing source, micro wire EDM, then inspection and drain. So, we can see the both throughputs use after connecting these experiments.

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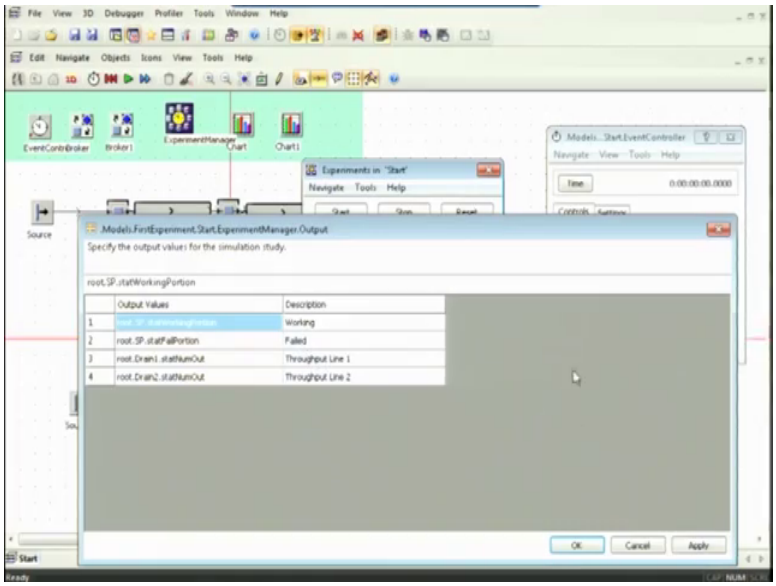

So, output values are all defined we need to see throughput 1, throughput 2 and also we need to see that working under failed percentages, so, let us start the simulation. So, current experiment is 1 if you see the current experiment is running 4th is running, now 50 is running for 6th experiment 50 observation for each experiment 50 observation what all the 25 experiment 25 observation will run. So, you can see the time 8 hours; 8 hours; 8 hours it is running the multiple runs here this is how the simulation is conducted using experiment manager.

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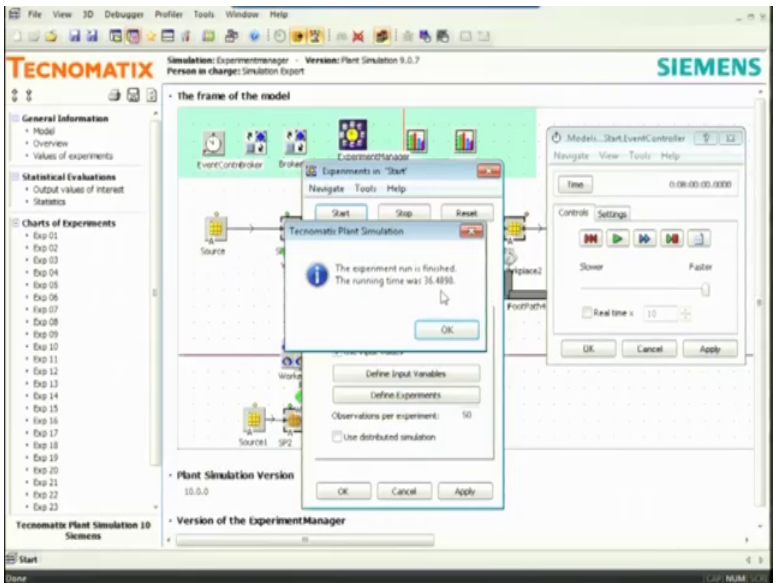

This is the exact therefore, what the user what simulation did, so it has generated a report. Total running time for the simulation is 36 seconds 25 into 50 is 1250, it has an run 1200 and 50 experiments in 36 seconds. So, this is my report, so let me take it here I would not close it this is my report it is saying ok; this is the simulation, this is the final picture that we have getting here this is simulation.

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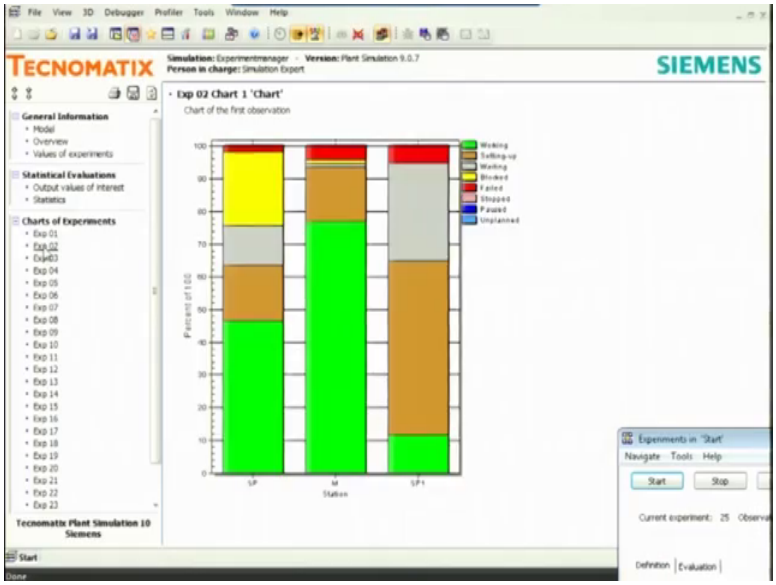

Experiment 1 if you like to see it is shown that single process 1, station 1 and single process 1 it is showing that these are the time for which it is working, these are the time for which it is blocked it is showing all these things.

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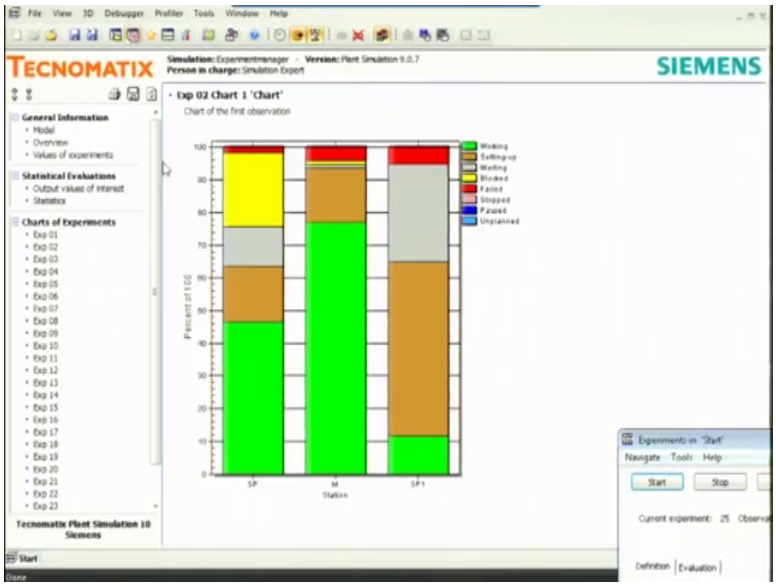

Experiment number 2 all these thing it is showing, so it is showing let me try to see the statistics here. So, mean value standard deviation minimum and maximum for experiment 1 for all the experiments.

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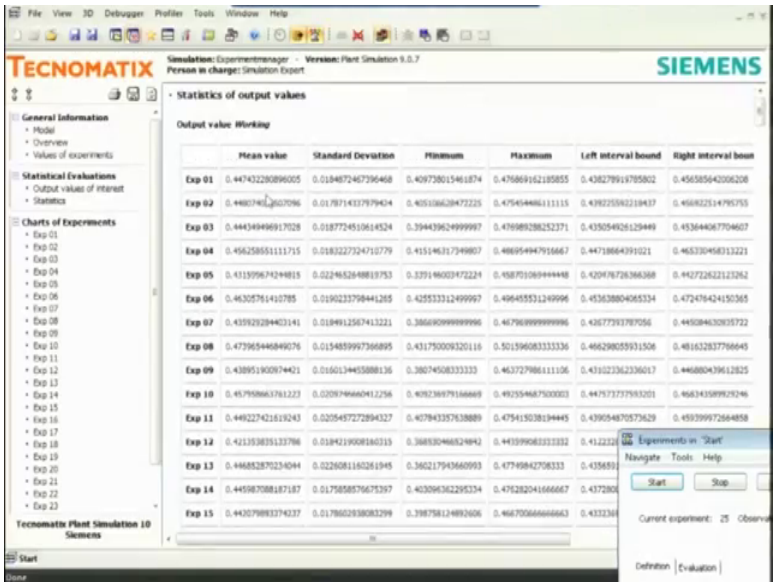

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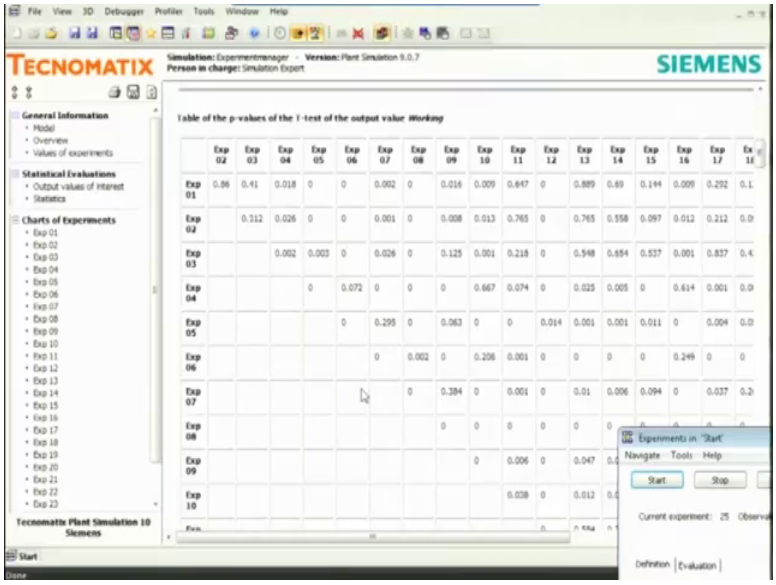

So, this is the p and t test you do not move to that, these are the test those are conducted and this is the chart for that not chart this is table for that; this is the failed time, working time and also it will show the throughput because we asked for a throughput.

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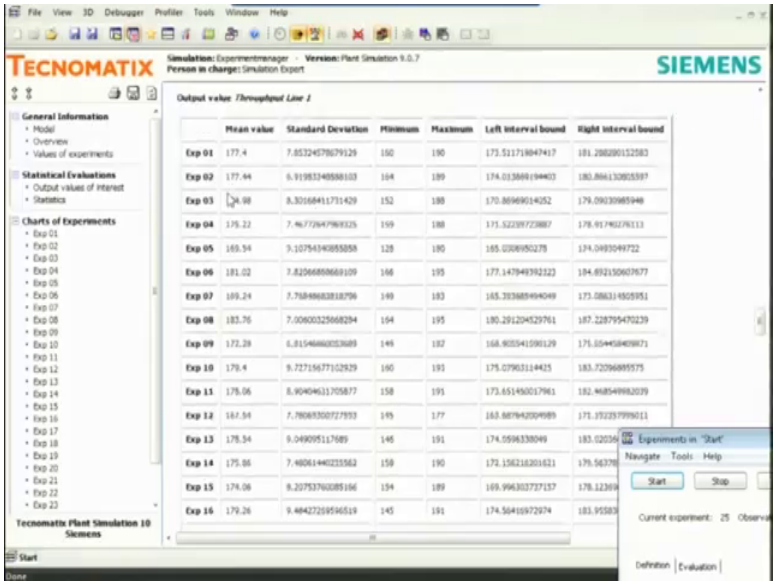

So, this is a throughput for the 50 observations in experiment number 1; experiment number 1 means 50 observation, the 25 experiments for each experiment 50 observations. So, experiment number 1 has 50 observations, these 50 observations have this mean 177.4 these 50 observations has the standard

deviation, it has this minimum value and this maximum value left and right bound is given.

So, for all these 25 experiments it is taken, the overall mean would be also one throughput that we also see for throughput of line 1 and throughput of line 2 we can also see here ok, this is are also again for 50 observation 25 experiments.

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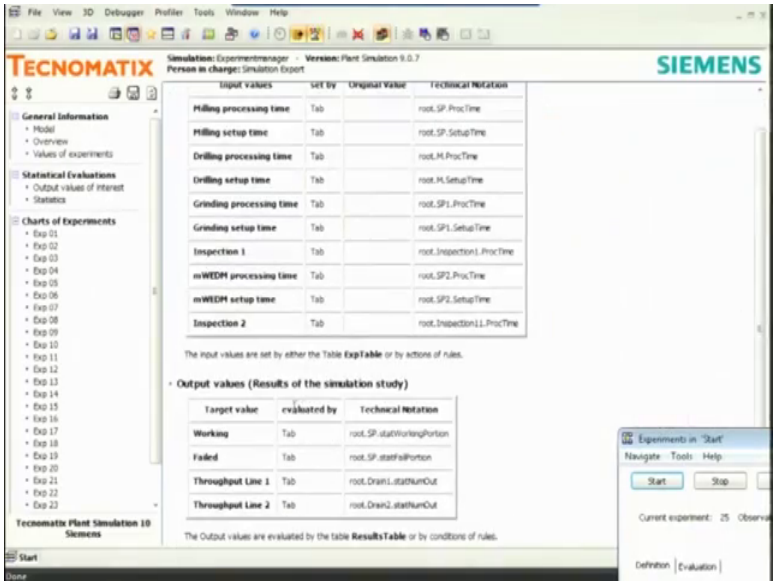

So, let me try to see this is the model, this is overview, this is values of experiments. Let me try to see the plots of these. So, these are the output values of interest.

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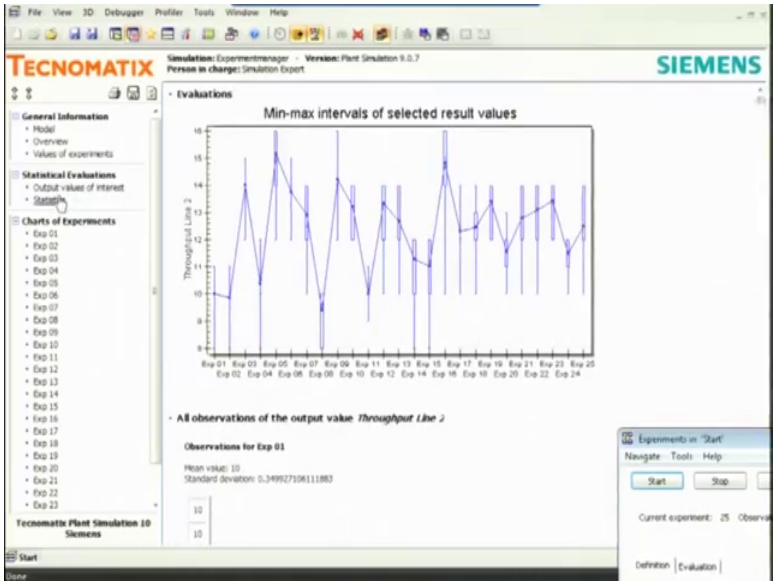

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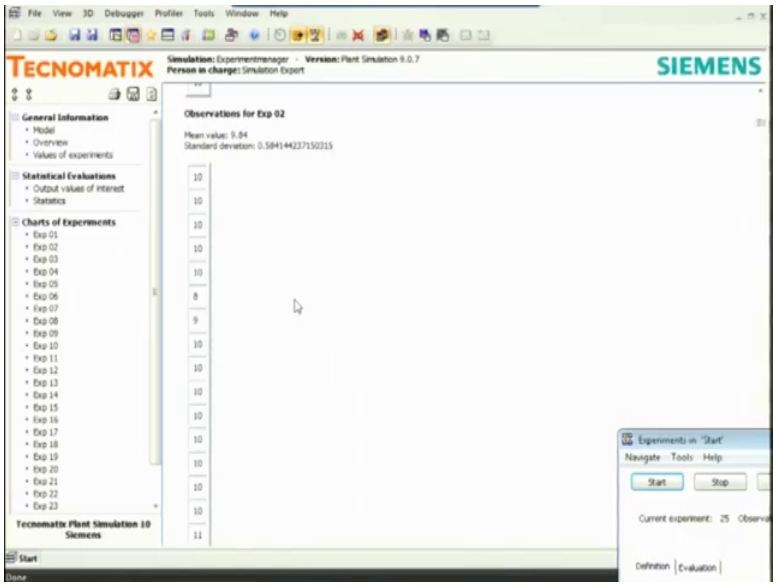

So, if you see these this is each experiment and 50 observations are given this is for the throughput 2, you can see now we have a box plot here. So, what does this so? This one instance this is my experiment number 5, this is my experiment number 5 this line.

In experiment number 5 there 50 observation and this is box plot, this is my median and you can say there is a whisker and the third quartile is quite lower and we do not have the first quartile; first quartile is kind of coinciding with my quartile 2.

So, the upper whisker is very smaller, so it is showing the box plot for each of the experiments ok. We can see the variation this one you know this is a very small variation here in a experiment number 11, in experiment number 16 you can see again this is a big variation on the lower side. So, you can also see the overall variability is very high ; overall variability is very high. Why it is there? Because the micro EDM or this is actually the behavior or you can say yeah behavior of the process only.

Micro EDM process we do not know the kind of experiments which we did, we did not know that what time would it take. Some time it took may be 50 it was actually about in 100, it 600 seconds it took 10 minutes some time it took 15 minutes, sometime it took 20 minutes, sometime it took like great variability was there in the whole process that is why this big variability is there number 1.

Number 2 is the number of throughput is very small, actually the final throughput that is obtained average throughput was 14 pieces, throughput is very small. So, with this small throughput is showing very high variation like in a day we can even you know we can see that we even have about 9 pieces in a day here ok, we have about 15 pieces in a day here. So, the total throughput is very small, so that is why this much high variability is there.

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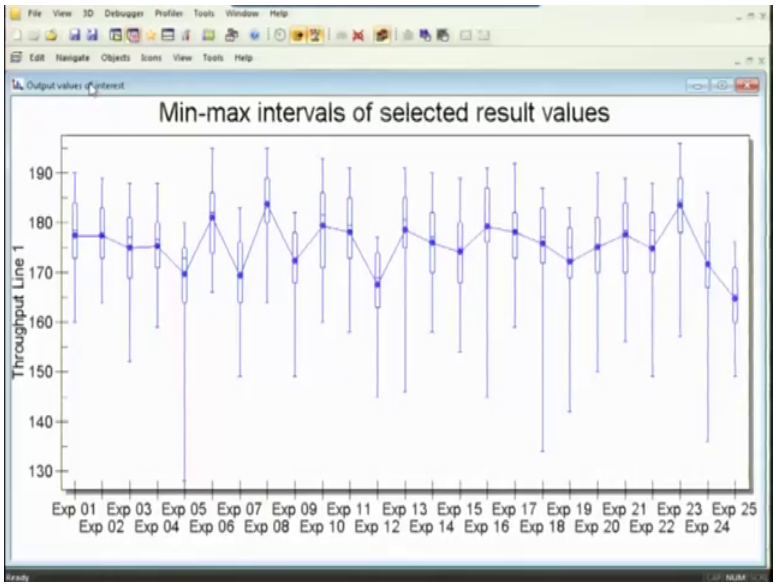

So, let me try to see this for throughput line 1. So, this have obtained a chart put for the throughput of line 1 you can say the throughput for line the variability is less. The two reasons for this number 1 the processing times were in control because the machines were CNC machines when we conducted a reliable experiments. However, the processing time for the inspection was a little variable because inspection was done manually.

So, but overall because there were three automated machines, so the variability is lesser than that we observed in our line two this is first reason. Second reason is this number the throughput value is 178, the overall average is 178 which is a big number and that like bigger number than that very small number 14. So, the throughput variability is lesser.

However, in regional processes because the simulation is trying to reimitate the realistic situation; so, in realistic situation we can have the outliers we can sometime

have the very long time or very lesser time, then it should be normal. So, this for instance in experiment number 5 you can see again the whisker is falling down, it all depends upon the random numbers and if I tell you the times were kept constant, but the seeds were all different.

So, depending upon different seeds for this different experiments and the observations were also very different these different box plots are obtained. So, we can infer that the variability is lesser in these and number of workers we can keep varying the number of workers.

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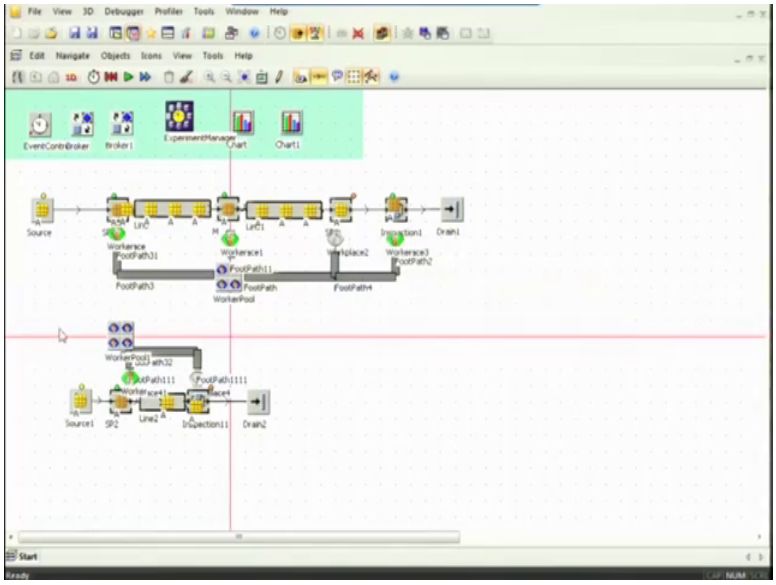

You know in this experiment the number of workers those were employed were 4, you know 1 2 3 workers in line 1 and 1 worker in line 2 we can also think of employing 5 workers that is 4 worker in line 1 one here, second here, third here which is not yet employed and fourth here and fifth one here. Then we can see ok; if we employ another worker we can do cost analysis as well.

If we employ another worker what is the wage of that worker and what is the overall throughput, what is the increase in the throughput? If the increase in the throughput is lesser than like the profit that you obtained from the increased throughput by employing the fourth worker is lesser than the wage that has to be paid to the worker. So, we can just take off the decision we can just deny this decision.

So, the certain experiments that we can do, certain simulations that we can do I think I should stop here we have discussed enough about the technomatix software for a ammeter this is the good start like you have an introduction to; to how the softwares work and how is simulation conducted in the software's and what are various kinds of layout.

And we can even optimize a layout using these softwares and at the certain you know as I have told this is a great capability of this specific software, but yes we can keep on using this, we can try to simulate a factory, we can make a big factory and this is just a manufacturing processes; manufacturing systems. We can also think of taking after this manufacturing system this is developed this systems or the actually report that we have got we can take that report to team centre to finally support when actually things happen.

So, we can just put ok; this is the schedule or the plan these are things which are actually happen so what is the variation of the actual things which are happening in a first few runs when we actually run this these kind of set up. So, we can test tools as well using these software tools. So, I like to stop here and thank you for being in the course, so we will meet next time.

Thank you.