Computer Integrated Manufacturing
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Lecture 47
Laboratory Demonstration Plant Simulation software (part 3 of 3)

Good morning, welcome back to the course. I am Dr. Amandeep Singh and I will take the Plant Simulation Technomatix in this lecture.

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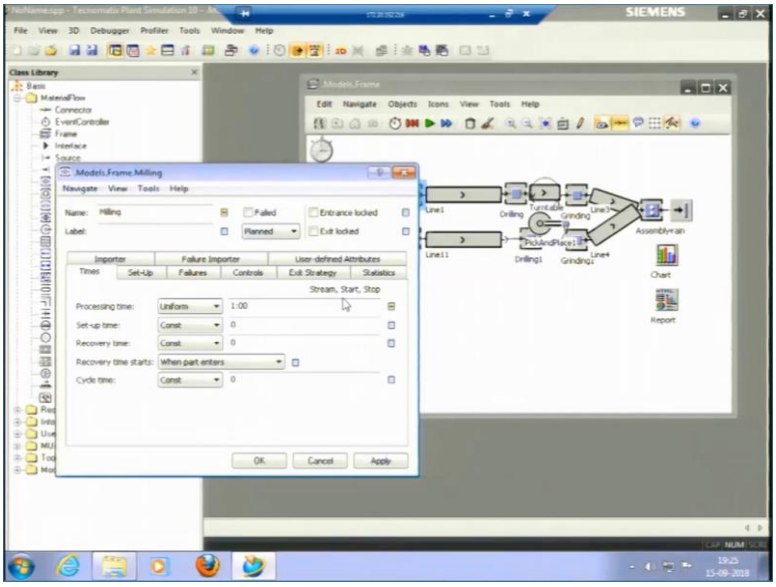

I like to talk about the distributions. I have just opened this milling process the processing time is one minute, if I put uniform distribution, uniform distribution do you know that it is also known as rectangular distribution so, where we have just this start and stop, we have the minimum and the maximum value and we know that the value would lie between these 2 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 2 or 3 or 5 or a very few number of observations and we do not know what 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 know the rectangular distribution is just we have A value and

B value that is all so, it is showing if you have to put it in 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.

So, this is there 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 talk when we talk about is simulation, 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 of subjects. It is the random numbers, random numbers which you are working on so, where does our random start form, of the specific so, that is the Stream.

So, if instance for they are 2 processes, I put 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 2 here in one process and seed value 2 here in another process so, the ninth random number, that is selected in this process and the ninth random number that is selected in this process that would be same, ninth, fifth 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 or at least a different seed for different processes to have the good simulation process. So, if we do not put any stream value here, the software would pick extreme value by itself. So, I am not putting any stream value so, they have just put uniform distribution.

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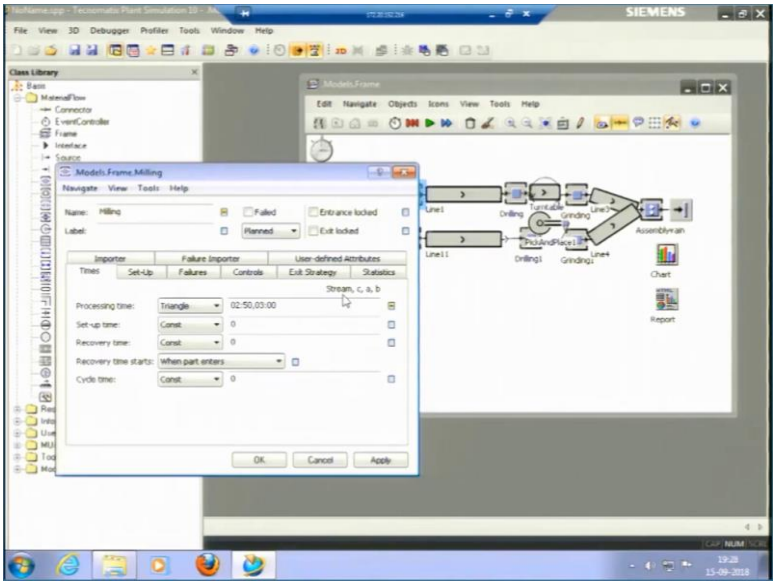

So, we know that the minimum time would be 2, or let me say time where is from 2 minutes 50 seconds to 3 minutes. We know that this is the minimum this is maximum. First, I will talk about triangle distribution. Triangle distribution is actually sum of 2 uniform distributions, 2 uniform distributions are there, 2 uniform distribution means, uniform distribution means, we just has the smallest value and the largest value we do not know what would happen but, in triangle distribution, we have 3 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 repeating maximum number of times, that value is mode.

What is mode? Like mean, median, mode is there, mean is actually the average of the values median is the central location value mode is the value that is an maximum frequency.

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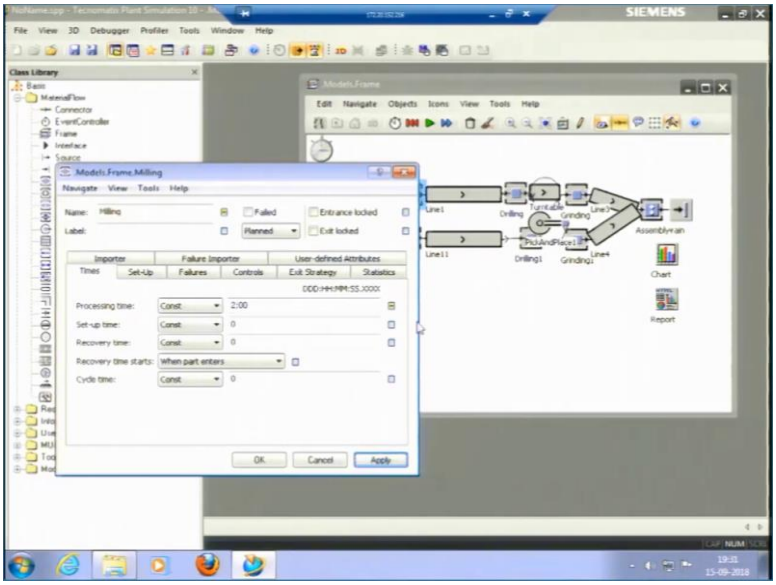

So here, we can put if I had pick the triangle distribution, it is showing stream c a b here, a is the smallest value, b is the largest value, c is the mode value that is, that is repeating for maximum number of time. When it is repeating, I am talking about the past data, in the past data I have 5 or 6 observations, I know this is the minimum value this is the maximum value but, there is one value which is trying to repeat maximum number of times so, I can pick the triangle distribution based upon the past data of a lot of observations in the past I can pick normal distribution.

If, get fixed good here, in normal distribution it is asking for its parameters the normal distribution, I would say normal distribution statistic it is asking, it asking for stream now, it is asking from Mu and Sigma, Mu is the mean or average, Sigma is a standardization also, it is

calling for the lower bound and upper bound, lower bound is the minimum value and the 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 your realistic conditions.

So, this is the work of a system engineer to design it in a proper way. So, if I change this time you can see, I do not apply because it is, it is showing you know, if I do not put it in the proper way this is stream, Mu, Sigma, I am showing the value of stream it has just pick I was showing the value there is 250 and 3, the value of mean was smaller than Sigma so, that is why it said ok, it is showing the negative value, it is not accept it would not accept any other format than is required.

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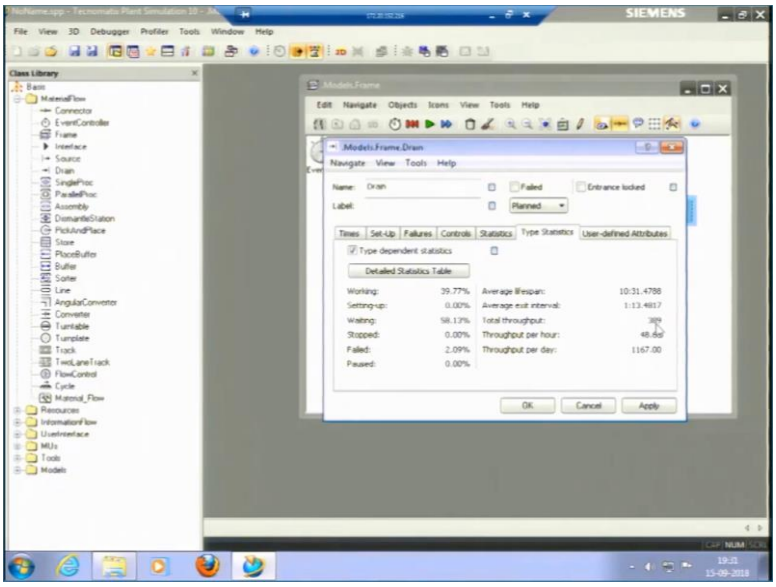

So, let me pick this constant time here and it was just to make you understand properly one minute I will apply. So, let me see if I run it for an 8-hour day and there to see the throughput open we try to see throughput it is throughput per day is 1167, per hour is 48 and the total throughput is 389 for an 8-hour day, for 8 hours.

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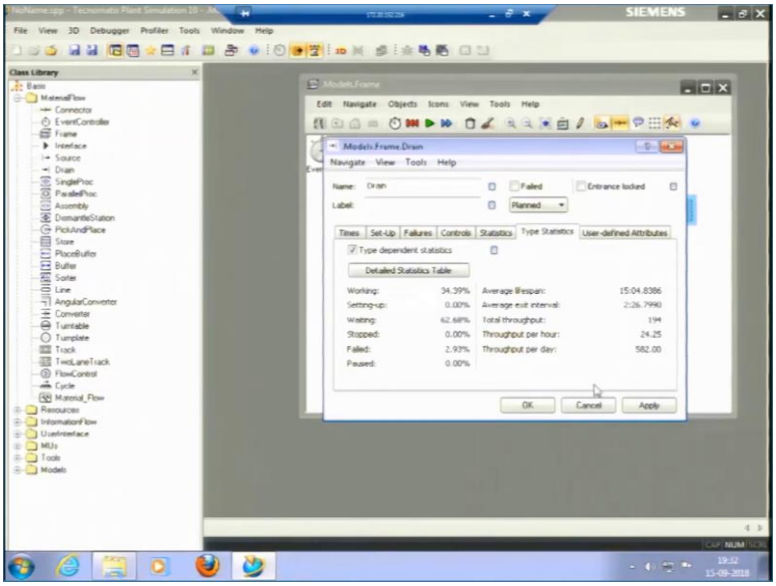

Now, if I change the processing times open if I change this processing time to let me take 2 minutes and I change this processing time also to 2 minutes, in actual conditions, we cannot change the processing time, the processing that is has to take it would take. The milling it has to, if it has to take 2 minutes unless we change the tools which change the machine or we have CNC machines or we have advanced machines we cannot but, work more on the processing times so, processing times are fixed yes, in the plant simulation 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 layout 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. So, if I change this time now, I have increase the time to 2 minutes now, I run the process and let me try to see 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.

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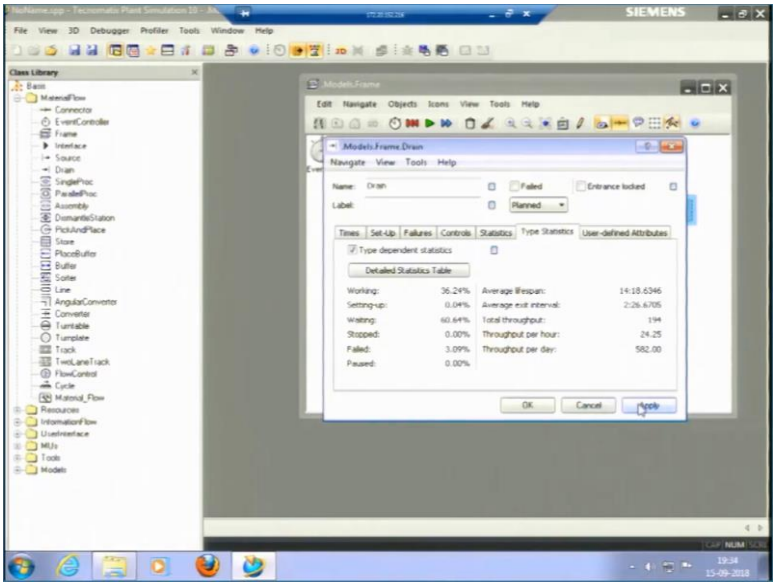

So also, we can have the setup time as for instance a workpiece is to be manufactured it will take 2 minutes for processing and 1 minute for setup, 1 minute for setup means, for instance, some milling is happening when your milling process what do we do? We just rotate the tool and remove the material. So, it is removing the material from one workpiece this is 2 minutes process. After 2 minutes, the machine stops, this workpiece is taken off and a new workpiece is brought in here, that is the raw one and it will start process on this.

Now, this setup, this setup takes 1 minutes here so, this is setup time, this is setup time, this is processing time. If I induce such a setup time as well and apply, let us see what happens to my throughput now, only in one line I have put some setup time so, the throughput is further reduced here, it was 197 pieces so, it is 194 pieces now, because the setup time is there now and another 1 minute is being taken so, total time taken in the milling process in the line one is 3 minutes now. 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 different layouts and also the experiment manager will use will try to see the simulation that we can do in the software.

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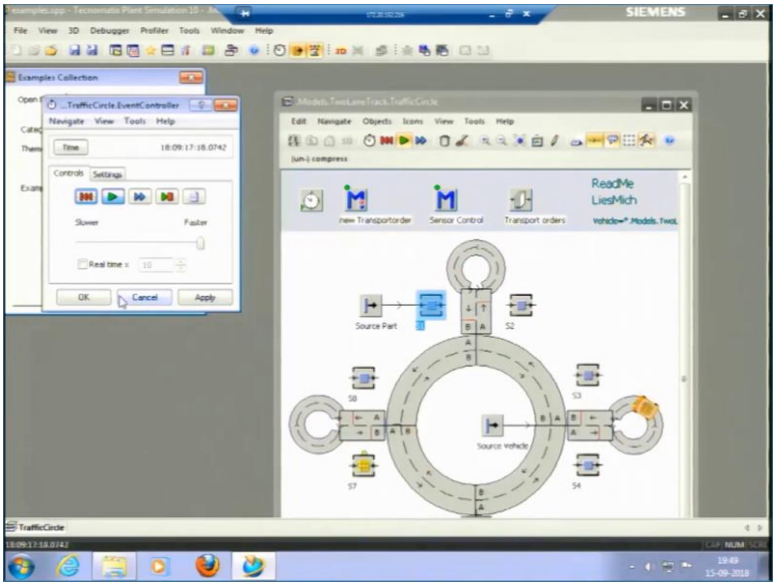

So, this is continuous material flow, I will select 2 lane track here so, traffic circle or segment table, traffic circle pick and open the model so, this is the model is already running so, I will just run the model you can see this is the trolley that can pick our material from so, this is source parts some processing is being done here, I can see what is the time of the processing here, the times is constant 1 minute.

So, you can see it is happening, let me make it a little faster control panel I will make it a little faster and then run this trolley is running trolley is continuously running through the 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 will continue for the infinite time so, this is kind of a just cell and O cell so, cancel stop.

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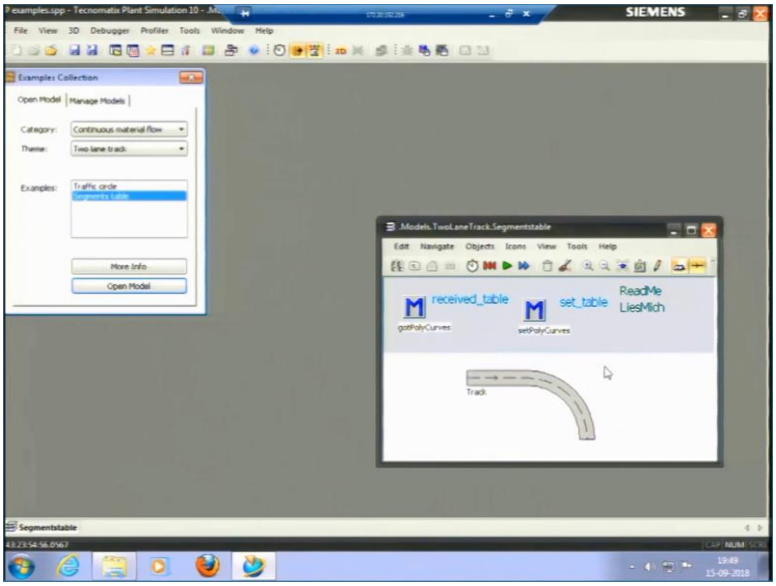

So, segment table, open model, this is just showing a track, how the track is built. So, let me pick user interface, dynamic statistics, display panel, or chart open.

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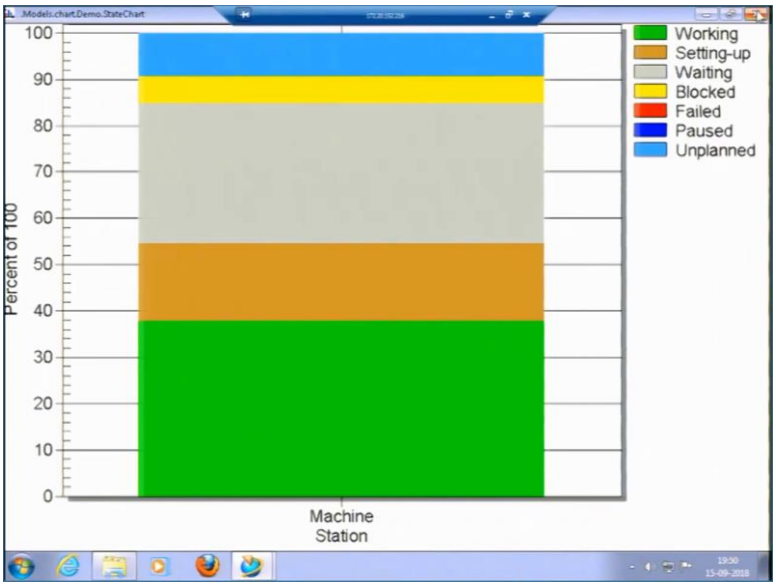

So, in this model we can see the chart, what is setting there is no end time I will put the end time here, 08:00:00, apply, okay. Let me try to run this model so, it has run for 1 day so, entity buffer is there, entity machine is there, this is similar to that. So, we can see the charts here, show chart. So, for only one machine it is showing the chart that, this is something unplanned blue colour is unplanned, then we have blocked we have, 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.

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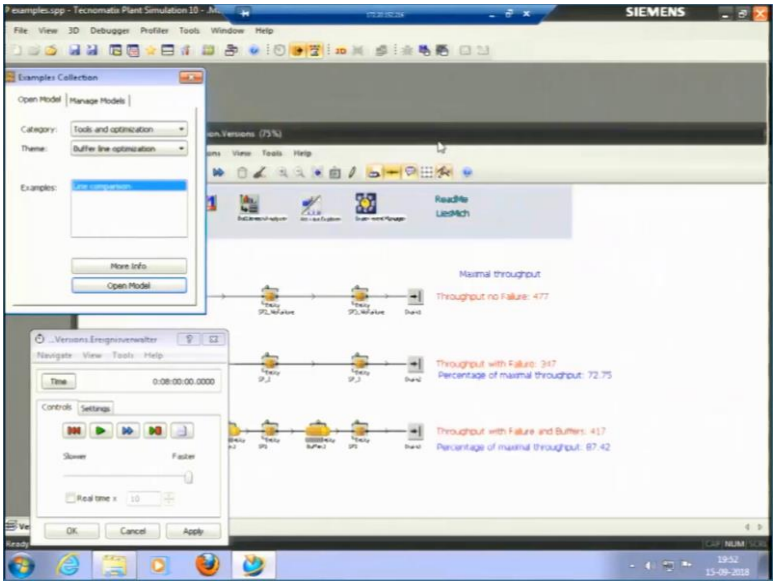

Then, tools and optimization the important is experiment manager. I will just pick the buffer and optimization this is line comparison open model so, in this model, what we have, we have 3 lines. In this line, they throughput with no failure, this is throughput with failure, throughput with failure, and buffers. So, there is buffer, their buffers kept in between, if I enlarge it, this is buffer, this is another buffer. So, a, back buffers in between, this is throughput, we need to see it throughput with no failure, another line in throughput we have put some failure rates here.

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. So, let me try to run this model. Yes, this model has run for an 8-hour day. So, for with no failure the pieces those are produced in a day work four 77, with failure it 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, maximum throughput is 477. So, it is with failure, we have 72 percent and with failure and but with buffers with have 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 work introduction worker introduction model.

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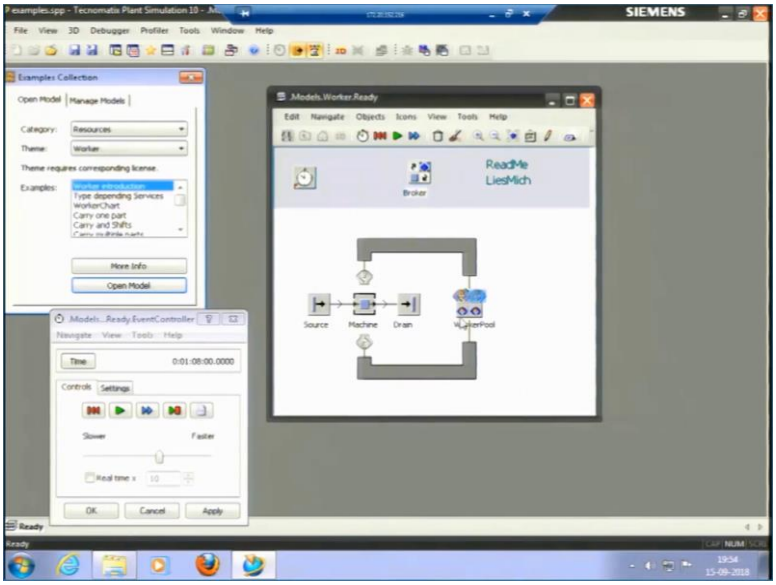

So, this is the worker introduction model. So, in this case, you can see the workers are just introduced into machine and if we run this. Let me try to make it a little slower, apply, now run, you can see the workers were running it. So, I can see the number of workers are 2 here and work pole is there and the broker is there, broker is trying to distribute the work to different workers. So, this is one of the examples then, let me come to the major simulation thing, that is the experiment manager, we have to optimization experiment manager.

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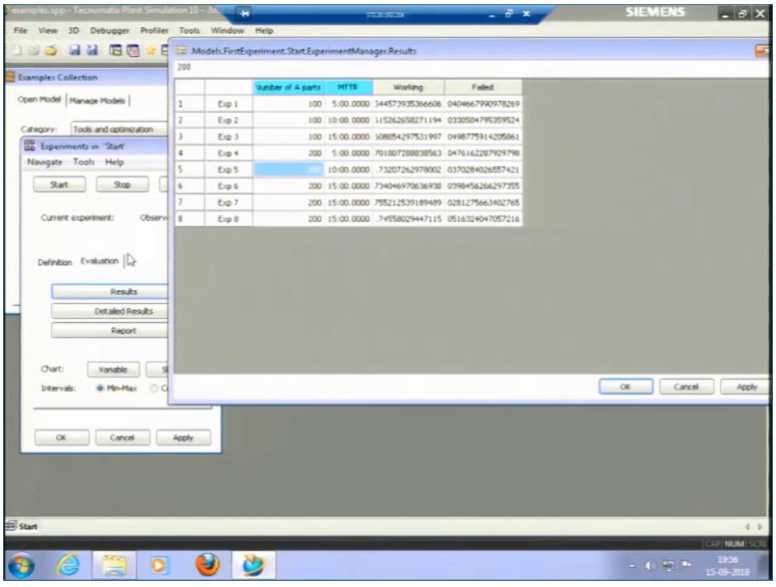

This is one of the models where we have experiment manager, this experiment manager can show the simulation if, I run this model for it if, let me open the experiment manager first, it said definition and evaluation in definition, we have defined the output value output value of

the work station portion start field portion it is working on field so, what output do we need and what inputs do we have, input is the root delivery and mean time to repair.

So, if I run this model, so also, I can define experiments that is for number of, hundred number of parts mean time to repair is this much 5, 10, 15 then 5, 10, 15, this is for 100 parts, this for 200 parts again. So, these number of experiments would run if, I run this experiment manager. Let me try to run, it has run for 8 hours. Now, let me try to see experiment manager now, I need to see the results.

It has shown the results at the meantime to failure if, it is kept 5 so, it is working for this much number of time is fail for this much number of time so, for the simulation of a 100 parts, for the simulation of 100 parts, again, this is for 200 parts. So, it has taken 8 experiments.

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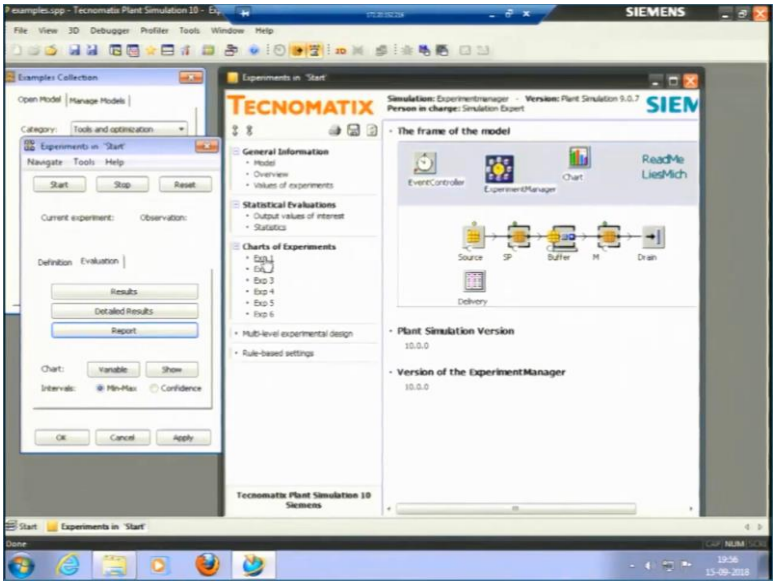

So, I can see the report as well here, in the report it is telling that they are number of experiments.

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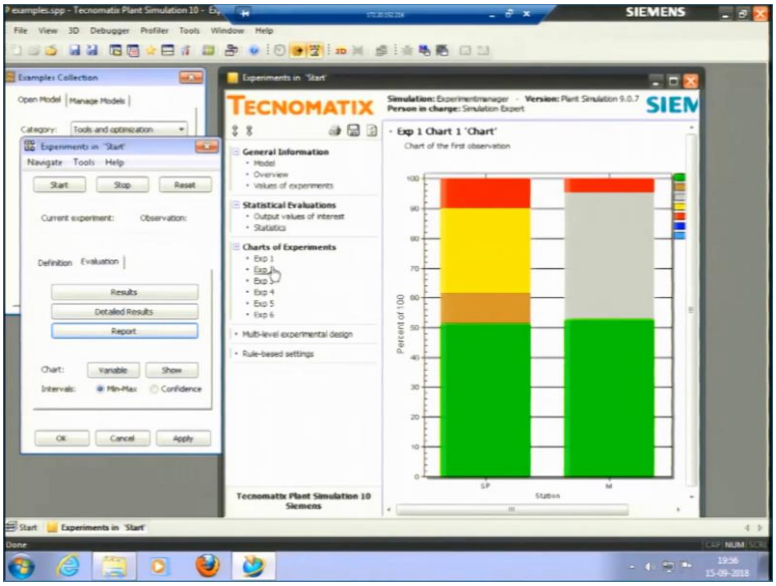

In experiment one, this happened. In experiment 2, this happened, this is the total failure, this is bought, blocked time, then grey colour is getting time, all these things it is telling in the report so, in experiments what has, what is it taken? It has taken different random numbers in experiment number one different numbers of random numbers are taken and experiment number 2 different numbers are taken. What is experiment number one?

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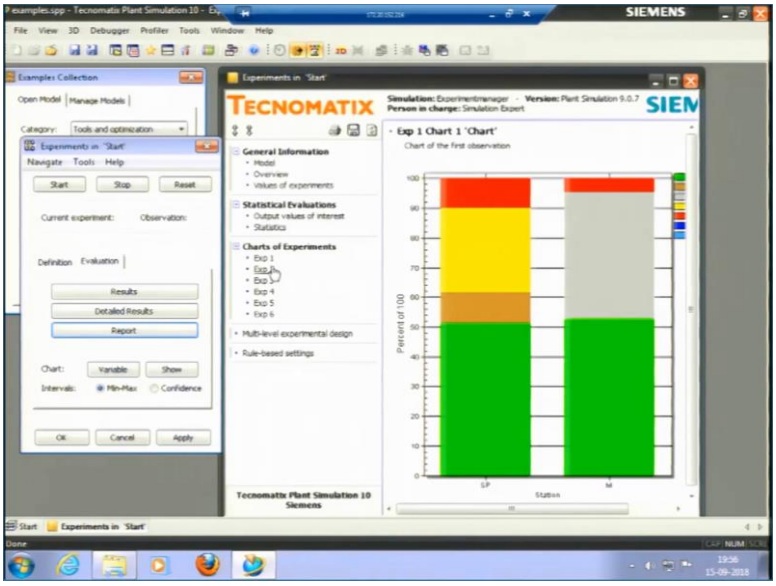

It was given here; the inputs that we gave output values sorry, output values are here, in these results. Experiment number one is a 100 parts with mean time to failure as mean time to repair as 5 minutes experiment number 2 is 100 parts with mean time to repair as 10 minutes.

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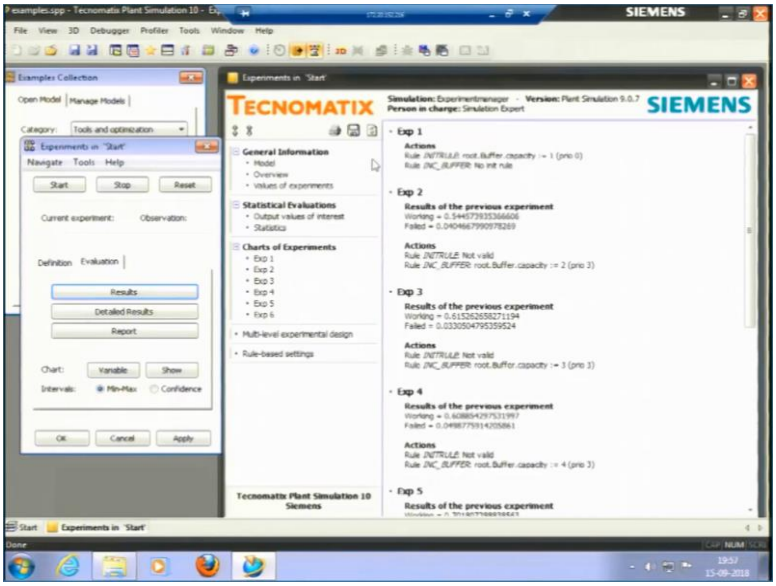

So, it is showing these experiments here. So, we can have all different kinds of designs, then rule we have not defined any rule be accepting can also be done this is and like if we go to the detail of the simulation, these things are possible.

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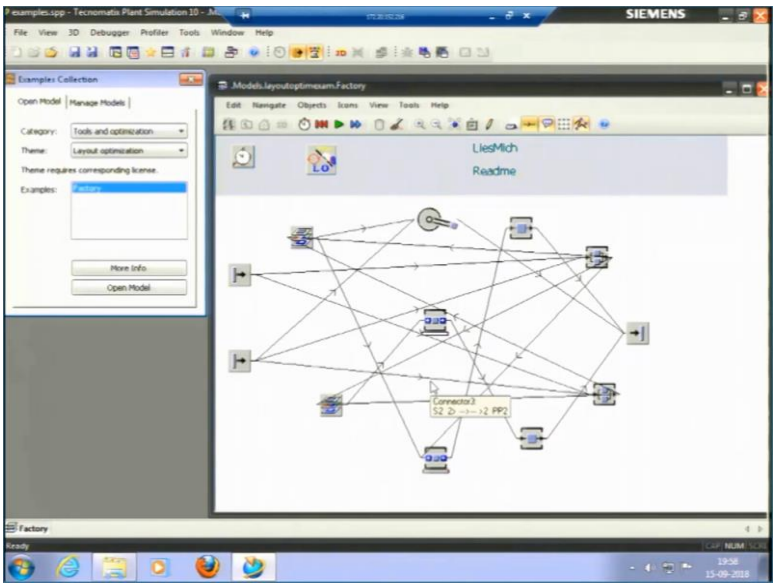

So, now layout optimization, factory optimization, factory layout is there. This is a factory, and we have made weird kind of connections here so, fact layout optimization can be done for where to keep, what machine then, what would be the overall, what would the maximum throughput if we do that? These models can be also we can prove through these things to find the optimization here.

So, another model I can pick here is from continuous material flow tool and track, distance control, sensors, sensors are like if, we need to for instance if, we need to accelerate at some point, or we need to put brakes or we need to put the curds this is a light and like, we can do anything let me open this mode, okay? Yes.

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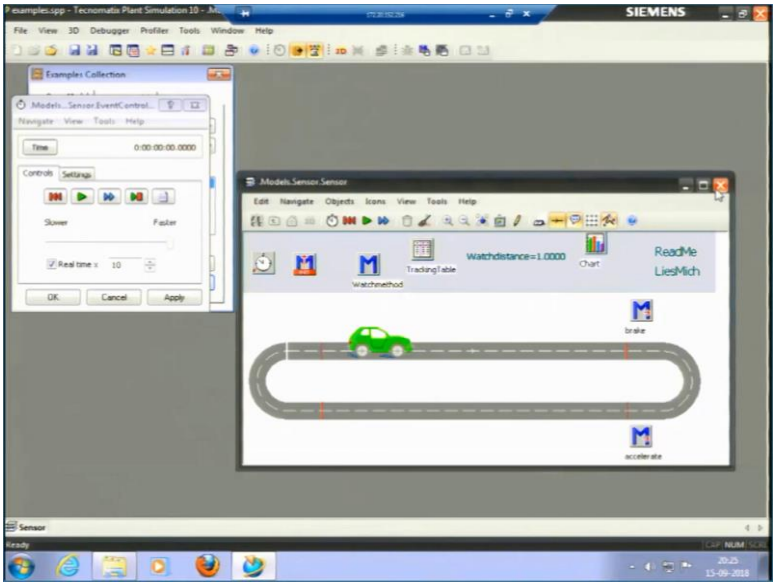

This is a brake and accelerate model. So, I have defined the method here, wash method, the method here is brake and accelerate. So, if I try to run this model first, let me see the events simulator, it is end time nothing but, just to see whether, how it runs you can see this is break, after break, it will just slow down after accelerated it will accelerate this is in this speed so, at this point break would apply it is accelerate now, to break would apply it will take a turn accelerate, it will accelerate from this point.

So, this is a kind of entity this car here, we had just one, one kind of entity this is another entity, which is in the form of car the name is auto sorter. So, this was a sensor in control limit continuous visual flow there are many models in this so, I will just pick randomly something some tools and optimization I can pick experiment manager then, I have tried to explain experiment manager in more detail and pick an example so, before that, let me pick something the transfer station, transfer station I have a demonstration model here.

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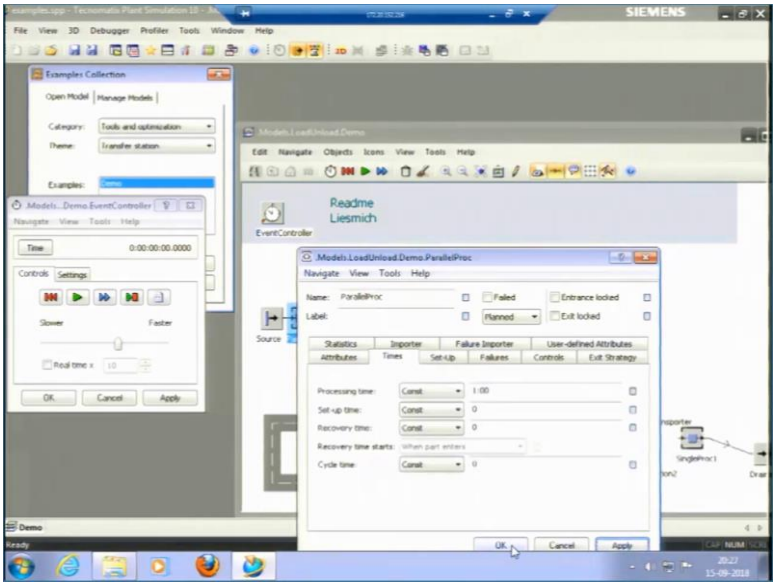

Transfer station is this is one cell, this is one cell, this O is one cell this is another track here, 2-way track, transfer station it will just transfer the material from this cell to this track, it will try to see the event simulator here, you can see the trolley or the container came here, the container is coming, some machining is happening here, some machining is happening at this parallel process let us first see, what are the process parameters here, this is a parallel process in which 2 into 2 to 4 processes are there and the times is again the default time 1 minute, so, is from source it comes in transfer station is here, we need not connect transfer station here, can we see the transfer station.

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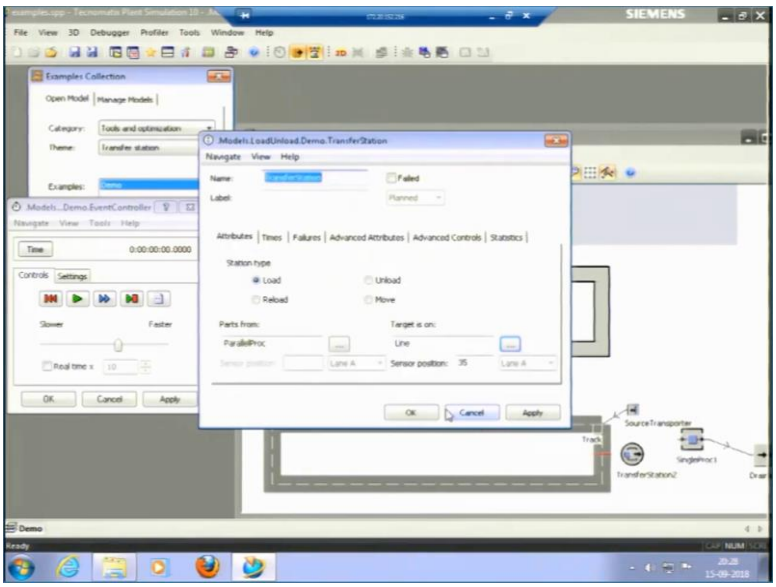

So, it will transfer it will load it will just load the process, it is connected correct path from the parallel process, we just need to put the name if, the process from which process it will pick the part from parallel process then, it will target or the transfer the parts to line. So, there is no connector required in between, we need to just mention the predecessor and the successor process is here so, sensor position is this one and all this so, we can select load, unload, reload, move, so, it is loading the parts. So, all these attributes available is 100 percent we can select this I would not change anything and let me try to run the simulation.

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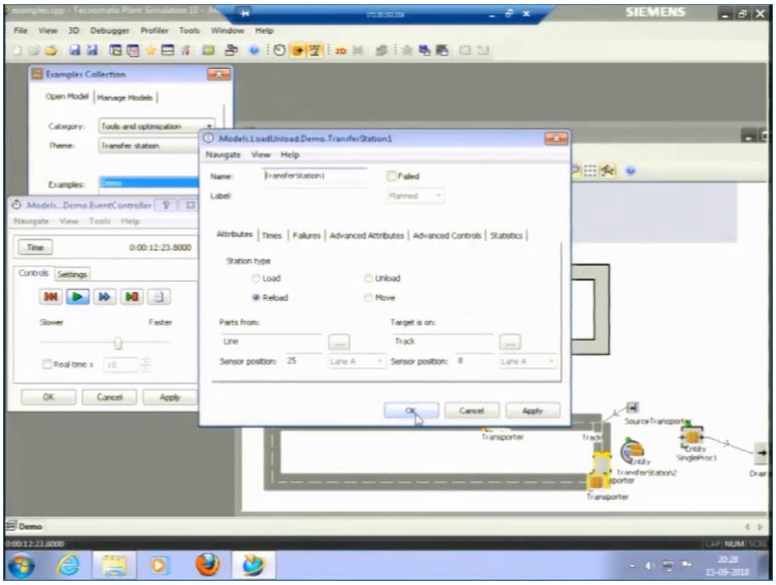

So, these containers are running, some processing is happening here, it will taking 1 minute so, transfer station is then transforming the path to this container so, this container is just coming here and this transfer station it is connecting the part from this line 1 to the 2-way track if, I see its properties it is from line to a track the name of this track is track only.

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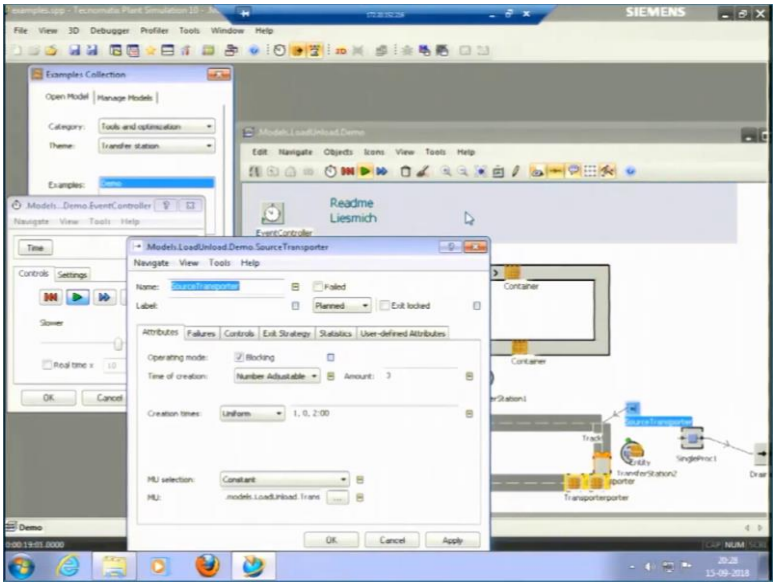

So, again from this there is another transfer station, the source transporter as well the source transporter that is a source is there, that is trying to transport material from some other frame of some other using some other interface it is trying to do that so, this is one of the objects that can be used. So, this is I say transfer station. Now, apply, okay. So, there are certain examples which are available for us to see how this thing happen so, I will just open the start page you can and try to open this factory simulation that we had made once.

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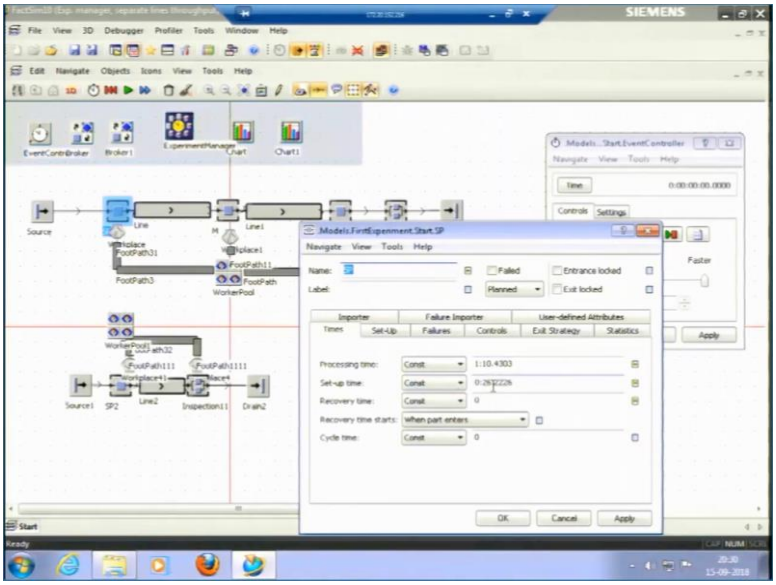

So, this is a factory simulation in which now, let me close these examples, this is a factory simulation in which these processes are there, this is the process if a put the names, this is the

process single process 1 and single process 2, single process 3 and the workers are working here, the time for the workers are put the speed of the worker which is defined by International Labour Organization is 80 meters per second and the times what the different machines are taken in a way that if it is an automated machine so, the time is actually noted while doing live experiments. So, these live experiments were conducted. So, this is a single process, this is milling, this single process I have not changed 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, setup time is about 26 seconds.

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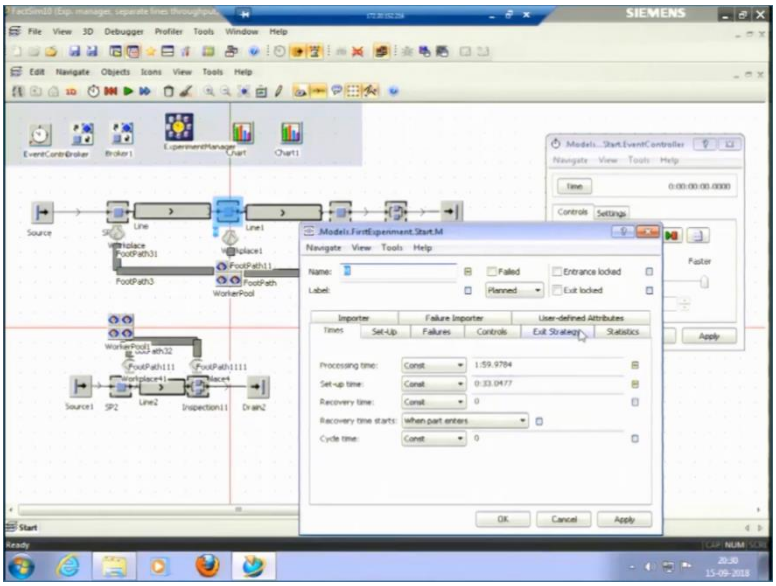

So, these are actual times which are taken from the experiments, live experiments are conducted. So, this times for the second machine this is the times, the about 2 minutes that is 1 minute 59 seconds for the processing and for set up it takes 33 seconds so, these are all taken constant here.

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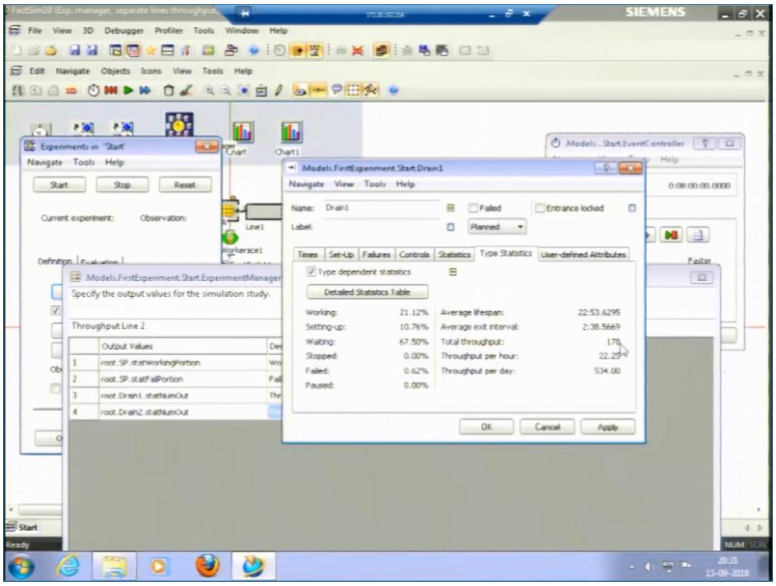

So, this is run for an 8-hour day and also an experiment manager we have defined the output values output values is one is working and fail and throughput of line 1 and throughput of line 2 we need to see. We can just see it throughput here, we can just see the throughput here, in the previous way we did so, we can just see the throughput of this run that we have done it is 534 pieces per day, 178 pieces an 8-hour day, 178. But if I run by simulation using experiment manager.

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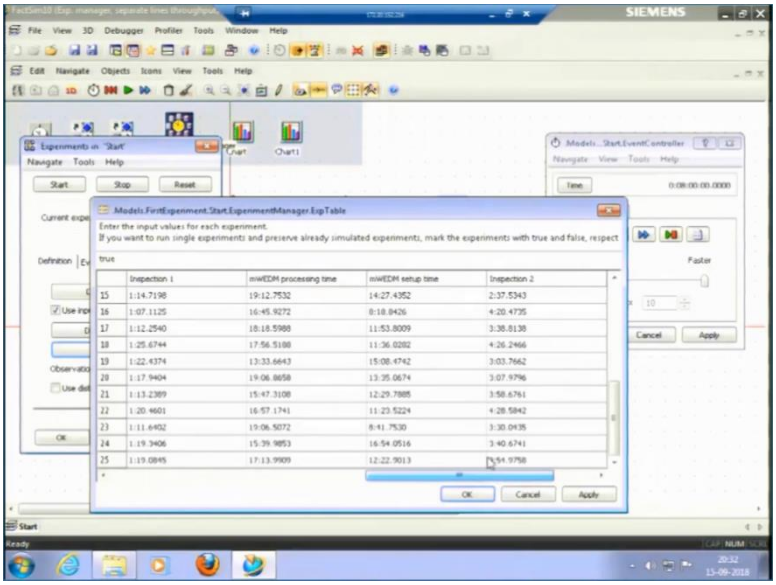

So, when I define the experiments I would defined 25 experiments here, 25 experiments and these processes processing time is taken actually 59 seconds and this 59 seconds using random

number table or using some random distribution, normal random distribution maybe so, we have selected at random times, those random times are put here, 59 seconds was the mean and this is the here, random times, not 59 actually 70 seconds is the time 70 seconds.

So, 70 it has 69 this is 69, 1 minute 9 in 69 is 70, 71, so, these are the random times, setup times are also random. So, these times are putting times for milling, processing milling setup, drilling process drilling setup, grinding processing, grinding setup then, after grinding we have inspection.

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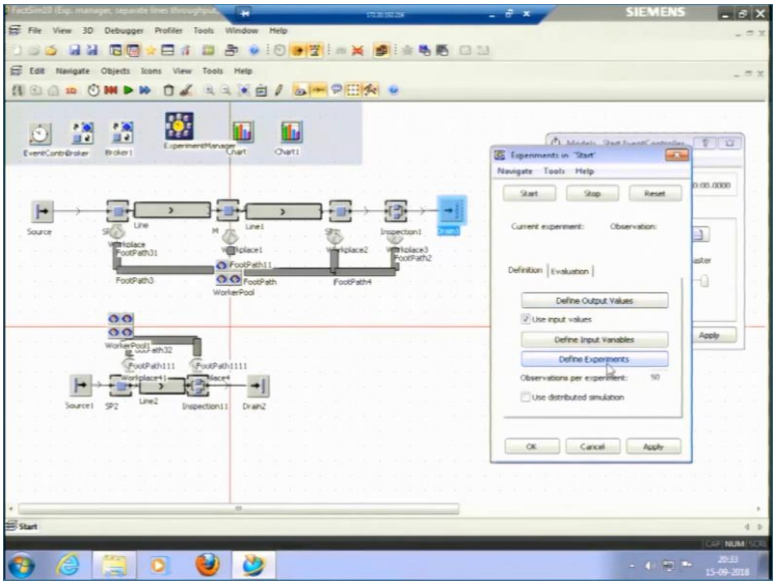

We have these machines here, it go back this is my milling machine, this is drilling, this is grinding this is inspection one this is throughput to line one then, worker certain pace of the work of footpath all those things are defined here, this is the model we made, this is an hypothesized factory so, defined observations per experiment.

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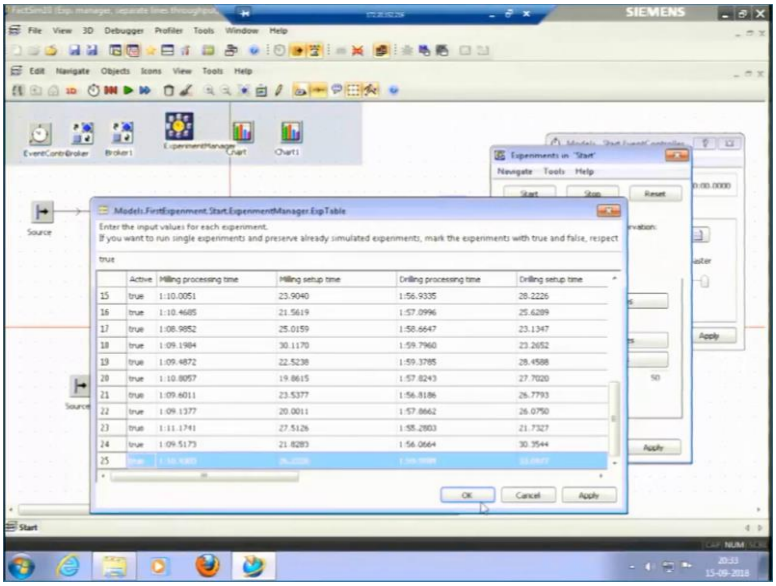

So, there are 25 experiments, 25 experiments which are conducted using the random numbers, and per experiments 50 applications would be taken, that is 50 times one experiment would repeat, and of this 50 times, the box plot can be made for these 50 experiments. This is one observation; one observation means 50 experiment, the second observation is another 50 experiments. So, it is about the total number of experiments, that happen is 25 into 50. So, 25 experiments are made and 50 observations per experiment to the given here, this is 50 observations per experiment.

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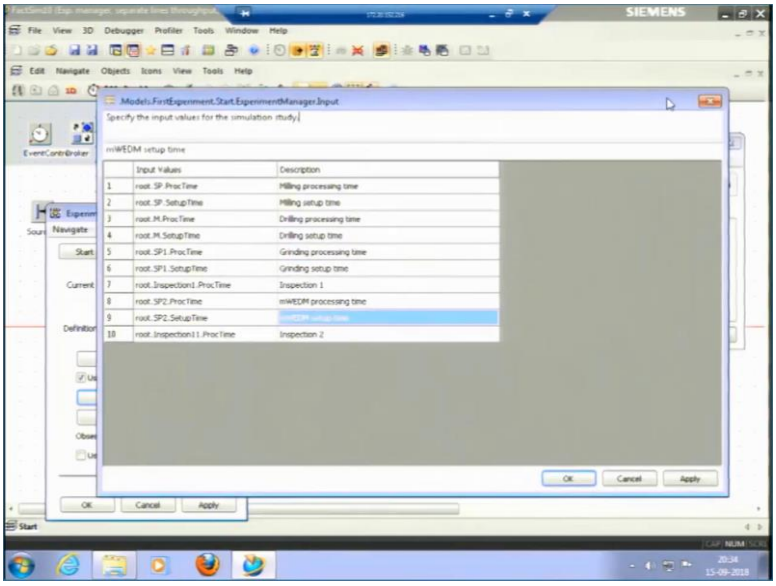

Then, input variables are all these times milling, drilling, grinding, processing, and setup times inspection one in the second line, we have a model manufacturing machine, which is micro-wire EDM Electric Discharge Machining. So, this is a modern manufacturing machine so, in this case, our setup nine is put these 3 machine inspection 2 is there.

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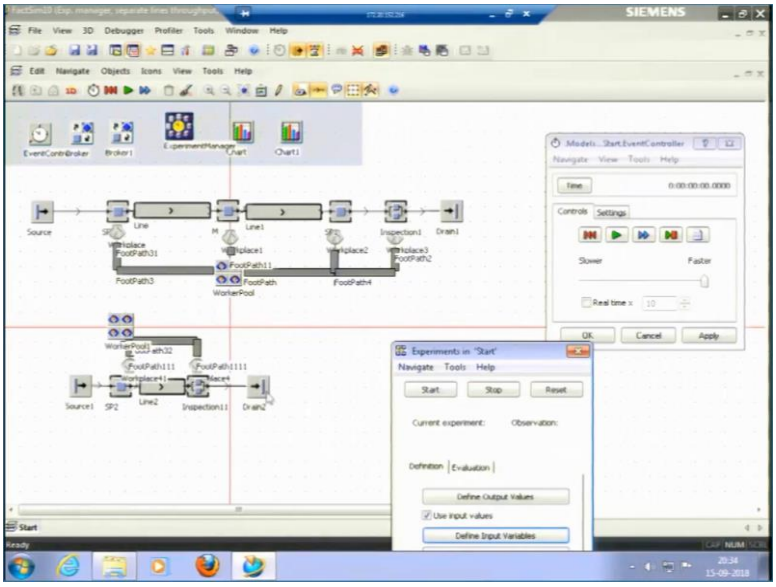

So, the 2 flow lines, if you can see the 2 flow lines first flow line is that conventional machines milling, drilling, grinding second flow line is our modern manufacturing source micro wire EDM, then inspection and chain so, we can see both throughputs use after conducting these experiments.

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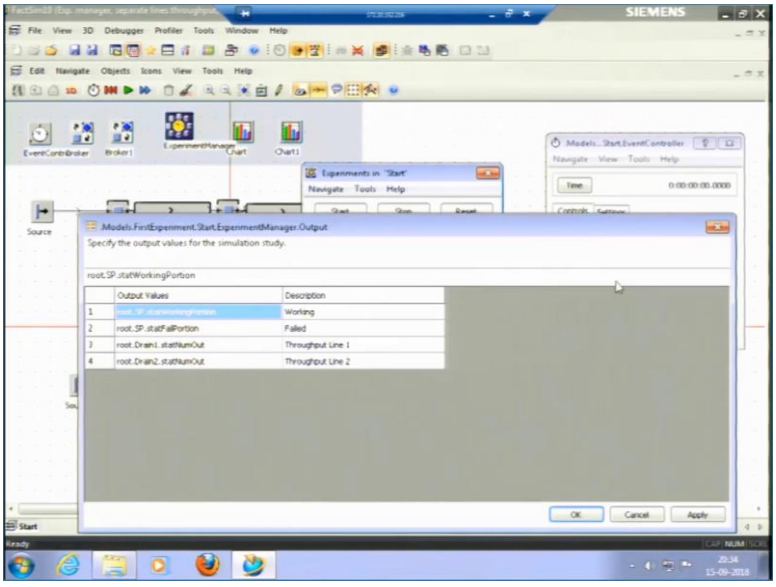

So, output values are all defined we need to see throughput 1, throughput 2, and also, we need to, we see the working and the failed percentages.

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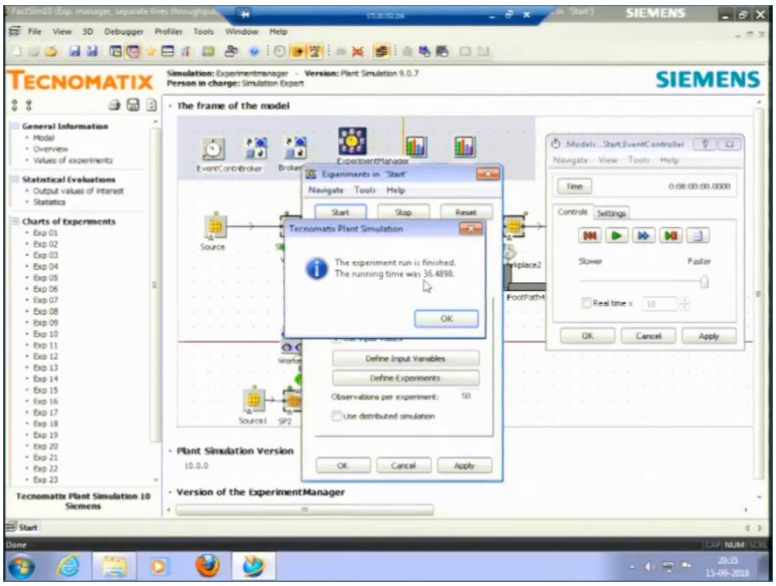

So, let us start the simulation so, current experiment is one if you see a third experiment is running, fourth is running now, fifth is running, fourth, fifth, sixth experiment 50 observation for each experiment 50 observation, for all the 25 experiment 50 observations would run so, you can see the time 8 hours, 8 hours, 8 hours, it is running the multiple runs here, this is how the simulation is conducted using experiment manager, this is the exact use of the word simulation did.

So, it has generated a report total running time for the simulation is 36 seconds, 25 into 50 is 1250, it has run 1250 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 this is the simulation, this is the final feature that we have getting here, this is a simulation, experiment when if you will like to see, it has shown that, single process 1.

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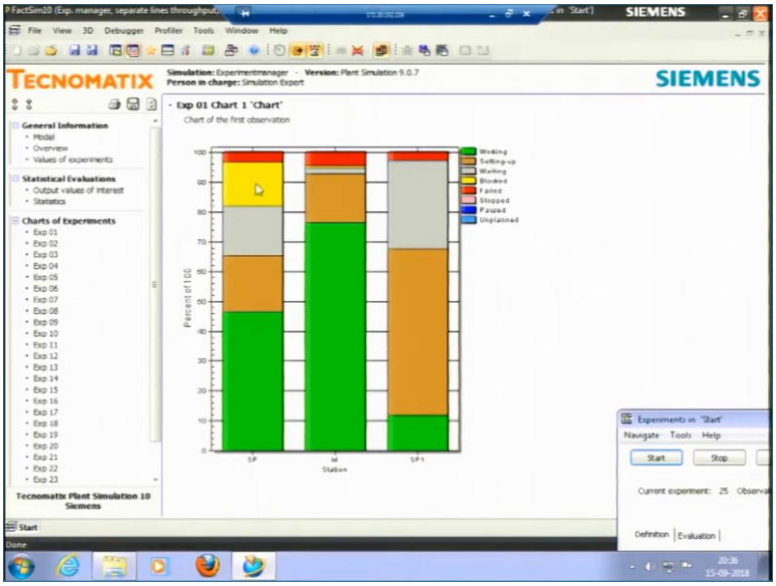

Station 1 and single process 1, it is showing that these are the time for which it is working this is the time for which is blocked, this is showing all those things. Experiment number 2, all this thing it showing so, it is showing.

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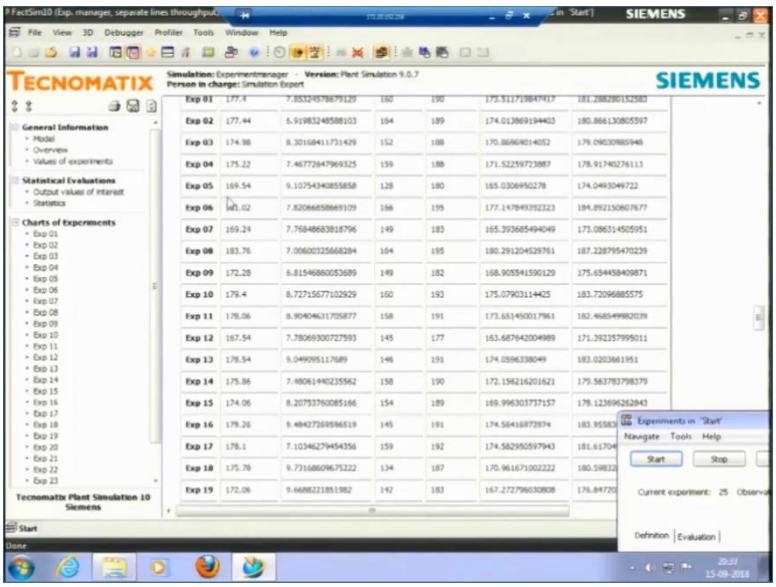

Let me try to see the statistics here. So, mean value, standard deviation, minimum, and maximum for experiment one for all the experiments. So, this is the p and t-test we would not move to that, these are the tests those are conducted, and this is the chart for that not charts this is a table for that, this is the failed time, working time and also it will show the throughput because you asked for the throughput.

So, this is the throughput for the 50 observations in experiment number 1, experiment number 1 means 50 observations that 25 experiments, for each experiment 50 observations. So, experiment number one has 50 observations these 50 observations have this mean 177.4. These 50 observations have this 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 one of throughput of line 2, we can also see here, these are also again 50 observation 25 experiments. So, let me try to see. This is the model.

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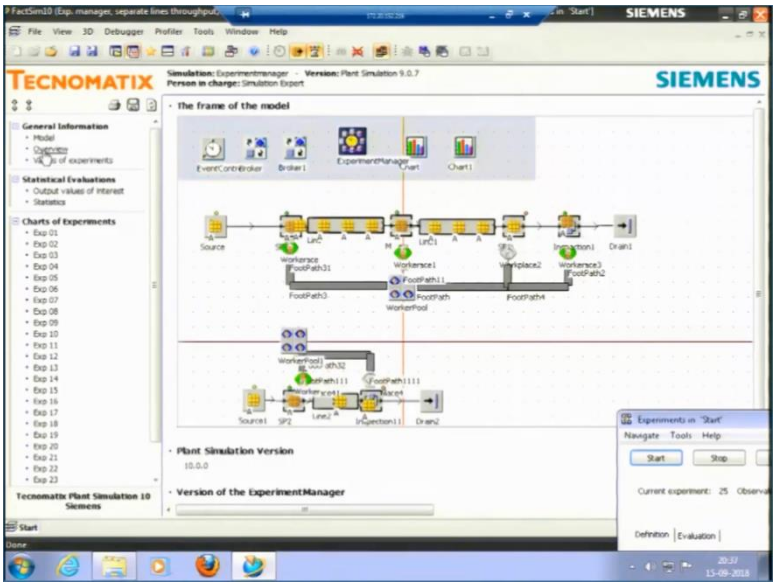

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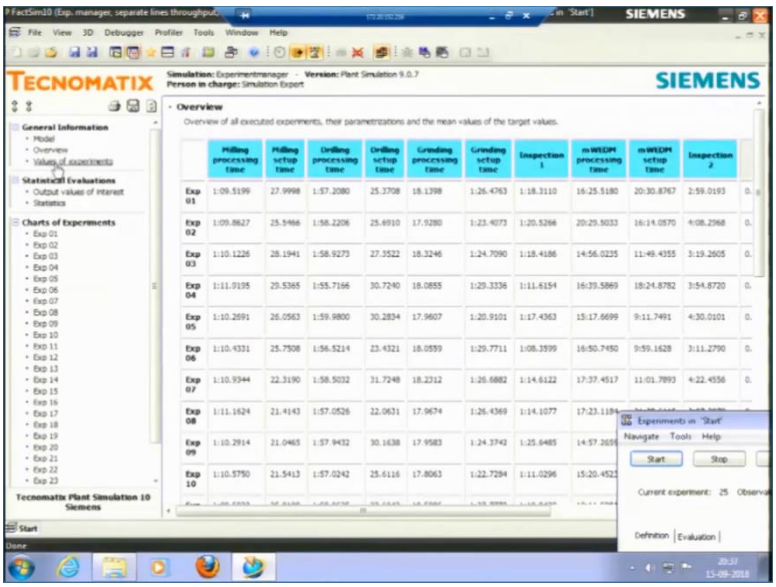

This is overview.

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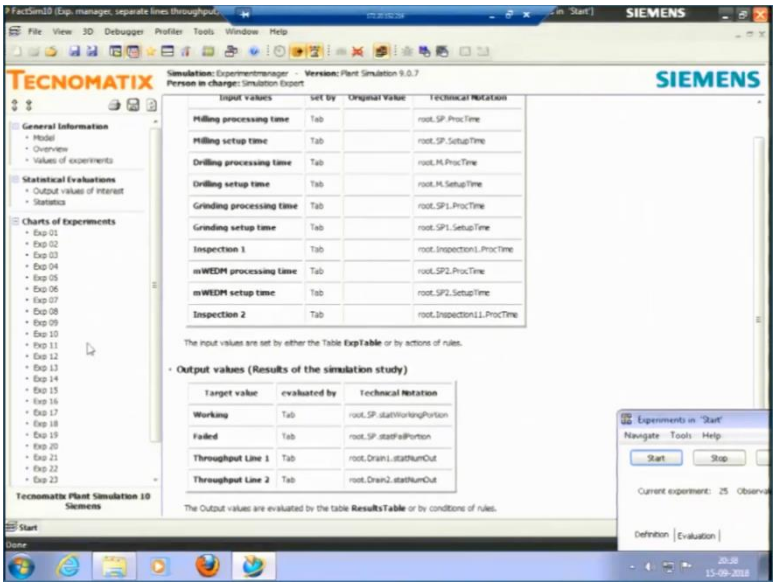

This is values of experiments, let me try to see the plots of this.

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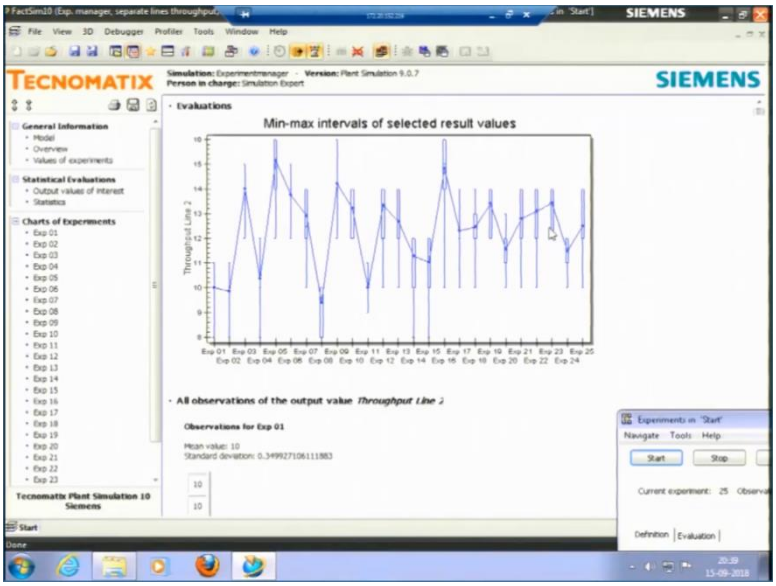

So, these are the output values of interest. So, if you see this, this is each experiment and 50 observations are given, this is for the throughput 2 you can see now, we have a box plot here so, what does this show? This, for instance, this is my experiment number 5, this line, in experiment number 5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

We can see the variation this you know this is very small variation here, in experiment number 11, in experiment number 16 you can see again there is a big variation of the lower side, 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 behaviour or you could say, behaviour 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? Sometimes it took maybe 50.

It was actually about in 100, if 600 seconds it took 10 minutes, sometimes it took 15 minutes, sometimes it took 20 minutes, sometimes it took like, big variability was there in the overall process that is why this big variability is there number one. Number 2 is the number of the throughput is very small, actually, the final throughput that is obtained the average throughput was fourteen 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, you have about 15 pieces in a day here so, the total throughput is very small so, that is why this much higher variability is there so, let me try to see this for throughput line one.

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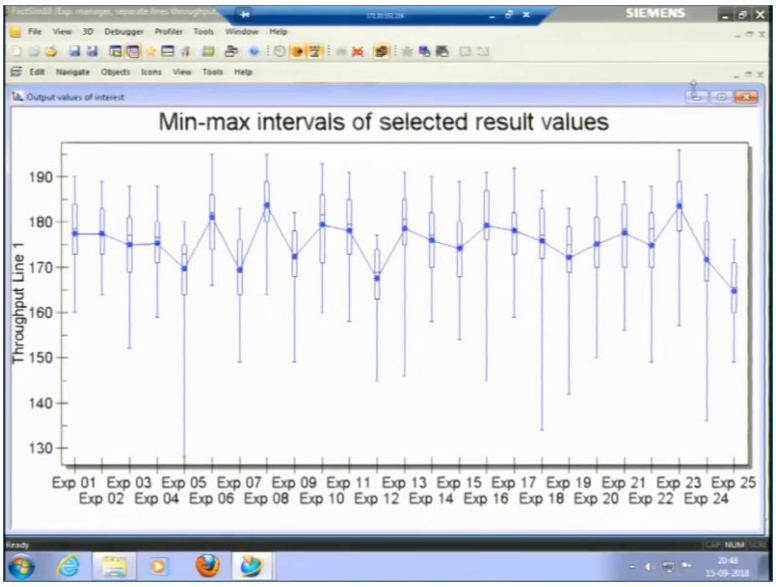

So, this I have obtained, the chart put for over the throughput of line 1. You can see throughput of a line, the variability is less, the two reasons for this: number 1 the processing times were in

control because the machines were CNC machines when we connect to the live of experiments. However, the processing time for the inspection was a little variable because inspection was done manually so, but overall, because of about 3 automated machines so, the variability is lesser than, that we observed in our line 2, 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, individual processes because, this simulation is trying to re imitate 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 were 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 this and number of workers we can keep wearing the number of workers.

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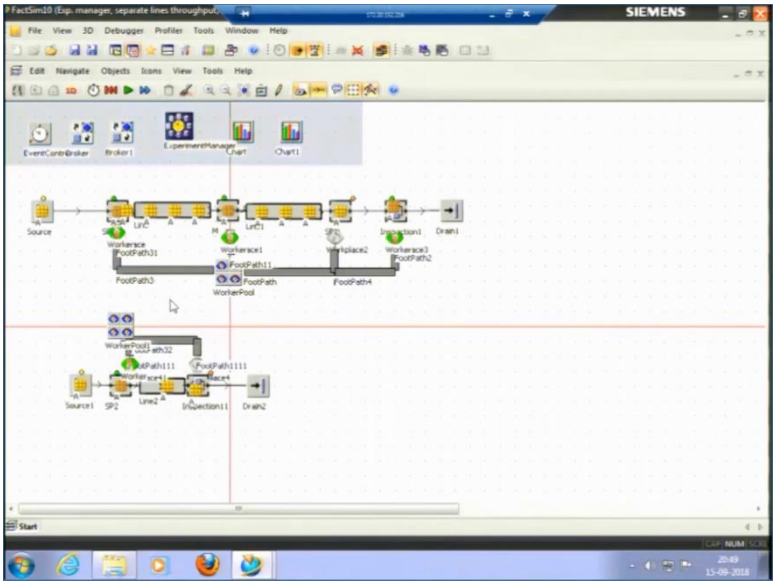

You know, in this experiment the number of workers those what employed were four, you know, 1, 2, 3 workers in line 1, and one worker in line 2. We can also think of employing 5 workers that is 4 workers in line one, 1 here, second here, third here, which is not yet employed and fourth here, and fifth one here. Then, we can see 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 we obtained from the increased throughput by employing the fourth worker is lesser than the wage that has to be pay to the worker so, we can just take of 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 an amateur, this is a good start like, you have an introduction to how the softwares work? And how is simulation conducted in the softwares and what are variables there is can of layout? and we can even optimize the layout using these, these softwares and certain you know I have, as I have told you this a great capability of this specific software but, yes we can keep on using this, we can try to simulate the factory we can make a big factory and this is just a manufacturing process, this is manufacturing systems.

We can also think of taking after this manufacturing system this is develop the systems or the actually report that we have got, we can take that report to the team centre to finally support when actually things happen so, we can just put, this is the schedule or the plan these are things which are actually happened. So, what is the variation of the actual thing which are happening in first few runs then, we actually this kind of setup so, we can test those as well using these new software tools. So, I will like to stop here and thank you for being in the course, so we will meet next time. Thank you.