Simulation of Business Systems

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Lecture -23

Tecnomatix: Plant Simulation - Part 3 of 3

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

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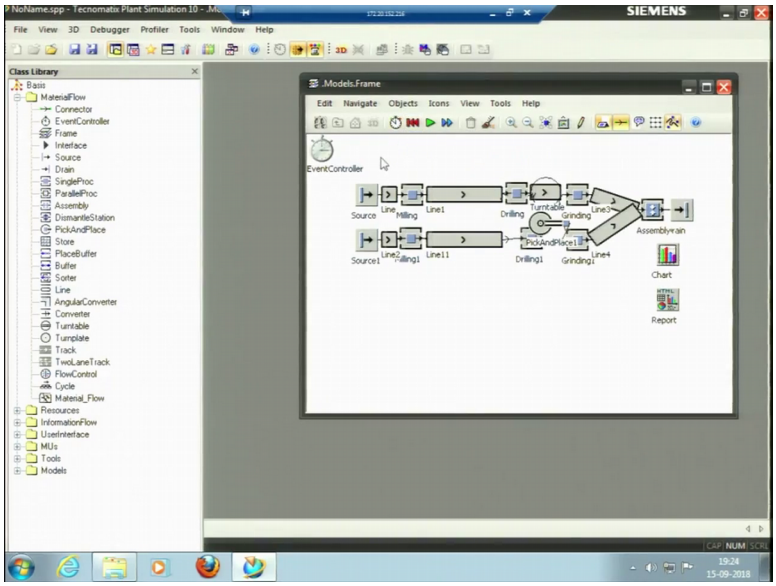

I like to talk about the distributions, I have just open this milling process the processing time is 1 minute. If I took uniform distribution uniform distribution you know that uniform distribution is the kind of its also known as rectangular distribution. So, where we have first this start and stop we have the minimum and the maximum value and we 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 a very few number of observations. 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 there now I have just put start and stop have not put any stream what is stream? If we know about random numbers stream is the seed of the (Refer Time: 01:57) numbers.

So, when we talk about the 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 or subjects it is the random numbers random number which you have working on.

So, where does our random number starts from the specific, so that is the stream. So, if we instance there two processes I put the same stream here same stream means the random number were start from the same seed and the successive random number would be same, for instance if I put the seed value two here in one process and see value two 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 number 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 we do not put any stream value here, the software would pick a stream value by itself ok. 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 2 is if 2 smaller let me say the time varies from 2 minutes 50 seconds to 3 minutes, we know that this is the minimum this is the maximum.

So, then we can pick ok, first I will talk about triangular distribution; triangular

distribution actually some of two is uniform distributions. Two uniform distributions are there two uniform distributions means uniform distributions means this just have the smallest value and the largest value we do not know what would happen.

But in triangular 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 from 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 an maximum frequency ok.

So, here we can put if I pick the triangular 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 of the 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 which is trying to repeat maximum number of times so, I can pick the triangular 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 its asking for its parameters, the normal distribution I would say normal distribution statistic it is asking it asking for stream now it is asking for mu and sigma. Mu is the mean or average sigma is the standard deviation.

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 software's 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 the 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 because it is 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 is just fit I was showing the value that is 250 and 3 the value of mean was smaller than sigma. So, that is why it is said it is showing the negative value, it is not accept it wouldn't accept any other format than is required.

So, let me pick just constant time here and it was just to make to understand properly it was 1 minute I will apply. So, let me see if I run it for an 8 hour day and try to see the throughput open it have to see throughput it throughput what it is 11167 per hour is 48 and total throughput is 3894 and 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 ok. And I change this processing time also to 2 minutes in actual conditions we cannot change the processing time with the processing that it has 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 machine or have advanced machine we cannot, but work on more on the processing times.

The 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 a 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 ok, it is 582 pieces per day 194 pieces in a 8 hour day ok.

So, also we can have the setup time as well 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 we are own milling process what do we do we just rotate the tool and remove the material. So, it is removing the material for one workpiece this is 2 minute 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 setup time as well and apply.

Let us see what happens to my throughput now only in 1 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 another 1 minute is being taken. So, total time taken in the milling process in the line 1 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 example I have some examples for you to show you different layout and also the experiment manager we will use we will try to see to see the simulation that we can do in the software. 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.

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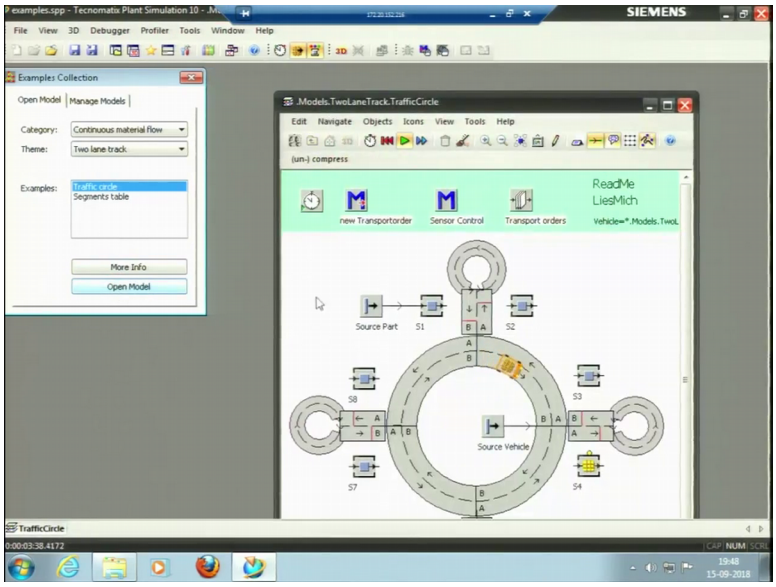

So, this is the model it is already running, so I will just run the model you can see this is the trolley that can pick of a material from. So, thus this is source part some processing is being done here I can see what is the time of the processing here the times is constant 1 minute. So, you can see it is happening I will make it little faster control panel I will make it a little faster and then run this trolley is running trolley is continuously running to the tracks this is actually about 20 times faster. So, the processing is happening it is happen for the 9 minutes it is now stopping, so what is the setting so there is no end time. So, it will continue for the infinite time so this is a kind of a just a cell an o cell so, cancel stop.

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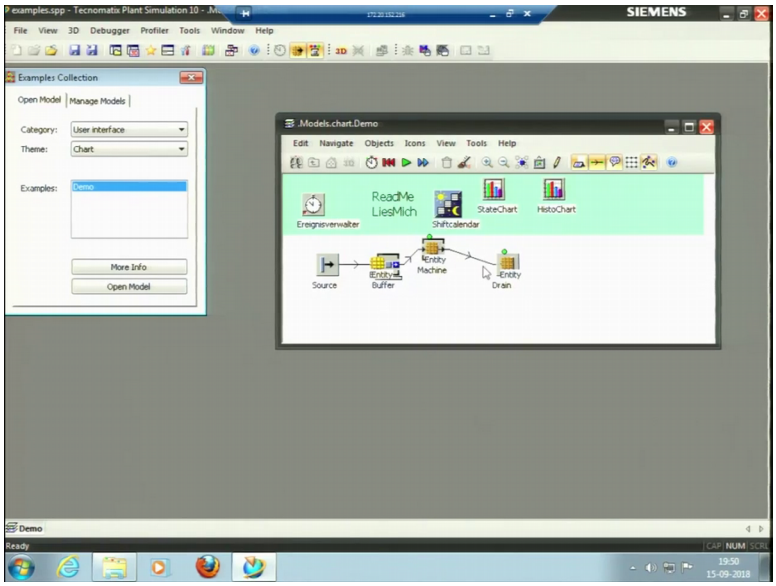

So segment table open model this is just showing a track all the track is built. So, let me pick user interface dynamic statistics display panel or chart open. So, in this model we can see the chart what is setting there is no end time, I will put the end time here 0 8 0 0 0 0 apply it will try to run this model, so it has a 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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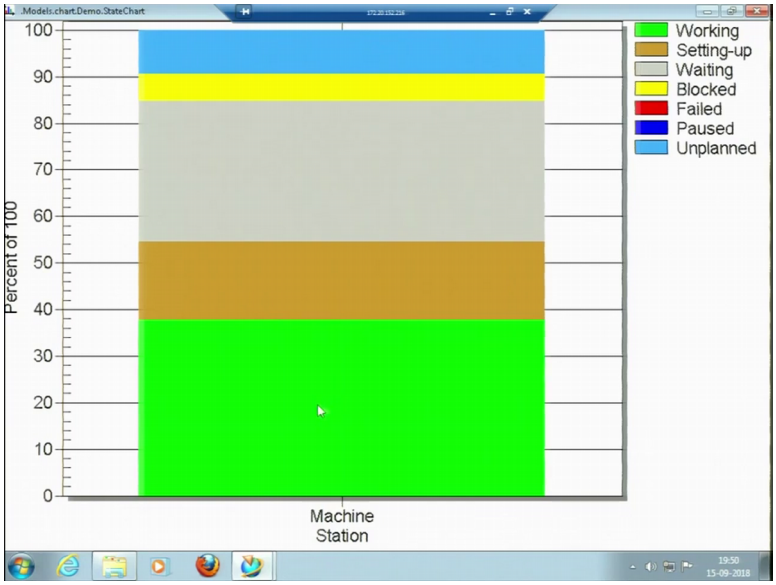

So, for only one machine it is showing the chart that this is something unplanned look that is unplanned then we have blocked, then have we do not have any failure here we

have this waiting time for the about 30 37 percent of time it has been working. So, this is another example then tools and optimization the important is experiment manager, I will just pick the buffer line optimization this is line comparison open model.

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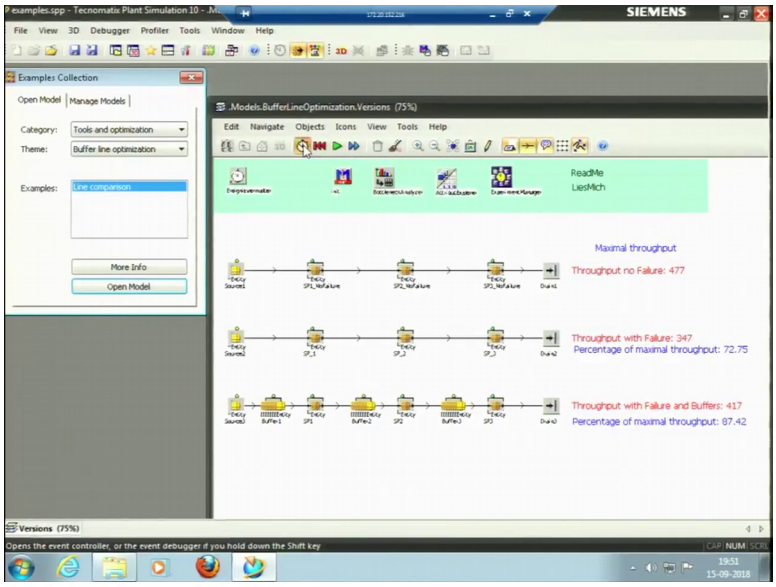

So, in this model what we have we have three lines and it is given here that this now its ok. So, in this line the throughput with no failure this is throughput with failure throughput with failure and buffers. So, there is a there buffer kept in between if I enlarge it this is buffer this is another buffer. So, I have kept buffers in between this is throughput we need to see the throughput with no failure another line is throughput we have put some failure rates here ok. If I see the failure 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.

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 in a day work for 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 we have it is 7 percent of the throughput of the maximum value ok.

Then I can pick some interface I can pick the five interface open model then in the source is I can see broker and animation. So, shift calendar worker, I will show you a

worker introduction worker introduction model.

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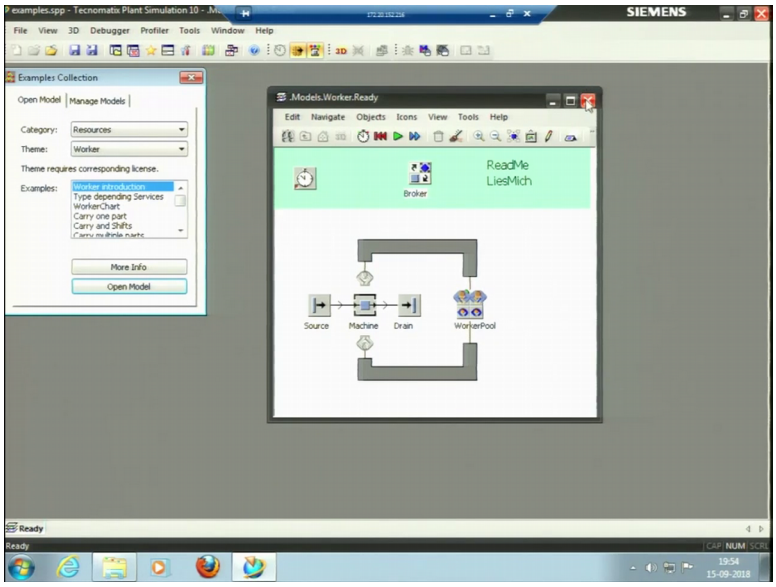

So, this is the worker introduction model, so in this case you can see the workers are just introduced into machine and if we run this ok. Let me try to make its little slower apply now run you can see the workers were running a two workers one worker is work working at two second worker is here I can see the number of workers here in the work pool to work pool controls entrance plant.

So, I can see the number of workers are two here and work pool is there and the broker is there broker is trying to distribute the work to different workers ok. 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 ok.

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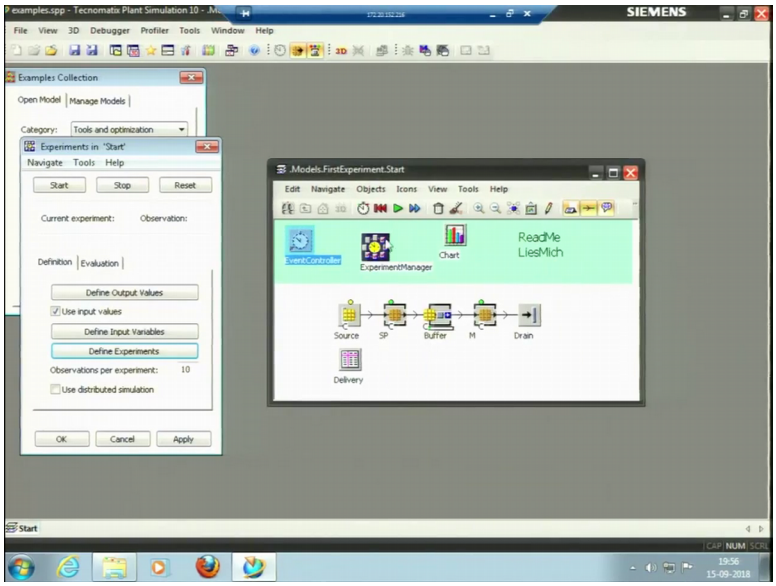

This is one of the models we are we have experiment manager this experiment manager can show the simulation if I run this model for let me open this experiment manager for instance definition and evolution, in definition we have defined the output value output value of the workstation portion start fail portion it is working and failed. So, what output do we need and what inputs do we have input is the root delivery and mean time to repair ok?

So, if I run this model so also I can define the experiment that is 4 number of 100 number of parts mean time to repair is this much 5 10 15 then 5 10 15 this is 400 part this is for 200 parts again. So, this number of experiments would run if I run this experiment manager let me try to run it has run for 8 hours ok. Now, let me try to see experiment manager now I need to see the results.

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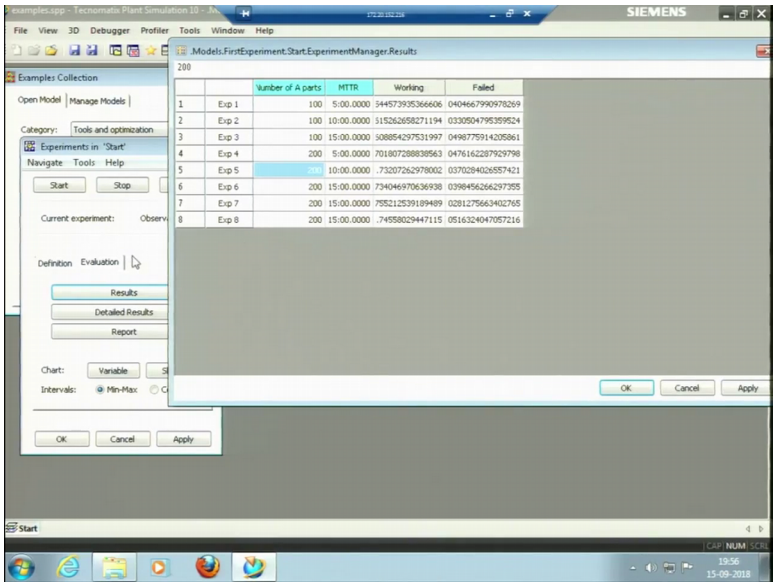

It has shown the results at mean time to failure if it is kept 5, so it is working for this much number of time it is failed for this much number of time. So, for this simulation of a 100 parts for the simulation of 100 parts again this is for 200 parts, so it has taken eight experiments so I can see the report as well here ok.

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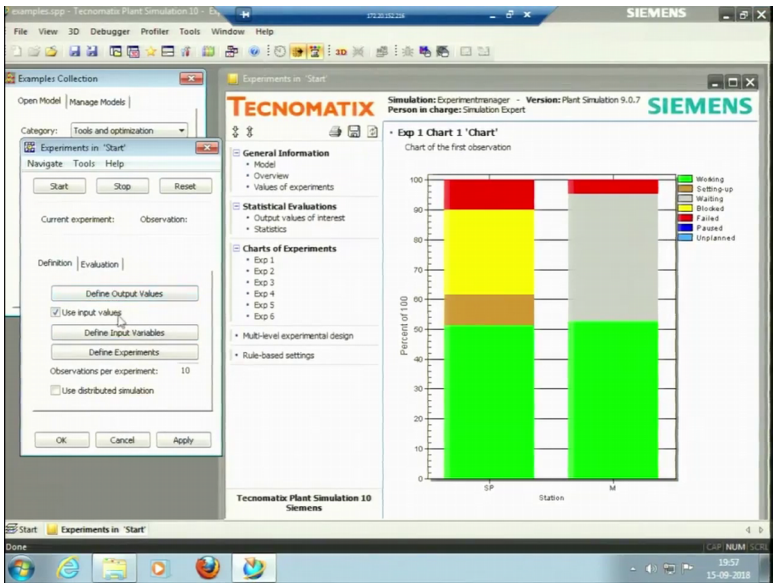

In the report it is telling that they are number of experiment in experiment one, this happened in experiment two, this happened this is the total failure this is both blocked time then grey colour is waiting time all these things it is telling in the report.

So, in experiments what has what is it taken? It has taken different random number in experiment number one different numbers are random numbers are taken experiment about two different numbers are taken. What is experiment number one it was given here the inputs that we gave output values sorry output values are here in this results experiment number one is 100 parts with mean time to failure has mean time to repair mean time to repair has 5 minutes.

Experiment number two is 100 parts with mean time to repair has 10 minutes ok, so it is showing this experiment here. So, we can have all different kinds of design then rule we have not defined any rule based setting can also be done this is an like if we go to the detail of the simulation these things are possible.

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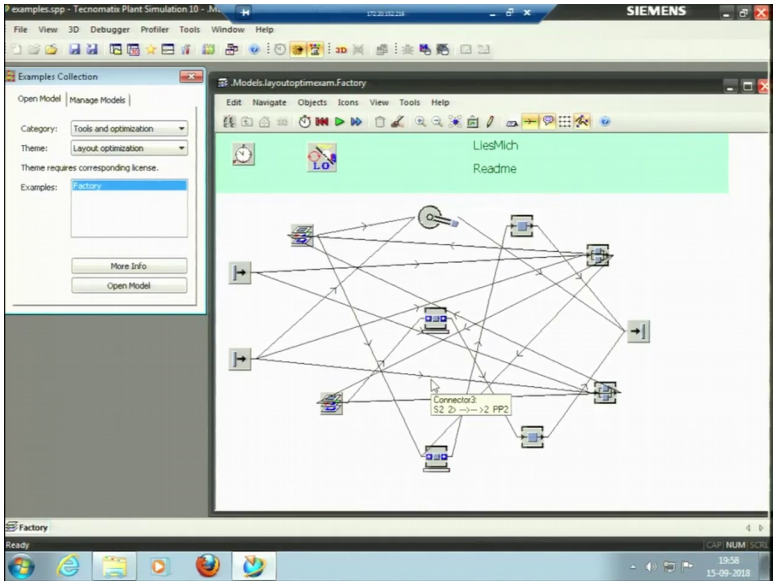

So, now layout optimization factory optimization factory layout is there this is a factory and we have made weird kind of connections here. So, layout optimization can be done we have to keep what machine then what would be the overall what would there maximum throughput if we do that. So, this can these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

So, another model I can pick here is from continues material flow two lane track distance control sensors; sensors, sensors are like if we need to for instance if we need to accelerate at some point or we need to put breaks or we need to put the correct decision light and like we can do anything let me open this model ok.

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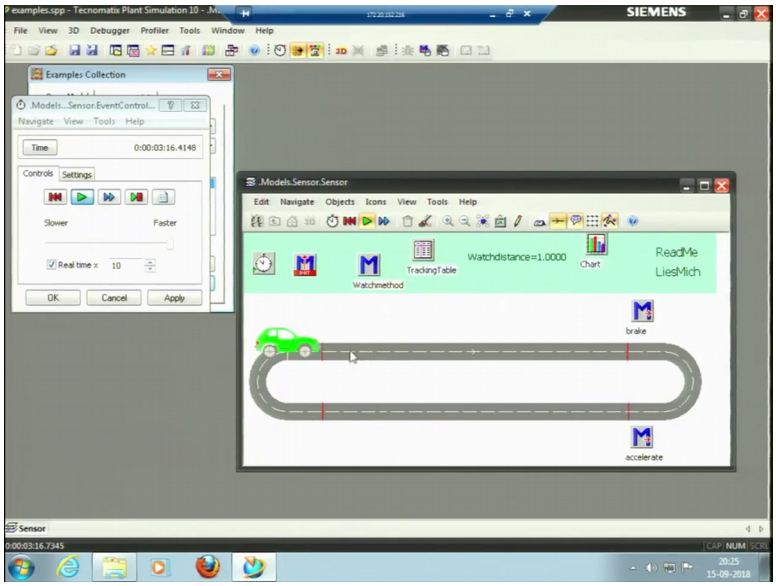

Yes this is an break and accelerate model so I have defined the method here watch method the method here is break and accelerate. So, if I try to run this model first let me see the event simulator it is end time nothing, but just to see whether how it runs you can see this is break after break it will just slowdown after accelerate, it accelerate this is speed in this speed. So, at this point break would apply it is accelerate now the break would apply it will take a turn accelerate it will accelerate from this point ok.

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

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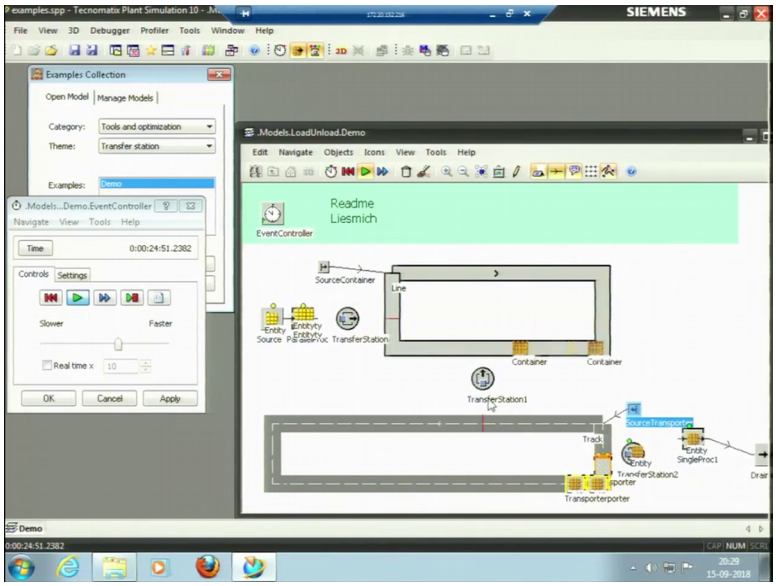

Transfer station is this is one cell this is one cell, this o is 1 cell this is another track here two way track ok. Transfer station transfer station it will just transfer the material from this cell to this track let me try to see the event simulator here you can see the trolley or the container came here ok. The container is coming the some machining is happening here some machining is happening at this parallel process ok.

Let us first see what are the process parameters here this is a parallel process in which 2 into 2 4 processes are there and the times is again the default time 1 minute . So, this from source it comes in transfer station is there we need to connect transfer station transfer station when we see a transfer station. So, it will transfer into load it will just load the process it is connected, connect path from the parallel process we just need to put the name.

If the of the process from each process it will pick the part from parallel process then it will target or the transport the parts to line ok. So, there is no connector got in between we need to just mention the predecessor and the successor process is here. So, sensor position is this one so all these so we can select load, unload, reload, move so it is loading the parts. So, all these attributes availability is 100 percent we can select this I would not change anything and let me try to run the simulation. So, this containers are running some processing is happening here it will taking 1 minute, so transfer station is in transfer the part to this container. So, this container is this coming here and this

transfer station it is connecting the part from this line 1 2 3 two way track ok, if I see its properties it is form line to a track the name of this track is track only ok.

So, again from this there is another transfer station a 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 user interfaces other interface it is trying to do that. So, this is one of the objects that can be used ok, so this is the say transfer station ok. Now, apply so they are certain examples which are available for us to see how these things happen. So, I will just open which start page again I am try to open this factory simulation that we had made once.

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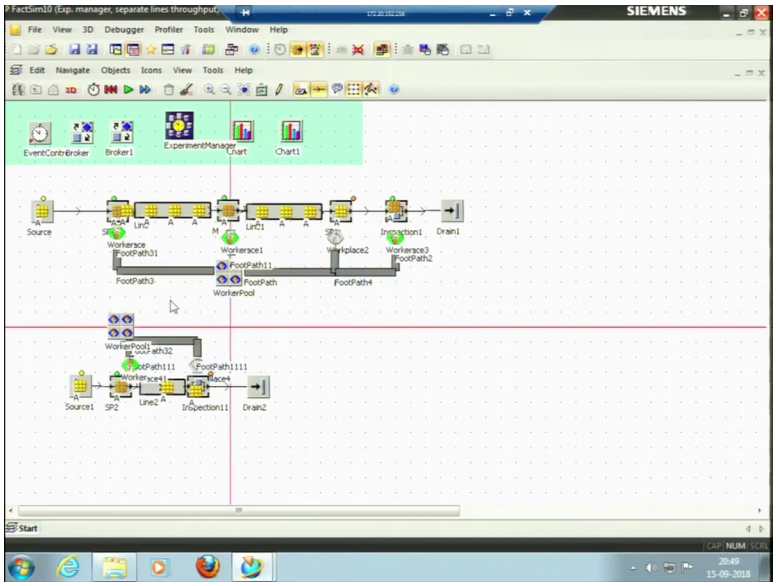

So, this is the factory simulation in which let me close this examples this is factory simulation in which these processes are there this is the process if I put the names this is the process single process one and single process two, single process three and the workers are working here the time for the workers are put. The speed of the worker which is defined by international labour organisation 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 this is live experiments were conducted. So, this is single process this is milling this is single process I have not change the name. So, this is milling this time is kept constant here and this time is 1 minute and 10 seconds like that is about 70 second it takes to do the machining then

setup time is about 26 seconds. So, for this machine these are actual times which are taken from the experiments live experiments are conducted.

So, this times the for the second machine these are the times the about 2 minutes that is 1 minute 55 seconds 59 seconds for the processing and for setup it takes 33 seconds so these are all taken constant here.

So, this is run for an 8 hour day and also an experiment manager we have defined the output values output values is the one is working and failed and throughput of line 1 and throughput of line 2 we need to see, like we can just see throughput here we can just through the 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 this is per day 178 pieces in an 8 hour day 178, but if I run my simulation using my experiment manager.

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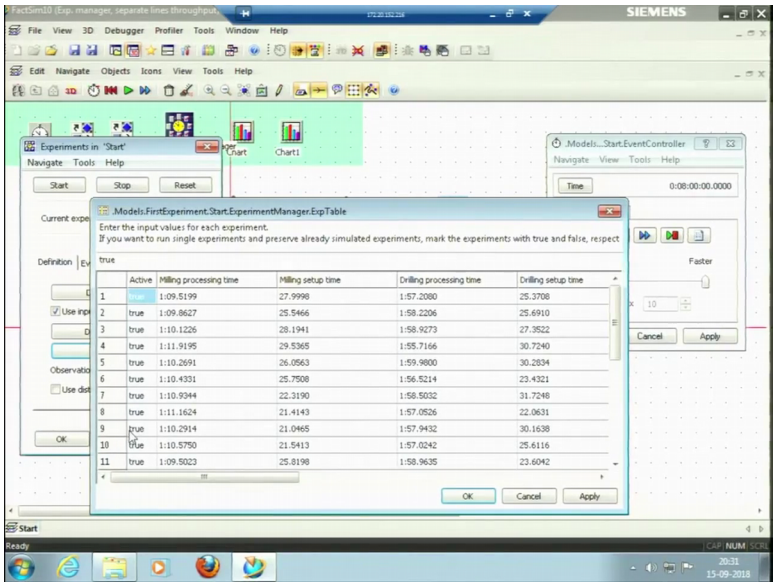

So, when I define the experiments I would defined 25 experiments here, 25 experiments and these possessing time is taken actually 59 seconds and this 59 seconds using random number table or using some random distribution normal random distribution may be. So, we have selected a random times those random times are put here 59 seconds was the mean and this is the real 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 minutes 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 processing drilling setup grinding processing grinding setup then after grinding we have inspection ok. 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 to line 1 ok. Then workers certain place of the worker footpath all those things are defined here this is the model we made to let me this is an hypothesise factory ok.

So, define observations per experiments so there are 25 experiments 25 experiments which are conducted using random numbers and per experiments 50 application would be taken that is 50 times one experiment would repeat. And how this 50 times the box plot can be made for this 50 experiments this is one observation, one observation means 50 experiment the second observation is another 50 experiments ok. So, it is about a total number of experiments that 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. 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 ok. So, this is a model manufacturing machine so in this case all setup time is put so these three machines inspection two is there so the 2 lines with which you can see the two flow lines.

First flow line is that 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 used after connecting these experiments. So, output values are all defined we need to see throughput 1 throughput 2 and also we need to see the working and the failed percentages ok.

So, let us start the simulation, so observation 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 what all the 25 experiments 50 observation will run ok. So, you can see the time 8 hours, it is running the multiple runs here this is how the simulation is conducted using the experiment manager.

This is the exact for what the use of simulation this is how the simulation actually you know actually 6000 experiments are conducted. So, it has generated a report total

running time for the simulation is 36 seconds in 36 seconds it has run 6250 experiment 6250 is 25 into 50. So, if 1 2 5 25 to 50 is 1250 it has not run 1200 and 50 experiments in 36 seconds ok, so this is my report. So, let me take it here I wouldn't close it this is my report it is saying this is the simulation this is the final which that we are getting here this is simulation experiment when if we like to see.

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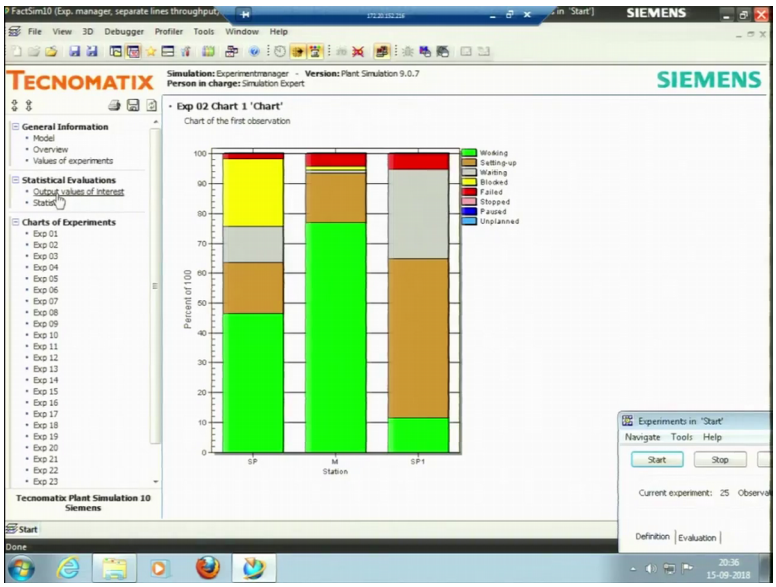

It has shown that single process one station one and single process one it is showing that these are the time for which it is working this is the time for it is blocked this is showing these things experiment number two all these thing it is showing .

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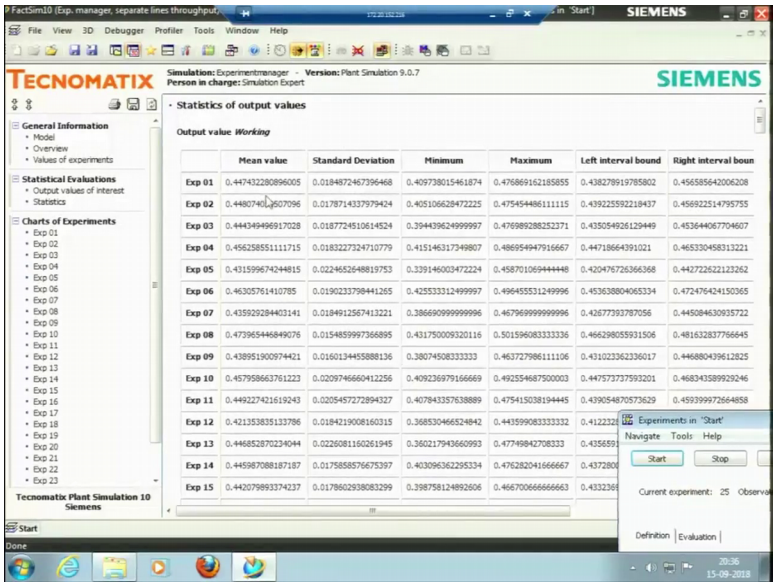

So, it is showing let me try to see the statistics here so mean value standard deviation minimum and maximum for experiment one for all the experiments.

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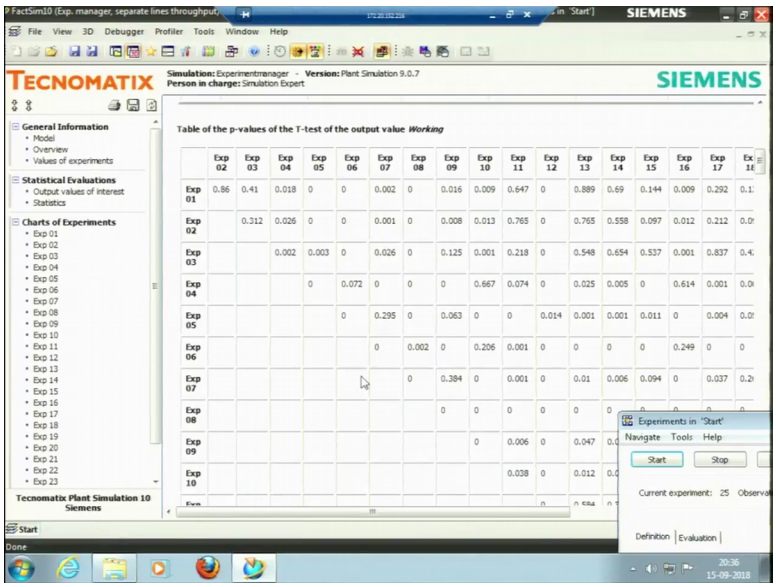

So, this is the P and T test we will do nott move to that these are the tests those are conducted and this is the chart for that not chart this is table for that this is the fail time working time and also it will show the throughput because we asked for a throughput. So, this is the throughput for the 50 experiment for the 25 experiments sorry, so this is the throughput for the 50 observations in experiment number one experiment number

one 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 this 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 experiment it is taken the overall mean would be also one throughput that we also see for throughput of line 1 have 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 this is overview this is values of experiments let me try to see the plots of this so these are the output values of interest.

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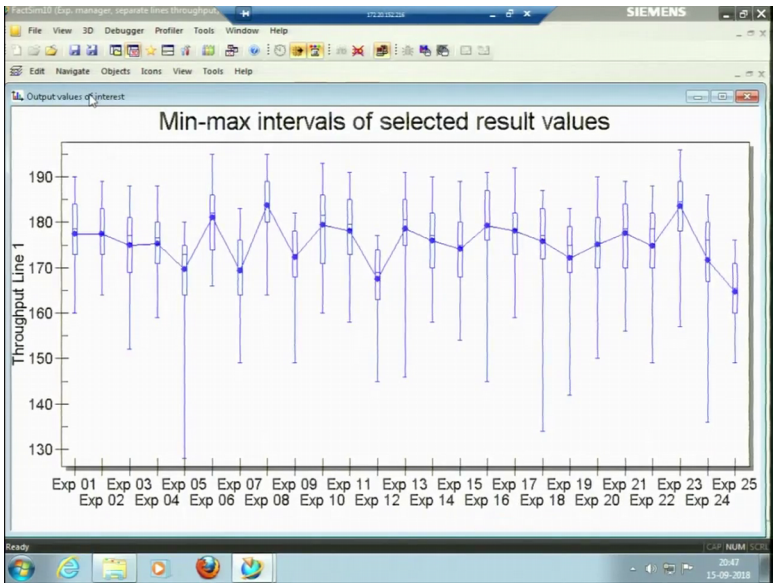

So, if you see, this is each experiment and 50 observations are given this is for the throughput 2 you can see now we have a box plot here. So, now, what does this show? This for instance this is my experiment number 5 this is my experiment number 5 this line in experiment number 5 there 50 observation.

And this is box plot this is my median and you can see there is vis curve and the third quartile is quite lower and we do not have the first quartile first quartile is kind of coinciding with my quartile two ok. So, the upper vis curve is very smaller, so it is from the box plot for each of the experiments ok. We can see the variation this one here this is the 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's very high overall variability's is very high white is there because the micro EDM or this is actually the behaviour or you can say yeah behaviour of the process only.

Micro EDM process we do not know the kind of experiment which we did we did not know that what time would it take some time it took may be 50 it was three about in 100 it 6, 600 second it took 10 minutes sometime it took 15 minutes sometime it took 20 minutes sometime it took like get variability was there in the overall process that is why this big variability's there number one.

Number two is the number of that the throughput is very small actually it the final throughput is obtained the 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 see that we even have about 9 pieces in a day here we have about 15 pieces in a day here. So, the total throughput is very small so that is why this is much high variability's is there.

So, let me try to see this for throughput line 1, so this I have obtained the chart put for the throughput of line 2. So, here you can say the throughput for line 2 the variability is less the two reasons for this number one the processing times were in control because the machines were CNC machines when we connected the live of experiments. However, the processing time for the inspection was little variable because inspection was done manually so, but overall because of they were three automated machines. So, the variability is lesser than that we observe 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 bad like bigger number then that very small number 14. So, the throughput variability is lesser however, in individual processes because the simulation is trying to re imitate the realistic situation. So, in realistic situation we can have the outlier we can sometime have the very long time or a very lesser time then it should be normal.

So, this for instance in experiment 5 you can see again the vis curve is falling down it all depends upon the random numbers and if I tell you the time were kept constant, but the seeds were all different. So, depending upon different seeds for these different experiments and the observations were also very different these different box plots are obtained ok.

So, we can infer that the variability is lesser in this and number of workers we can we can keep varying the number of workers you know in this experiment. The number of workers those who are employed were 4 you know 1 2 3 workers in 9 1 in 1 worker in line 2 we can also think of employing 5 workers that is 4 worker in line 1 1 here second here third here which is not yet employed and fourth here and 51 here.

Then we can see of a 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 paid to the worker. So, we can just take of the decision we can just deny this decision.

So, the certain experiment that we can do certain simulation that we can do I think I should stop here we have discussed enough about the tecnomatix software of for amateur this is a good start like you have an introduction to how the software's work. And is simulation is conducted in the software then what are where this kinds of layout and we can even optimise the layout using these software's. And just certain you know I have told you this is 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 in manufacturing systems.

We can also think of taking after this manufacturing system this is developed the systems or the actually report that we have got we can take that report the team centre to finally, support when actually things happen. So, we can just put this is the schedule or the plan, these are in 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 kind of setup. So, we can test those as well using these software tools, so I will have to stop here and thank you for being in the course so we will meet next time.

Thank you.