Description of the
Small Parts Demo Model
for Tecnomatix Plant Simulation

Last Change: December 2008

CONTENT

1. Description

This model shows a production and assembly system with a pallet-based transport system. The system contains manual and automatic Workstations. One part per pallet runs through the system and is processed on the stations according to the process times.

Each station has cycle times, a certain availability and the manual stations need a worker to start. These parameters determine the time a part stays on the station.

Note, that some actions in this description are not available in the Plant Simulation Viewer (in case you run this model from the Plant Simulation Demo-CD), since the Plant Simulation Viewer does not allow any modeling or changes of parameters. Actions which are not allowed in the Plant Simulation Viewer are marked with an asterix (*). In the model for the Plant Simulation Viewer, some of the actions marked with an asterix (*) will happen automatically at the end of the simulation.

1.1 Objective

The objective is to optimize the number of workers, pallets and the capacity of buffers to maximize the throughput. Therefore, this model shows how to solve two typical problems every simulation engineer has:

(1) In a real production system, there are always several values to optimize (e.g. maximize throughput rate and minimize throughput time) and several parameters you can change (capacities, logic, layout). In most cases, some parameters affect other parameters, too (e.g., if you decide to decrease the capacity of buffers, the optimum number of pallets might decrease, too). This results in the problem, that a user should run experiments for all possible combinations of values for those parameters to find the optimal result result. Normally, this is not possible. The ExperimentManager in Plant Simulation can solve this problem by executing a certain number of simulation runs by itself and by using neural networks to calculate the optimum combination of parameters from the results.

(2) Some values in a real system have a random behavior, e.g. the point in time when a machine breaks down or the cycle time of manual operations. In this case, it's not sufficient to run just one simulation experiment, because the results of this simulation experiment are based on the random numbers from this experiment. When you run the same experiment with different random numbers, you will get different results. So how can you base a decision over a multi-million dollar system on simulation experiments? The solution is, to run multiple experiments with different random numbers and to calculate a confidence interval from the results. The ExperimentManager in Plant Simulation can tell you that e.g. with a probability of 99% (which is the "confidence level"), the throughput of your system will be in the range of 45.2 to 45.5 units per hour.

2. Demo Instructions

2.1 Study Overview

Start a simulation run in the frame Assembly1 using the Start/Stop icon in the toolbar of the model.

Figure 1: Start/Stop icon in the toolbar

Watch the simulation run. On the left hand side, pallets enter the system. The LoadStation on top loads parts on the pallet. Then, the pallet moves through several manual and automated workstations. When the pallet enters a manual workstation, a worker is allocated from the worker pool. At station MS3 on the right hand side, assembly parts are assembled on the main part. The assembly parts arrive from the station PreProduction. Double-click this station to look at the content.

Then, the pallets with the main part move on to additional stations. At the bottom, 40% of the parts are loaded on a cross transfer element and have to pass a test station. On the UnloadStation, the main part is removed from the pallet and leaves the system. The pallet moves on to take the next part.

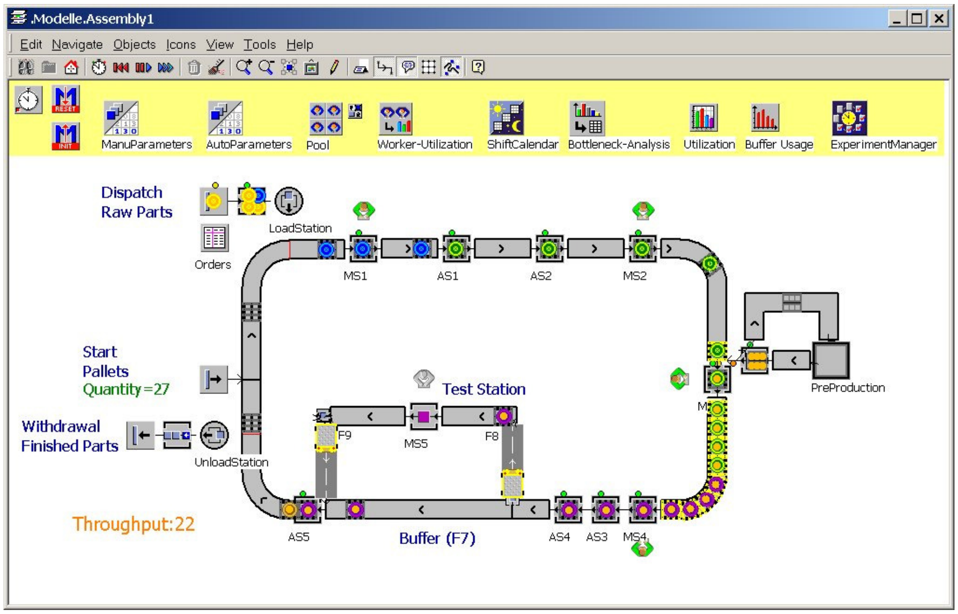
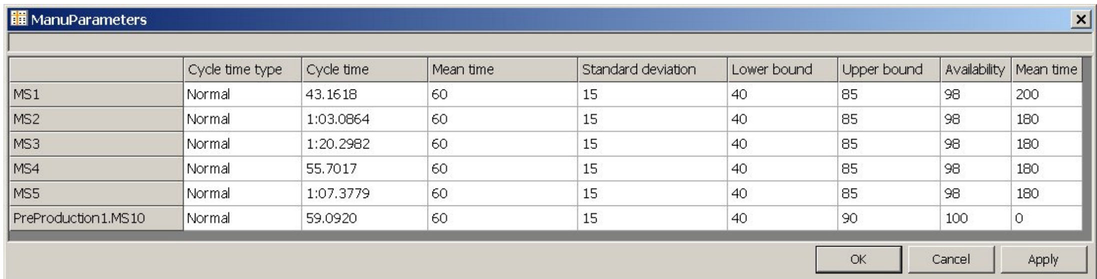


Figure 2: Assembly1

2.2 System Parameters

Right-click the attribute explorer ManuParameters and choose Show Display Window from the context menu. You can see that we use the Normal distribution to create random numbers for the cycle time. All stations have an Availability of 98%.

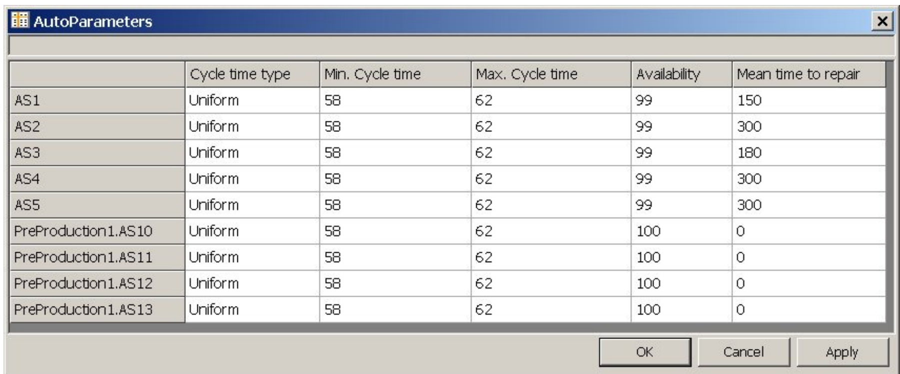

ManuParameters

	Cycle time type	Cycle time	Mean time	Standard deviation	Lower bound	Upper bound	Availability	Mean time
MS1	Normal	43.1618	60	15	40	85	98	200
MS2	Normal	1:03.0864	60	15	40	85	98	180
MS3	Normal	1:20.2982	60	15	40	85	98	180
MS4	Normal	55.7017	60	15	40	85	98	180
MS5	Normal	1:07.3779	60	15	40	85	98	180
PreProduction1.MS10	Normal	59.0920	60	15	40	90	100	0

OK Cancel Apply

Figure 3: Attribute Explorer for the manual workstations

Right-click the attribute explorer AutoParameters and choose Show Display Window from the context menu. You can see that we use the Uniform distribution to create random numbers for the cycle time. All stations have an Availability of 99%.


AutoParameters

	Cycle time type	Min. Cycle time	Max. Cycle time	Availability	Mean time to repair
AS1	Uniform	58	62	99	150
AS2	Uniform	58	62	99	300
AS3	Uniform	58	62	99	180
AS4	Uniform	58	62	99	300
AS5	Uniform	58	62	99	300
PreProduction1.AS10	Uniform	58	62	100	0
PreProduction1.AS11	Uniform	58	62	100	0
PreProduction1.AS12	Uniform	58	62	100	0
PreProduction1.AS13	Uniform	58	62	100	0

OK Cancel Apply

Figure 4: Attribute Explorer for the automated workstations

To change the number of pallets [(*)], double-click the Quantity object and change the value in the dialog.

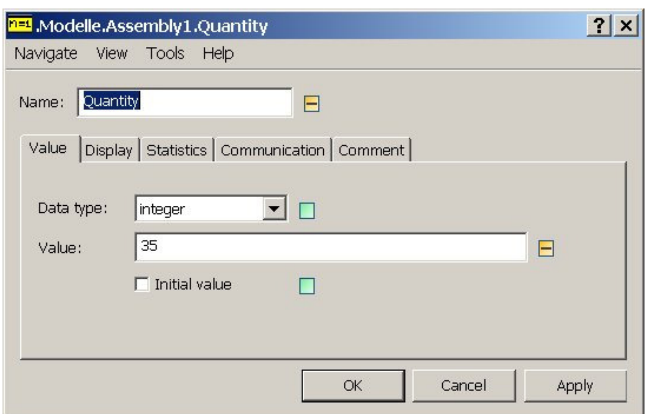


Figure 5: Quantity of pallets

We use a 2-shift system in this model. Double-click the ShiftCalendar to look at the shift times.

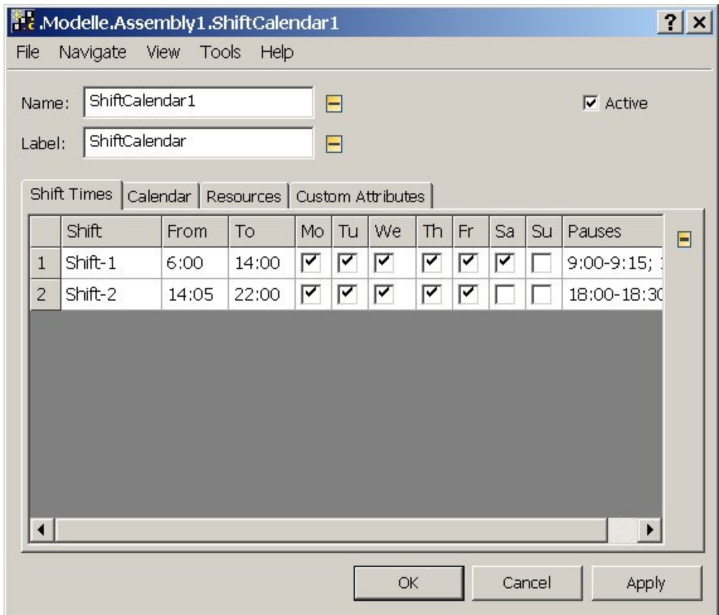


Figure 6: Shift calendar

To change the number of workers [(*)], double click the Pool object and click on Creation Table. In the table which opens, you can see the type worker we use and the quantity for each shift. The column Worker refers to the type of worker you have in the class library (different workers can do different jobs).

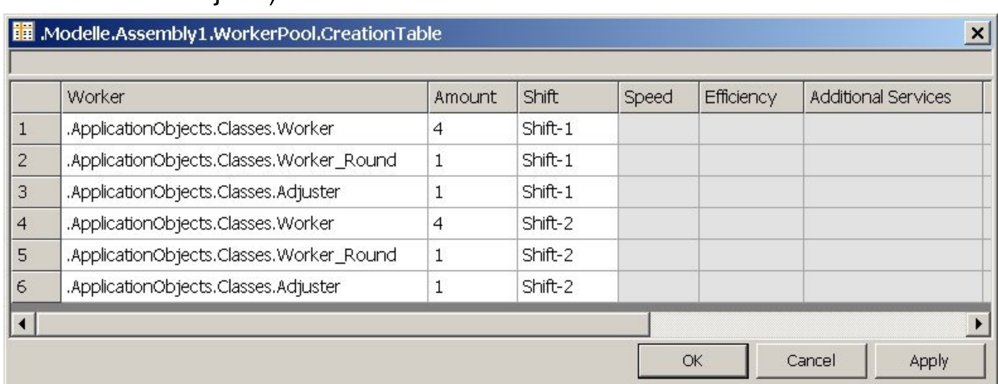


Figure 7: Creation table of the worker pool

Note that the shift name in the column Shift corresponds to the shift name in the ShiftCalendar.

2.3 Find the Optimum number of Pallets [(*)]

We would like to find out, what is the right number of pallets to maximize the throughput of the system. Besides that, we would like to run several simulation experiments with different random numbers, to get reliable results.

Double-click the ExperimentManager object. On the tab Define click on Output Values. This table shows the result value we would like to optimize. Then click on Input Values. This table shows the parameter we would like to change to optimize the result. A mouse-click on Define opens a table which shows in which steps we would like to change our parameters. On the bottom of the tab Define, you find the Confidence level and the number of simulation runs with different random numbers ("Observations").

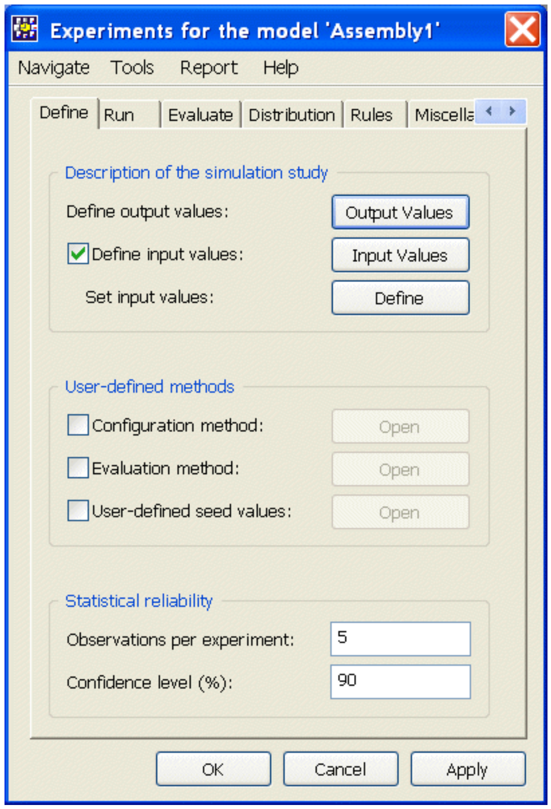


Figure 8: The ExperimentManager – tab Define

On the tab Run click on Reset and Start. Now the ExperimentManager executes 5 simulation runs (5 observations) for each input value we defined. We defined 11 steps, so we execute 5 x 11 = 55 simulation runs. Each run simulates 24 hours. At the end, an HTML report opens. Look at the page Output values of the report. It shows the output for each step. On the page Interesting output values, you see a chart which shows the confidence interval for each step. It shows for each step the range of the throughput the system will have with a 90% probability.

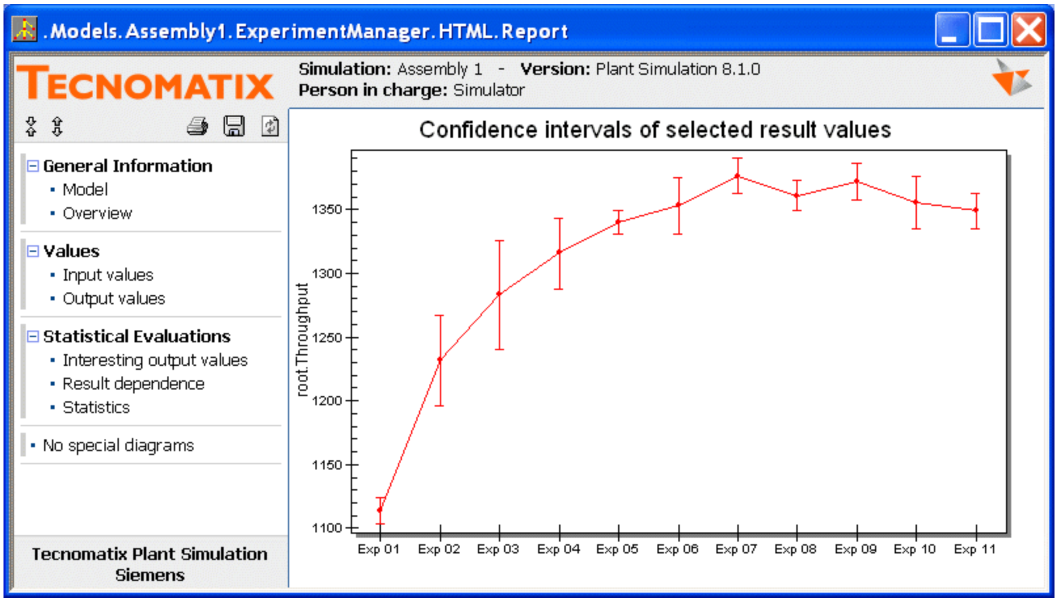


Figure 9: The confidence interval of results

From the HTML report we see, that experiment 7 shows the highest throughput. On the page Output Values of the HTML report you find that 1376 parts were produced in this experiment. When you look at the table Define on the tab Define of the ExperimentManager, you see that experiment 7 used 27 pallets.

Double-click the Quantity object in the Assembly1 frame and set the value to 27. Click on the Reset icon and on the Start/Stop icon in the toolbar of Assembly1.

Summary: Using the ExperimentManager of Plant Simulation, you can very easily run multiple simulation experiments with different random numbers to verify if your simulation results are reliable.

2.4 Find the Bottleneck

Right-click the Utilization chart and choose Show from the context menu.

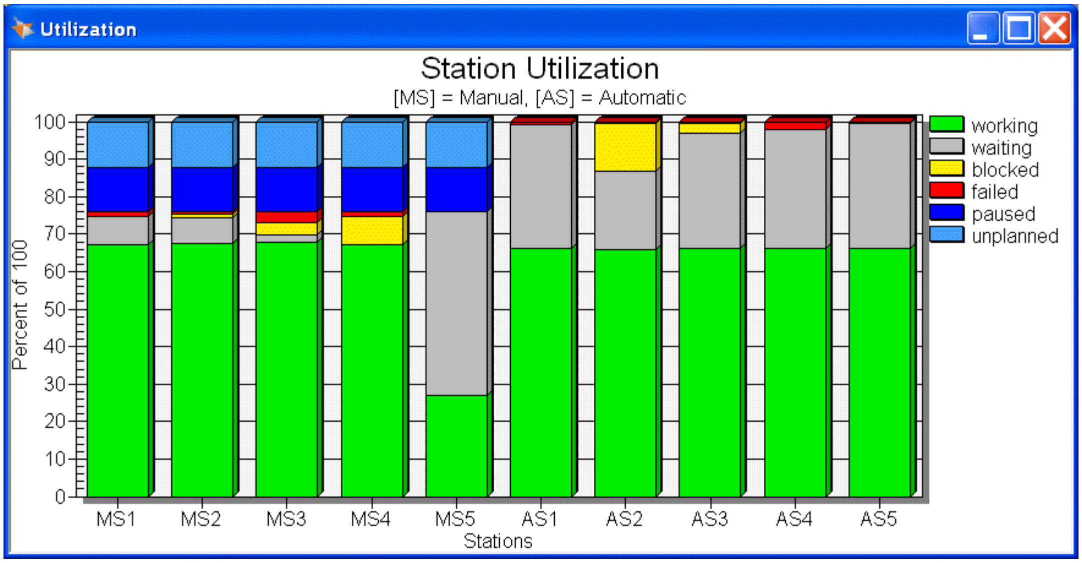


Figure 10: Utilization chart of the stations

The chart shows the percentage of time where a station was

- Working (green)
- Waiting (grey)
- Blocked (yellow)
- Failed (red)
- Paused (dark blue)
- Unplanned (light blue)

From the chart you can see, that the stations MS3, MS4 as well as AS2 and AS3 show a certain blocking percentage (yellow). On the other hand, you see that most stations show a waiting percentage (grey). This indicates that there is a bottleneck at stations AS3/AS4 and MS4.

Right-click the Buffer Usage histogram. It shows the percentage of time a certain quantity of parts was located on a conveyor.

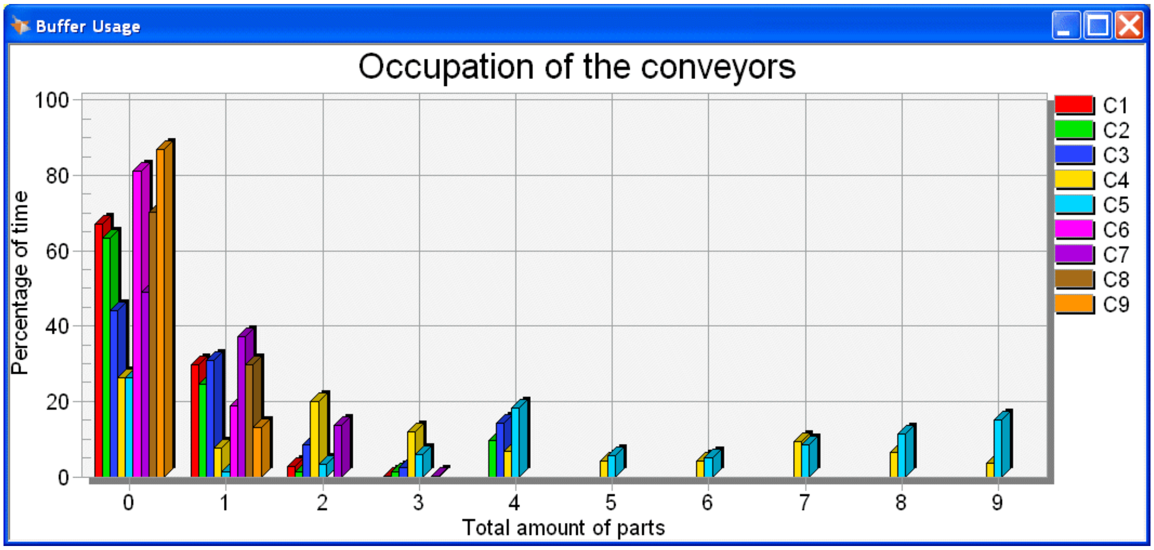


Figure 11: Occupation of conveyors

Note, that the conveyors C4 and C5 (yellow and turquoise) are quite often fully occupied. Again, this indicates that there is a bottleneck at station AS3/MS4. So the problem is the direct connection of manual and automated workstations. To solve the problem, we insert a buffer between MS4 and AS3.

2.5 Test New Layout

Look at the frame Assembly2. It shows a buffer between MS4 and AS3. Double-click the buffer. In the dialog of the buffer you see, the buffer has a capacity of 6 parts. Close the dialog.

Open the ExperimentManager in Assembly2 and run the same experiments again (*). Look at the Interesting Output Values tab of the HTML report.

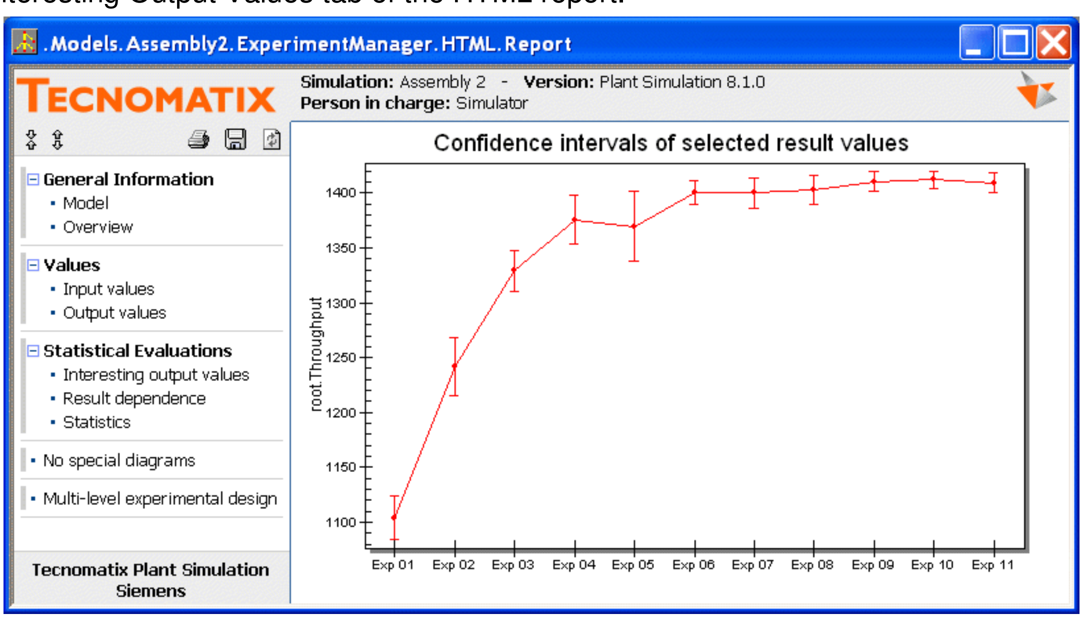


Figure 12: The confidence interval of results of Assembly2

In the report you see, that the throughput of Assembly2 is higher, but the optimum number of pallets now is 33 pallets (Experiment 10 shows the highest throughput). So the buffer increased the number of required pallets. In this experiment, we could improve the total output from 1376 (from the model Assembly1) to 1410 parts.

Double-click the Quantity object in the Assembly2 frame and set the value to 33. Click on the Reset icon and on the Start/Stop icon in the toolbar of Assembly2. Open the utilization chart for the stations and compare the result.

3. Worker Utilization

To look at the utilization of the workers, right-click the Worker-Utilization object and choose View Chart from the context menu.

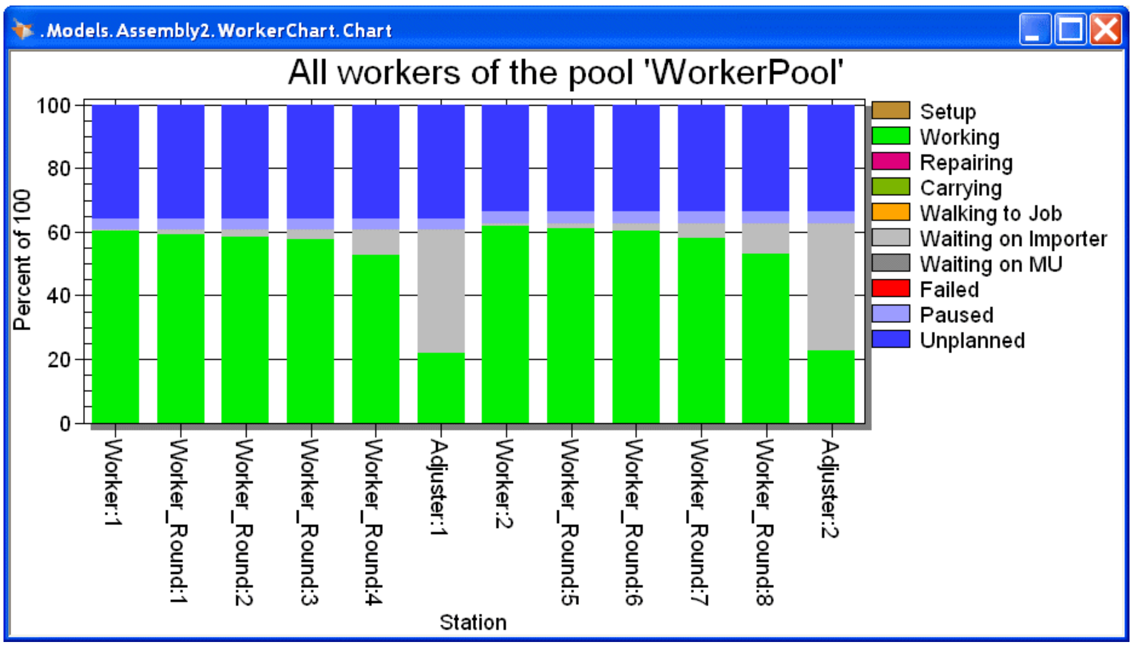


Figure 13: The worker utilization chart

The diagram shows the percentage of time when an operator was

- Working (green)
- Waiting (grey)
- Paused (dark blue)
- Unplanned, meaning there was no shift time (light blue)

The chart tells you that the Workers at the manual workstations have a high utilization. The utilization of the Adjusters is very low.

Summary: Plant Simulation provides multiple easy-to-use tools to evaluate your system. These tools allow you to identify bottlenecks and find resources which are not well utilized.

4. Conclusion

Even a system that looks so simple shows a complex behavior, due to stochastical parameters.

Even if two stations have the same mean value of the cycle time, the second station can be a bottleneck, if the two stations use a different random numbers distribution.

Plant Simulation provides all the tools you need to base your decisions on reliable results.