Description of the Small Parts Demo Model for Tecnomatix Plant Simulation
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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, 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. Normally, this is not possible. The ExperimentManager in Plant Simulation can solve this problem by executing a certain number of simulation runs by itself.

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 confidence level of 99 %, the mean 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 button Start in the model.
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.

Right-click the attribute explorer ManuParameters and choose Show 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 %.
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Figure 3: Attribute Explorer for the manual workstations

Right-click the attribute explorer AutoParameters and choose Show from the context menu. You can see that we use the Uniform distribution to create random numbers for the cycle time. The stations AS1, …, AS5 have a reduced availability of 99%.

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.
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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).

![Shift Calendar Image](image)

**Figure 6: Shift calendar**

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

![Creation Table Image](image)

**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 statistically reliable results.

Double-click the ExperimentManager object. On the tab Definition click on Define Output Values. This table shows the result value we would like to optimize. Then click on Define Input Variables. This table
shows the parameter we would like to change to optimize the result. In both tables you can provide understandable descriptions that are used in the evaluation of the experiments.

A click on Define Experiments opens a table which shows in which values we would like to set. On the tab Definition, you find the number of simulation runs with different random numbers (“Observations”).

![Image of ExperimentManager]

**Figure 8: The ExperimentManager – tab Definition**

Click on the bottoms Reset and Start. Now the ExperimentManager executes 10 simulation runs (10 observations) for each input value we defined. We defined 11 steps, so we execute $10 \times 11 = 110$ simulation runs. Each run simulates 24 hours. At the end, a report opens.
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Figure 9: Overview over all executed experiments

Look at the page Overview of the report. It shows the input and output values for each experiment. On the page Output values of interest, you see a chart which shows the confidence interval for each step. It shows for each experiment the range in which the mean value of the throughput will be with a confidence level of 90%.

Figure 10: The confidence intervals of the throughput

From the report we see, that experiment 10 shows the highest throughput. But experiment 7 is only insignificantly worse in comparison to experiment 10 with 27 pallets.
Double-click the *Quantity* object in the *Assembly1* frame and set the value to 27. Click on the *Reset* button and on the *Start* button of *Assembly1*. After the simulation run you will get a single observation of the throughput.

**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 on the *Utilization* chart and choose *Show* from the context menu show the utilization of the stations.

![Utilization chart of the stations](image)

**Figure 11: Utilization chart of the stations**

The chart shows the percentage of time where a station was

- Working (green)
- Setting-up (brown)
- Waiting (grey)
- Blocked (yellow)
- Failed (red)
- Stopped (rose)
- 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 side, 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 shows the percentage of time a certain quantity of parts was located on a conveyor.
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 B between MS4 and AS3.

2.5 Test New Layout

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

Open the ExperimentManager in Assembly2 and run the experiment study again (*). Look at the Results.
You see, that in most experiments the throughput of Assembly2 is higher. So the insertion of the buffer increased the throughput of the produced parts.

Double-click the Quantity object in the Assembly2 frame and set the value to 29. Click on the Reset button and on the Start button 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 14: The worker utilization chart](image)

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.

**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.

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