Possibilities of Using Computer Simulation in Production Process

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Abstract

This paper is engage in possibilities of using computer simulation in production process for gaining of competitive advantage in today's competitive world. The main goal is to show how the simulation software can help to design or optimize complicated manufacturing. First part of this paper provides basic piece of knowledge about using simulation in manufacturing. In the second part the Plant Simulation is introduced. It includes the explanation of how this simulation software works and what kind of advantages can arise if we use it. The last part contains a case study in which the simplified model of real manufacturing can be introduced and explained.

Keywords
System, simulation, modeling, Plant Simulation

1. Introduction

Process designing and optimizing of manufacturing is very complicated and expensive. Companies as a whole are very complex systems including huge quantity people and equipment. If we need to make sense of complex system we do not without modeling and simulation in most cases.

Simulation modeling and analysis is the process of creating and experimenting with a computerized mathematical model of a physical system. (Chung 2004) We can use either mathematical model or discrete-event simulation by helping software designed for this purpose.

When we simulate the real world, we must know what objects and ties between them are very important for behavior of system and what are not. If we make very detailed model, it can be very complicated and unnoticed. On the other side, if we ignore some of the very important feature of real system, the simulation process will be generating erroneous data. The model's representation of reality will not be precise enough.

It is important to say that in complex system a small change in initial conditions may result in very different state of system in future. In the same way if we pass over some characteristics, the result of simulation can be very different. It can lead in wrong decision making.

2. Using simulation in manufacturing

Banks (1998) defines simulation as "*the imitation of the operation of a real-world process or system over time.*" The simulation is used to describe and analyze the behavior of system. A simulation is an applied methodology that can describe the behavior of that system using either a mathematical model or a symbolic model. (Sokolowski 2009)

Manufacturing systems include very large amount of different objects. Each of them can be described by huge number of attributes. Some of them are the same for more objects but many of them are strictly individual. Manufacturing system include, for example, single processes, parallel processes, assembly stations, dismantle stations, buffers, stores, tracks, trucks, workers, robots, lines and many other objects. Attributes as processing time, exit strategy, capacity, etc. are obvious in most of them.

Hierarchy of a model enable to us to build the model at the desired level of complexity while keeping lucidity and simplicity. It means that the one object in main frame, for example SingleProc (object simulating one machine), can be described in another frame which can contain a number another objects and ties between them.

The main reason of utilization of simulation in the manufacturing is optimize production system as a whole. By using knowledge of Chung (2004) and Gregor (2002) we can identify some purposes of simulation:

- gaining insight into the operation of a system
- developing operating or resource policies to improve system performance
- testing new concepts and/or system before implementation
- gaining information and prediction of system behavior without disturbing the actual system
- support of decision-making process
- and finding savings in various areas of company

On the opposite side, the simulation doesn't enable (Gregor 2002):
- automatic optimizing system
- manufacturing management
- substitution man in decision-making process
- finding of right solution in using incorrect data

Procedure of simulation includes these steps:
- formulation of problems
- test of the simulation-worthiness
- formulation of targets
- data collection and data analysis
- modeling
- execute simulation runs
- result analysis and result interpretation
- documentation

(Bangsow 2010)

The most important from these steps is probably data collection a data analysis. Quality of model is critically dependent on inputs. If we work with incorrect data the model will be display fiction instead of reality. This phase is also exacting work because it is necessary to deal with people in the manufacturing and obtain correct data.

Result analysis and interpretation and documentation are also very important. While result analysis and interpretation serve to the solution was revealed the documentation provides basic information for employees that were not add in solving problem.

3. Research Methodology

The paper is based on study qualitative research of simulation software named Plant Simulation. The main aim is to analyze functionality of Plant Simulation and to show its using in practice.

The First part contains analyze of basic characteristic of simulation software. In this section is analyzed the main functionality including material flow objects, mobile units, information flows and resources. The case study in the second part shows practical use of analyzed functionality on specific manufacturing.

4. How the Plant Simulation works?

Plant Simulation is software for Discrete Event Simulation. There are many different programs for discrete-event simulation, for example Arena, Plant Simulation and Witness. For this study I choose Plant Simulation. The system modeled is created by using specific objects containing default attributes that can be customized for any purpose. The space where the system is modeled is called Frame. In this frame we can model the whole manufacturing. But we can also create hierarchy. It means that one frame can be object in the other frame.

Software offers many object in the class library that we can use for modeling. Material Flow Objects are the basic objects for modeling of a system. We can divide them into two groups: static and mobile. Static objects include objects such as machines (single process, parallel processes), tracks, assembly stations, dismantle stations, lines, and so on. These objects do not move through the system. On the opposite side, Mobile Units (MU) is part coming through the system. In Plant Simulation we can three basic kind of MU: Entity, Container and Transporter. Objects are tied by helping Connector.

For each object we can specify attributes that determine the object behavior. The different objects can have different kind of attributes but large amount of them can be same or very similar. For example, we can define processing time, recovery time, set-up time, failures, shifts, exit strategy (rule for distributing MU to successors) and we can also define own attributes on the User-defined Attributes tab.

The picture 1 displays object for assembly. On the left side of the picture the main attributes are displayed. On the right side of the picture is displayed the list of attributed and methods used in this object.

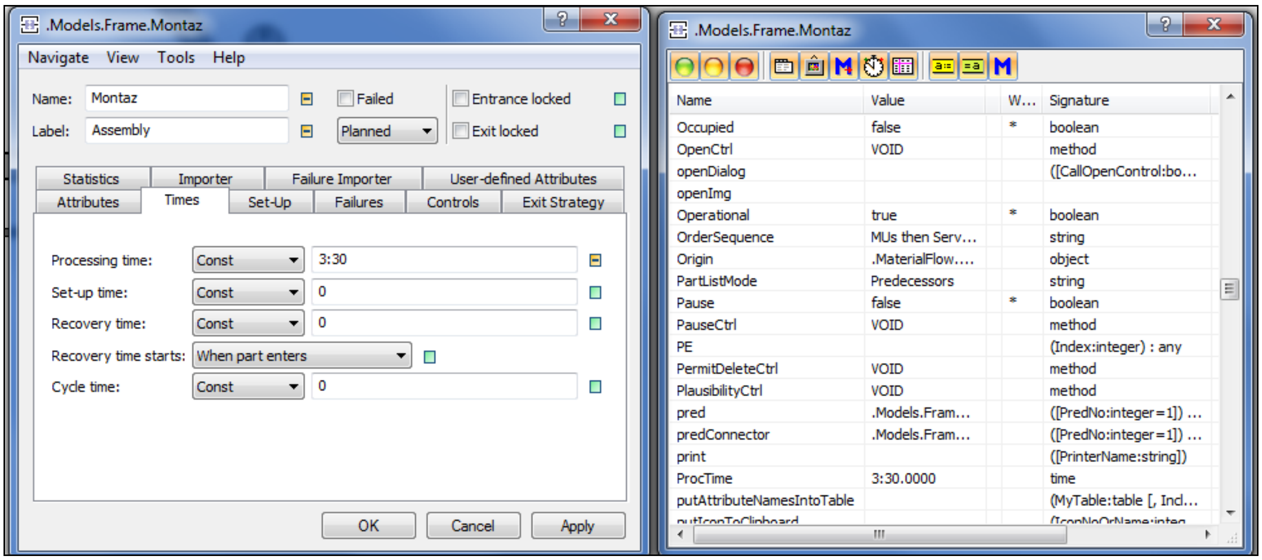


Figure 1: Attributes of the assembly station (source: own)

Each manufacturing is open system. It means that the manufacturing is linked with the environment around it. For modeling of this connections serve Source and Drain. Source is input of system and by helping it we generate mobile units. Drain is output of system that removes mobile units from system. Every system can contain any amount of inputs and outputs.

Plant Simulation offers more ways of generating mobile units. We can adjust generating in interval or set certain number of part that must be generated in a certain time (picture 2) or we can upload delivery table containing time and number of parts that will be generated. In the “Drain” object is the most important the Type Statistics tab that informs us about such things as total throughput or throughput per certain amount of time (hour, day).

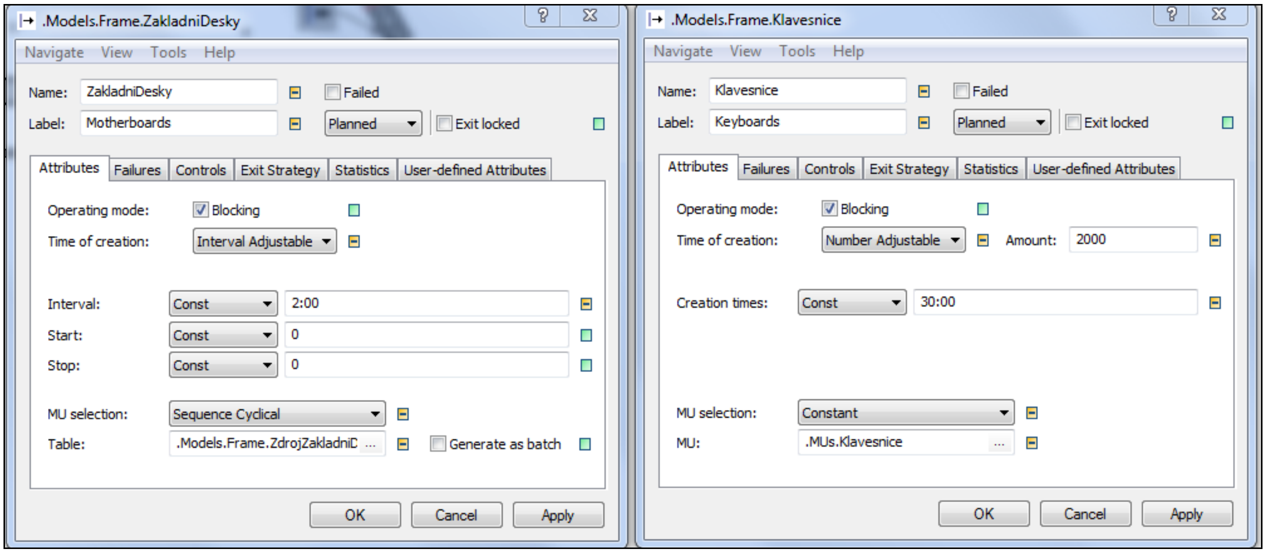


Figure 2: Source - generating entities (source: own)

In the Plant Simulation we can also model workers. We can generate various numbers of workers, modeling shifts including pauses for these workers and to design paths. Every worker can be design to operate with specific machine or machines. We can also set up that the worker takes a part from one machine and transport to another (Exit strategy "Carry part away").

In the real system the failure can occur during processing time. That is reason we can model failures of most of objects that Plant Simulation offers. Failures can be related to simulation time, operating time or processing time. We set up availability (for example 80 % as picture 3 shows) and MTTR (Mean Time to Repair). For one object can be modeled more failures with different features.

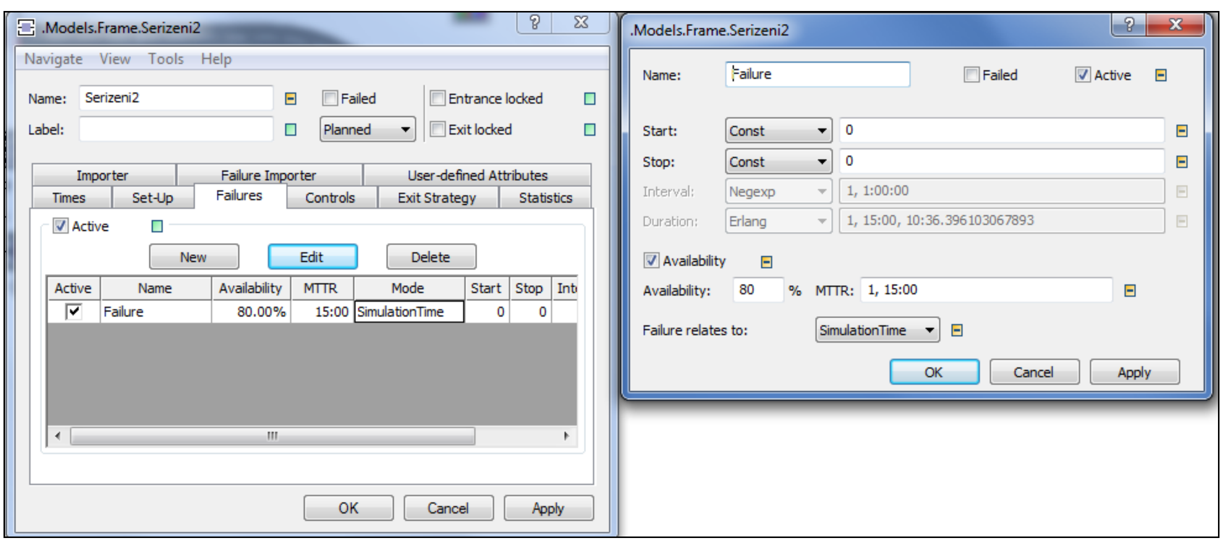


Figure 3: Failures (source: own)

For extension of object possibilities (characters) we can use Simtalk. Simtalk is programming language. Very simple examples of using Simtalk for settings of processing time and for delete MUs from passive object (Store) show pictures 3 a 4.

Processing time settings by helping Simtalk:

```
: time
is
do
	if @.Name = "Ntb_X55C"
	then
		result := 480;
	elseif @.Name = "Ntb_K53BE"
	then
		result := 600;
	end;
end;
```

Delete mobile units from Store:

```
is
do
	if Scrap.numMU = 500 then
		Scrap.deleteMovables;
	end;
end;
```

5. Results: A case study

The above mentioned information can be presented on the simply model of hypothetical factory for assembly of computers. Some of the settings were shown in the previous chapter (figures 1 – 3). Layout of this manufacturing shows picture 4. On the left side of the picture you can see part of class library including created entities, cars, workers, and so on.

The two kind of computer are assembled in this model. The first one, Ntb_X55C (blue color) and the second one, Ntb_K538E (red color). In this simplified model four inputs are created. Three of them are for entities that have to be assembled and the fourth for cars that transport entities to the second process. Next to every source you can see number of parts that have been generated by that time. These ones you can create by helping Display object.

At the bottom of picture you can see three workplaces. Workers walk along the footpath towards machines. All of them are created in the WorkerPool. In this object we can set up number of workers, shifts, and so on. Parameters of shifts are set up in the ShiftCalender.

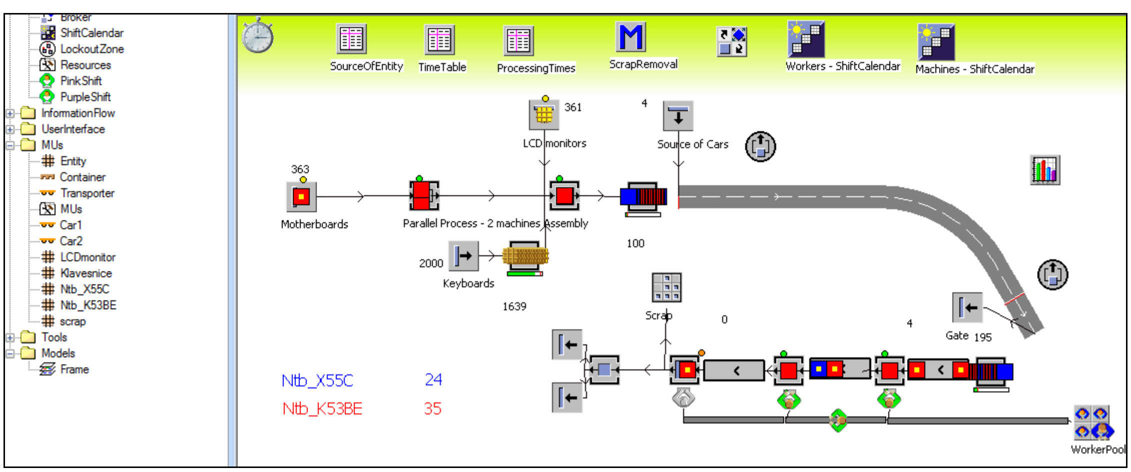
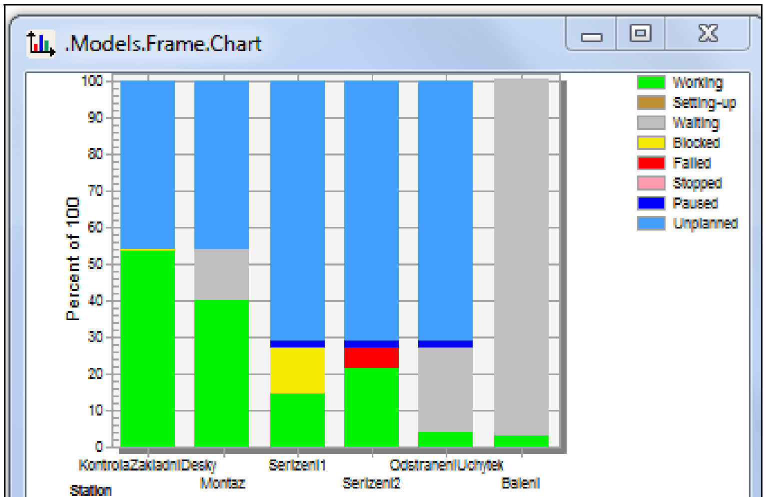


Figure 4: Running of simulation (source: own)

For more detailed analyze of machines behavior the chart is created. This simply chart displays how much period of time machines processing, waiting, are blocked, are failed or paused and so on (Figure 5). You can also display this data in percent. This information is very important when we are trying to find the improvement of the system. You can see where the bottleneck is and where the capacity is not put to use.



Station	KontrolaZakladniDesky	Montaz	Serizeni1	Serizeni2	OdstraneniUchytek	Baleni
Working	53,40%	39,90%	14,15%	21,01%	3,95%	2,63%
Setting-up	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Waiting	0,00%	13,68%	0,01%	0,11%	22,84%	97,37%
Blocked	0,17%	0,00%	12,62%	0,00%	0,00%	0,00%
Failed	0,00%	0,00%	0,00%	5,67%	0,00%	0,00%
Stopped	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Paused	0,00%	0,00%	1,79%	1,79%	1,79%	0,00%
Unplanned	46,43%	46,43%	71,43%	71,43%	71,43%	0,00%

Figure 5: Chart (source: own)

In the Drain the statistics tab display very important figures as total throughput, throughput per hour, throughput per day and average lifespan. In the figure 6 the data for Ntb_x55C are displayed. These data are very important to optimization of system.

Working:	96.97%	Average lifespan:	1:13:20:05.2177
Setting-up:	0.00%	Average exit interval:	20:28.0414
Waiting:	2.87%	Total throughput:	187
Stopped:	0.00%	Throughput per hour:	1.11
Failed:	0.03%	Throughput per day:	26.71
Paused:	0.14%		

Figure 6: Statistics for Ntb_X55C (source: own)

The final state of simulation after lapse a period of time is showed in the picture 7. This include information as total throughput, workload of workers and machines and naturally number of products that are created through period of time when the system was running.

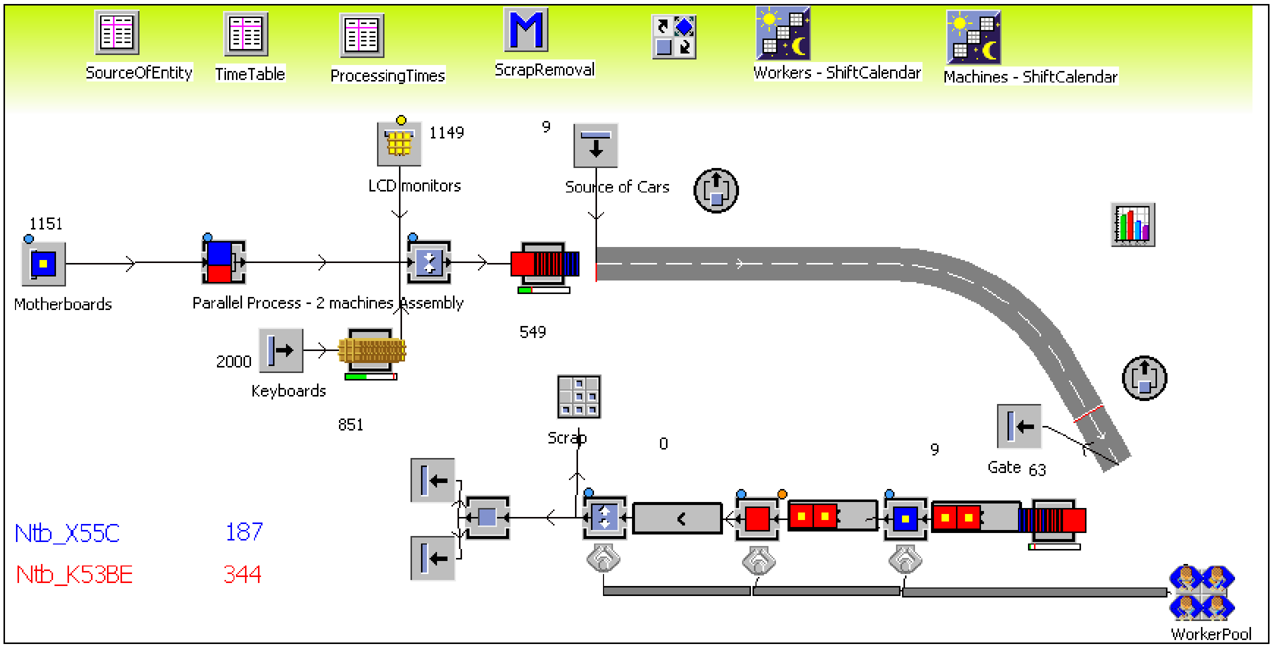


Figure 7: Final state of system (source: own)

6. Conclusions

As we have seen the simulation of manufacturing system can be very useful. Its utilization can reduce perceived complexity of engineered or optimized system. This is useful when we try to gain insight into system to improve it.

Very useful is possibility to change individual attributes of object and to create different variants of system. It means that we are able to explore variety of settings and to choose the one that is the most optimal. Time is critical value that can be accelerated or decelerated. It enables to follow the evolution of the manufacturing system in short period of time.

Statistics in every object of simulation, charts and other tool for visualization can help to find any problem. It can also serve for presentation to management and staff. Sense of urgency can be achieved because people understand how the system works and see its constraints. The main advantage is that we can experiment with system without wasting money and time of our workers.

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References

Bangsow, S., *Manufacturing Simulation with Plant Simulation and SimTalk*, Springer, Berlin, 2010.
Banks, J., *Handbook of Simulation*, Wiley, New York, 1998.
Curry, G. L.; Feldman, R. M., *Manufacturing systems modeling and analysis*, Springer, Berlin, 2011.
Chung, C. A., *Simulation Modeling Handbook: A practical approach*, CRC press, Boca Raton, 2004.
Gregor, M.; Mičieta, B.; Košturiak, J.; Bubeník, P.; Růžička, J., *Dynamické plánovanie a riadenie výroby*, Žilinská univerzita v Žilině, Žilina, 2000.
Sokolowski, J. A.; Banks, C. M., *Principles of Modeling and Simulation*, Wiley, New York, 2009.
Zeigler, B. P.; Praehofer, H.; Kim, T. G., *Theory of Modeling and Simulation*, Academic Press, London, 2000.

Biography

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