Acta Logistica - International Scientific Journal about Logistics
Volume: 2 2015 Issue: 3 Pages: 1-5 ISSN 1339-5629

SIMULATION AS A TOOL FOR PROCESS OPTIMIZATION OF LOGISTIC SYSTEMS

Radko Popovič
TU of Košice, Faculty SjF, Institute of Technologies and Management, Department of Industrial Engineering and Management, Nemcovej 32, 042 00 Kosice, e-mail: radko.popovic@tuke.sk
Marek Kliment
TU of Košice, Faculty SjF, Institute of Technologies and Management, Department of Industrial Engineering and Management, Nemcovej 32, 042 00 Kosice, e-mail: marek.kliment@tuke.sk
Peter Trebuňa
TU of Košice, Faculty SjF, Institute of Technologies and Management, Department of Industrial Engineering and Management, Nemcovej 32, 042 00 Kosice, e-mail: peter.trebuna@tuke.sk
Miriam Pekarčíková
TU of Košice, Faculty SjF, Institute of Technologies and Management, Department of Industrial Engineering and Management, Nemcovej 32, 042 00 Kosice, e-mail: miriam.pekarcikova@tuke.sk

Keywords: digital factory, simulation, process simulate
Abstract: The paper deals with the simulation of the production processes, especially module of Siemens Tecnomatix software. Tecnomatix Process Simulate is designed for building new or modifying existing production processes. The simulation created in this software has a posibility for fast testing of planned changes or improvements of the production processes. On the base of simulation you can imagine the future picture of the real production system. 3D Simulation can reflects the actual status and conditions on the running system and of course, after some improvements, it can show the possible figure of the production system.

1 Introduction

Process Simulate is a part of the software package Tecnomatix produced by Siemens company. Process Simulate can offer many possibiliets of the process simulation. The same as in the Tecnomatix Process Designer, it can also take a static 3D models of the productive processes and in the same time you create a realistic video of the running system with all employess, machines, products and all that stuff. Every simulation consist of huge small processes which are associated by the relationships between them. This article is showing a basic theory about the types of simulation in this software.

2 Simulation in Process Simulate

Simulation is the imitation of the operation of a real-production process or system over time. Simulations are divided into:

- Process Simulation - this type of simulation is used for planning complex production and material own systems.
- Finite Element (FEM) simulation are used primarily for calculating the stability or load capacity of a system.
- Graphical 3D simulations - 3D simulations of kinematics systems that can display and optimize the motions of a production system.

Process Simulate is orientated on Graphical 3D simulations. In the Process Simulate we can choose the type of the simulation - time-based simulations or event based simulations [1]. Time-based simulation can be created in Standard Mode and partly also in Line Simulation Mode of Process Simulate. Event based simulations are enabled only in Line Simulation Mode of Process Simulate. The difference of the simulation logic and relationships between operations is on the next picture (Figure 1).

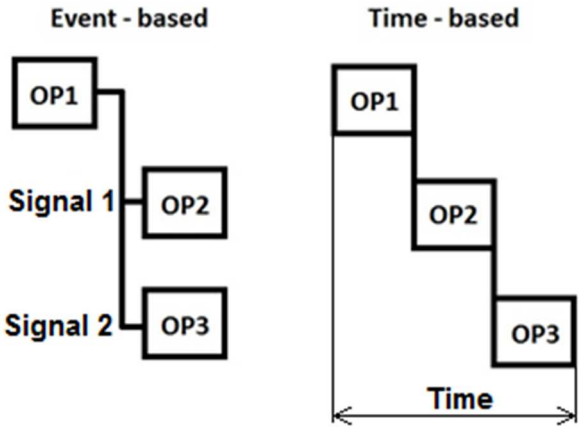

Figure 1 Event - time based simulation

3 Time Based Simulation

Main build stones of a time-based simulation are resources, products and operations. Time-based simulation is limited by its duration of operation and it is strictly defined to one scenario of a given simulation. Logic of time-based simulations is based on Gantt chart (Figure 2). It describes a sequence of operations in simulations, so all relationships between operations and duration of each process defined in the operation tree.

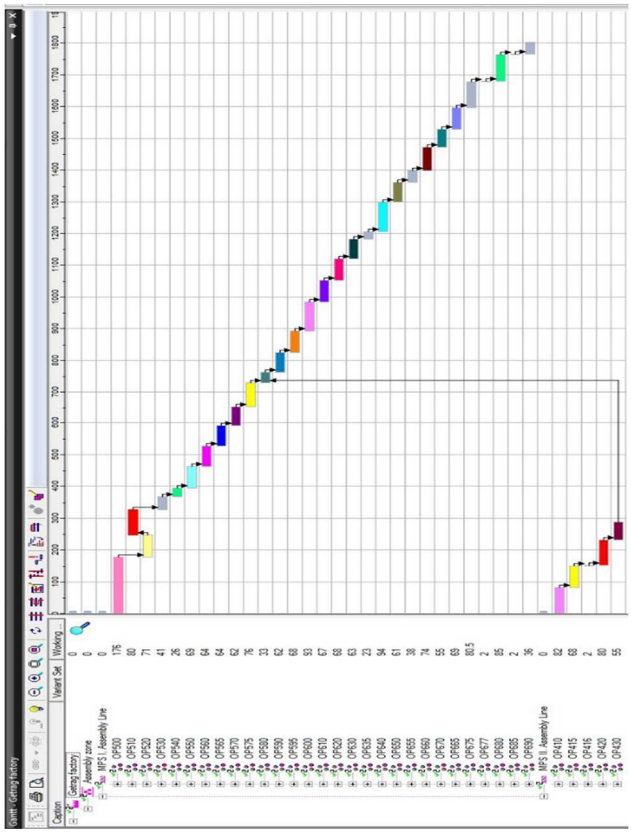

Figure 2 Gantt chart

To build a time-based simulation it is necessary to define kinematics of functional elements (gripper,weld gun, etc.), modeling of all operations (human operations, robotic operations, material flow operations) and create relationships between those operation [2].

4 Material Flow

If we want to create an event based simulation, first we need to define material flow. It consist of operations, links between them and information about part and resources assigned to the operation (Figure 3). To show and define a material flow we need to open material flow viewer from top menu View – Viewers – Material Flow Viewer.

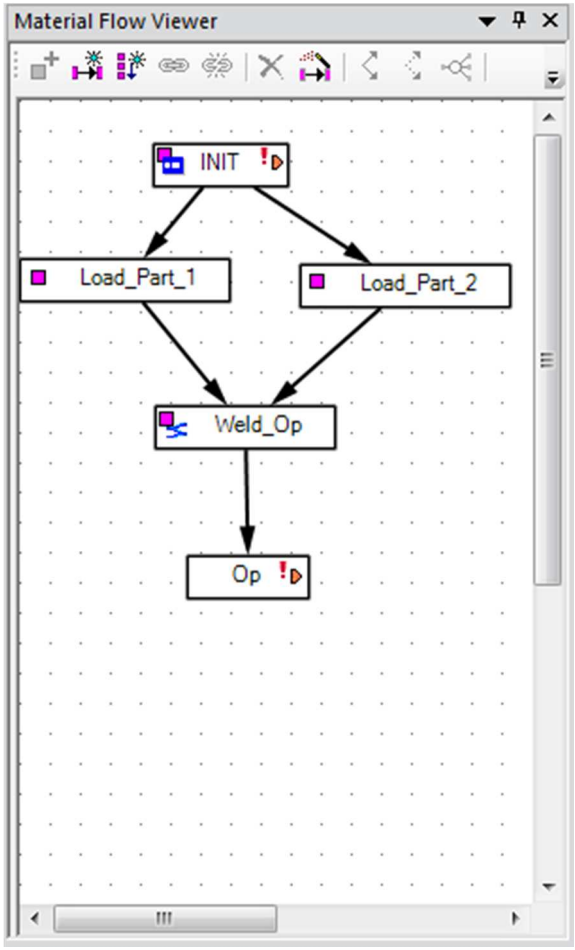

Figure 3 Material flow

5 Event Based Simulation

The main build stones of event-based simulation are resources, appearances, operations and signals. Event-based simulation is endless simulation with many variants of scenarios. It means that one simulation can follow to many different solutions [3]. Event based simulations are subdivided into Cyclic Event Evaluator (CEE) simulation and Virtual Commissioning (connected to PLC). Nevertheless they are really similar. Main difference is in their logic. Cyclic Event Evaluator is a processor of the simulation engine and it runs cyclically in Process Simulate. In Virtual Commissioning the external PLC (or a PLC Simulation) is a processor of the simulation engine.

The Event-Based Simulation module provides a simulation environment that supports the design and verification of sophisticated production stations. The module can simulate production stations where a variety of robots, manufacturing resources, and control devices must function in full synchronization. Process Simulate's Event-Based Simulation module offers an approach that is much more accurate than conventional time-based (sequence) simulations, creating programs off line and an

event-based and flow control simulation that enables you to simulate multiple robots and the surrounding devices in the production station. Using the unique simulation capabilities of the Event-Based Simulation module, OEMs, line builders and system integrators can save time and costs by identifying synchronization and automation problems, long before they start the expensive process of deploying new production stations.

In a conventional time-based simulation, the predefined sequence of operations (SOP) dictates the simulation of the process [4]. In event-based simulation, the logic of the process and the events that occur during the simulation determine the course of the simulation. The sequence of the operations is only one element of the complete logic definition. Because the events that occur during a simulation can vary, each simulation of the same process can be unique. With a PLC as well as event driven simulation, the sequence of operations is controlled using signal based logic [5]. Various devices are stopped and started through the simulation by setting a Bit (signal) High (TRUE) or Low (FALSE). The logic defined for the process uses two types of events to determine the course of a simulation:

Resource-triggered events. For example:

- A clamp reaches a specific pose.
- A robot reaches a specific location.
- A robot completes a weld operation.
- A conveyor starts to operate.
- An operator pushes the emergency button on a control panel.

Non-resource-triggered events. For example:

- A process completes 4 cycles.
- A specific operation starts for the first time.
- A specific operation runs for 10 seconds.

The sequence of the simulation is largely determined by the prerequisite conditions that are defined for each operation in the process [6]. The conditions are defined by a single event or a combination of events.

- Single event - For example, a device operation that closes a clamp may start only after the part is placed in the fixture.
- Combination of events - For example, a robotic weld operation may have a condition to start only when the parts are in the fixture, all clamps are in the CLOSE pose, and the robot is not performing another operation.
- The operation cannot start until an operation that closes the clamp is complete.
- The part is in place.
- The robot is not performing another welding or handling operation.
- No maintenance operation is required.
- The Emergency button was not pushed.

The goal of simulation is to connect the 3D aspect of the process (resources, parts and operations) to the logic of the process. The Event-Based Simulation better approximates the shop floor process, taking into account many additional elements such as failure scenarios, mixed production, maintenance, and operational problems [7]. In addition to creating a more realistic simulation, event-based simulation enables you to analyze aspects of the manufacturing process that are not possible to analyze in time-based simulations. For example:

- Calculating average cycle time, robot-added and non-added values, idle time, etc.
- Analyzing and optimizing a mixed production process in terms of:
- Collisions, flow of material, logistics, bottlenecks, time difference between different mixture ratios, etc.
- Analyzing and optimizing maintenance operations; For example:
- Robot tip dressing
- Analyzing and optimizing QA related tasks, such as inspection.
- Reporting statistics of the process, such as
- The number of products produced after a given time,
- The number of times an alternative was applied, etc.

6 CEE Simulation

Cyclic Event Evaluator simulation is closer to real processes of factory than timebased simulation, but further than OPC simulations. CEE simulations contains three logic types:

- Sequence transition condition - it is a combination of the time-based approach of simulations with transition condition signals. Therefore to use a transition there has to be de_ned a link between two operations (Gantt Chart) in Sequence Editor. If the transition condition is satis_ed following operation is triggered. In the transition to multiple operations we can create simultaneous operations or variant branches. Each variant branch has its extra transition condition.
- Modules - modules are special logic blocks which behave like an internal PLC of Process Simulate. Module conditions control all devices connected to the PLC.
- Logic Block - logic block control logic of devices, robots and processes input signals. In a real product line not all of components are controlled by a robot or a PLC controller. For example, smart drilling machines or CNC machines contain their own logic. To determine this logic we use logic blocks.

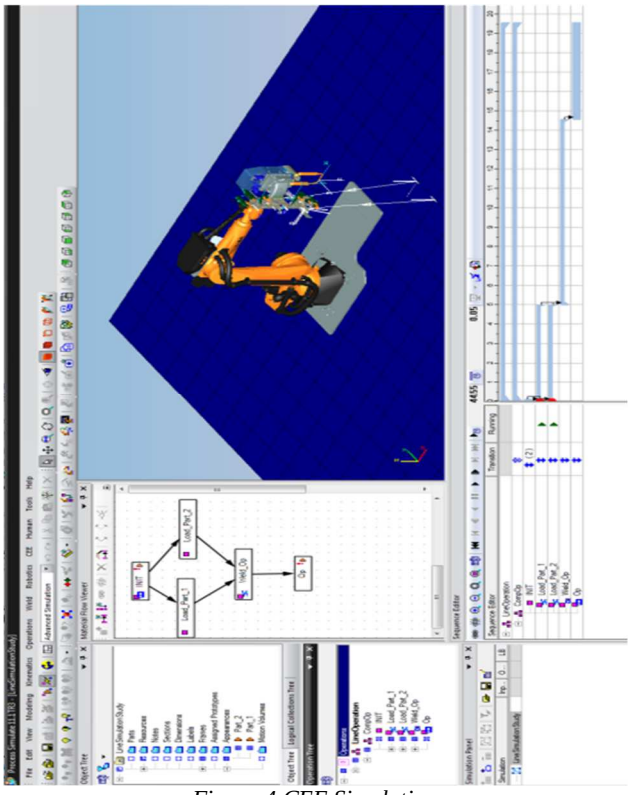

Figure 4 CEE Simulation

We can combine all three types mentioned above and create a powerful simulation (Figure 4). For this is used combination of time-based approach with modules, transition conditions and logic blocks. The Cyclic Event Evaluator (CEE) is at the core of the event-based simulation engine. The CEE acts as a control center for the simulation. For each cycle of the simulation, the CEE collects and evaluates the PLC signals to determine the flow of the simulation. Because the CEE functions cyclically, the event-based simulation is a continuous, infinite simulation that starts when you click Play and ends only when you stop the simulation. During the simulation you can also pause the simulation and play forward or jump to the start of the simulation. The simulation may include identical cycles of the same process or different variations of a process.

7 Part appearance

CEE simulation requires a new concept for defining parts in the simulation. A standard time-based simulation simulates the process only once and requires only one instance of each part in the simulation. In contrast, CEE simulation uses part appearances instead of part instances (Figure 5). It means that the part will be visible during the simulation only if an appearance has been set. When an operation that requires a part begins, the simulation creates a new appearance of the part instance if necessary, according to a set of rules, including inheritance and location rules.

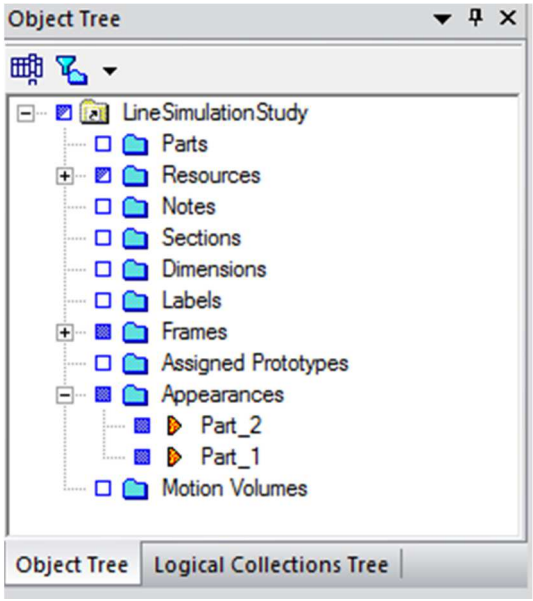

Figure 5Part appearance

Conclusion

This article shows the basic types of simulation, that can be created in the Tecnomatix Process Simulate. Difference between Standard mode and Line simulation mode is in their logic. In the standard mode there is a possibility to create a time based simulation, but on the other side, in the Line simulation mode we can build an event based simulation. Nowadays, companies needs a detailed simulation of the production processes and therefore they need to choose, if the time based simulation will be enough for further analysis. Event based simulation can show much more realistic picture of the production process, but also contains of many settings (signals, events, appearances) and the eventual simulation can be a littlle bit complicated.

Acknowledgement

This article was created by implementation of the grant project KEGA 004TUKE-4/2013 *"Intensification of modelling in teaching II. and III. degree in the field of study 5.2.52 Industrial Engineering"*

References

[1] http://www.plm.automation.siemens.com/en_us/products/tecnomatix/manufacturing-simulation/assembly/process-simulate.shtml

[2] MALINDŽAK, D. et al: *Modeling and simulation in logistics*, Košice 2009. (Original in Slovak)

[3] VOTAVA, V., ULRYCH, Z., EDL, M., KORECKY, M., TRKOVSKY, V.: *Analysis And Optimization Of Complex Small-Lot Production In New Manufacturing Facilities Based On Discrete Simulation*, EMSS 2008:

20TH European Modeling And Simulation Symposium, p. 198-203, 2008.
[4] GREGOR, M. et al: Simulation of systems, Žilina: Vysoká škola dopravy a spojov v Žiline, p. 229, 1992. (Original in Slovak)
[5] GABAJ, I., MIRANDOVÁ, G., KRAJČOVIČ, M.: FactoryCAD and FactoryFLOW – logistic tools of Tecnomatix. *Produktivita a Inovácie*. p. 18-19. (Original in Slovak)
[6] MORHÁČ, M.: PLM solutions – new strategy of enterprises development. [online]. [cit. 2014-09-04]. (Original in Slovak) Available: http://www.efocus.sk/images/archiv/file_45_0.pdf
[7] SZABO, S., FERENCZ, V., PUCIHAR, A.: *Trust, Innovation and Prosperity*. In Quality Innovation Prosperity / Kvalita Inovácia Prosperita. Vol. XVII, No.2, p. 1-8, 2013. Available: http://www.qip-journal.eu/index.php/QIP/article/view/224/206

Review process
Single-blind peer reviewed process by two reviewers.