DISCRETE AND CONTINUOUS SIMULATION OF MANUFACTURING PROCESSES

DISKRÉTNA A SPOJITÁ SIMULÁCIA VÝROBNÝCH PROCESOV

Ing. Maroš Fill, prof. Ing. Gabriel Fedorko PhD.
Technická univerzita v Košiciach
fedorko.gabriel@gmail.com

Abstract
This paper deals with simulation capabilities specified for discrete and continuous manufacturing processes using the object-oriented (block-oriented) software tools called Extend and Plant Simulation. Introduction of this paper describes differences between the discrete and continuous simulation and their mutual comparison, further part presents a possibility of simulation of manufacturing processes using the simulation program Extend and then it is pointed out innovation of simulation using the Plant Simulation.

INTRODUCTION
The simulation software products are such useful tools, which are able to test various decisions using a simulation model, to evaluate the individual production capacities and duration of working operations, together with evaluation of other parameters in the given production system as well as they are useful for elimination of an unfavourable possibility to involve some undesirable change into the manufacturing process. [1] Nowadays, creation or development of simulation software is a simple task and a user-friendly process because it requires only knowledge of simulation blocks, their properties and application possibilities. Creation of a simulation model by means of these blocks and the following simulation process is such task, which can be mastered by a standard user of the up-to-date PC-technology. There are presented in this paper two block-oriented (or subject-oriented) software applications that are specified for simulation of discrete and continuous manufacturing processes.

COMPARISON OF CONTINUOUS AND DISCRETE SIMULATION
The next Table 1 describes the basic differences between the continuous and
discrete simulation. Such tabular comparison of the individual characteristic features and differences can be helpful for users during their decision-making process concerning a question about model, which should be chosen and applied for the given simulated system. [2]

<table>
<thead>
<tr>
<th>Factors</th>
<th>Continuous Simulation</th>
<th>Discrete (Discontinuous) Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>What will be</td>
<td>Flows (materials, roughs)</td>
<td>Discrete items (things, needs, requirements)</td>
</tr>
<tr>
<td>simulated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>Simulation is typical for flows, i.e.</td>
<td>Application of the individual values, which are applied in the whole</td>
</tr>
<tr>
<td></td>
<td>calculation process is sequential</td>
<td>simulated system</td>
</tr>
<tr>
<td>Time step</td>
<td>Interval between the individual time steps</td>
<td>Time step is changing according to occurrence of the individual occasions</td>
</tr>
<tr>
<td></td>
<td>is the same</td>
<td></td>
</tr>
<tr>
<td>Queueing</td>
<td>Flows are managed by the FIFO system only</td>
<td>There are applied various managing systems, e.g. the FIFO, LIFO, etc.</td>
</tr>
<tr>
<td>Routing of flows</td>
<td>The flows can be situated in the same</td>
<td>Dominant is the first suitable flow, which can be situated at one point</td>
</tr>
<tr>
<td></td>
<td>time at various points simultaneously</td>
<td>only in the given time</td>
</tr>
<tr>
<td>Statistical details</td>
<td>There are applied general statistics only</td>
<td>Every requirement can be evaluated individually</td>
</tr>
<tr>
<td></td>
<td>that are describing the system</td>
<td></td>
</tr>
<tr>
<td>General application</td>
<td>Scientific branches: biology, chemistry,</td>
<td>Manufacturing, services, business processes, computer networks, phone</td>
</tr>
<tr>
<td></td>
<td>physics, electronics, control systems,</td>
<td>networks, complex systems</td>
</tr>
<tr>
<td></td>
<td>artificial intelligence systems, dynamic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>systems,</td>
<td></td>
</tr>
</tbody>
</table>

SIMULATION LANGUAGE EXTEND

The simulation language EXTEND belongs into a group of simulation languages that are able to perform both the discrete and continuous simulation process. From this reason the EXTEND is a widely used simulation tool, which is suitable and specified for the platforms PC-IBM and Macintosh.

The simulation language EXTEND is a product of the company Imagine That, Inc. USA. This company offers the EXTEND in the next four different versions with various application possibilities or various number of blocks developed for creation of the simulation models: EXTEND CP, EXTEND OR, EXTEND Industry and EXTEND Suite. [2]

DISCRETE MODELS AND SIMULATION USING THE SIMULATION LANGUAGE EXTEND

The discrete simulation (Fig.1) should be applied in order to simulate the main kinds of the bulk-service systems, i.e. the simple, serial and parallel bulk-service system. The blocks required for building of the discrete simulation models are at disposal in the library.
The next application part of the simulation language EXTEND is oriented into the area of a continuous simulation. The main difference between the discrete and the continuous simulation consists in a fact that in the case of the continuous simulation there are obtained values or results from the simulated system in every time moment, even at that time when the system remains without a change.

The continuous simulation in the simulation language EXTEND is performed using a discrete time behaviour with the fixed time step, i.e. during the continuous simulation the time behaviour is recorded always in the same time intervals, also without any change in the simulated system. If the fixed time step value is small enough, then the time behaviour of the simulation process is very similar to the continuous time behaviour.

Application of the continuous simulation (Fig.2) is relevant for biology, chemistry, physics, electronics and economy as well as for the control systems, systems of artificial intelligence and for dynamic systems.

In order to generate the basic simulation models within the framework of a continuous simulation it is necessary to know the blocks from the library “Generic”. [2]
The Plant Simulation (Fig. 3) is standard software used for simulation of very complex production systems and managing strategies. This software simulation tool is characterised by the object-oriented, graphical and integrated simulation or animation of the systems and company processes. It is an important part and basic tool of a digital factory from the Siemens PLM software portfolio. [3]
The Plant Simulation enables to generate a simulation model of the given production/assembly process and to test influence of changes in the manufacturing process on the monitored parameters. An advantage of this process is a possibility to use a drawing technical documentation as a base for arrangement of the individual elements or objects in the existing or planned production plant. It enables to solve the next tasks:

- to determine influences of changes in the manufacturing programmes on the production and assembly equipment,
- to test priority rules during scheduling of production,
- to define storage capacities,
- to verify influence of production and transport portion on workflow,
- to determine time interval necessary for start-up of new product manufacture,
- to define a total production output of the plant or its part.

SIMULATION OF LOGISTIC PROCESSES – TRANSPORT AND STORAGE

An advantage of dynamic simulation is implementation of dynamics into the proposed static processes. Monitoring of movement is important in the area of material transport within the framework of external or internal transportation. The Plant Simulation enables to assemble the simulation model of external and internal logistic systems and to verify dynamically the systems before implementation of them into the real operation. Therefore the dynamic simulation is applied in the next areas predominately:

- testing of changes in the transport system and their influence on the production/assembly system,
- testing and evaluation of the various material supply systems,
- testing of changes in the applied transport equipment with regard to the given system capacity,
- testing of changes in the transport task priorities with regard to the production,
- monitoring of influences of the crossroads and nodal points on the transport equipment utilisation,
- monitoring of random event influence – failures and changes – on the total storage capacity in the given plant. [5]

SIMULATION OF HUMAN SOURCE DEMAND [5]

As it was mentioned already, the Plant Simulation contains a large amount of the specialised modules. One of them is the special modulus developed for the simulation of
human activities (Fig. 4). Everyone source, which is used in the company, i.e. also the human work, is a limited source. Therefore the given software provides simulation of persons like simulation of sources that are able to perform the following activities:

- operating of equipment,
- manipulation of products,
- setting-up activities and maintenance activities.

![Fig. 4 Simulation of human sources in the Plant Simulation [5]](image)

**PLANT SIMULATION AND INTERCONNECTION WITH SAP**

A possibility of intuitive and fast data transfer between the central company software SAP and the simulation software Plant Simulation is a necessity nowadays.

After a primary simulation of the individual workplaces and plants the data concerning production are exported from the company software to the simulation model. The required data are transferred through the central database of the company in order to perform the discrete simulation. Another possibility of data transfer is exporting of data in a structured form by means of the created Excel tables that are representing subsequently the main source of data used for the simulation process control. [6]

**VISUALISATION**

The Plant Simulation enables to illustrate manufacturing sequences using the 2D and 3D visualisation. The 3D-visualisation (Fig.5) is useful predominately as a sale tool or for in-house communication of the planned measures. Furthermore, it enables to present a whole
concept of the given system in a virtual, interactive surrounding. [4] The 3D-visualisation is created and saved in the standard format JT. The CAD-applications (e.g. NX, Solid Edge) are able to export their models in this format.

![Fig. 5 Visualisation in the Plant Simulation [7]](image)

**CONCLUSION**

On the present there are various possibilities how to simulate various kinds of the production processes. One of the possibilities is application of the software Extend. The simulation language Extend belongs to a group of such simulation languages, which are able to perform the discrete and continuous simulation. The Extend enables to create simulation of the production process very simply and quickly using the individual blocks that are selected from a large amount of the libraries offered by the Extend itself. It also offers visualisation of the processes in a logistic model or in a virtual surrounding; it is able to discover possible hidden failures in the production process, to investigate potential influences of the system modifications and to optimise the individual activities performed inside of the production process, as well.

The Plant Simulation is a standard software tool, which was developed for the simulation of very complicated production systems and managing strategies. The main characteristic feature of this simulation tool is the object-oriented, graphical and integrated modelling as well as simulation and animation of the systems and company processes. It is an integrated part and a basic tool of a digital factory, together with implemented ability to simulate and to analyse the multi-level systems, human source needs, energy consumption, data transfer from the SAP system and to offer the 2D or 3D-visualisation of the production sequences, too.

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LITERATURE


