The simulation model as a tool for the design of number of storage locations in production buffer store

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We often meet temporary storage of semi-product in the production buffer stores in industrial companies. These buffer stores are located either directly in production halls or near them. One of the questions that resonate in practice is size-capacity of storage places and dimensions of buffer stores. Here is presented the simulation model in the paper, which simulates the number of incoming and outgoing semi-products in the production buffer store, by which we can determine the number of stored semi-product in a certain period of time. The simulation model is created for four types of semi-products, which have fixed times of storage that resulting from technological process of the production. The simulation model was created by using EXTEND program. The outputs of the model are presented in the paper. The simulation results can be used as a supporting tool at determining the storage capacity, and at optimizing storage locations.

Key words: *simulation model, material flow, storage*

Introduction

Storage of materials is subsystem of handling and it means interruption of material flow in the manufacturing process [6]. In other words, it is storing of material by handling equipment into the storage device with the aim to prepare it in the required time for picking. Warehouse (storage) is the place in which different type of materials is temporarily kept or it is the place through which this material is moved. Warehouses are divided according to several criteria and properties. One of the most known warehouses dividing in the manufacturing enterprise is dividing according to the status of warehouses in the manufacturing process (according to the phases of value added process) as following:

- input (supply) stores, for maintaining inventory of input materials,
- production buffer stores intended for stock creating among the various phases of the manufacturing process,
- output stores, having the task to balance the time difference between manufacturing and shipping processes.

Storages are often divided by the stock character, e.g. stores of material and raw material (inventories), stores of semi-product – buffer stores, stores of finished products, waste storages, support stores of tools, spare parts, consumables, etc. Storages in manufacturing enterprises have different character, the size of the area, they are equipped with different types of service equipment and storage facilities which determine its capacity - the maximum supply, which can be in the warehouse efficiently and effectively store.

Several factors have to be taken into account, which more or less influence their size and capacity, in designing new or reconstruction of existing stores. Influencing factors, to the size and capacity of storage, can be divided into three main groups:

1. factors of stored items,
2. factors of manipulation,
3. factors of storage area.

The first group of factors characterizes the state of stored items, geometrical shape and sizes of stored items, the weight of stored items, kind of - assortment (groups) of stored items, properties of stored items and price (value) of stored products.

An important factor is the type of storage unit in which the material is stored, as this is in most cases the basic handling units in storage. We can meet most often with pallets and crates of various types in practice.

One of main important factor is the quantity of stocks, which has to be stored in a given warehouse and its turnover rate. The turnover rate may be different depending on the demand eventually it depending on the technological process in production.

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Simulation is an experimental method in which the real system is replaced by a computer model. It is possible to make a number of experiments with such model, to evaluate and to optimize it and then results can be applied to the real system. The first step in the simulation is to build simulation model of the real system. The next step is to provide experiments with the simulation model by which there are achieved results, which need to be correctly interpreted and applied. Application possibilities of computer simulation can be applied in designing of manufacturing and logistics systems [2, 3, 7, 8], which can solve various questions e.g.:

- What type and number of machines and supporting equipment are needed to be used?
- What is the throughput of the system?
- What is the best layout of workplaces?
- What is the balanced flow of materials?
- Where are the bottlenecks?
- How large warehouses and storage facilities should be?

The mentioned simulation model will assume answer to the last question.

Characteristics of solved problem

There are many technological procedures that require temporary storage of in-process products in different phases of the manufacturing process in industry. At designing of such buffer store, flows from individual departments, from which semi-products flow to the buffer store and prescribed time of temporary storage, which affects the output flows of semi-products from buffer store to next manufacturing operations should be taken into account. For this situation it was chosen simulation – the creation of the simulation model of flows of semi-products which enter to and leave buffer store, as a tool for the capacity design of this buffer store. The scheme of the situation of input and output flows for needs of the simulation is shown in the Figure 1.

Two types of operation produced 4 types of semi-products which have to be stored for the following manufacturing operations, based on the technological process. The first operation produces semi-product **"SP 1"**, with storage time 24 hours - one day, the second operation produces three semi-products **"SP 2"** with storage time 48 hours - 2 days, **"SP 3"** with storage time 72 hours - three days and **"SP 4"** with storage time 96 hours - 4 days.

The model of operation works on the PULL principle – custom (order) manufacturing.

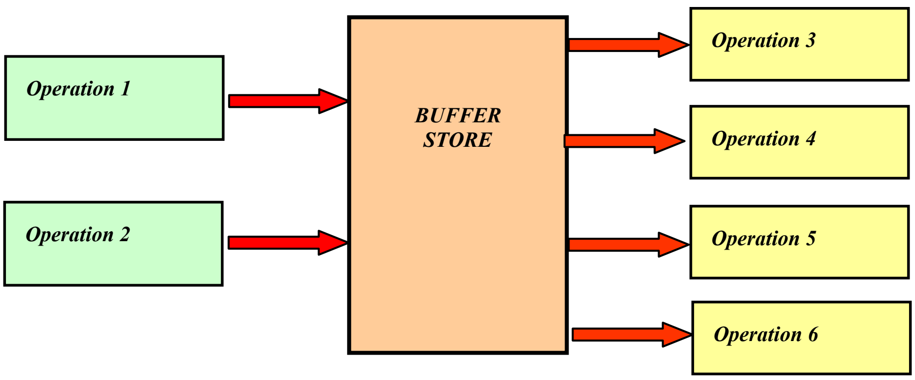


Fig. 1. Schematic situation.

Simulation of buffer store semi-products flows
Simulation model

The simulation model was created by EXTEND program, which is a product of Imagine That, Inc. USA. The simulation program environment EXTEND is one of the modern means of simulation where the simulation models consist of blocks, that are in the library. Their use is simple and intuitive [1, 5]. The created simulation model is shown in the Figure 2.

The inputs were defined by the "***program***" block. The leaving inputs were defined randomly, during the day by using "***input random number***" block. The input flows were combined by using "***combine***" block and then it is followed by 4 "***multiple activity***" blocks, which represents buffer store, where semi-products are located. Each “***multiple activity”*** block is a part of the buffer store corresponding of storage period (for our conditions 1, 2, 3 and 4 days). There are modules “***Plotter Discrete Event”*** in the model, which are used for graphic representation of simulation results. Description of the blocks is shown in the Table 1.

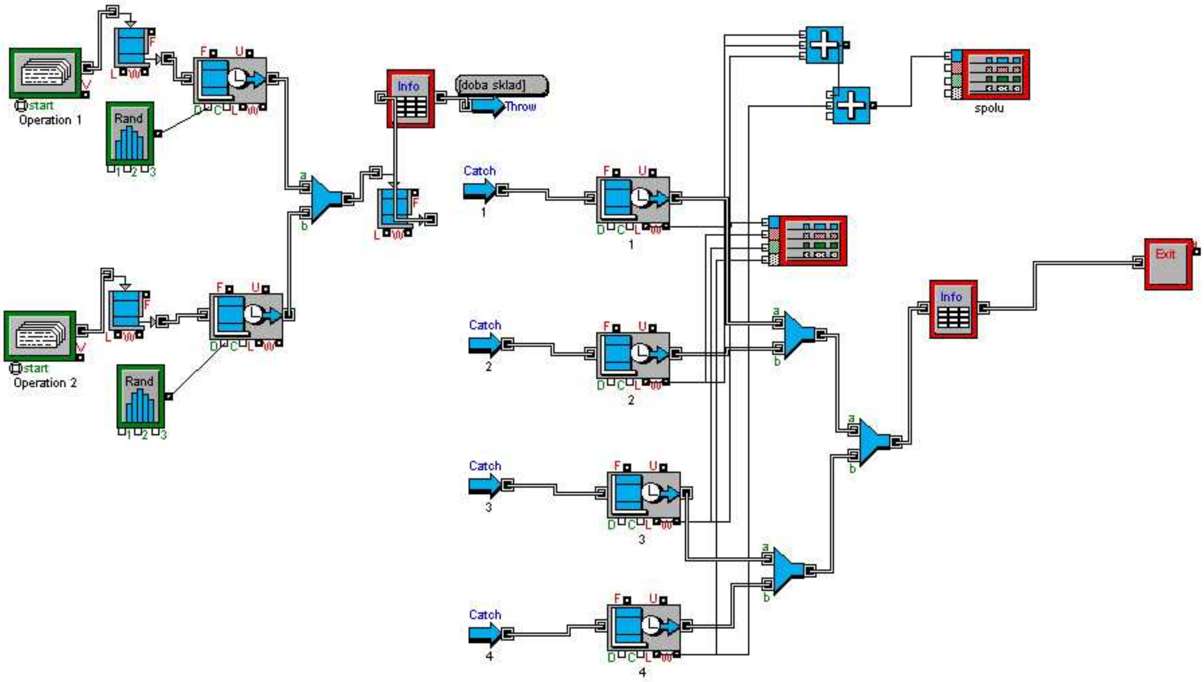
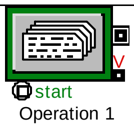
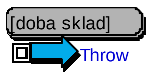
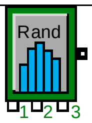
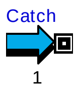
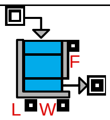
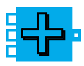
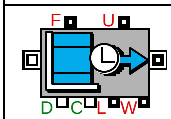
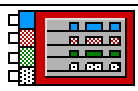
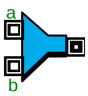
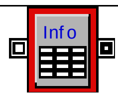


Fig. 2. The created simulation model.

Tab. 1. Blocks.

	**Program** – schedules many items on a regular basis.		**Throw** – it is instrument to move the requirements for block **Catch** without using output terminals and connecting lines.
	**Input random number** is used to generate random time of delays, it is possible to set different, random times of delays under different types of division.		**Catch** – it is used to capture the requirements from the blocks “Throw” without the use of interconnection lines based on a defined block name or attributes.
	**Queue FIFO** – the requirements wait in a queue system FIFO - First In First Out		**Add** – it summarizes the input values.
	**Activity Multiple –** this block holds the particular requirements during a defined period and it allows processing of more requests at once.		**Plotter, “Discrete Event”** – it is block that enables to depict the input values of simulation in the form of graphs and monitored values are entered in a table.
	**Combine** – this block enables to combine the entering requirements from two different sources into a single output stream, while keeping knowledge of the origin of requirements.		**Information** – it displays information about items.

The simulation results

The simulation was performed over of 30 days a period. Particular semi-products from individual operations were transferred to the buffer store they were stored there the desired time. These semi-products were removed from the buffer store after the expiration of the required time. The values, for the purpose of simulation were obtained by analysis in the selected company. The simulation results are shown graphically in the following figures (Fig. 3 to 8). Each coloured curves give the actual number of semi-products during simulated time.

There is showed the simulation of input and output of semi-products "SP 1" with 24 hours storage time in the manufacturing buffer store (blue curve) in the Fig. 3. The simulation shows that it was given 2144 of semi-products to the buffer store and 2079 were removed during the simulated time of 30 days. The daily average 72 semi-product "SP 1" were stored in buffer store. The curve indicates that semi-products "SP 1" enter to the buffer store unevenly, but its progress was dependent on received orders. The simulation of input and output of semi-product "SP 2" is shown in the Figure 4 – the red curve, semi-product "SP 3" in the Figure 5 – the green curve and semi-products "SP 4" in the Figure 6 – the yellow curve. There are obtained values from the simulation in the Table 2.

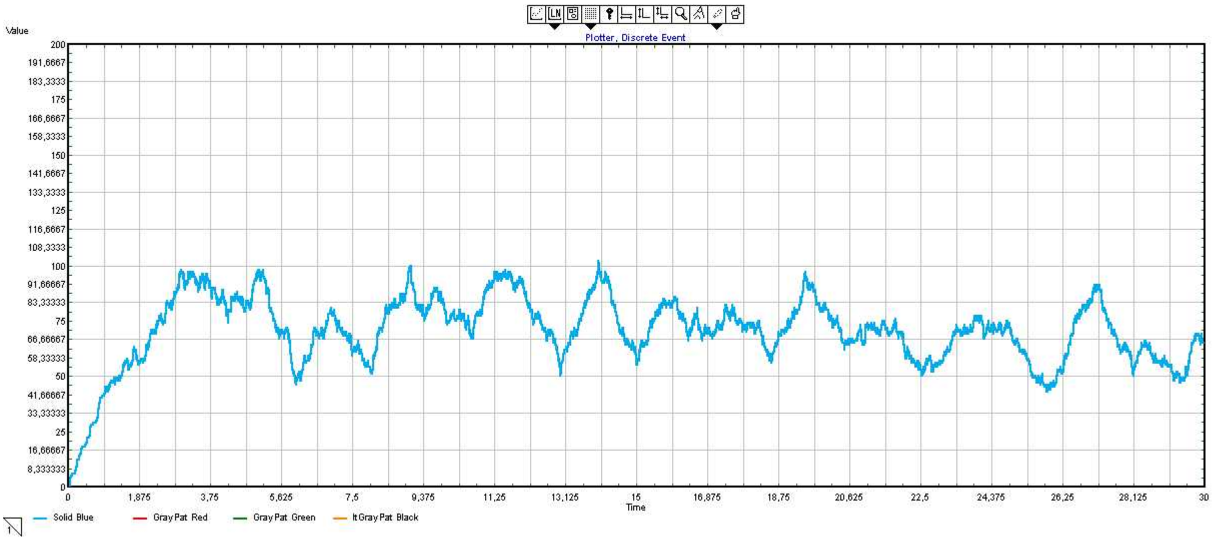


Fig. 3. Semi-products "SP 1".

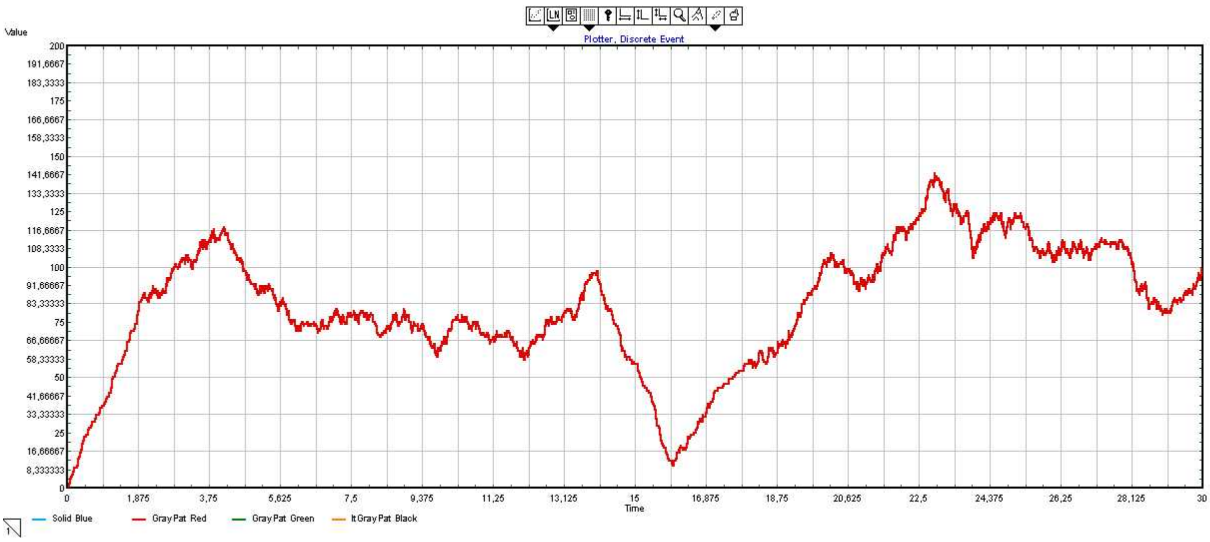


Fig. 4. Semi-products "SP 2".

Tab. 2. The results of simulation.

Semi-products	Number of inputs	Number of outputs	Daily average
SP 1	2144	2079	71
SP 2	1280	1181	82
SP 3	542	448	50
SP 4	197	191	24
Σ			227

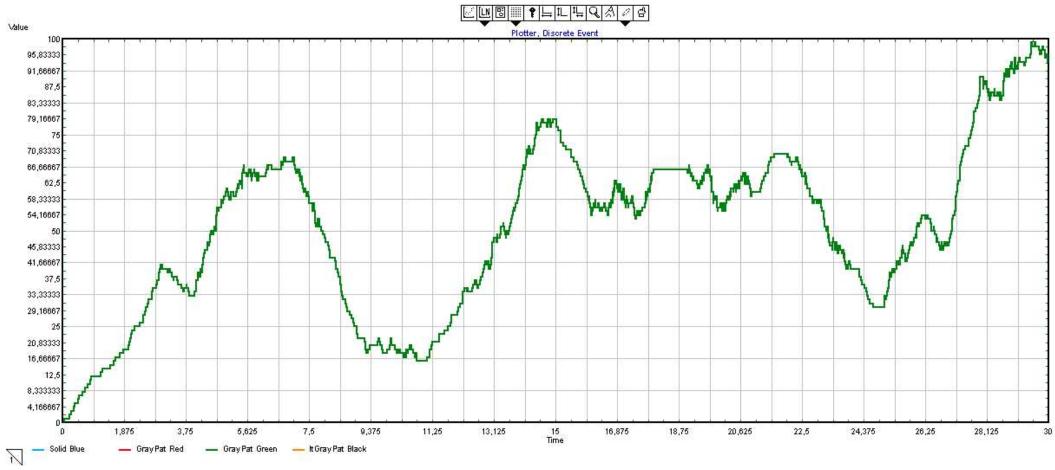


Fig. 5. Semi-products "SP 3".

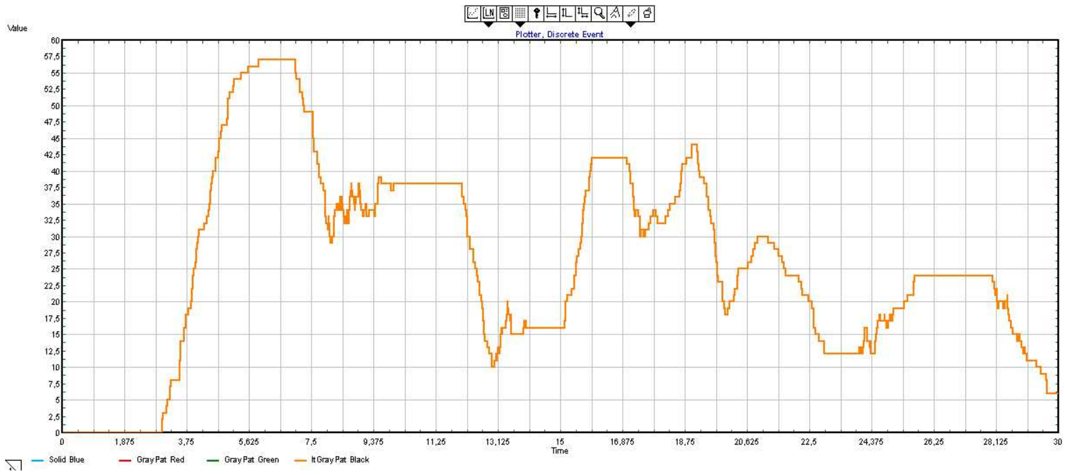


Fig. 6. Semi-products "SP 4".

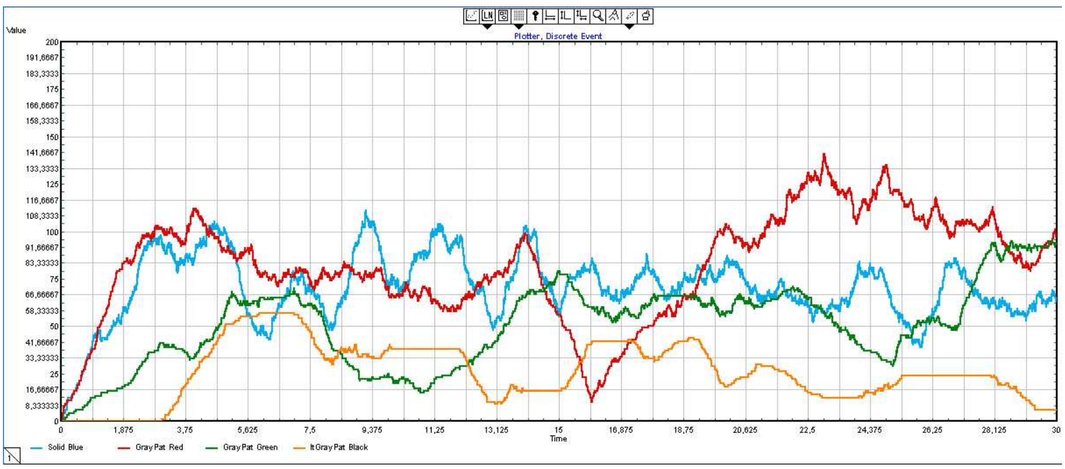


Fig. 7. Semi-products in the buffer store.

The Figure 7 shows the curves for all kinds of semi-products. The Figure 8 shows the cumulative curve of semi-products.

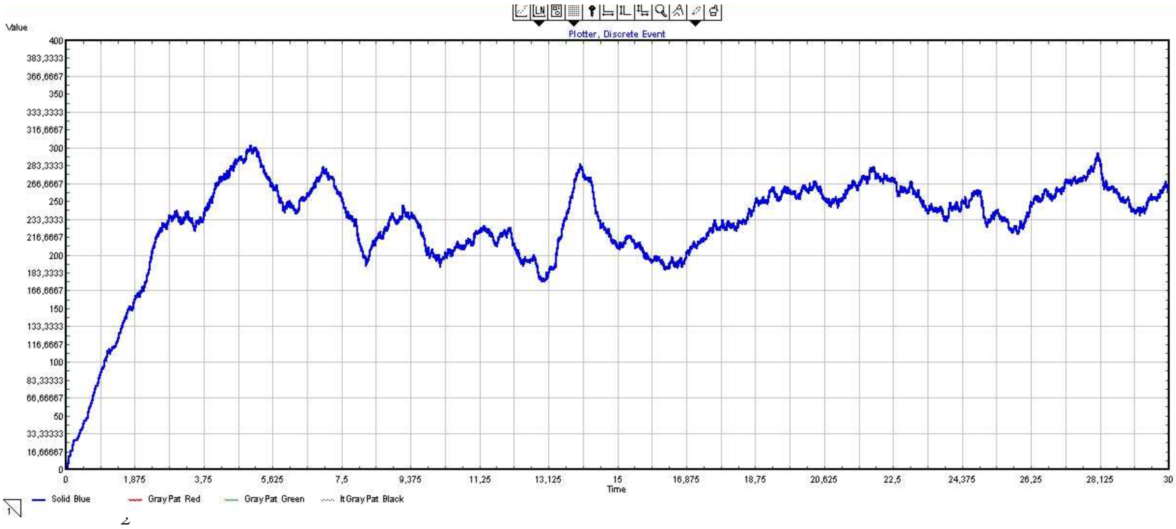


Fig. 8. The number of semi-products in the buffer store – cumulative progress.

The dark blue curve (in the Figure 8) shows the number of semi-products in the buffer store in the simulated time. As it is shown in the Figure 8, the number of semi-products is ranged from 167 to 305 units in the simulated time.

Conclusion

This paper presents the simulation model, on which it can be determined the number of semi-products stored in the manufacturing buffer store. The obtained results can be used as auxiliary information for optimizing of storage places in an existing warehouse or at a design of a new warehouse. The number of stored semi-products is necessary to transform on the storage units and to determine their number. The storage units can take different forms (loaded pallet, crate, box, etc.). Based on the number, size and weight of the storage unit it can be proposed new storage system or changes in existing storage system and also required dimensions of a warehouse. The proposed simulation model can be used as a control tool in warehousing system [4] e.g. at monitoring of the capacity and time utilization of the storage system.

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