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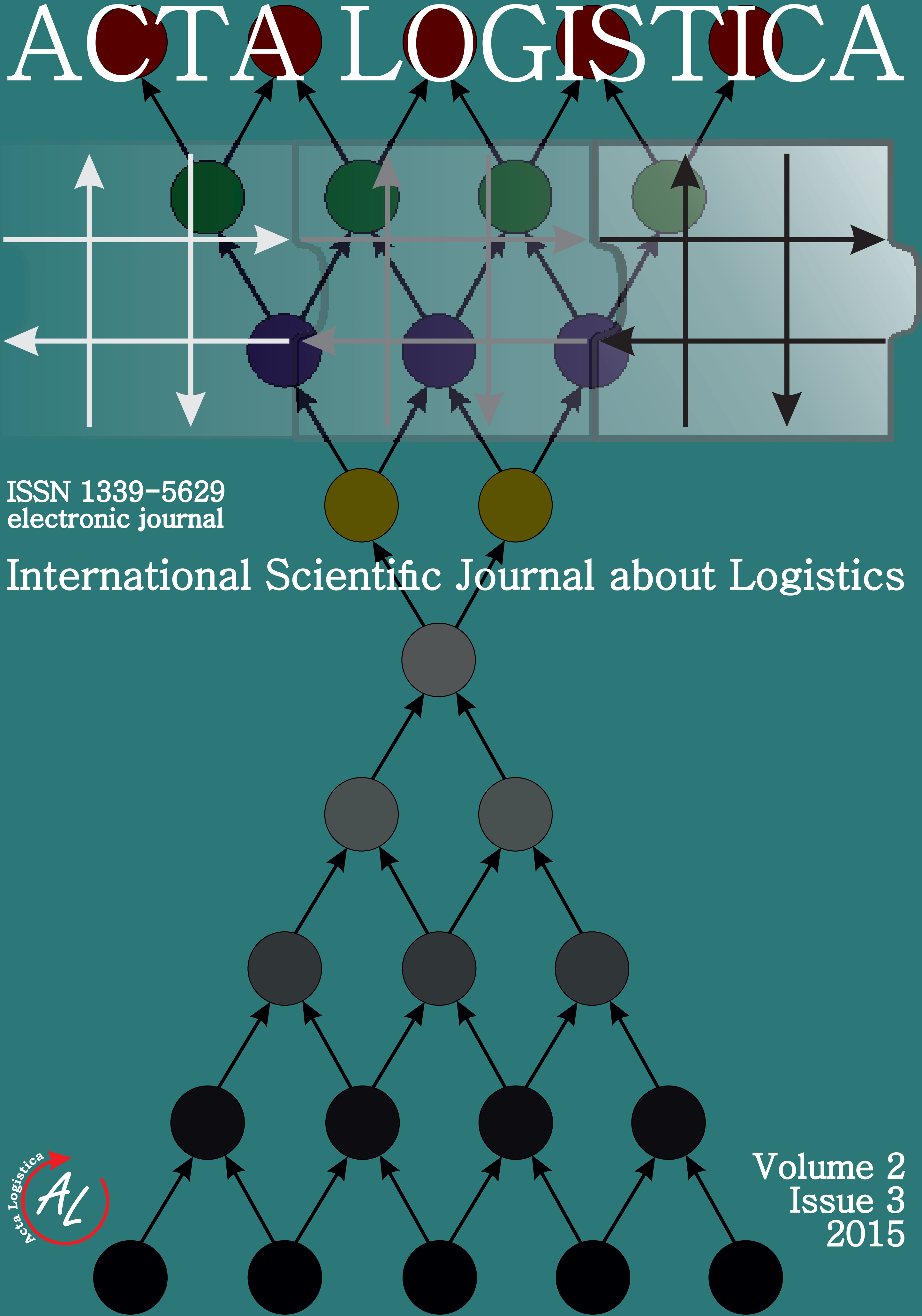

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SIMULATION AS A TOOL FOR PROCESS OPTIMIZATION OF LOGISTIC SYSTEMS

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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).

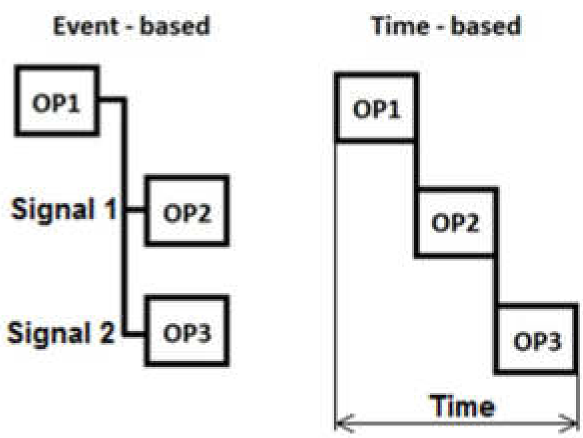

Figure 1 Event - time based simulation

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.

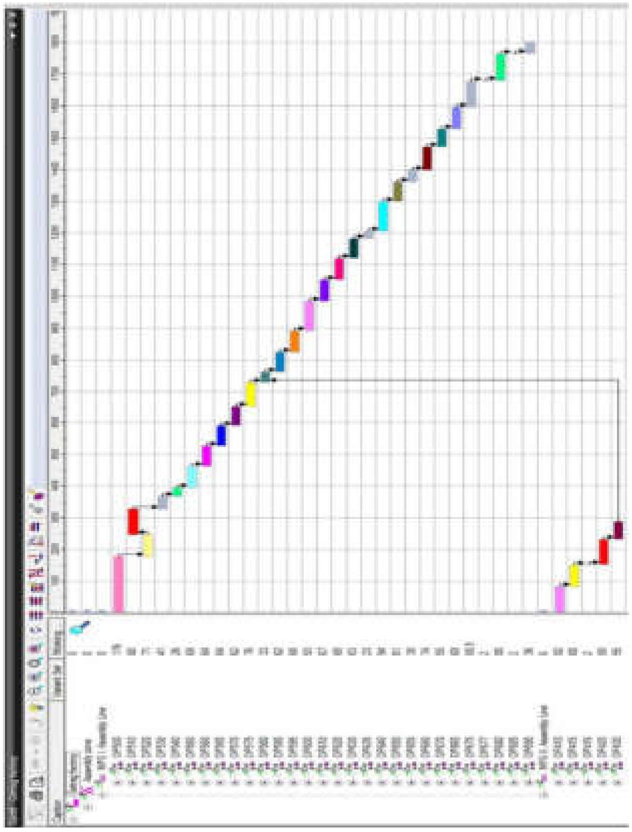

Figure 2 Gantt chart

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.

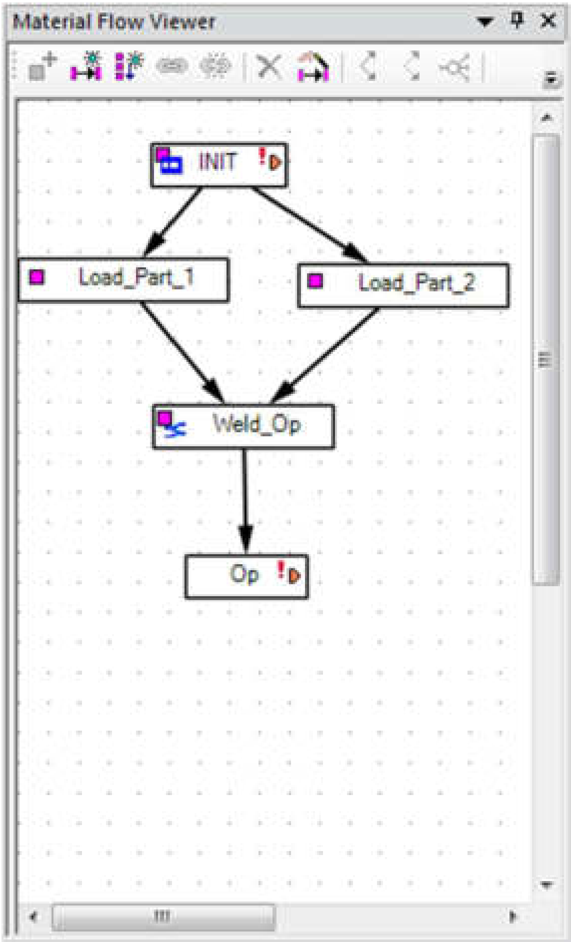

Figure 3 Material flow

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.

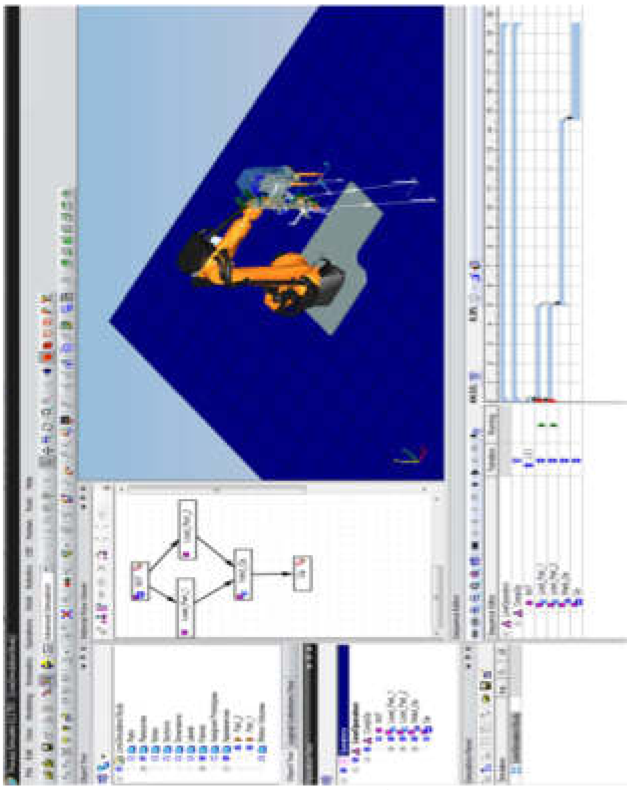

Figure 4 CEE Simulation

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.

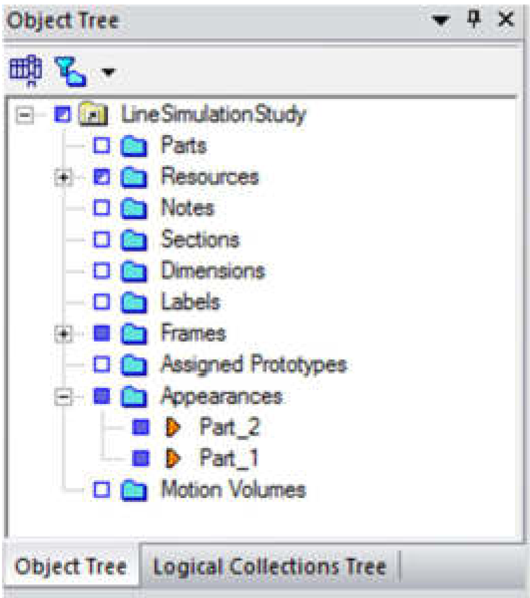

Figure 5Part appearance

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

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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

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THE ANALYSIS OF THE COMMODITY PRICE FORECASTING SUCCESS CONSIDERING DIFFERENT LENGTHS OF THE INITIAL CONDITION DRIFT

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Keywords: exponential approximation, numerical modelling, price forecasting, commodity exchange
Abstract: In the paper the numerical model based on the exponential approximation of commodity stock exchanges was derived. The price prognoses of aluminium on the London Metal Exchange were determined as numerical solution of the Cauchy initial problem for the 1st order ordinary differential equation. To make the numerical model more accurate the idea of the modification of the initial condition value by the stock exchange was realized. By having analyzed the forecasting success of the chosen initial condition drift types, the initial condition drift providing the most accurate prognoses for the commodity price movements was determined. The suggested modification of the original model made the commodity price prognoses more accurate.

1 Introduction

Observing trends and forecasting movements of metal prices is still a current problem. There are a lot of approaches to forecasting price movements. Some of them are based on mathematical models. Forecasting prices on commodity exchanges often uses the statistical methods that need to process a large number of historical market data [6]. The quantity of needed market data can sometimes be a disadvantage. In such cases, other mathematical methods are required.

In our prognostic model numerical methods were used. Their advantage is that, in comparison with statistical models, many fewer market data are needed. Our numerical model for forecasting prices is based on the numerical solution of the Cauchy initial problem for the 1st order ordinary differential equations [1-4].

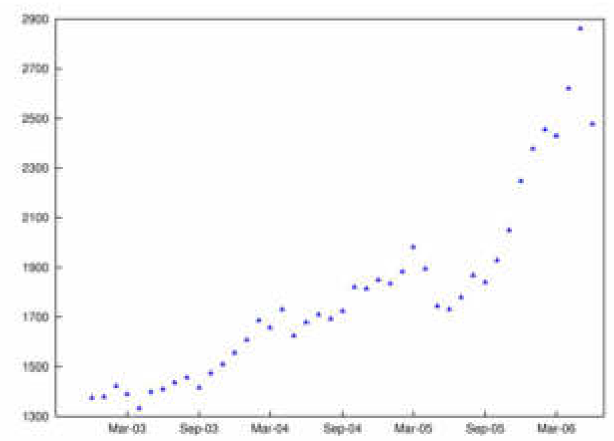

Figure 1 Course of aluminium prices on LME in the years 2003 – 2006

The aluminium prices presented on the London Metal Exchange (LME) were worked on. We dealt with the monthly averages of the daily closing aluminium prices "Cash Seller&Settlement price" in the period from December 2002 to June 2006. The market data were obtained from the official web page of the London Metal Exchange [7]. The course of the aluminium prices on LME (in US dollars per tonne) within the observing period is presented in Figure 1.

2 Mathematical model

We considered the Cauchy initial problem in the form

$$y' = a_1 y, \quad y(x_0) = y_0 \tag{1}$$

The particular solution of the problem (1) is in the form $y = k\, e^{a_1 x}$, where $k = y_0 e^{-a_1 x_0}$. The considered exponential trend was chosen according to the test criterion of the time series' trend suitability. The values $\ln(Y_{i+1}) - \ln(Y_i)$, for $i = 0,1,\dots,42$ have approximately constant course, where Y_i is the aluminium price (stock exchange) on LME in the month x_i. The price prognoses were created by the following steps:

The 1st step: Approximation of the values – the values of the approximation term were approximated by the least squares method. The exponential function in the form $\tilde{y} = a_0 e^{a_1 x}$ was used. When observing the influence of the approximation term length on the prognoses accuracy, we found out that the prognoses obtained by longer approximation terms were more accurate [1], [3]. Let us consider two different variants.

Variant B: The values from the period January 2003 – June 2003 were approximated. The next approximation terms were created by sequential extension of this period by 3 months. Thus the duration of the approximation

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terms was extended (the n^{th} approximation term has $6+3(n-1)$ stock exchanges) (Figure 2).

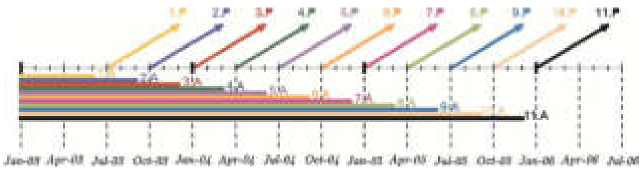

Figure 2 Variant B
(A – approximation term, P – forecasting term)

Variant E: We approximated values within 12 months and each term was shifted by 1 month (Figure 3). (The first approximation term was January 2003 - December 2003.)

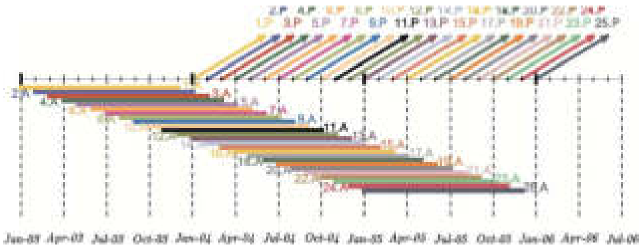

Figure 3 Variant E
(A – approximation term, P – forecasting term)

36 forecasting terms of the original model in both variants B and E within period from July 2003 to June 2006 were observed. From among all forecasting terms, 11 of them belonged to variant B and 25 ones were part of variant E, whereby 9 forecasting terms were common for both variants.

The 2nd step: Formulating the Cauchy initial problem – according to the acquired approximation function $\tilde{y}$, the Cauchy initial problem (1) was written in the form

$$y' = a_1 y, \quad y(x_i) = Y_i \tag{2}$$

where $x_i = i$ and Y_i is the aluminium price on LME in the month x_i, which is the last month of the approximation term.

The 3rd step: Computing the prognoses – the formulated Cauchy initial problem (2) was solved by the numerical method based on the exponential approximation of the solution. A detailed solution method is seen in [5]. The method uses the following numerical formulae (3.1), (3.2):

$$x_{i+1} = x_i + h \tag{3.1}$$

$$y_{i+1} = y_i + bh + Qe^{vx_i}\left(e^{vh} - 1\right) \tag{3.2}$$

for $i = 1, 2, 3, \ldots$, where $h = x_{i+1} - x_i$ is the constant size step.

The unknown coefficients are calculated by means of these formulae (4.1), (4.2):

$$v = \frac{f''(x_i, y_i)}{f'(x_i, y_i)}, \quad Q = \frac{f'(x_i, y_i) - f''(x_i, y_i)}{(1-v)\, v^2 e^{vx_i}} \tag{4.1}$$

$$b = f(x_i, y_i) - \frac{f'(x_i, y_i)}{v} \tag{4.2}$$

If we consider the Cauchy initial problem (2), the function $f(x_i, y_i)$ has the form $f(x_i, y_i) = a_1 y_i$ and then $f'(x_i, y_i) = a_1 y'(x_i) = a_1^{\,2} y_i$, $f''(x_i, y_i) = = a_1^{\,2} y'(x_i) = a_1^{\,3} y_i$.

We calculated the prognoses within six months that follow the end of the approximation term in this way:

- **The first month prognosis was** determined by solving the Cauchy initial problem in the form (2). The interval $\langle x_i, x_{i+1} \rangle$ of the length $h = 1$ month was divided into n parts, where n is the number of trading days on LME in the month x_{i+1}. We got the sequence of the division points $x_{i0} = x_i$, $x_{ij} = x_i + \frac{h}{n} j$, for $j = 1, 2, \ldots, n$, where $x_{in} = x_{i+1}$. For each point of the subdivision of the interval, the Cauchy initial problem in the form (2) was solved by the chosen numerical method. In this way we obtained the prognoses of the aluminium prices on single trading days y_{ij}. By calculating the arithmetic mean of the daily prognoses we obtained the monthly prognosis of the aluminium price in the month x_{i+1}.

  So, $y_{i+1} = \frac{\sum_{j=1}^{n} y_{ij}}{n}$.
- **The prognoses for the following months** were calculated after modification of the initial condition value. The initial condition value in the month x_{i+s}, $s = 1, 2, 3, 4, 5$ was replaced either by the calculated monthly prognosis y_{i+s} or by some aluminium stock exchange (in case of higher absolute percentage error of given monthly prognosis y_{i+s}). The Cauchy initial problem $y' = a_1 y$, $y(x_{i+s}) = y_{i+s}$, respectively $y' = a_1 y$, $y(x_{i+s}) = Y_p$ (where Y_p is chosen aluminium stock exchange) was used for calculating daily prognoses and their arithmetic mean served to define the monthly price prognosis y_{i+s+1} for the month x_{i+s+1}.

By comparing the calculated prognosis y_s in the month x_s with the real stock exchange Y_s, the absolute percentage error $|p_s| = \frac{|y_s - Y_s|}{Y_s}.100\,\%$ is determined. The price prognosis y_s in the month x_s is acceptable in practice, if $|p_s| < 10\,\%$. Otherwise, it is called the critical forecasting value of. To compare the accuracy of forecasting of all forecasting terms, the mean absolute percentage error (MAPE) $\overline{p} = \frac{\sum_{s=1}^{t} |p_s|}{t}$ is determined, where, in our case, $t = 6$.

The modification of the initial condition value by the real aluminium stock exchange price was called the initial condition drift. Let us name the selected minimal absolute percentage error of the prognosis, causing the initial condition drift, the limiting value error. The month in which the absolute percentage error of the prognosis has at least the limiting value error was considered as the limiting month.

The limiting value error of the size 7 % was chosen. Three types of the initial condition drift with regard to their length were considered, namely one-month drift, drift before the limiting month and drift to the limiting month. One-month drift was the shortest chosen initial condition drift, where the initial condition value was replaced by the stock exchange Y_{i+p}, $p = 1, 2, 3, 4, 5$ in the month x_{i+p}, where x_i was the last month of the approximation term and p was the initial condition drift order in the forecasting term. Using drift before the limiting month, the initial condition value was replaced by the stock exchange Y_{L-1} in the month x_{L-1}, where x_L was the limiting month and by means of drift to the limiting month the stock exchange Y_L in the month x_L changed the initial condition value.

3 Results

3.1 The success of the initial condition drifts with different lengths at commodity price forecasting

We started from the original model calculating the prognoses within six months following the approximation term after modification of the initial condition value by the obtained monthly price prognoses [2], [3], [4]. The original model forecasted the aluminium price reliably (the absolute percentage errors were less than 10 %) within the stable price course, when the price did not changed rapidly. Within the rapid increase or decrease of stock exchanges, but also in the case of changes in the price course the forecasting failed. Since the variability with rapid and sudden changes is typical of the commodity price course, we judged the possibility of making the forecasting more accurate by using the modification of the initial condition value by aluminium price.

Within the studied group of 36 forecasting terms, the forecasting within 14 of them was so accurate that the initial condition drift did not occur. The initial condition values were replaced just by calculated monthly prognoses. Since in the remaining 22 forecasting terms the forecasting was less accurate, some of the prognoses gained the absolute percentage error higher than chosen limiting value error, and the initial condition drift occurred. Therefore the forecasting results differ from the original model.

Within each forecasting term for the variants B and E, three different lengths of the initial condition drift were taken into account. For each forecasting term, in which the initial condition drift was occurred, we defined the type of the drift's length to obtain the most accurate forecasting results. (The lowest MAPE of the forecasting term was gained.) The following table shows the number of the forecasting terms in which the forecasting by the determined types of the initial condition drift was the most accurate.

Table 1 The comparison of the success rate of the chosen types of the initial condition drift

Variant	The initial condition drift did not occur	The type of drift		
		One-month drift	Drift before the limiting month	Drift to the limiting month
B	4	1	1	5
E	10	3	1	13
Total	14	4	2	18

With regard to the initial condition drift length, the most accurate forecasting results were obtained in both variants B and E by using drift to the limiting month, in other words, the longest initial condition drift. This type of drift had the lowest MAPE in eighteen forecasting terms. In two of them we obtained the same results by using one-month drift (the initial condition drifts were the same). Shorter initial condition drifts were far less successful. One-month drift was the most advantageous for four forecasting terms, two of them were already mentioned in the previous drift type. Drift before the limiting month was the most accurate only in two forecasting terms. The success rate of the determined types of the initial condition drift was analyzed within different moves of the aluminium price course and was demonstrated at the specific forecasting terms while considering commodity price evolution.

3.2 The forecasting success of the longest initial condition drift

The longest initial condition drift was the most advantageous. It acquired the most accurate results within most price movements. We recommend to use it, especially within the steep stable price course, and also when the price evolution changes significantly.

- **stable price increase**

Within the steep stable price course, the increase rate of the forecast stock exchanges was higher, in comparison with the increase rate of the stock exchanges during the approximation term. Therefore the stock exchanges increased faster than the calculated prognoses. Thus the prognoses at the end of the forecasting term contained the absolute percentage errors which caused the initial condition drift. When the price evolution in the forecasting term was stable, the longest initial condition drift was the most advantageous and the nearest to the stock exchanges.

In the forecasting term *October 2003 – March 2004* (Figure 4), the initial condition drift was caused by the prognosis in the third month of the term (December 2003, the percentage prognosis error was -8,24 %). In the next calculated prognoses after drift to the limiting month, the absolute percentage error was lower than 10 %, and all critical forecasting values were eliminated. By means of drift to the limiting month, the mean absolute percentage error of the forecasting term decreased from 9,44 % to 4,98 %.

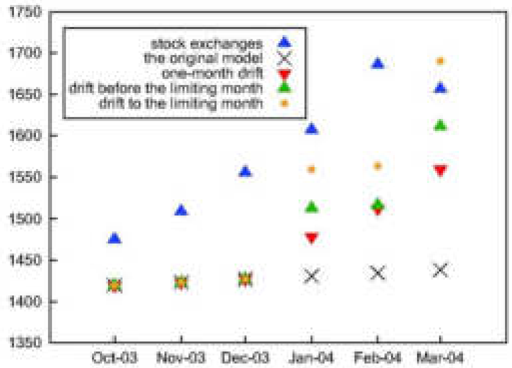

Figure 4 Forecasting success of drift to the limiting month within October 2003 – March 2004 (variant B)

- **steep price decline after price increase**

There was steep price decrease from April 2005 to June 2005. Within this period, the price decrease was significant compared to the previous increase. The stock exchanges in approximation terms were increasing, the approximation functions had also an increasing course, and the prognoses calculated by the original model were increasing too, so they were not sufficient to accommodate to a steep decline of the stock exchanges. The longer was the decline period, the higher was the absolute percentage error of the prognosis. Drift to the limiting month was the most successful within all forecasting terms with the price decline.

The forecasting term A*pril 2005 – September 2005* (Figure 5) was an example of the period when the original forecasting failed. Although the stock exchange decline occurred in April 2005, the highest decline was seen in May 2005. The prognosis absolute percentage error in this month exceeded the limiting value error 7 %, which caused the initial condition drift. At the longest drift, the initial condition value approached the prices in decline. Thus, unlike at shorter drifts, the critical value in June 2005 was eliminated. Since the stock exchanges in the next period increased, the forecasting by drift to the limiting month remained successful and no further corrections were needed. The absolute percentage error of the prognosis in May 2005 was at least 10 %, and within the forecasting term just one critical value occurred. After having used the longest initial condition drift, the remaining four critical values were eliminated, and a significant improvement of the forecasting was obtained. The mean absolute percentage error of the forecasting term decreased from 12,55 % to 4,96 % (variant B) and from 12,63 % to 4,94 % (variant E).

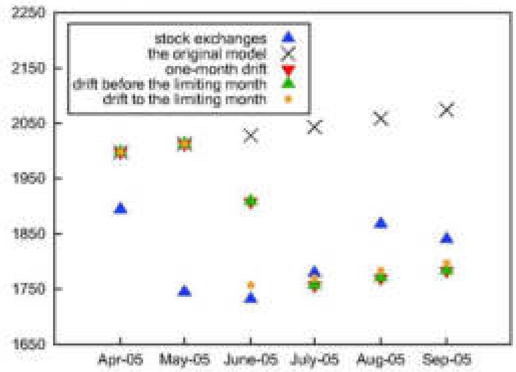

Figure 5 Forecasting success of drift to the limiting month within April 2005 – September 2005 (variant E)

- **price increase after price decline**

The end of the year 2005 and the first half of the year 2006 appeared as the most problematic. The problems in forecasting were caused by the steep increase of the stock exchanges after their important decline. The approximation terms with the price decline belonged to the mentioned forecasting terms. The higher was the number of the decline prices in approximation term, the slower was increase of the approximation function. Its course could be even decreasing. As these approximation functions served for the price prognoses within the rapid increase periods, the original forecasting being highly inaccurate. Slower increasing prognoses obtained lower values than quicker increasing stock exchanges; this is why the forecasting accuracy was decreasing with time (critical values applied to the months at the end of the forecasting terms). The forecasting was the most accurate when using the longest drift. By applying it, we put prognoses the nearest to the steep increasing stock exchanges.

Within the forecasting term *September 2005 – February 2006* (Figure 6), the initial condition drift occurred in the month with a steeper increase of the stock

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exchange (November 2005). Thanks to a moderate increase, the prognosis absolute percentage error in the limiting month was lower than 10 %. By using drift to the limiting month, the increase was captured and the prognoses for the following months were more accurate. Thus in the next steep increase period, by repeating the longest initial condition drift, the absolute percentage errors of the prognoses were lower than 10 %. MAPE decline in the forecasting term moved from 12,55 % to 6 %. Using the drift to the limiting month, all three critical values of the original model were eliminated.

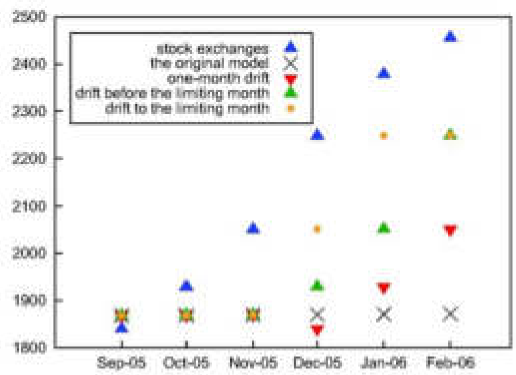

Figure 6 Forecasting success of drift to the limiting month within September 2005 – February 2006 (variant E)

3.3 The forecasting success of shorter initial condition drifts

If within a forecasting term, a more significant price fluctuation appeared, the most accurate was the drift that allowed placing the initial condition value the nearest to the real stock exchanges evolution. Thus, at the fluctuating stock exchanges, shorter drifts were more advantageous, namely one-month drift and drift before the limiting month. Using the longest drift the initial condition value was often replaced by the local maximal or minimal values that had caused the initial condition drift, which was not advantageous for forecasting following unstable price course.

The advantage of one-month drift was seen at the steep fluctuating increase with the significant price decline in the last month within the forecasting term *January 2006 – June 2006* (Figure 7). The first initial condition drift caused by the prognosis in the second month of the term (February 2006, the prognoses with the percentage error -7,35 % (variant B) or -7,49 % (variant E) were obtained). Therefore the absolute percentage error of the prognosis in the fourth month of the term was reduced to under 10 % (the original prognoses in April 2006 had the percentage error -12,18 % (variant B) and -12,43 % (variant E)). Using shorter drifts, the absolute percentage error of the prognosis in the fourth month was higher (at least 8 %), which caused the next initial condition drift, unlike at the longest initial condition drift. While the first initial condition drift was identical for both shorter drifts, the second drift allowed to obtain different initial condition values. The initial condition value for forecasting the price in the fifth month had the value of the stock exchange either in February 2006 (one-month drift) or in March 2006 (drift before the limiting month). But the stock exchange in March 2006 decreased, which was disadvantageous for forecasting steeply increased stock exchange in the fifth month, May 2006. This steep increase resulted in getting the critical value for all chosen drifts. Its following drift made the forecasting using one-month drift more accurate again. The price decline in the third month of the forecasting term (March 2006), which was the one-month drift initial condition value, was suitable for forecasting the price in the last month of the forecasting term, where the significant decline was observed. Conversely, the initial condition value using the drifts before the limiting month and to the limiting month was determined by significantly higher stock exchanges, which were not suitable for forecasting the price in decline. MAPE of the observed period decreased by the most advantageous one-month drift from 9,20 % to 6,17 % (variant B) and from 9,43 % to 6,26 % (variant E). The number of the critical values in both variants was reduced from two in the original model to one critical value.

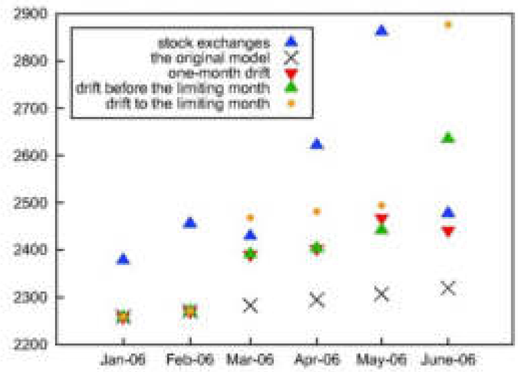

Figure 7 Forecasting success of one-month drift within January 2006 – June 2006 (variant E)

Drift before the limiting month was the most successful only in one forecasting term, *January 2004 – June 2004* (Figure 8). Within this term both observed variants B and E obtained the same results for all determined lengths of the initial condition drift because of the same approximation term in both variants. The period was characterized by moderate fluctuating increase. Within the period, the increase rate of the forecast stock exchanges was higher than the increase rate of the stock exchanges in the approximation term. Therefore the stock exchanges increased faster than calculated prognoses. The initial condition drift was caused by the prognosis in the month with local maximal aluminium price (the fourth month, April 2004, the percentage prognosis error was

-8,30 %). Since in the following months, the price increase did not continue, to the contrary the stock exchanges decreased, the initial condition drift to appropriate values was the most suitable. In this case it was the drift before the limiting month, because the stock exchange in the third month of the forecasting term, March 2004, was the closest to the stock exchanges at the end of the forecasting term. MAPE of the forecasting term was improved from 4,81 % to 4,23 %. As a result of a moderate increase, the critical value did not occur within the forecasting term.

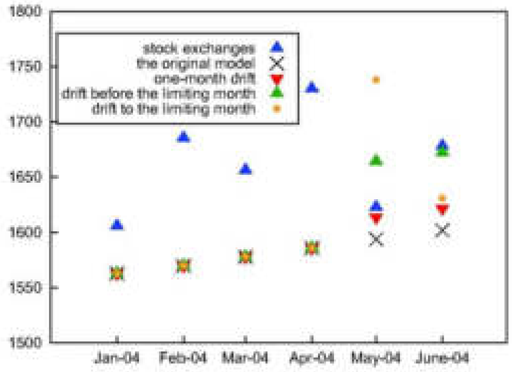

Figure 8 Forecasting success of drift before the limiting month within January 2004 – June 2004 (varianty B and E)

Conclusions

By having analyzed the forecasting success rate of the commodity price by means of initial condition drifts with different lengths, it was found out that the most accurate prognoses were the most often acquired when using the longest initial condition drift, drift to the limiting month. We recommend to use this initial condition drift type, especially at stable increase, or decrease and during larger changes in price evolution.

Within moderate price increase or decrease, the original forecasting was mostly so accurate (the absolute percentage prognosis errors were lower than 7 %), that the initial condition drift did not occur. When within the observed period the price fluctuations appeared, the longest drift was not always the most accurate. The drift replacing the initial condition value by the stock exchange the nearest to the next price course was the most accurate. For this reason, within significant price fluctuations we recommend to use shorter initial condition drifts where the initial condition value did not acquire local maximal or minimal values.

By the most appropriate types of the initial condition drift the original forecasting was significantly improved and the strategy of initial condition drift contributes to prognoses accuracy.

Acknowledgement
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References

[1] LASCSÁKOVÁ, M.: Contribution about the influence of the approximation period on the accuracy of aluminium prices forecasting on the London Metal Exchange, Acta Montanistica Slovaca, Vol. 12, No. 4, p. 298-303, 2007. (Original in Slovak)
[2] LASCSÁKOVÁ, M.: Numerical models of forecasting prices on the commodity exchanges, Transfer inovácií, No. 16, p. 216-220, 2010. (Original in Slovak)
[3] LASCSÁKOVÁ, M.: The study of numerical models' properties with the aim of improving accuracy of forecasts of commodity prices, Manufacturing and Industrial Engineering, Vol. 11, No. 1, p. 34-37, 2012.
[4] LASCSÁKOVÁ, M.: The influence of using the different forecasting types to the accuracy of the forecasted prices of the commodity, Transport & Logistics, Vol. 12, No. 23, p. 1-8, 2012.
[5] PENJAK, V., LASCSÁKOVÁ, M.: Solution of the Cauchy problem for the ordinary differential equation $y'=f(x,y)$ by means of the exponential approximation, Studies of University in Žilina, Vol. 1, p. 163-166, 2001.
[6] VARGA, M.: Forecasting commodity prices with exponential smoothing, Ekonomie a Management, Vol. 11, No. 3, p. 94-97, 2008.
[7] http://www.lme.com/home.asp.

Review process
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VALUE STREAM MAPPING AND ITS SIGNIFICANCE IN THE PRODUCTION PROCESS

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Keywords: value stream mapping, value added, value flow
Abstract: Monitoring of flows (material, information, personal, energy, financial, etc.) in the production process is always inevitable approach while searching for improvements. There are, radical improvements known as innovations, and continuous improvement established by KAIZEN principles and its useful methods. Both approaches focus on processes that add value, and minimise or eliminate those without added value. The main target of this paper is to analyse the Value stream mapping approach and its benefit to the practical world.

1 Process Improvement

1.1 Methods for Improvement

The border between process innovation and improvement of processes has been clearly established. Innovation creates in the process higher radical change leap. Improvement can be understood as continuous daily activities of people involved in a process that aims to increase the efficiency of the process itself (reducing wastes, costs, downtime, increasing performance and quality). Elementary differences between innovation and improvement of processes can be found in Table 1. When improving the entire process chain as a comprehensive system of processes it is *Value Stream Mapping*.

1.2 Value Stream Mapping

Being capable to apply the principles of Lean techniques and due to method VSM (Value Stream Mapping) find and configure a bottleneck, so that raised the level of effective production and associated revenue-generating, it is necessary to collect the data. Having a data offers the opportunity to understand the observed phenomenon. Therefore, define what the value stream mapping method is focused on, detail value streams what essentially it entails and comprise of values.

Value stream, flow values or entities is a comprehensive package of activities that are in the process of transformation of materials into products, and thus causes the final value for the customer. However, it includes activities that add and not add value to the final product. Flow values can also refer to the total events around the product in real time, which provides transformation of a product from idea to introduction on the market.

Table 1 Elementary differences between innovation and improvement of processes

Field	Improvement	Innovation
Benefits	Thousands – ten thousands euro	Hundreds thousand euro and more
Organization	individual, workshop, cascade workshop, SixSigma projects	innovation project
Employees involvement	maximal – people from process	limited - specialists
Impact area	local issue	Sectional issue
Time	short (days, weeks)	long (months)
Methods	intuitive (brainstorming, workshop)	systematic (WOIS, TRIZ)
Results measurement	Team productivity, savings, cost reduction	Team creativity, new value, originality, difference
Environment	improved process, use of local knowledge	Detachment from current stave, use of global knowledge

The product, during its life cycle, follows the journey two main streams [1]:

- The flow of design from the “drawing table” to the start of production
- production flow from raw materials to delivering the product to customers.

When using the method of VSM, generally in most cases the primary material (transition) flow is being monitored, which has the majority part regarding the

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transformation of the material into the final product. Equal importance due to mapping posses the flows that accompany the material flow and are of necessary support, respectively which finally form the flow - information, personnel, waste, energy and others.

Material flow according to source [2] can be defined as that the material flow is defined as an organized movement of material (raw material, work in progress, finished goods, scrap) in the production or circulation, expressed by:

- frequency - number of shipments per unit time (valid for discrete ways of handling)
- intensity - the amount transported per unit of time,
- length - the distance that the material must pass from the source to the end points,
- power - the product of the intensity and length of material flow,
- direction – the difinition of placement from - to,
- handling factor - number of realized handling operations.

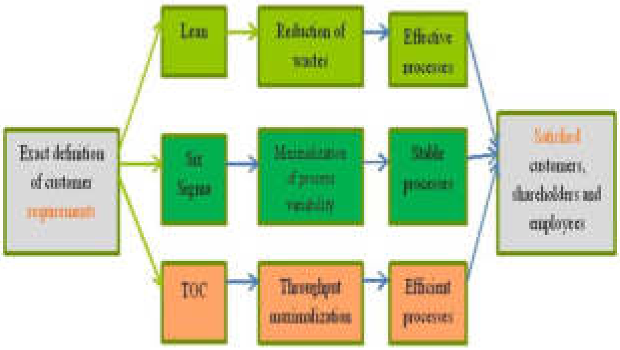

Figure 1 Common principles of Lean, Six Sigma and TOC

Material flow is influenced by several factors:

- volume and the range, nature and type of production,
- level of technological complexity and segmentation processes and assemblies, groups,
- number of operations of individual parts and workplaces,
- shape, segmentation of the space,
- operational method, and the inter-departmental transport,
- location of auxiliary and ancillary operations and services (expenditure tools, maintenance office),
- location of cooperating and outsourcing production departments, sections, units, etc.

Straightforward and simple course is dependent on optimal spatial distribution of the company (production and storage buildings) as well as series of separate operations and appropriate organization of production [2].

The principles of effective organization of material flows and creation of productive disposition are, as follows: [3]

- minimization of performances, minimizing shipping costs - handling and transport operations do not add product value.
- minimizing space - depending on the location of workplaces, balancing capacity,
- provision of safety and hygiene requirements,
- flexibility and freedom of future changes,
- suitability for teamwork,
- minimizing inventory and intermediate times,
- simple material flow - clear, without unnecessary crossings.
- connection to external logistics chain.

In recent years, many enterprises implement effective management concepts. The closest connection with the one of those concepts for the Lean Enterprise are (Figure 1):

- Six Sigma
- Lean
- Theory of Constraints (TOC).

Lean, Six Sigma and TOC are looking at the business through the eyes of the customer and try at minimum cost to meet customers' requirements. *TOC* focuses on the systematic search of bottlenecks in the enterprise, maximizing flow, minimize inventory and operating costs. *TOC* provides a very effective tool for managing bottlenecks in production, distribution and project - DBR (Drum Buffer Rope theory) and Critical Chain. DBR can be considered as an alternative to Kanban system with a focus on bottlenecks.

Six Sigma seeks to systematically reduce process variability and increasing their utilization. This is not about the dispersion due to the quality, but the stabilization time, and other parameters necessary for the synchronization of processes in the Lean Enterprise. Six Sigma and TOC provides a sophisticated system for managing changes.

Value Stream Mapping (VSM) is a useful tool for the transfer of an ordinary enterprise to a Lean Enterprise. Broadly, there are two ways to generate (higher) earnings (Figure 2), their principles are as follows:

I. The conventional way – enterprise needs more revenue, thus increases sales price, without trying to reduce costs. A reaction to the price increase, however, is usually a drop in sales.

II. Slim operates - to increase the difference between the cost and the revenues could help enterprise to reduce costs, elimination of waste, extending the bottleneck, respectively its effective use.

Lean thinking is aimed at removing all activities that do not add customer value (defined by the customer). When applied to Lean Manufacturing practices, companies have to adhere to some basic principles of Lean Manufacturing [4], [7], [10].

Value flow, and the flow of entities, comprises of all the processes (increasing or not increasing the values), which is on the way from the material to the finished product. Flow entity management is an essential tool for the analysis of waste in processes in manufacturing, logistics, development and administration. It allows planning the changes in the flow of the objectives for modeling the current and future values and state. It is therefore a tool for analyzing processes and improving their communication [5], [8], [11].

The significance of value flow management embodies:

- Graphical representation of the current value stream - value stream map,
- Define new, efficient flow of entities to the customer and its continuous improvement,
- Making steps that change process from the current to the new state.

The potential scale and complexity of mapping allows various applications: the production with high repeatability and uniformity, the mapping of processes in production, during operations, processes between enterprises and logistics during the administrative and development processes. However, it is inappropriate for custom production, where cycle times are too long.

Benefits according to [6], [9] achieved by application of the method: Reduction of production lead times of 20 to 50% in a few days, reduction in the area (operation space), better understanding of the process course and the links between them - the "big picture", simplifying management system, reduction batches and process synchronization, elimination of waste from the process.

Figure 2 Principles for generating higher earnings

1.2.1 VAI - value added index

Index value added output as Value Stream Mapping is the proportion of times that add and not add value to products produced in the analyzed company. Index is visual and numerical confirmation of assumptions where is the bottleneck of the company. When looking for bottlenecks and VSM operations, *time* (time traces of cycle times) represent key information. The necessary time values are not acquired from the official figures, reported as performance parameters of the machine, but from the actual measurement times measured in production. Particularly at the production plant, which is semi-automated - part of the work is performed by workers and one part by the machinery. A large part of production is carried out in the analyzed company mutually as a man – machine interfaction. Measured times are listed and written in pencil on a paper.

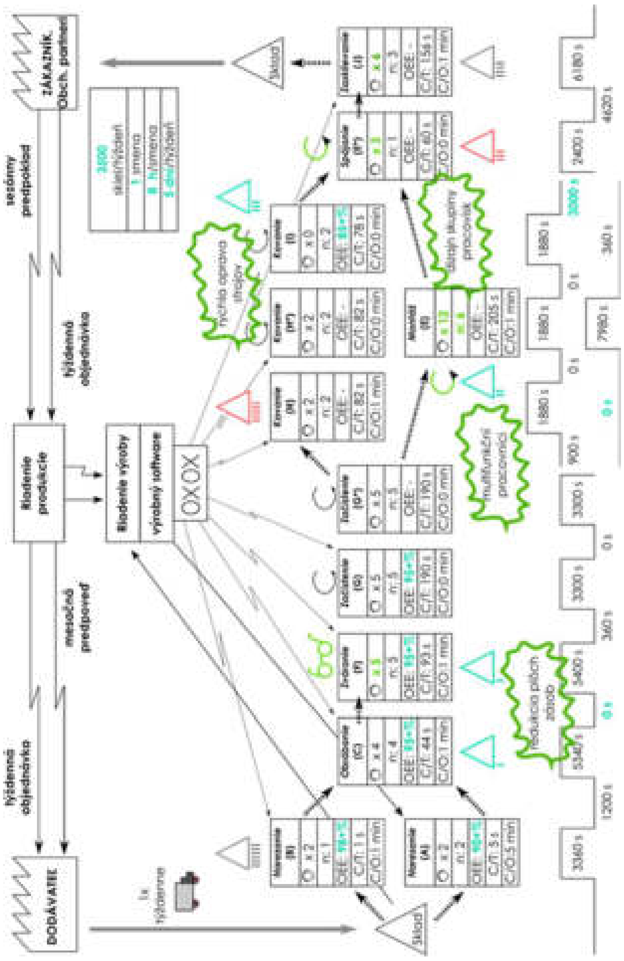

Figure 3 Future state of the production improvements using VSM method

Obtaining time data on production flows and knowledge about the production plant, next step is to create value stream maps. Base maps are manufacturing processes that convert the sequence of input material obtained from suppliers on the finished product shipped to customers through business partners. To create a map of the current state of enterprise value streams one need to get a picture of the manufacturing enterprise. The value streams map contains following information:

- customer orders,
- working hours,
- ordering of materials from suppliers,
- inventory and stockpiling before the trial processes
- workplace, production processes and technological operations,
- material processing times,
- downtime times for material.

Using these data and knowledge, it is possible to create a value stream map (VSM). Such maps gives a comprehensive view of the operation of the company, focusing on manufacturing operations. The output of maps are graphically outlined VAI timelines of monitored production batches, necessary for calculation of material processing times that adds value to the product, hence the customer and production company and times that do not add value to the product. The ratio in these times set VAI (Value Added Index).

$$Value\ Added\ Index = \frac{\sum_t t_{AV}}{t_{NAV}} \quad (1)$$

where
t_{AV} - sum of times that add value,
t_{NAV} – sum of times that do not add value.

Conclusions

Acquiring times at a workplace individually can enable to monitor parameters from manufacturing processes, but to obtain a comprehensive overview of production flows and in efforts to the Value Streams Mapping, one must obtain information on the flow - material, information, personnel directly at the production plant. Using the method VSM - Value Stream Mapping as a tool to redesign the manufacturing flow is, a key output is VAI - Added Value Index. This value compares the times that do not add value and times that add value in a process of products manufacture. In this case, technological operations, which transforms an input to the finished product are activities that add value. Production flow in the production plant (Figure 3) is not smooth, there are frequent material downtimes (or work in progress) due to inventory accumulation next to technological operations - it is an activity that does not add value to the product and therefore neither the customer nor manufacturing company.

In terms of theories of continuous improvement (Kaizen), Lean Production and cost reduction (Lean Logistic) and bottlenecks, the target is to to uncover bottlenecks, expand bottlenecks and minimize stockpiling in front of such operation unit. Helpful here, there are the time frames of different production batches obtained from the normal operation of the production facility in the analyzed company. These time frames also represent the process of mapping the value stream operation - continuity of the production flow, material flow operation, obtaining information and creating information flow.

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References

[1] ROTHER, M., SHOOK, J.: *Learning to see*. Lean enterprise institute, Brooklin 1999.
[2] BIGOŠ, P., KISS, I., RITÓK, J.: *Material Flow and Logistics logistika.* Michala Vaska, Kosice, 2002 (Original in Slovak).
[3] KOSTURIAK, J. et al.: *Design of Production Systems for 21. Century*. Zilina, ESIS, 2000. (Original in Slovak)
[4] SKOLAR, P.: *VSM - Value Stream Mapping*, [online], Available: www: http://www.utb.cz/file/24118_1_1/ [23 Febr 2015], 2015. (Original in Czech)
[5] KOSTURIAK, J., FROLIK, Z.: *Lean and Innovative Enterprise*, Alfa, 2006, 237 pp.. (Original in Czech).
[6] KOSTURIAK, J., BOLEDOVIC, L., KRISTAK, J., MAREK, M.: *Kaizen – Prooved Studies in Czech and Slovak Enterprises*, Computer Press Brno, 2010, 234 pp., (Original in Czech).
[7] KOROBANICOVA, I., PACUTOVA, G.: '*The human capital in the creative economy in region* ', In: CERS 2014, Kosice: TU, pp. 421-431, 2015.
[8] ONOFREJOVA, D.: *Process Innovation Models in Service Providing Companies,* Innovation transfer, No. 29, pp. 259-263, 2014.
[9] SZABO, S., FERENCZ, V., PUCIHAR, A.: Trust, Innovation and Prosperity. In: Quality Innovation Prosperity, Kvalita Inovácia Prosperita, Vol. XVII, No. 2, pp. 1-8, 2013.
[10] BOŽEK, P., MORAVČÍK, O., ŠTOLLMANN, V., ŠURIANSKY, J., PRAJOVÁ, V., WALEKOVÁ, G.: *Virtual program imported into the real technological workplace*. In: Annals of DAAAM and Proceedings of DAAAM Symposium. p. 0157-0158, 2008.
[11] ONOFREJOVA, D.: *Patterns for production improvement by technology innovation in manufacturing company*, Innovation transfer. No. 29, pp. 290-293, 2014.

Review process

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ANALYSE OF ELECTROMOBILE CHARGING STATIONS FOR THE NEEEDS OF URBAN PROJECTION

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Keywords: analyse, electromobile, charging station, urban elements, system
Abstract: Electrification of road vehicles is one of the basic characteristics for energy transformation in the future. An important prerequisite to this is to transform the results of research and development to many areas of practice. This includes development of efficient, affordable and practically usable accumulators or safe charging equipment and communication tools. Electromobility is a process that presents a considerable challenge for energy companies. The concept of electromobility offers a complex solution for expansion of electric vehicles and its infrastructure to be needed. There are battery manufacturers, electric vehicles manufacturers, end users, cities and countries (should provide some benefits for users of electric vehicles), as well as electricity distributors that play an important role.

1 Introduction

Renewable energy sources are not only a perspective alternative of the energy gaining but they are also bringing the opportunities for the development of the alternative drives in the field of the transport. They are environmentally friendly and they are helping to permanently sustainable growth [12]. One of the alternatives of the mobility is electric energy, which powers the electric vehicles. Although, they are commonly existing and working in the world, in our country are electric vehicles starting very slow. Besides the high purchasing cost, the relatively short driving range may discourage from their purchasing. Other states support the urbanism and electromobility related to it with the construction of the public charging stations by different forms of subsidies or concessions [2]. When buying they offer the advantages of the electric vehicles at the entry to the historic centres of the cities or when parking. Electric vehicles are becoming more and more popular in the world. They appear to be one of the alternatives to the vehicles with the combustion engine. Such a vehicles need appropriately deployed charging infrastructure regarding to the driving range, that is lower than that of vehicles with combustion engine. The development of the agglomerations, the urbanism has to take account of the future development in this area [5]. The number of the public charging stations (Charging Stations, ChS) did not change in Košice in two years [10]. Looking to the future, Košice do not have enough charging points for the electric vehicle's needs. The same problem is also in the other countries of the European Union.

Regarding to the future, there are big changes waiting for the vehicular traffic. One of the alternatives of the replacing of the classical gasoline and diesel engines is electromotor powered by electric energy from the accumulators stored in the vehicle [5]. Electromobility deals with the electrification of the transport. It is dedicated to the new trends of the given branch, development of the affordable and practically applicable accumulators, materials and technologies, supporting the development of the electric transport, design and development of the required infrastructure, interconnection of the distributors of the electric energy, cities, states and users themselves, providing of the advantages by the state, standardization and legislation [14], so that the conception of the development of the electric vehicles would be able to assert in the competition of the classic automobiles. System of the urbanism has to develop such as the field of the electromobility is developing and it has to take into account the modern ways of the transport [4].

The advantage of the electric drive, if we are using any electric vehicle, is that we do not need gasoline/diesel, oil changes, catalyst, fuel pump, fuel filter, injectors, exhaust, spark plug key, fuel canister, air filter, emissions measurement, gearbox, starter, water pump, alternator, cylinders, oil pump, motor block, flywheel, brake pads replacement, Exxon, Shell, Chevron and other oil companies, gas stations, oil wells, wars for oil, etc.. Electric vehicles additionally offer absence of the emissions, high efficiency, quiet and smooth running. Electromobility brings benefits to all, and is one of the modern elements of the urbanism. It is improving the environment. The benefits of the electromobility are obvious and they are constantly examined from the different perspectives. Within the fluent development and the usage of the electromobiles in the practice, it is

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necessary their logic allocation within the agglomeration taking into account the amount of the criteria [9]. Currently is the EU vehemently pushing for the using of the green energy, i.e. renewable sources. This will bring the jobs, improvement of the environment and, of course, the mobility at a somewhat higher level than today, which gives the perspective of the development and the prosperity of the whole society [11].

2 Analysis of the current state of the electromobility

Is the electromobile the vehicle of the future? In Slovakia, it does not seem so far, which is caused by the policy of selling of the oil products, producers of the classic cars and also by the legislation of the appertaining states, including Slovakia [6]. Other states, which support the electromobility, already have the charging stations, different types of the subsidies or concessions when buying, advantages at the entrance to the historic centres of the cities or when parking. In Slovakia, there is around 30 electromobiles and hybrid vehicles on the roads. Electromobile is mainly made for the short distances. It is relatively a good investment but electromobile have to be used effectively, in order to be worth. Before the buying, it is necessary to consider what type of the route is driver riding and what style of the riding driver prefers. The future owner have to carefully count the pros and cons, to decide whether to buy an electromobile, which is the process of the multi-criterial decision making according to the subjective requirements and criteria of the customers [1]. Ordinary motorist, who is not using car daily, may return back to the idea of the combustion engine. The companies, which make several trips a day, are better on it.

The high price, few charging stations and the short driving range can be ranked to the minuses. It is necessary to divide the price of the electromobile into the price of the accumulator and the price of the vehicle itself. When it is compared in this regard, it is brought to the totally different numbers, as it is known today. The price depends on the development of the accumulators. Someone has to pay for it. However, the price should gradually increase. Although it is nice to produce no gas from the exhaust, but why would you buy a small electric car, when you could buy two cars of the lower middle class with the combustion engine for the same price. If we need to replace accumulator after some times, another additional cost will occur. Offered services in the subjected area are questionable [13], since the amount of the electomobiles does not match to the proven classic, yet.

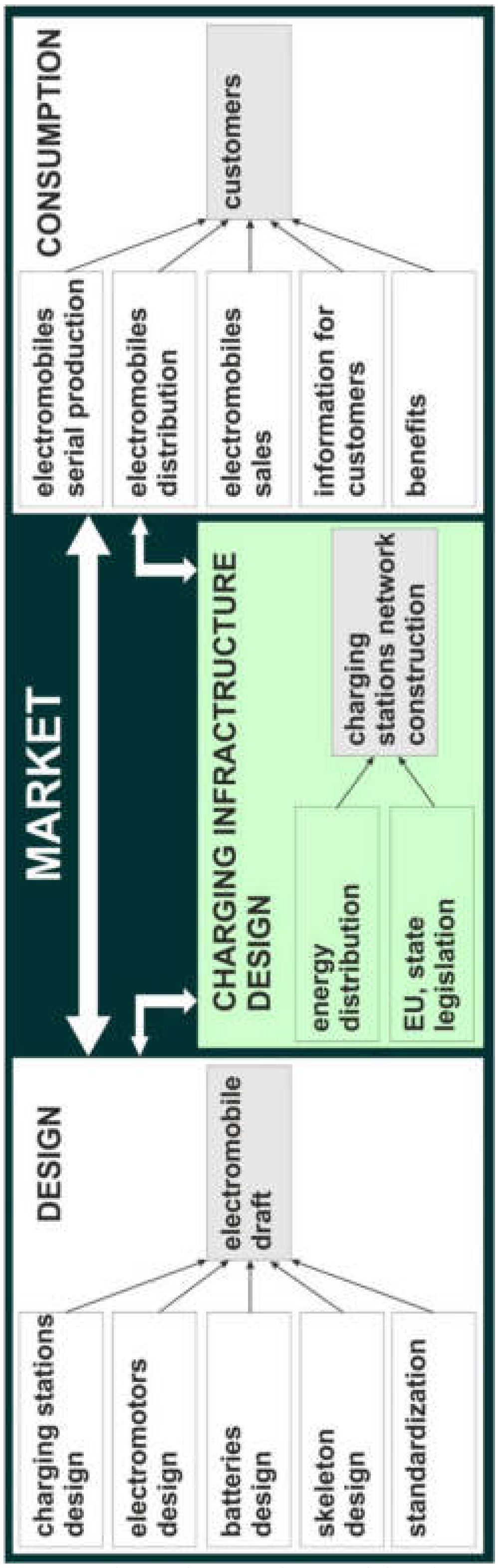

Figure 1 Relations between electromobility elements

The recharging of the electric vehicles at the public ChS will be free for some times. Will the initial investment be returned back? Despite the fact that the development in this field is rapidly progressing, the reality of the market is in many aspects different, which gives an opportunity for the usage of the different simulation models [7]. Constant monitoring of the driving range check light will additionally belong to the drive. Such arguments may also work to the disadvantage of the electromobiles, which are not even the alternative source of the mobility in Slovakia. Current owners of the electric vehicles are complaining about the lack of information about the location of the nearest charging station and their system allocation within a specific region [8]. Therefore it is necessary to focus on the development of the information and communication technologies for the electromobiles, which would allow navigating the driver to the closest charging station. Fuel tank capacity of the middle class vehicles is about 50 litres, which provides the driving range 500-1000 km, depending on the driving conditions, automobile and the system of the work with the vehicle. For comparison, accumulator in the electric vehicle has the weight of 100-700 kg according to the type and the total capacity. Driving range of the electric vehicles is currently in the range of 100-450 km. The energy contained in one litre of the fossil fuels is therefore greater than the energy produced by 1 kg of the accumulators. According to the driving range, the combustion engine is a better solution. But do not forget that 1 km by electric vehicle costs about 5-time less than 1 km by the vehicle with the combustion engine and the average annual costs of operation are lower by half.

Economic operation and many others already mentioned advantages belong to pluses. Regarding to the driving range, test with forty electromobiles during the six months took place in the Germany. They drove 400 thousand km. Causes, of what affects the driving range of the electric vehicles, were examined. There occurs the transition from the objective physical situation (what is objectively measured during the driving cycle) to the subjective psychological situation. Everything is conditioned by the user behaviour. Additional technology, which consumes the energy, is used in the vehicle during the winter. This falls under the technical side of the vehicle. One driver drives for a time, second for consumption and the third for the length. This belongs to the psychological aspect. The maximal driving range is defined according to some driving cycle. Each user has his own criterion, abilities to estimate the driving range and adapt it to his needs. Therefore, there occurs, that the maximal driving range is decreasing by a certain amount. We talk about so called sufficient driving range. The driver scans the dynamics of the driving range and confronts it with the current situation, which is on the road. The operating driving range is lower than the sufficient driving range. Everyone has a suggested comfort level of the driving range. It is a balance between the mobility option, which means to move with the mobility means, i.e. to choose such a vehicle, which will ensure it to him. It is a distance from the one charging point to another charging point. Each person interested in the buying of the electromobile should think about these things. Before the buying of such a vehicle it is good to do statistics of the travelled km on average per day, week and month. Often occurs, that the interested person has the exaggerated claims and requires from the vehicle the driving range of 150 km and more. In fact, he will not drive 150 km, he will drive only the 50-60 km. It is possible to extend the driving range by 20 to 25 %, which are formed by the psychological barriers of the every single user.

3 Current state of the electromobility in the world

About one billion cars currently drive in the world, while quarter million vehicles is registered in the North America. 60 million new cars are produced each year in the world. Slovakia contributes 640 thousand produced vehicles, which represents circa 1 %. In Europe, selling of the new vehicles stagnated due to the economic crisis, but in the Asia it rapidly increased. It is expected, that 10 million electric and plug-in hybrid vehicles will be driving in the whole world in the next decade. These vehicles will be concentrated in the urban areas and will have the positive impact on the local environment. Full transition to the electric mobility will last several decades. Panasonic company invited several supplier companies to join the investment in a US factory for the production of the car batteries. It plans to build this plant with the Tesla Motors company. Plant will be in charge of everything from the material processing to the installation of the batteries. It will produce small, lightweight accumulators. Except Tesla, it should supply also the Toyota car factory and other companies.

4 Current state of the electromobility in Slovakia

The electromobility in Slovakia is currently in its first phase, which means, that the electromobility is currently being solved as a project. This situation has not changed until today. The number of public charging stations has increased minimally. However, the number of private charging stations has increased. Currently, there are 6 charging stations in Slovakia (5-AC a 1-DC), which are available for public charging of electromobiles. The first public charging station, which was used for slow AC charging, was made available in 2010. The first public fast-charging station was made available in 2012 in Bratislava. There are currently several pilot projects in the area of electromobility being solved in Slovakia. These concern the construction of the charging stations and the entry of electromobility into service. The Slovak government has to treat legislatively with the extensive entry of electromobility into service. The electromobility in Slovakia is in the stadium of commenting process at the moment, it waits for the approval from the General Director of the section.

Volkswagen has run the construction of their first electromobile (VW eUP) in 2013 in Slovakia. In the second half of 2014, car factory Kia has run the construction of their first global electromobile Kia Soul EV. It will be based on the second generation of their conventional model Soul. In Europe, it should occur with the warranty of 7 years or 150 thousands km of mileage. The top speed should reach 145 km/h and the driving range should be 200 km.

Conclusions

It is important to have the option to charge your vehicle at any publicly accessible charging station while driving abroad. It can be done by agreements and full cooperation of all parties including all providers of electricity. By this charging can be carried out anywhere and sales account thereafter is realized through national electricity provider where the vehicle is registered. It is only possible if all the charging process will be standardized.

Parking places for the electric vehicles were variant designed on the free spaces and in the parking houses based on the analysis and there was designed graphical design of the charging stations. The work brought another view to the mobility, which is shown in the form of the electric energy, analyses the electromobility, new technologies in the field of the electric vehicles and the charging stations, thereby it meets the goal to inform, to get the electromobility into the awareness of the wide public.

The automotive industry is subjected to new trends in the last few years. Automobile manufacturers started to use the old-new drive - the electricity. They have started with selling cars called hybrid and plug-in hybrids that combine the advantages of the internal combustion engine and the batteries. It is only temporary period until full electrified vehicles will be supplemented on the market.

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References

[1] IŽARÍKOVÁ, G.: Using of multi-criterial evaluation methods to assess position of the object in the market. Acta Logistica, Vol. 1, No. 3, pp. 17-22, 2014.

[2] JOBSON, E., RONG, L.J.: Development of electromobility in public transport. Sustainable Urban Transport, September 2013, pp. 22-29, 2013.

[3] KAMIYA, M.: Development of traction drive motors for the Toyota Hybrid System, e-mobile, 2005/321, pp. 1-8. 2005.

[4] MASOUMI, H. E.: A theoretical approach to capabilities of the traditional urban form in promoting sustainable transportation. Theoretical and Empirical Researches in Urban Management, Vol. 9, No. 1, pp. 44-60, 2014.

[5] NEWMAN, P., KENWORTHY J.: Urban Design to Reduce Automobile Dependence, Opolis, Vol. 2, No. 1, pp. 35-52, 2006.

[6] PEPUCHA, Ľ, REMEK, Ľ., ŠRÁMEK, J., DANIŠOVIČ, P., SLABEJ, M., GRINČ, M.: Implementation of asset management in road administration of Slovak Republic. Acta Logistica, Vol. 1, No. 1, pp. 31-38, 2014.

[7] SANIUK, S., SANIUK, A., LENORT, R., SAMOLEJOVA, A.: Formation and planning of virtual production networks in metallurgical clusters, Metalurgija, Vol. 53, No. 4, pp. 725-727, 2014.

[8] STRAKA, M., BALOG, M.:. What way determine the correct allocation and layout for the needs of parking freight design in concrete region. Acta Logistica, Vol. 1, No. 4, pp. 9-16, 2014.

[9] STRAKA, M., BINDZÁR, P., KADUKOVÁ, A.: Utilization of the multicriteria decision-making methods for the needs of mining industry, Acta Montanistica Slovaca, Vol. 19, No. 4, pp. 199-206, 2014.

[10] STRAKA, M., CHOVAN, T., BINDZÁR, P., ŽATKOVIČ, E., HRICOVÁ, R.: Possibilities and limitations of electromobiles utilization. Applied Mechanics and Materials, Vol. 708, pp. 159-164, 2015.

[11] SZABO, S., FERENCZ, V., PUCIHAR, A.: Trust, Innovation and Prosperity. Quality Innovation Prosperity, Kvalita Inovácia Prosperita, Vol. 17, No. 2, pp. 1-8, 2013.

[12] TWIDELL, J., WEIR, T.: Renewable Energy Resources, second edition, Taylor & Francis, p. 581, 2006.

[13] WINKLER, R., MOCZULSKA, M.: Quality of service and conditions of customer satisfaction measurement. Acta Logistica, Vol. 1, No. 3, pp. 23-26, 2014.

[14] WITKOWSKI, K., SANIUK, S.: Aspect of logistics management of the city infrastructure, Logistyka, Vol. 41, No. 2, pp. 589-600, 2011.

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THE POSSIBILITIES OF THE STRUCTURE AND VARIABILITY EVALUATION OF INVENTORY CONSUMPTION

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Keywords: inventories, logistics, variability, costs
Abstract: Inventory can be evaluated from the point of view of a number of aspects. Production and trade organizations nowadays are under great pressure from their competitors and face high expectations from their customers. That is why the cost cutting in all areas can provide a significant competitive advantage. Inventory and its management and administration can therefore represent a source of substantial potential savings. Large inventory volume can significantly increase the costs, but its shortage influences the course of the manufacturing process and, ultimately, the customer satisfaction. It is therefore necessary to continuously optimize the inventory management system in the enterprise. The conducted research also involved an analysis of the structure and variability of the inventory consumption in a business organization dealing with the sale and storage of metallurgical materials. The objective of this article is to evaluate the possibility of the application of the tools used to analyze the structure and variability of inventories in the industrial and commercial practice.

1 Introduction

Inventory management involves an effective handling and management of inventories, the use of all the reserves that exist in this field, and respecting all the factors that affect the efficiency of inventory management [1, 2]. The existence of inventories at the moment when they are not used and there is no demand for them means unnecessary spending. The lack of inventories at the moment, when it is necessary to satisfy the customer's order, results in lost sales, followed by the loss of the customers and goodwill. Of course, it is necessary to maintain an adequate inventory level in the area of continuous manufacturing processes, given the need to carry out their technological adjustments. The agglomeration processes in metallurgical production, through which the ore concentrate passes prior to entering the blast furnace process, can serve as an example. It is therefore essential to maintain an adequate inventory level within the scope of these manufacturing processes, because their adjustment is very time consuming.

Generally speaking, the aim of inventory management is keeping the inventory in such a level and in such a composition to secure the rhythmical and uninterrupted production, as well as the promptness and completeness of the deliveries to customers, while keeping the total related costs as low as possible. Inventory management includes, in addition to the very existence of inventories and their development, other elements as well, namely the care about the structure of inventories, their storage and use, the efficient inventory management and the utilization of all available reserves - these should be the focal points of interest and attention of every company [3, 4]. Effective inventory management can fundamentally influence the economic results of the manufacturing enterprises. Inventory management consists of a number of activities, which are based on forecasting, analysing, planning, and operational activities and control operations within the individual inventory groups and within the inventory as a whole. The right inventory management is one of the factors deciding about the fulfilment of company objectives with the optimal allocation of costs.

2 Inventories and their impact on cost development

The costs associated with keeping inventory can be looked upon in various ways. One of the alternatives is the classification of inventory according to the model of the economic order quantity. This model divides the costs associated with inventory into two groups: the cost of maintaining inventory and the ordering costs. The costs of maintaining inventory include all the items that are related to the physical possession of the inventory. These are, above all, the following costs:

- the costs of capital frozen in inventory,

- the costs of maintaining a warehouse,
- the costs of inventory and warehouse space insurance,
- the costs of risk [5].

The costs of capital frozen in the inventory can be defined as the potential profit the funds intended for the purchase of inventory could have brought if they had been invested in a different way [6]. You can usually use the current standard interest rate. The costs of maintaining a warehouse include all the costs associated with the operation of the warehouse and the inventory records. The cost of inventory insurance can be defined as the amount spent on the inventory insurance for a certain period of time. The costs of risk represent a potential risk related to the fact the inventories might not be saleable or usable in the future, mainly due to physical or moral wear. The second group of the costs associated with inventory management are represented by the costs of ordering [7]. These costs include especially the expenses related to the monitoring of inventory usage, processing, issuance and delivery of the order, but also the expenses associated with the transport, control and storage. An efficient inventory management system is optimal if it is possible to calculate these costs for a specific unit (piece tonne, packaging, and pallet). Given the wide nature of the monitored costs, however, the determination of the unit costs does not tend to be easy and objective. The process of the definition of all costs always requires the application of certain simplification in order to make the solution easier.

3 Planning future inventory consumption

A forecast of the future development is always an essential prerequisite for quality planning and management. The link between the forecast and direct inventory management is most evident in the area of the buffer stock level setting. The accuracy of the future state forecast is directly proportional to the buffer stock level reduction. The more accurately we can predict the future state as far as the demand dispersion from the mean value is concerned, the lower the buffer stock. Steep seasonal fluctuations, new trends, and turbulent external economic environment - these are the factors that make forecasts increasingly difficult. Sometimes, they even lead to a false feeling that forecasts are impossible, and they are not worth dealing with. This is not true. It only sometimes happens that certain exact forecasting methods are more difficult to apply in practice. However, in situations where these methods cannot be used, they must be replaced with intuitive ones [8, 9]. If you use the exact methods, you must also realize that each planning will, in practice, deal with a certain error. That is why it can be said that the exact methods can use their name mainly due to the unique process of their implementation. The standard exact methods are based on the principle of extrapolation of the course of the values from previous periods. This principle is based on placing a curve or a straight line extended into the future through the curve of the course of previous values. The most commonly used exact methods include, for example: the method of moving averages, the weighted moving averages, the regression analysis, the correlation analysis and other methods. The methods of moving averages are based on the principle of placing a straight line through the present development, the direction of which is determined by the potential estimate. The regression and correlation analysis works with mathematically described curves used to search for further development. Large multinational companies, however, also often use the intuitive planning methods. This principle is based primarily on experience, intuition, knowledge of the environment, ability of analytical thinking and the creativity of workers. These principles can be used wherever the exact methods fail – i.e. especially in situations where the historical data necessary for the exact analysis are missing or are highly imprecise and biased [10]. In ideal case, the intuitive forecasts are verified by means of the exact methods. In the event that an intuitive estimate meets the calculated values with a certain corresponding tolerance, the degree of forecast accuracy is higher. However, the global economic crisis has shown that the market environment involves situations that cannot be predicted by any methods. It is important for the companies to be able to plan and optimally set their buffer stock values in shorter periods of time. Excessive inventory level can significantly increase the costs, while inventory shortage threatens the continuous course of the production process.

4 Inventory structure analysis

Inventory can be assessed according to many different factors. The logistics process optimization often makes it necessary to consider various criteria. The basic options include the use of Pareto analysis as a tool for inventory structure assessment. Pareto analysis is also known as the ABC method, according to the number and names of the groups into which the individual inventory items are classified. Inventories are mostly classified into three groups according to their size (significance). The basic principle of the Pareto analysis is the assumption that 20% of causes are responsible for 80% of consequences. In the area of inventory, we try to identify a narrow group of inventory items that are the key ones in terms of the total volume. In industrial practice, the differences among the individual inventory items are often very little, which is why it is possible to classify inventories into more than three groups. When the Pareto analysis is applied, we can define groups ABCDEF etc. The development of the Pareto analysis preparation can be simply described in the following points:

- Accurate determination of the value of all inventory items and their total sum.

- Determination of the percentage share of each item on the total.
- Ranking of the items according to the percentage content.
- Determination of the cumulative totals.
- Classification of the items into groups ABC or other. Group A should contain the items contributing to the total consumption in the amount of about 80%, Group B - 15% and C - 5%.

The second crucial factor in inventory management is the variability of consumption. We can use a wide range of statistical indicators to determine it. The most widespread ones include the variation coefficient used by the XYZ classification method. Unlike the ABC analysis, this method evaluates the regularity of consumption. It is logical that a different approach will be selected for materials whose consumption is regular and for inventories that are used only sporadically. The items are again classified into three or more groups. Group X contains the items with highly regular consumption, which do not have any significant fluctuations in their consumption. Group Y contains the items that show strong seasonal variations (trends). Group Z includes the items whose consumption is most irregular and the consumption forecast possibilities are limited. The items are classified into the XYZ groups according to their variation coefficient values (Formula no. 1): X – variation coefficient of up to 50%; Y – variation coefficient of 50-90%; Z - variation coefficient exceeding 90%. The variation coefficient essentially determines the actual disparity of the statistical set. Higher dispersion and remoteness of the individual values from the mean rate position will mean a higher degree of variability in consumption. The variation coefficient is calculated as the quotient of standard deviation and the simple arithmetic average, and this figure is subsequently multiplied by the constant of one hundred (the result is a percentage value).

$$V_x = \frac{S_x}{\bar{x}} \times 100 \qquad (1)$$

The evaluation of the intensity of inventory consumption variability allows us to identify the trends and irregularities in consumption. The dynamic changes, which are typical for current markets, mean more and more intensive occurrence of irregularities for companies. The companies must continually quantify their intensity in order to be prepared for these fundamental changes. The processing of XYZ analysis can be generally classified into the following points:

- Elaboration of the record of inventory consumption during a given period.
- Calculation of the average - simple arithmetic average.
- Calculation of the standard deviation.
- Calculation of the coefficient of variation.
- Classification of the items into different groups.

The area of inventory management in industrial companies often witnesses a situation where these two methods (Pareto analysis and variability analysis) are used simultaneously. The items are analyzed according to their volume and variability of consumption and are classified into complex groups: AX, BY, CZ.

5 Experimental part

An analysis of the structure and variability of inventory consumption in companies engaged in the sale and distribution of metallurgical materials was conducted as part of the research. The monitored firm is an important local company. The inventory analysis took advantage of the Pareto analysis and the XYZ method allowing for the evaluation of the variability in consumption. The assessment included the most significant traded commodities. Table 1 shows the key inventory items together with their specific volumes. At the same time, the table also shows the percentage share on the total inventory volume. In the next step, the individual metallurgical products were sorted from the most important ones in terms of their volume to the less important items. A cumulative total was determined for these items sorted in descending order, and the inventories were classified into groups ABC. The results are shown in Table 2. The crucial group A includes strips and slabs. These inventory items were the most significant in terms of their volume, but, at the same time, they were very similar (26.4% and 27.4%). The Pareto ratio for this inventory group is 20/53.9. The second most important inventory group (B) consists of forgings and billets. These inventory items are less bulky compared to group A, but they still belong to the significant ones. The Pareto ratio for this group is 20/25.7, which means that they are items which also require the necessary attention. Group C includes the remaining inventory items.

These items can be seen as less significant. They are inventory items with 1.8 - 5.3% share on the total volume. The Pareto ratio in this group is 60/20.4. The analysis clearly shows that the important inventory items can be found especially in Group A. These two inventory items amount for 53.9% of the total volume.

The variability analysis is another method applied here. It was applied to the inventory item of concrete reinforcing bars, which show long-term large fluctuations in the monitored company. Table 3 presents the volume of sales in 2015 in the individual months. The coefficient of variation has been determined for these data. It can be determined as the standard deviation and arithmetic average ratio. The quotient is subsequently multiplied by a constant of 100. Table 3 also shows the specific values of these statistical indicators. The established coefficient of variation is 68.9%, which puts this item to the variability group of Y (50 - 90%).

Table 1. The values of the key inventory items

Inventory type	Value (thous. EUR)	Share on the total volume (%)
Bars	2980	5.3
Slabs	14789	26.5
Billets	6500	11.7
Wires	2200	3.9
Strips	15290	27.4
Sheets	1450	2.6
Concrete reinforcing bars	1980	3.6
Forgings	7800	14.0
Burnt segments	980	1.8
Welding material	1780	3.2
Total	55749	-

Table 2. Pareto analysis results

Inventory type	%	Cumulative total	Group
Strips	27.4	27.4	A 20 / 53.9
Slabs	26.5	53.9	
Forgings	14.0	67.9	B 20 / 25.7
Billets	11.7	79.6	
Bars	5.3	84.9	C 60 / 20.4
Wires	3.9	88.8	
Concrete reinforcing bars	3.6	92.4	
Welding material	3.2	95.6	
Sheets	2.6	98.2	
Burnt segments	1.8	100	

They are therefore inventory items with a relatively high variability of consumption. Figure 1 shows a graphic development of consumption in that year. The chart clearly shows a steep inequality in consumption during the year. Given that this is a metallurgical product used in building industry, such a fact can be expected. The largest sales volumes are concentrated in the summer months, which are also important in terms of the building industry. It seems appropriate to create a higher buffer stock level for this inventory item, exactly for this period of time. One can assume that a similar character of consumption can also be anticipated in the following years, with regard to the business segment in question. A potential shortage of concrete reinforcing bars in the market in the spring months can be a complication during the creation of the buffer stock for this time period. This may be a result of the system of ordering and production in metallurgical enterprises. It is therefore beneficial to create long-term higher inventory volumes for the items with such a high variability in consumption, because they will allow you to eliminate these risks. A loss of customers may often be a greater threat for companies than the risk of high inventory levels and the resulting costs.

A correct setting of the inventory levels, however, requires an evaluation of the volume of sales over a longer period of time, particularly with respect to the power of trends in the high-risk months of the year.

Table 3.Variability analysis – concrete reinforcing bars

Month	Concrete reinforcing bars / sales (thous. EUR)
January	90
February	106
March	89
April	120
May	380
June	290
July	330
August	260
September	150
October	105
November	40
December	20
Average	165
Standard deviation	113.8
Vx	68.9 %
Variability group	Y

Conclusions

In today's highly competitive environment, inventories represent one of the key factors deciding about the success of companies. This research has also included an analysis of the structure and variability of inventory consumption. The Pareto analysis has been used to identify the dominant inventory items in the company dealing with the trade of metallurgical materials.

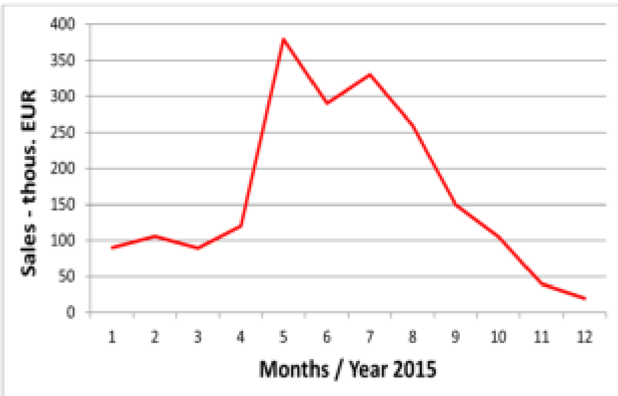

Figure 1 Development of inventory item sales – Concrete reinforcing bars in 2015

At the same time, the research has also assessed the variability of consumption (sales) for a highly trendy inventory item. If the companies want to succeed and be prosperous in the long term, they must continually evaluate their practices and strategies in the area of inventory management.

The setting of the inventory levels should be adjusted operatively according to the current development. The dynamic changes in the market environment require a constant search for optimal solutions.

References

[1] BAZALA, J. et al.: Logistika v praxi. Praha: Verlag Dashöfer, 2004.
[2] KOŠTURIAK, J.: Inovace – Vaše konkureční výhoda. Praha: Computer Press, s.r.o., 2008.
[3] BESTA, P.; HULA, L.; ŠVAJDOVÁ, L.: Optimalizace nákupního procesu v průmyslovém podniku. In: Inovace a zlepšování v podmínkách ekonomické krize. Ostrava: Vysoká škola báňská – Technická univerzita Ostrava, 2011, p. 4-7.
[4] PERNICA, P.: Logistika pro 21. století, 2. díl. Praha: Radix, s.r.o., 2005.
[5] WILSON, L.: How to implement Lean Manufacturing. McGrawHill Professional, 2009.
[6] LENORT, R., BESTA, P.: Logistics of End of Life Electronics Equipment Disassembly. Acta Montanistica Slovaca. 2009, Vol. 14, No. 3, pp. 268-274.
[7] MONCZKA, R, M.; HANDFIELD, R., B.; GIUNIPERO, L.: Purchasing and Supply Chain Management. Cengage Learning, 2008.
[8] TOMEK, J.; HOFMAN, J. Moderní řízení nákupu podniku. Praha: Management Press, 2009.
[9] TAKEDA, H. Low cost intelligent automation. Verlag Moderne Industrie Landsberg, 2004.
[10] GHIANI, G.; LAPORTE, G.; MUSMANNO, R. Introduction to logistics systems planinng and control. John Wiley and Sons, 2004.

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