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PRODUCTION SYSTEM VIRUS ANALYSIS TOOL (PSVA) - PROBLEMS IDENTIFICATION AND ANALYSIS FRAMEWORK - CASE STUDY

Piotr Cyplik, Lukasz Hadas

Poznan University of Technology, Poznań, Poland

ABSTRACT. Background: Identification and analysis of problems occurring in complex machine-building company production systems is a very crucial stage in the process of improving these systems. Effective production systems nowadays are a key to the success for this type of companies.

Material and methods: On the basis of production system problem identification and analysis tools known from the subject literature (among others ASIS model, Ishikava (fishbone) diagrams, impact wheels, current reality tree, risk assessment mapping tools (FMEA), cause and effect diagrams) the authors of this paper proposed their author's identification and analysis framework of problems occurring in machine-building enterprise production systems. The proposed tool is a specific hybrid of solutions known from the literature. The model has been developed and verified in a running business conditions.

Results: Author's tool has been successfully used within the frames of a project aimed at improving the production system of one of the Polish biggest machine building's sector manufacturer. Problem identification and analysis framework of production systems in machine-building companies developed within this project has been called Production System Virus Analysis (PSVA) for the reason of results presentation specific character. In this paper basic assumptions and methodology of the tool developed by the Authors have been included. Additionally, in the practical part the Authors present an example of PSVA adoption for problem identification and analysis in the production system of one of the Polish biggest machines building company.

Conclusions: Every organization needs to use a proper combination and selection tools, methodologies and techniques for identification and analysis of their own problems on the path to implementation of improvements. The authors experience show that the appropriate tool: able to identifying core problems, indirect causes and symptoms, significantly improve the efficiency of long-term process of rebuilding production and logistics systems.

Key words: production system analysis, machine-building company, problems identification, ASIS model.

INTRODUCTION

An effective production system can be perceived as one of the main elements of competitive edge of manufacturing enterprises. Efficiently working production system underlie effective functioning of a manufacturing enterprise itself as well as functioning of a supply chain, which the enterprise is the part of. Unfortunately, not all enterprises can recognize their production systems as an effective one so they undertake some permanent activities correcting actual state. The process of improving such system is complicated and difficult - as a rule. Heterogeneity and diversity of challenges appearing in the enterprises' production systems heighten difficulties with identification of key problems determining effectiveness of whole system. A useful tool in identifying and analyzing such problems

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can be the author's Production System Virus Analysis framework - a specific hybrid of solutions known from the literature.

Main objective of the authors performance was creating a tool to identification and analysis of a production system' problems which enables indicating proper correcting activities to the improvement of financial condition of the enterprise through the better use of its potential.

THEORETICAL BACKGROUND

Improving of production system brings many difficulties. Finding answer to questions: which way should the enterprise follow?, which model of production system to choose?, which solution of a problem will bring the best effects? is not easy. In the literature of subject, one can find many various hints, case studies as well as recommendations of the "best solutions" e.g. Cochran and Kaylani (2008), Umble at all. (2005) etc. The choice of one solution, adjusted to a specificity of the enterprise being studied, which is to support transformation of a current system into effective production system - brings many problems. According to guiding principles in the literature, the first step to be taken in any operation aimed at improvement is to understand a business process, which is to be improved. One of the tools used to understand a business process is a process mapping, which serves several purposes. Firstly, it allows good understanding of the elements of a process - actions, results and participants. Secondly, it helps to define a process range and separate it from adjoining processes. Thirdly, it offers a point of reference against which a range of improvements is measured (Bozarth and Handfield 2006). Apart from the process mapping, companies must apply more formalized procedures in order to be certain that a problem has been diagnosed correctly. Root Cause Analysis is a procedure, which first involves brainstorming, which is meant to identify any potential causes of problems, and then collecting data and analysing them in an organized manner, gradually narrowing down the area of interest to a few root causes. Causal maps are one of the tools for the root cause analysis. In the operations management literature, causal maps are known under many names, including Ishikawa (fishbone) diagrams, impact wheels, issues trees, strategy maps, risk assessment mapping tools (FMEA) and, cause and effect diagrams. Operations management researches often use causal maps as a key tool for building and communicating theory, particularly in support of empirical research (e.g. Hays and Hill 2001). The only widely accepted approaches for capturing cognitive data for a causal map are informal brainstorming, formal brainstorming (Pande and Holpp 2001), and structured interviews (Chmeilewski et al. 1998).

Tools for root cause analysis

The Ishikawa diagram, also known as the fishbone diagram and root cause analysis, is a simple causal map developed dr. Kaoru Ishikawa, who first used the technique in the 1960s (Enarsson 1998, Kelley 2000). The basic concept of the Ishikawa diagram is that the basic problem of interest is entered at the right of the diagram, at the "head" of the main "backbone." The possible causes of the problem are drawn as bones off the main backbone. The categories often used as a starting point include materials, machines (equipment), manpower (people), methods, Mother Nature (environment), and measurement. Other causes can be chosen as needed. Brainstorming is typically done to add possible causes to the main "bones" and more specific causes to the "sub-bones." This subdivision into ever increasing specificity continues as long as the problem areas can be further subdivided. The maximum practical depth of this tree is usually about four levels. As an Ishikawa diagram becomes more and more complex, it becomes more difficult to understand and use. Most quality management authors recommend using brainstorming methods to generate Ishikawa diagrams (Pande and Holpp 2001).

The impact wheel is a simple structured brainstorming approach designed to help managers fully explore the potential consequences of specific events and to identify consequences that they might otherwise fail to anticipate. The facilitator writes the name for the change, or event, in a circle in the centre of the whiteboard and then engages the group participants in a discussion of three points.

- The inferences - The "impacts" of the change (drawn like spokes of a wheel).
- The probabilities - The likelihood (probability) for each impact.
- The implications - The cost and benefit of each impact.

The group then focuses on each impact and repeats the process.

Consulting firms often apply a causal mapping tool called an issue tree analysis. The approach helps break down an issue (a problem) into its major components (causes) in order to create the project workplan (Miller 2004). The approach usually puts the main issue on the left and then disaggregates the issue into smaller issues on the right.

Causal mapping is also a key tool for risk assessment and management (Hodgkinson et al. 1996), and is known by several names such as fault tree analysis (Jetter et al. 2001), event tree analysis (Kumar, 2000), and Failure Mode and Effects Analysis (FMEA) (Franceschini and Galetto 2001). These maps are used to provide a systematic method for identifying all types of potential failures, their potential causes, and their consequences. These methods are beneficial in the design of a product and a process, in improving understanding of the system, focusing risk mitigation efforts, and identifying root causes of failures. The most popular of these methods in practice is Failure Modes and Effects Analysis (FMEA), which is a systematic way of looking at process and product failure modes.

A cause and effect diagram is a causal mapping tool for quality improvement and plays a prominent role in quality management programs such as the Six Sigma program (Pande and Holpp 2001). A cause and effect diagram is an extension of the Ishikawa diagram and is not constrained to the "fish" diagram (e.g., does not require any pre-defined structure and does not use the "M" alliteration to identify potential causes) and uses ovals to represent variables. Many popular books (Pande and Holpp 2001) suggest asking the "five whys," which ask "why" five times in order to uncover the root causes of a problem. Goldratt's "current reality tree" (Goldratt 1994) is a cause and effect diagramming technique that helps identify root causes. The diagram is unique in that allows for the creation of logical "and" between relationships leading into a cause. Most quality management authors recommend using brainstorming methods to generate cause and effect diagrams (Pande and Holpp 2001).

Theory of Constraint in root cause analysis

Management problems are too numerous and new problems always occur one by one in organizations. Moreover, some apparently intractable problems exist that cannot be solved by past experiences, making many managers worried about which solutions is effective. Therefore, an effective new managerial tool is urgently required to solve the intractable problems. TOC developed an effective technology for solving problems called the "Thinking Process", This process can be used as diagnosis in medical treatment, to list symptoms and identify "core problems", then to look for a new method of solving problems. Such new tools create the "Cause-and-Effect Diagrams" based on the pattern of establishing "Logical Trees", Three questions then are discussed: "What to change?" "What to change to?" and "How to change?" An optimal solution to these questions then is devised. The research and training of these technologies helps significantly in improving organization management. The Thinking Process consists of formal analytical tools that are designed to help people answer these three questions.

Such technology uses the "Current Reality Tree (CRT)" to diagnose causes or core problems, and the symptoms are called "Undesirable Effects". A common cause is deduced based on the pattern of observed symptoms. Up to a point, the diagnosis becomes easier to make with increasing numbers of symptoms, A single symptom can have many causes, but a pattern of different symptoms may have just one plausible cause. Rather than relying entirely on intuition to find the cause, a formal cause-and-effect map (Current Reality Tree) is constructed to identify a few core problems that can explain all of the observed Undesirable Effects (Noreen et. al. 1995). Another useful technique of root cause analysis, which is a continuation of CRT, is "Evaporating Cloud" - a specific technique to identify the assumptions underlying the apparent conflict and break the deadlock. The above techniques described by Goldratt (1994) have both found their place in the tool designed by the Authors of this paper.

BRIEF METHODOLOGY OF PRODUCTION SYSTEM VIRUS ANALYSIS (PSVA)

PSVA is a practical method of identifying and analysing problems, which occur in a production system. The final result of realizing the subsequent stages of such analysis is creating the Production System Problem Virus. The virus attacks healthy tissues of a production system and causes their death or transforms them into hybrids, which do not fulfil their basic functions they are supposed to fulfil. Diseased tissues cause malfunctioning of a production system, which translates into a decline in its effectiveness. Thus, clear identification of the problem virus becomes a key to its full elimination or at least restriction of its area of activity, which improves the effectiveness of the whole production system. PSVA methodology assumes the realization of seven subsequent stages:

1. Determining the objective of changes.
2. Determining the performance measures.
3. Appointing the team of experts.
4. Identifying problems.
5. Statistical analysis of identified problems.
6. Current state analysis (ASIS).
7. Designing the production system problem virus.

All these stages will be shortly elaborated on. We now short elaborate on each of these stages.

Determining the objective of changes

Problem analysis is usually the first stage in the realization of a production system streamlining project, and that is why a clear definition of the objective of changes becomes an essential element of the PSVA framework application. The objective should be clear and comprehensible to all managers and employees in a company.

Determine the performance measures

Objectives of a streamlining project should be measurable. It is thus essential to evaluate the advantages resulting from the implementation of improvements aimed at increasing the effectiveness of a production system in a selected company. At this stage main performance measures of a production system should be selected, and they will constitute a measurable effect of improvements. A large number of measures may pose certain problems. However, top managers are expected to manifest an ability to take right decisions and select maximum 10 main performance measures in a production system, which will reflect a current state of affairs as well as future changes in the widest context possible (compare: example in chapter 4.2).

Appointing the team of experts

A team of experts should be appointed during direct workshops based upon brainstorming methods in order for them to identify and analyse problems in a production system. Such team should include employees directly involved in a production process, as well as employees from the auxiliary areas. The wider this spectrum is, comprising a wide area of company's operation, the more effective the problem identification process will be in a production system. Covering all areas of the company's operation with team members' competencies guarantees the identification and analysis of problems appearing on the border of a production area and other functional areas in a company. There is a possibility of further division of the team of experts into smaller groups in order facilitate the conduct of problem identification workshops based upon brainstorming methods.

Identifying problems

Identifying problems in a production system within the PSVA assumes two stages:

1. Workshops with experts where problems in a production system are identified with the use of brainstorming methods. During such workshops commonly known tools, such as Ishikawa diagram, impact wheel tools, etc. can be used.
2. Drawing and analysing maps of processes with the use of well known tools for creating such elements.

On the basis of the identified problems where both above-mentioned practices were applied, the Team of Experts should determine the influence of each identified problem on the objective of the project of changes and its parameters described at the first two stages of the PSVA. It is suggested that relative dispersion rate should be applied in order to clearly determine the experts' agreement.

Statistical analysis of identified problems

A statistical analysis of identified problems is a stage where problems reported at the workshops by the Team of Experts are subject to grouping and a preliminarily analysis. What is analysed here is the influence of the defined problems on particular parameters of a success determined within the second stage of the PSVA. In such analyses various statistical tools are applied, such as histograms, bar charts, etc. Such prepared data are used to realise the next stage, which is a current state analysis and finding root causes.

Current state analysis (ASIS)

The main objective of this stage is to find root causes of a current state of affairs leading to low effectiveness of a production system. According to PSVA methodology, the material gathered at the previous stages is analysed here. For the purpose of this task modified methodology of "Current Reality Tree" analysis has been applied. This analysis was described in "It's not luck" by E. Goldratt (1994). The basis for establishing relationships among identified problems within "Current Reality Tree" is, to a great extent, the 5 Whys method described in "The Toyota Way" by J.K. Liker. When analysing the current reality tree downwards one starts with the most general problem and through why-questions comes to the main causes of such a state of affairs. An upwards analysis enables the following statement: if I solve the major problem a problem, which arises from it, should solve itself too.

The production system streamlining process must be based on facts, not opinions. Although members of the team may seem to have discovered the root cause of a problem, they must verify their views before they proceed to design a solution. A real data analysis based on tools including correlation diagrams, control sheets, Pareto analysis, etc. allows approval or rejection of the diagnosed root cause.

Designing the production system problem virus

The last stage of the PSVA is designing the production system problem virus. It consists of a central part called the nucleus and an external and internal coating. The nucleus reflects root causes identified and confirmed through the data analysis during the previous stage. In the internal coating there are major problems, which cause a decrease in the effectiveness of a production system of a company. The external coating is made up of protrusions, which symbolise symptoms of problems, which appear in a production system. Picture 2 in chapter 4.7 shows an example of the Production System Problems Virus.

THE EMPIRICAL VERIFICATION OF THE PSVA

The framework of identifying and analysing problems in a production system proposed by the Authors for machine building companies has been implemented within a production system streamlining project by one of the main Polish machines building manufacturer. The production system in the analysed company is in many aspects a typical representative of a machine building company operating in a traditional way. The production is realised in a standard way typical of heavy industry: 1. forging/casting/etc. - 2. treatment - 3. assembling. An expected result of the PSVA application was identification of the key problems in the production system and then their elimination.

Defining the objective

The main objective of the streamlining project in the analysed company was to design solutions whose implementation would improve the effectiveness of the production system. It is required that the concept of improvement of the production system's effectiveness should be defined first. Thus, an effective production system will be understood as practical activity connected with planning, current steering and control of a number of finished products, works in progress and raw materials, as well as an extent to which resources are used to meet customers' demand, minimizing production costs, delays and stock, along with maximising productivity and, indirectly, maximising profits and return from the invested capital. A crucial element of an effective production system will be eliminating a waste of time and resources and incorporating quality into systems of a workplace.

Determine the performance measures

From among many performance measures used to evaluate the streamlining in the production system of the analysed company nine were selected. They were not chosen at random, however. This choice was dictated by a wide range of the company's operations, which is covered by these measures. Among others, there are financial measures, cost measures, safety at work measures, innovation measures and customer service measures. The group of selected measures comprises:

1. DDT - Dock to Dock Time - shows how long the stock is kept in the stream. The time is measured from the moment raw materials are delivered to a plant, through the time they go through production until a finished product is delivered to a customer.
2. OEE - Overall Equipment Effectiveness - a basic measure applied in TPM (Total Productive Maintenance) implementation, which is the outcome of three measures: availability, usage and quality.
3. VDP - Vendor Delivery Performance - informs of the percentage of order items realised in accordance with the first confirmed delivery date and in the full quantity ordered.
4. IFG - Indicator of Faulty Goods - shows the percentage of faulty items of goods against the overall volume of production/sales within a given period of time.
5. II - Indicator of Implementation - describes effectiveness of a company within the implementation area. It is understood as the percentage of approved streamlining implementations per a time unit.
6. EIPFC - Effectiveness Indicator of Production Flow Control - a ratio of the quantity of final products manufactured in a sequence, which complies with MSP to the overall number of final products, manufactured within a specified period of time.
7. IHSW - Indicator of Health and Safety at Work - shows the percentage of persons who suffered an accident on the premises of the company in the last quarter of the year.

8. SC - Stock Coverage - informs of a number of days covered by the stock of finished products, works in progress, materials and raw materials.
9. SPP - Sales per Person - describes a monthly value of stream goods sales per an employee in the production area.

Appointing the team of experts

In order to identify and analyse problems in the production system of the analysed plant at direct workshops based upon brainstorming methods the Project Team was appointed and then divided into three groups:

- Steering Committee - the Company's Board consisting of three members
- Core Team - consisting of twenty key employees of the company who are in charge of the main and auxiliary processes realised within the production area and incorporating among others: Production Manager, Innovation Manager, Sales Manager, Logistics and Maintenance Manager, Foundry Manager, Treatment Manager, Quality Control Manager, Service Manager, Purchasing Department Manager, etc.
- Support Team - consisting of eight employees in charge of the auxiliary processes and comprising among others: Chief Accountant, Human Resources Manager, Head of Stock Department, Head of Environmental Protection Management and Safety at Work Team, etc.

Each of the groups described above has an equal saying and influence on the final result of the works. The division into smaller groups enables effective conduct of workshops based upon brainstorming methodology. The full approval of decisions made by the other groups lies with the Steering Committee. Such selection of employees, which covers all areas of the company’s operations, can guarantee identification and analysis of problems in the production system in a broad context of their effect on the overall performance of the company.

Identifying problems

A list of problems, which occur in the production system, was defined during workshops where brainstorming techniques were applied. Two analytical tools were used: the Ishikawa diagram and elements of the Impact Wheel. In the course of these workshops the Team of Experts identified 245 problems. For each problem a degree of gravity for the realisation of the project objective was determined (selected from the four options: very high, high, medium, low) according to the measures - compare chapter 4.2. On account of the right selection of employees for the Team of Experts the identified problems covered all the areas of the company's operations.

Statistical analysis of identified problems

All the problems reported in the course of workshops were analysed in greater details. Table 1 (below) shows the identified problems along with the differences in their influence on the measures (DDT, OEE, VDP, IFG, II, EIPFC, IHSW, SC, SPP) and a category of gravity ascribed to them (VH - very high, Hi - high, Mi - medium, Lo - low).

Table 1. Statistics of problems
Tabela 1. Statystyka problemów

	DDT	OEE	VDP	IFG	II	EIPFC	IHWS	SC	SPP	**Total**
VH	29	28	18	17	1	27	3	3	5	**131**
Hi	81	33	75	25	1	76	5	18	12	**326**
Me	21	9	18	9	0	15	2	3	3	**80**
Lo	0	0	1	1	0	0	0	0	1	**3**
Total	**131**	**70**	**112**	**52**	**2**	**118**	**10**	**24**	**21**	**540***

**The total number of problems presented in the table above does not correspond to the actual number of problems identified during the workshops where 245 problems were identified. The total number of problems in the table results from to the fact that the problems may affect more than one measure.*

According to the above table, important problems (60%) constitute the biggest group. The second largest group comprises problems classified as Very Important (24%). Other problems constitute only 16%. Thus, it is clear that classic Pareto principle was applied here - approximately 20% of all the problems were regarded as very important. The estimation shows that solving these problems will allow realisation of 80% of the assumed effects.

Current state analysis (ASIS)

The process of documenting the current state of affairs starts with identification of a major problem - ineffective production area. The reason for this problem in the analysed company lies in an ineffective casting system, ineffective treatment area and ineffective assembling of final goods. On account of quite an extensive current reality tree, each of the areas described above will be analysed separately below. Within the ineffective area of casting there are two main reasons for such a state of affairs - untimely production (delivery of rough castings to the final customer/untimely delivery of castings to the internal customer (treatment) and high production costs.

Untimely production results from:

- high defectiveness - production recoveries after failures increase defectiveness,
- frequent failures and shutdowns - failures and shutdowns delay planned production recoveries,
- incorrect planning of casting production - within planned castings certain constraints which result from the productive capacity of the Foundry are not always taken into account - a planning process depends largely on the experience of a planning officer,
- long decision loop - a complicated decision loop has its implications connected with a flexible decision making process, which can translate into delays in production,
- organisational and decisional chaos - has a considerable effect on a delayed delivery due an extended time for making necessary current decisions.

Considering the reasons for high defectiveness the most prominent ones are non-compliance with technological and quality regimes (this notion should be understood in a very broad sense, i.e. not only as typical technology but also as the best practice principle, strict compliance with safety at work regulations and the culture of work) and frequent failures and shutdowns. The reasons for non-compliance with technological and quality regimes are lack of motivation among employees, low awareness of work standards and, in some cases, incorrectly formulated technological regimes. The root causes for such a state of affairs are as follows:

- Lack of incentive scheme - incentive scheme is understood here as planned activities which aim at determining motivational components (reward and punishment system) for each workplace,
- Lack of clear standards of work - standards of work are understood here as a description of the best practice of performing particular activities for each workplace,
- Lack of training system - understood here as planned activity which leads to improving employees' qualifications.

While analysing the reasons for frequent failures and shutdowns the main reason seems to be lack of pre-emergency maintenance system, which results from "constant struggle for on-time deliveries" (making up for overdue production) and lack of ongoing inspection plans (machines frequently work until a failure occurs, which halts the whole production process). The reason for both above-mentioned effects is a permanent process of "extinguishing fires" (an ongoing increase in efforts to solve local problems). Extinguishing fires is essentially connected with an incorrect correlation of activities, which is regarded to be the next root cause. Local activities, which disregard the process as a whole from the supply-production-sales perspective, are considered an incorrect correlation of activities.

The next important element of the Current Reality Tree diagram is a long decision loop. Its basic reason lies in lack of confidence in employees and incorrect information flow. This lack of confidence in employees results directly from low awareness among employees as to standards of work. The problem of incorrect information flow, though, is closely connected with the root cause of incorrect correlation of actions and with unreliable data. It is non-compliance with procedures or lack of procedures that appears to be the reason for unreliable data. They result directly from two root causes, i.e. lack of clearly determined standards of work and lack of a real owner of an area/process. The latter root could be described as lack of a real host who has clearly determined rights and duties.

The reasons for high production costs, which can be reduced by implementation of organisational and maintenance changes are as follows:

- long decision loop - described above,
- high defectiveness - described above and
- organisational and decisional chaos - in general understanding it is a lack of decision syndrome, lack of clearly determined competencies and responsibilities.

Organisational and decisional chaos is caused directly by incorrect information flow, with the reasons described above. Another important reason for such chaos to arise is fuzzy boarders of responsibility, which stem from ambiguously defined competencies and a scope of responsibility for each particular workplace. Lack of a real owner of an area/process is regarded to be its root cause.

Picture 1 illustrates the analysed problems.

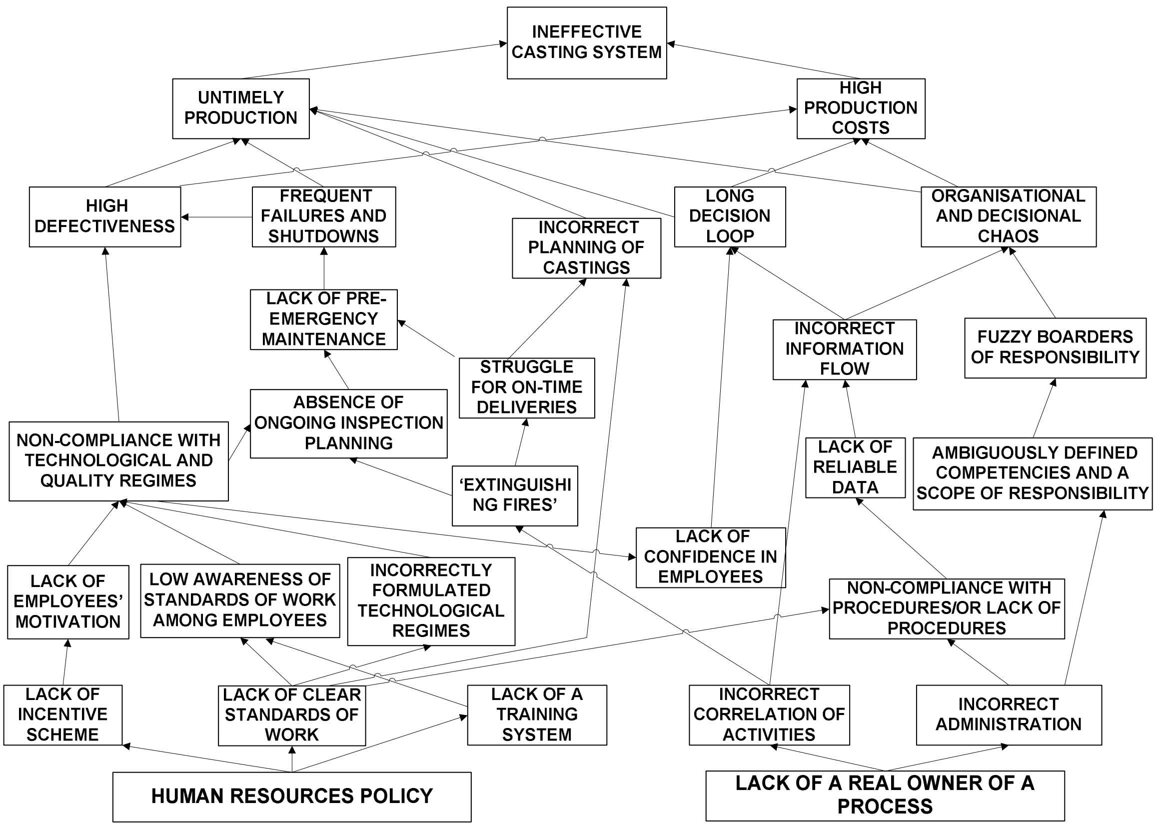

Fig. 1. Current Reality tree for the casting production area
Rys. 1. Reality tree w obszarze produkcji odlewów

The other two production areas in the analysed company (Treatment and Final Goods Assembling) have been analysed in a similar manner.

Designing the Production System Problems Virus (PSPV)

On the basis of the discussions resulting from the earlier stages the Production System Problem Virus of the analysed company was designed according to the methodology described in chapter 3.7 (see Picture 2).

The analysed company manufactures a wide range of products within its operations. At the same time, however, production is characterized by high costs. Apart from problems which strictly belong to a production area (high machine failure frequency, malfunctioning maintenance - renovation work and supply department which acts in emergency), the company must tackle a number of aspects linked with a company management process. These are primarily aspects of information flow, division of competencies (decision making process, hierarchy) and own workplace management. A remedy for the company's current condition is returning to old but still up-to-date good practice principles - an organizational order. Applying praxeology principles in company management will allow the company to raise effectiveness of the realised processes, while simultaneously understanding effects of both successes and failures of particular activities.

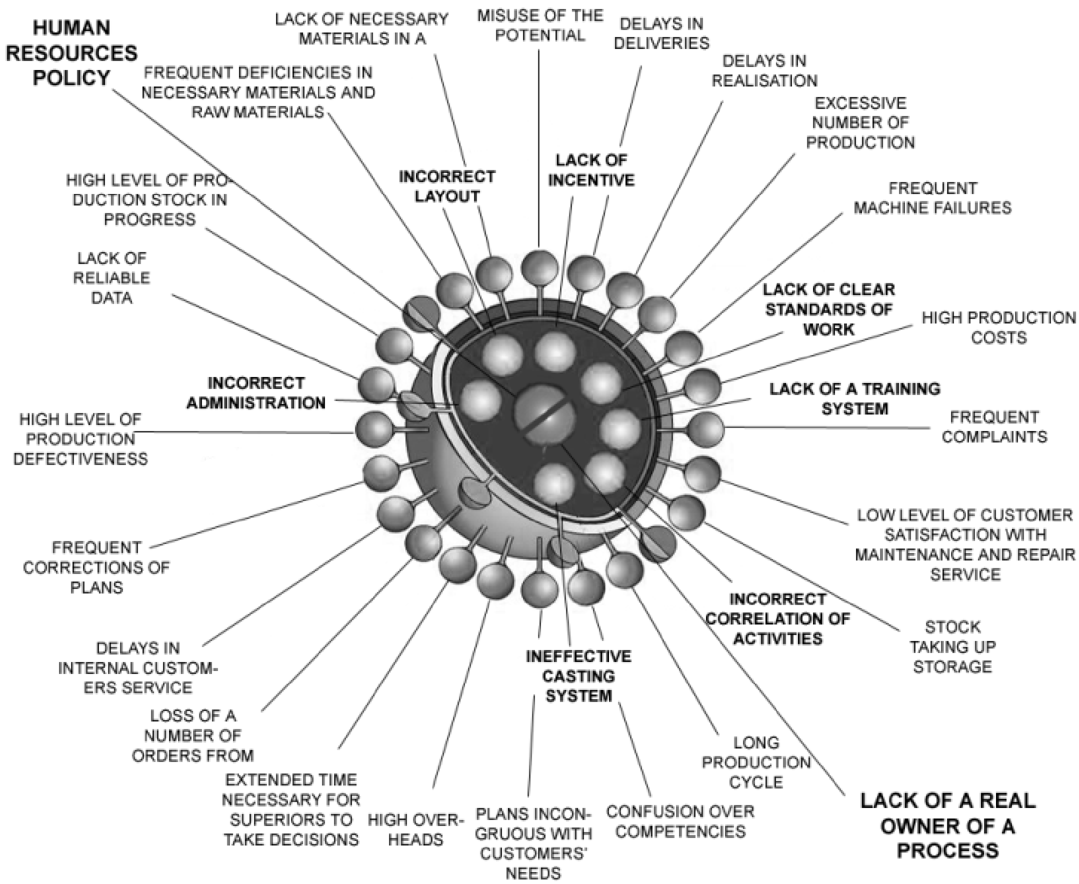

Fig. 2. The Production System Problems Virus of the analysed company
Rys. 2. Wirus problemów systemu produkcyjnego analizowanego przedsiębiorstwa

Destroying the virus, which is the reason for ineffectiveness of the production system, depends on destroying the reasons, which are its innermost part that is the root causes. They are:

- human resources policy,
- lack of a real owner of a process.

Production system streamlining projects should be directed mainly towards these two root causes. It will enable the elimination of major problems in the company:

- lack of incentive scheme,
- lack of clear standards of work,
- lack of a training system,
- incorrect correlation of activities,
- incorrect administration,
- incorrect layout,
- ineffective casting system.

and, consequently, the symptoms of the problems will disappear too.

CONCLUSION

At a cognitive level of the conducted research, the most important finding is an empirical confirmation of the view according to which well known methods of problem identification and analysis deriving from various branches and attitudes can be integrated. The framework of production system problem identification and analysis (PSVA) proposed by the authors is a compilation of the classic methods (Ishikava (fishbone) diagrams, impact wheels, current reality tree, etc.), which together with a different visualisation of results constitutes an interesting complementation of such methods. Originality of the proposed tool relies in an original selection of tools and methods known in the subject literature and a sequence of their use. Effectiveness of the proposed framework of production system problem identification and analysis has been confirmed by its empirical verification.

At a utility level of the conducted research the main result, which has been reached, is, apart from successful implementation of the tool in the environment of market economy, creating the methodology, which allows support of managerial decisions within the production system problem identification and analysis.

The authors of this paper consider it necessary to continue the works over improving the PSVA within the following areas:

1. improvement of conduct of workshops based on brainstorming methods with a view to better identifying key problems of a production system in analysed companies,
2. improvement of statistical tools used for the analysis of identified problems,
3. determining the next stage of the PSVA - designing the methodology of selection and deciding on the sequence of implementation of appropriate solutions which eliminate the production system virus in analysed companies.

The last area in particular poses a major challenge for the authors of this paper. The analysed company is currently carrying out implementation works aimed at improvement of the production system, which are a consequence of the applied PSVA.

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WIRUSOWA ANALIZA SYSTEMU PRODUKCYJNEGO (PSVA) - ZAKRES IDENTYFIKACJI I ANALIZY PROBLEMÓW - STUDIUM PRZYPADKU

STRESZCZENIE. **Tło badań:** Identyfikacja i analiza problemów występujących w złożonych systemach produkcyjnych branży budowy maszyn jest niewątpliwie bardzo ważnym etapem w procesie poprawy ich efektywności funkcjonowania. Efektywny system produkcyjny, jest postrzegany jako jeden z głównych elementów przewagi konkurencyjnej przedsiębiorstw produkcyjnych jak również łańcucha dostaw, którego ogniwem jest to przedsiębiorstwo. W związku w tym podejmują one permanentne działania korygujące obecny stan. Proces usprawniania systemu produkcyjnego jest z reguły skomplikowany i trudny. Heterogeniczność oraz różnorodność problemów występujących w systemach produkcyjnych przedsiębiorstw potęguje trudności z identyfikacją kluczowych problemów, które determinują efektywność całego systemu.

Metody: Na podstawie doświadczeń w usprawnianiu systemów produkcyjnych branży budowy maszyn oraz analizy znanych w literaturze przedmiotu narzędzi identyfikacji problemów (m.in. takich jak: model ASIS, diagram Ishikawy (tzw. „rybich ości", diagramu stanu obecnego, metody FMEA czy diagramu przyczynowo-skutkowego) autorzy artykułu zaproponowali własne złożone narzędzie identyfikacji i analizy problemów nazwane Wirusową Analizą Systemu Produkcyjnego (ang. Production System Virus Analysis - PSVA).

Rezultaty: Model został z powodzeniem użyty w ramach realizacji prac usprawniających system produkcyjny jednego z największych polskich producentów z branży budowy maszyn, przyczyniając się do poprawy sytuacji finansowej przedsiębiorstwa poprzez lepsze wykorzystanie jego potencjału. W artykule autorzy przedstawili ramową metodykę zastosowania opracowanego narzędzia a w części praktycznej przytoczyli studium przypadku jego użycia w rzeczywistych warunkach biznesowych.

Konkluzja: Każda organizacja musi używać odpowiedniej kombinacji narzędzi, metod i technik identyfikacji i analizy własnych problemów w procesie doskonalenia efektywności działania. Doświadczenia autorów wskazują, że odpowiednie narzędzie pozwalające na: identyfikacji problemów źródłowych i pośrednich oraz objawów znacznie usprawnia długotrwały proces przebudowy systemów produkcyjno-logistycznych. Pomocnym narzędziem identyfikującym i analizującym te problemy może być opisana na łamach tego artykułu Wirusowa Analiza Systemu Produkcyjnego będąca swoistą hybrydą znanych z literatury rozwiązań.

Słowa kluczowe: analiza systemu produkcyjnego, przedsiębiorstwo budowy maszyn, identyfikacja problemu, model ASIS.

WERKZEUG FÜR DIE VIRUSANALYSE DES PRODUKTIONS-SYSTEM (PSVA) - RAHMEN DER ANALYSE UND DER PROBLEMENIDENTIFIZIERUNG - FALLSTUDIE

ZUSAMMENFASSUNG. Hintergrund: Die Identifizierung und Analyse von Problemen, welche in den komplexen Produktionssystemen in der Maschinenbaubranche auftreten, gelten ohne weiteres als eine sehr wichtige Etappe auf dem Weg zur Verbesserung deren Effektivität. Ein effektives Produktionssystem ist einer der Bestandteile des Wettbewerbsvorteils, sowohl in Bezug auf die betroffenen Produktionsunternehmen als auch die Lieferketten, deren Bestandteile sie sind. In diesem Zusammenhang leiten sie permanente Korrekturmaßnahmen ein. Die Rationalisierung eines Produktionssystems ist in der Regel einer schwierige und komplizierte Aufgabe. Durch die Heterogenität und die Vielfalt der in Produktionssystemen der Unternehmen aufgetretenen Probleme steigt die Anzahl der Probleme mit der Identifizierung der Schlüsselprobleme an, welche die Effektivität des ganzen Systems determinieren.

Methoden: Aufgrund von Erfahrungen mit der Rationalisierung der Produktionsprozesse in der Maschinenbaubranche sowie der Analyse der Werkzeuge zur Identifizierung von Problemen, die aus der Fachliteratur bekannt sind (u.a. ASIS Modell, Ishikava Diagramm, Ist-Stand-Diagramm, FMEA Methode, Ursache-Wirkung-Diagramm), haben die Autoren ein eigenes komplexes Werkzeug zur Identifizierung und Analyse der Probleme, als Virusanalyse des Produktionssystems (Production System Virus Analysis – PSVA) genannt, vorgeschlagen.

Ergebnisse: Das Modell wurde im Rahmen eines Projektes zur Rationalisierung des Produktionssystems bei einem der größten polnischen Produzenten aus der Maschinenbaubranche erfolgreich eingesetzt. Dadurch hat es zur Verbesserung der Finanzlage des Unternehmens durch eine bessere Nutzung dessen Potenzials beigetragen. In dem Beitrag wurde eine Rahmenmethodik der Implementierung des erarbeiteten Werkzeuges dargestellt und in dem praktischen Teil ein Fallstudium dessen Anwendung in der Praxis aufgeführt.

Fazit: Jede Organisation muss eine entsprechende Kombination von Werkzeugen, Methoden und Techniken zur Ermittlung und der Analyse ihrer eigenen Probleme bei der Rationalisierung ihres Geschäfts anwenden. Die Erfahrungen der Autoren weisen darauf hin, dass ein entsprechendes Werkzeug, dass die Ermittlung von Kernproblemen sowie der Symptome den langfristigen Prozess der Umgestaltung der Produktions- und Logistiksystemen bedeutend rationalisiert. Ein hilfreiches Werkzeug, das diese Probleme identifiziert und analysiert, kann die in diesem Beitrag beschriebene Virusanalyse des Produktionssystems (Produktion System Virus Analysis – PSVA), welche als eine Art Hybride der in der Fachliteratur beschriebenen Lösungen gilt. Die Identifizierung und die Analyse der auftretenden Probleme in der Produktionssysteme des komplexen Maschinenbau-Unternehmen von Maschinenbau ist eine sehr wichtige Etappe im Prozess der Verbessung dieser Systeme. Ein gut funktionierendes System der Produktion ist heute der Schlüssel zum Erfolg für diese Art von Unternehmen. Aufgrund von Werkzeugen für die Identifizierung und die Analyse der Problemen der Produktionssysteme, die aus der Fachliteratur bekannt sind (u.a. ASIS Modelle, Ishikava (Fishbone) Diagramme, impact wheels, aktuelle Realität-Baum, Abbildungswerkzeugen für Risikobewertung (FMEA), Ursache- und Wirkung-Diagrammen), die Autoren von diesem Artikel vorschlagen ihres Autorenidentifizierung- und Analyserahmen der Problemen, die in der Produktionssysteme der Maschinenbau-Unternehmen auftreten. Das vorgeschlagene Instrument ist eine Hybrid der Lösungen, die aus der Literatur bekannt sind. Dieses Werkzeug wurde entwickelt und erfolgreich im Rahmen eines Projektes der Verbesserung des Produktionssystems eines der größten polnischen Maschinebauenhersteller verwendet. Die Rahmen für die Identifizierung und die Analyse der Problemen in dem Produktionssystem des Maschinenbau-Unternehmen, entwickelt im Rahmen diese Projekts, wurden Virusanalyse des Produktionssystem (Produktion System Virus Analysis – PSVA) genannt. Der Grund dieses Namens ist der spezifische Charakter der Präsentation von Ergebnisse. Die von Autoren entwickelten Grundannahmen und die Methodik des Werkzeugs, wurden in diesem Artikel präsentiert. Zusätzlich, im praktischen Teil, die Autoren präsentieren ein Beispiel der PSVA – die Verwendung für die Identifizierung und die Analyse der Probleme des Produktionssystems eines der größten polnischen Maschinebauenherstelle.

Codewörter: Analyse des Produktionssystem, Maschinenbau-Unternehmen, Identifizierung des Problems, ASIS Modelle.

Piotr Cyplik, Lukasz Hadas
Institute of Engineering Management
Poznan University of Technology
Strzelecka 11 St, 60-966 Poznan, Poland
e-mail: piotr.cyplik@put.poznan.pl
e-mail: lukasz.hadas@put.poznan.pl