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PRACTICE OF BUILDING PRODUCTION PLANNING SYSTEM OF COMPANY WITH A WIDE RANGE OF PRODUCTS - CASE STUDY

Łukasz Hadaś, Piotr Cyplik

Poznan University of Technology, Poznan, **Poland**

ABSTRACT. Background: The complexity of the manufacturing environments of today's mechanical engineering companies and the number of both internal and external restrictions affecting to need of building tailored production planning and control systems. This statement is particularly important in conditions of companies with a wide range of products and different customer service strategies (different locations of the logistics decoupling point otherwise called "order penetration point"). Streams of materials in these conditions require different management what is the main reason for carrying out research in business conditions by the authors.

Material and methods: The research was carried out in industrial engineering in complex environmental conditions of production. This was a specializing in technology, multi-departments environment, with multiple streams of values and a wide range of products (about 500 items). The work was carried out under the transformation of the production system from the "push" logic of flow to "pull" logic of flow and building a dedicated system based on the best practice approach.

Results: The paper describes the process of building tailored hybrid systems in the area of planning and shop flow control of production. The authors present the theoretical considerations on the issue and practical experiences. The authors present factors of selection of the transformation path and its road map. The article describes the part of the authors' own experience in the work on the methodology of transformation of Polish companies in the running business condition.

Conclusions: Establishing the methodology of transformation of the production system is not a simple task. This paper presents only selected aspects of complex decision-making process. However, the authors presented work shows the important aspect of the transformation of production systems for these organizational conditions.

Key words: production planning system rebuilding, decupling point: Make to Order (MTO), Make to Stock - Open to Buy (MTS OTB) and MTS Buffer.

INTRODUCTION

The complexity of the manufacturing environments of today's mechanical engineering companies and the number of both internal and external restrictions affecting to need of building tailored production planning and control systems. Among many known planning methods, the following should be mentioned [Encyclopedia of Production 2000, APICS 2008] the traditional Reorder Point (ROP) method, Manufacturing Resource Planning (MRP) or the Just-in-Time method with the Kanban operating tool. The MRP II system is considered an effective tool for aggregate production potential planning [Muhlemann et. al 1992, Orlicky 1975] and a source of information used in various functional areas of a company. In the flow of material streams, it works effectively as a manufacturing scheduling tool on the level of the main schedule. However, the considerable variability of schedules and wrong decisions on the volume of production batches and delivery batches affect the total level of stock and the potential is used. On the executive level, it is clearly more effective to control material stream flow using Just-in-Time [Liker 2003, Ohno 1995]. Thanks to its basic component in the area of manufacturing, the Kanban tool, work-in-progress inventory can be kept at low levels [Ohno 1995,

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Hadas and Domanski 2008] and ensures a pace of production suitable for the demand through the effective use of the pull flow logic. However, in real-life situations in industry, the effectiveness of the pull logic depends also on many factors shown in simulations [e.g. Kim et. al 2002, Huang and Kusiak 1998, Hopp and Spearman 2004].

The selection of an appropriate method for production planning and control depends on many parameters such as: the level of complication and variety of the products offered, production repeatability or market conditions, e.g. the nature and variability of demand [Hadas and Cyplik 2010, Hadas and Cyplik 2007]. Because each manufacturing environment differs much from another, there are no standard solutions that fully meet requirements on the operating level. Probably in each case of industrial practice, a process of developing tailored solutions is necessary, based on the general guidelines of established manufacturing planning and control systems. The reason for this is that the secret of the potential of manufacturing planning and control systems lies in specific solutions, usually developed or customized for the needs of the existing conditions. This is what tailored solutions are about, and what industry practitioners usually cannot adequately do.

In other words, the construction of tailored production planning and shop floor control systems is closely and directly connected to the needs of the industrial practice, identified in our consulting and research activities. We present a case study of a multi-department company with many value streams and a wide range of products manufactured in technological production structure.

CONSTRUCTION OF TAILORED PRODUCTION SYSTEM

Framework methodology for the construction of a tailored system

The purpose of the research was to search for the best solution for the manufacturing conditions under analysis. Within the research a methodology of constructing a dedicated system of planning and controlling the flow. The methodology used consists of the following sequence of operations (see the fig. 1). The first step is the analysis of the factors of choosing a system of planning and controlling the flow of production. At this stage the factors which influence the environment of a manufacturing system are defined. The next step includes independent analyses on the level of planning and the level of the flow of material streams (steps 2a and 2b). The purpose of these analyses is to select of the logic of planning as well as the logic of the flow for "the factors of choice" identified in the first step. In the next step the possibility and the operational way of integrating both layers (the planning stage and the stage of controlling the flow) should be determined. "The core of integration" which has been created constitutes the foundation of building a hybrid system.

The next fourth step is connected with using selected support tools. They support the realization of functions from the level of planning and the level of the flow. It is a level of so called horizontal integration, which is process integration in the chain of planning and the chain of a physical flow. In the fifth step the final structure of the model of an identified hybrid model is created.

The further developments of the model - the concept of a dedicated system are connected with the stage of its verification during the implementation and operational functioning.

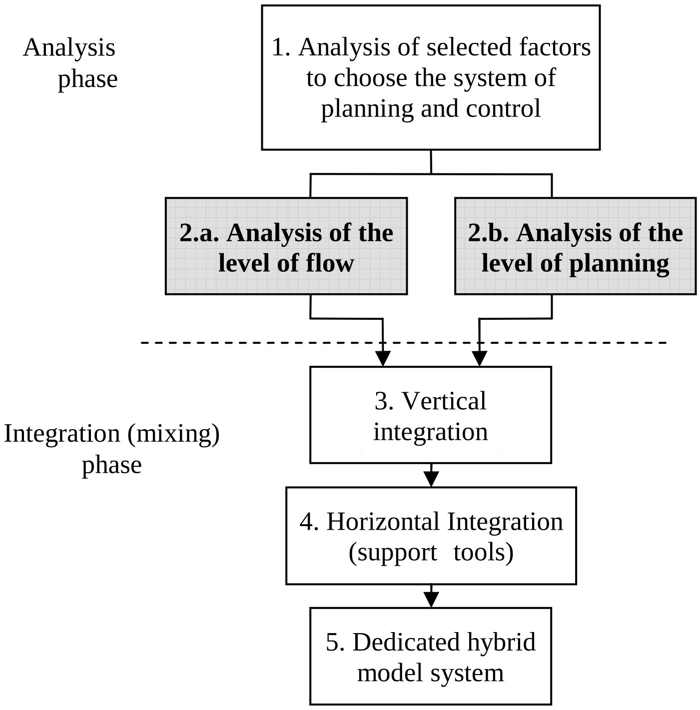


Fig. 1. Framework methodology of constructing a dedicated system of planning and shop floor control of production
Rys. 1. Ramowa metodologia konstruowania dedykowanego systemu panowania i sterowania przepływem produkcji

Description of the manufacturing environment - the place of the research

The work on the development of the tailored production planning and shop floor control system started with a thorough identification of the existing practices in the company. The discussed company's functioning can be described as traditional, with a hierarchical and centralized planning structure supported by an MRPII/ERP system. On the level of long-term planning (1 year), annual sales plans/forecasts are drafted to verify revenue and costs and to roughly balance the demand for output capacity in terms of machines and staff. On the level of medium-term planning (1-2 months), sales plans and confirmed orders are used to develop production and supply plans. In the short term, production is ordered to start in the foundry (the department beginning the production process). Orders are pushed along further departments (the push flow logic) all the way to the Assembly Department (where the final product is prepared to put on the market) or the processing department (orders for a partner in the supply chain). The planning of machine duties is tentative and the assignment of tasks to individual workstations is planned according to their technological profile.

In our analysis of the production planning and control system, we identified the following issues:

- on the long- and medium-term level:
  - low level of plan integration, both vertically (Management Board-Managers) and horizontally (supplies-production),
  - low level of the implementation of MRPII/ERP (marked C according to the ABCD Checklist),
  - low planning discipline (no clear process owner);
- on the short-term and running control level:

- numerous conflicts about resources,
- chaotic, spaghetti-like flow for the Processing Department,
- large batches,
- variability of production priorities.

In conclusion, the production system displayed significant instability in the duration of the production lead time. The variations in the production lead time were directly related with high (and expensive) level of work in progress both on the shop floor (in the process) and in inter-department storehouses. Under these circumstances, it was difficult to ensure a high logistics service level. The level of service essential for the Management Board from the perspective of the credibility of the supply chain was achieved at the cost of high levels of stock and expensive interventions in production plans (overtime work, priority changes, short batches).

A tailored planning system - framework transformation path

The changing of the company's production planning system took place in the following sequence:

- analysis of the possibility of shaping diagnosed organisational conditions,
- formulation of planning principles based on the Best Practice analysis,
- transformation of the planning system and physical flow based on the Lean production model,
- framework concept for system integration and its implementation.

In the first step, we identified the organisational situation of the company and discussed which of them could actually be changed. What turned out to be particularly important here were long-term customer relations and market characteristics (e.g. the occurrence of the end-of-the-month syndrome and its effect on the method of planning). In the next step we formulated the principles of planning for the company by reviewing Best Practices in production logistics and supply chain management. The key conclusions here are the following:

- the pull logic in planning allows for better control of flow in the links of the process,
- information on demand should be shared along the entire chain of the process, the moment something pertinent happens at any of its links,
- the location of the decoupling point should be specified based on market requirements (Customer Tolerance Lead Time and demand characteristics).

At a further remove, these were used as the leading principles for the construction of the tailored planning system. The basic direction of the transformation included the modification of the MRPII planning logic (so far operating unsatisfactorily) and the push flow logic (see fig. 2.). On the diagnostic stage, it was established that the MRPII computer system operates on a low implementation level (class C according to the ABCD Checklist), a decision was made to use the existing application for handling orders and planning demand for components, or to function according to the MRP logic.

The balancing of potential in a long-term perspective was entrusted to integrate planning in the form of Sales and Operation Planning. S&OP took over the role of MRPII, supporting decisions on such areas as liquidity, human and machine resources balancing and supply function planning. On the executive level, the main aim was to increase the flow intensity by the practical implementation of the flow and pull lean production steps.

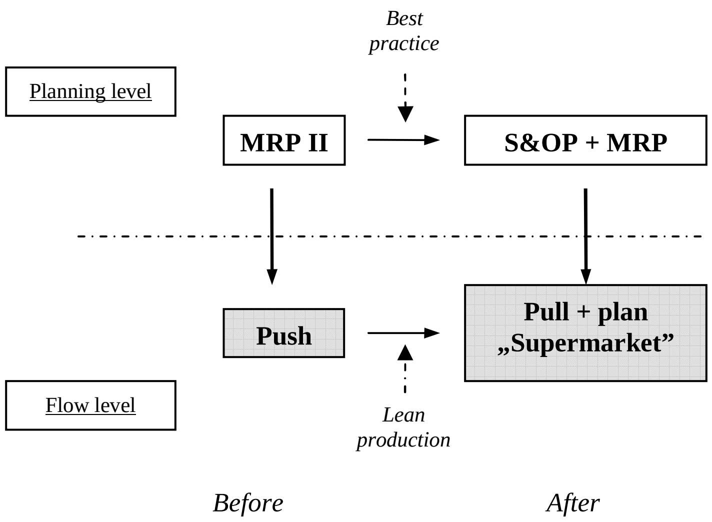


Fig. 2. The direction of transformation of the production planning system
Rys. 2. Przyjęty kierunek transformacji systemu planowania produkcji

Implementation in running business conditions - specific modification of solution

On the level of planning, the activities started with the modification of the existing MRPII planning logic in the ERP system. The principles for the construction of an S&OP integrated plan were developed. The S&OP team members were selected as well as information input and output, manner of information processing and the procedure for information approval and distribution. Based on such market conditions as:

– the volume and regularity of demand for a given group,
– key accounts (long-term contracts),
– the accuracy of forecasts or conditions for the maintenance of emergency stock,
– and the policy of product range development,

all 500 items in the sales plans were divided. The following categories were distinguished: Engineering to Order (ETO), Assembly to Order (ATO), Make to Stock - Open to Buy (MTS OTB) and MTS Buffer. The categories were located in the S&OP based on contracts and forecasts (production capacity reservation). The ready S&OP model was then embedded in the existing ERP system. The implementation process was finished by developing procedures for the planning of volume and monitoring of monthly buffers for MTS OTB and MTS Buffer, the development of a seasonal stock taken into consideration.

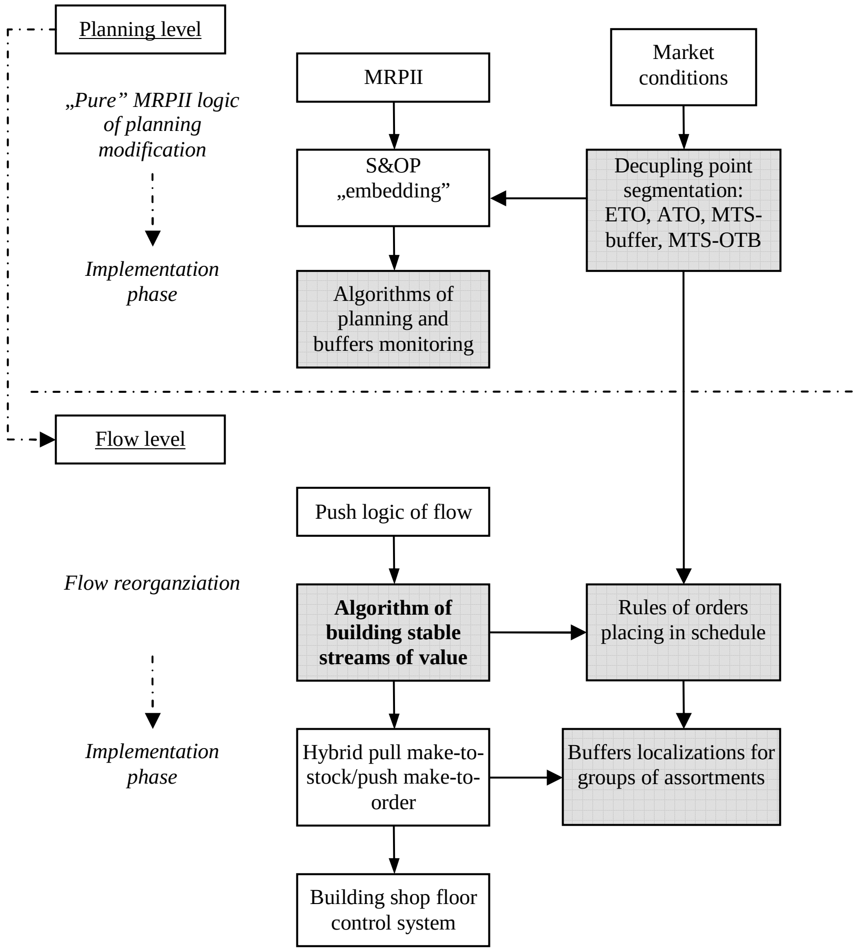
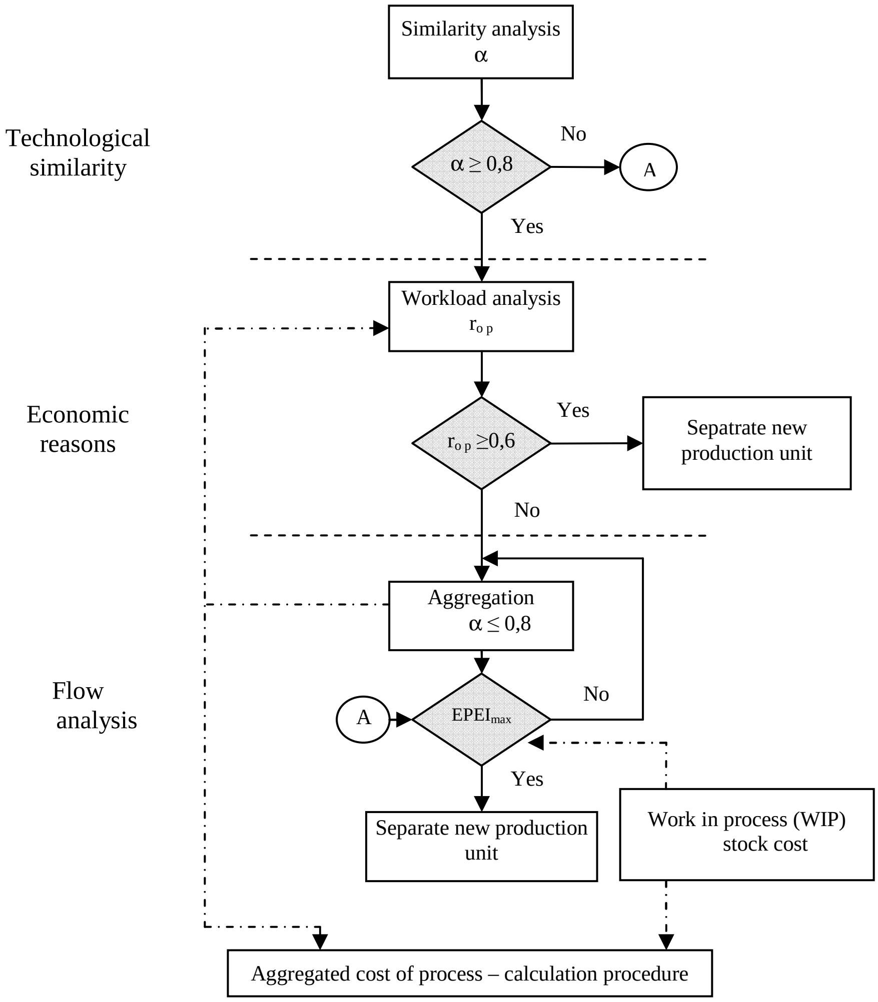


Fig. 3. The process of the transformation - sequence and critical decision
Rys. 3. Proces transformacji - sekwencja oraz krytyczne decyzje

On the level of flow, the reorganization started with the transformation of the push logic of flow into a flow initiated by demand of links down the stream of value. The framework methodology of the activities involved: the identification of value streams, creation of continuous flow and the introduction of principles for the initiation of pull flow. The reorganization was conducted using an original algorithm for establishing production units for the benefit of stable value streams (see Figure 4.). In the design of the algorithm, we considered the existing organisation of the Processing Department: the spaghetti-type flow, the range of products (500-700 items in the sales plan) and the volume and repeatability of orders. The analysis of technological similarity [Domanski and Hadas 2008] and the volume of works showed that it is impossible to build stable streams of value in line with the Lean philosophy.



α (alfa) – similarity coefficient
r_{op} – average load for each group of machines
$EPEI_{max}$ – every part every interval (maximum value)

Fig. 4. Manufacturing unit separation algorithm for building stable streams of value
Rys. 4. Algorytm wydzielania jednostek produkcyjnych w procesie budowy stabilnych strumieni wartości

It was here that the decision essential from the point of view of the future planning system was made. A system based on the Pull Make to Stock logic was selected instead of one based on the Pull Make to Order logic. The establishment of production units was essential to facilitate planning sequence and the control of the production cycle. It was decided to establish production units (see Fig. 4.) with the maximal possible duties (economical reasons) without a dramatic effect on the duration of the production lead time (analysis of aggregated EPEI). This was necessary to maintain an acceptable level of inter-departments buffers in the production process.

In the next step, market conditions contained in the ETO, MTS-buffer etc. categories were "crashed against" the developed organisation of material stream flow. The outcome is a mixture of the Pull Make-to-Stock/Push Make-to-Order systems. Then, the location of buffers was defined for each product group and specific procedures for production flow control were developed.

The final form of the planning and shop flow control system

The final form of the planning and shop flow control system is the result of the initial concept (transformation according to the Lean philosophy) having been significantly modified in consequence of encountered restrictions, however without losing the purpose of the transformation.

On the level of planning, the system transformed from a classic hierarchical planning in line with the MRPII logic to an S&OP model with MRP algorithm material planning. The model covered 18 months with a one-month planning accuracy. The system became the basis for liquidity analysis and long-term balancing. What changed on the level of operational planning and flow control were information feeding and the sequence of initiating tasks. Order execution priorities were redefined for product groups. On the executive level, logic of buffer renewal was introduced in 1-2 week cycles (depending on product group) as well as the principles for the optimization of retooling sequences in the event of non-rhythmic production. As mentioned above, here the system took on the form Pull Make-to-Stock/Push Make-to-Order. However, for product groups covered by the Pull Make-to-Stock solution, different mechanisms of initiating tasks were adopted. For the MTS-buffer category, this was the classic buffer penetration mechanism. It needs to be noted that in the Assembly Department, the buffer penetration mechanism was physically implemented by means of a supermarket and in Processing Departments by means of control of work-in-progress stock. The MTS-OTB category featured a "plan like supermarket" mechanism; in this mechanism, the collection from buffer in a period of one week is at the same time the weekly task for the preceding link (which does not wait for actual physical collection). This solution allowed for reducing the level of inventory at inter-departments work-in-progress buffers and for optimizing the sequence of works within a weekly task. Both issues are important as, if successful, they contribute to the aim of shortening and stabilizing lead time. In a situation when it is impossible to build a one-piece flow-type, this is the alternative way to achieve the aim.

The construction of a tailored solution with such varied solutions raises many questions concerning how reasonable it is to apply many practices and to modify them under the specific circumstances. Some issues worth mentioning here are the unorthodox character of the principle of production leveling or the need to monitor the lengthening the production cycle depending on machine duties. During the transformation, we identified the influence of establishing production units (for highly variable works) on the production cycle and the buffers controlling the pull mechanism.

CONCLUSION AND FUTURE RESEARCH

In any case, the development and implementation of a hybrid planning and shop flow control system is not an easy task. An operation on the living organism of a manufacturing company always involves many issues which cannot be predicted at the conceptual stage. The designing of the development path for a company and, what follows, the direction of its transformation, turn out to be a task that practically can only be done in a tentative manner, i.e. on the level of aims, framework solutions and measurement methods. The practice of implementing at a very early stage of preliminary calculations verifies the applicability of individual solutions or the classic sequence described in the literature of the subject. It is necessary to mark out your own, flexible path for transformation. In the discussed case the idea for the construction of a MRP/JIT hybrid system evolved from the classic Lean path to a fully tailored way of implementation. The final solution itself also took on the form of quite a specific hybrid, which, however, turned out to be the most reasonable from the point of view of the existing and forecast (for a perspective of 3 years) internal or market restrictions.

In conclusion, it should be noted that the final system is not static. It will evolve as a consequence of both continued B+R activities within the company and the changeability of the market environment. Currently, work is in progress on the definition of the audit cycle for critical aspects of the functioning of the planning and control system. Both time and merits-based range of the audit will be specified. The purpose of this cyclical schedule for monitoring the system is to prevent the effect of inert drifting, typical of many transformations.

The research work is aimed at creating a general methodology for the selection, implementation and evolutional shaping of the planning and shop flow control system. This methodology should limit the probability of taking the wrong way in the transformation, increase the effectiveness of implementation and overcame the inertia to the existing system (based on the measurement of the "hard" parameters). The practice of enterprise transformation shows that there is a need for such methodology as much of the work done ended in failure. The main causes of this failure are the following: selection of a wrong way of transformation, wrong selection and modification of tools on the operational level and the inertia of the system once implemented.

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PRAKTYKA BUDOWY SYSTEMU PLANOWANIA PRODUKCJI PRZEDSIĘBIORSTWA O SZEROKIM ASORTYMENCIE PRODUKOWANYCH WYROBÓW - STUDIUM PRZYPADKU

STRESZCZENIE. **Wstęp**: Złożoność środowiska produkcyjnego dzisiejszych przedsiębiorstw z branży budowy maszyn oraz istniejąca liczba wewnętrznych i zewnętrznych ograniczeń funkcjonowania wpływa na potrzebę budowy dedykowanych systemów planowania przepływu produkcji. Stwierdzenie to jest szczególnie ważne w warunkach firm z szerokim asortymencie produkowanych wyrobów oraz różnych strategiach obsługi klienta (różnych lokalizacjach logistycznego punktu rozdziału). Strumienie materiałowe w takich warunkach wymagają odmiennego sposobu zarządzania, co jest głównym powodem prowadzenia badań przez autorów w tym zakresie.

Metody: Badania przeprowadzono w przedsiębiorstwie budowy maszyn o złożonej wielowydziałowej strukturze produkcyjnej. Celem prac było usprawnienie przepływu produkcji w warunkach szerokiej gamy produktów (ok. 500 pozycji) tworzącej kilkadziesiąt strumieni wartości oraz różnych wymagań rynkowych co do czasu i poziomu obsługi klienta w odniesieniu do poszczególnych grup asortymentowych.

Wyniki: W artykule opisano proces budowy dedykowanego systemu zarządzania przepływem produkcji. Autorzy przedstawiają krótkie teoretyczne rozważania na temat problemu oraz zdobyte doświadczenia praktyczne. Autorzy przedstawiają czynniki wyboru ścieżki transformacji systemu planowania produkcji, na podstawie diagnozy stanu obecnego, jej ramowy algorytm oraz wybrany aspekt wydzielania strumieni wartości o rożnych strategiach obsługi klienta (różnych lokalizacjach logistycznego punktu rozdziału).

Wnioski: Wypracowanie metodyki transformacji systemu produkcyjnego nie jest zadaniem prostym. Niniejszy artykuł przedstawia tylko wybrane aspekty złożonego procesu decyzyjnego jaki towarzyszy pracom nad transformacją systemu zarządzania przepływem produkcji. Niemniej autorzy artykułu kreślą obszar ich dalszych badań inspirowanych potrzebą praktyki przemysłowej.

Słowa kluczowe: Rekonfiguracja systemu produkcyjnego, logistyczny punkt rozdziału: Make to Order (MTO), Make to Stock - Open to Buy (MTS OTB) and MTS Buffer.

PRAKTISCHER ANSATZ ZUM AUFBAU EINES SYSTEMS FÜR PRODUKTIONSPLANUNG IM UNTERNEHMEN MIT EINEM BREITEM SORTIMENT VON HERGESTELLTEN ERZEUGNISSEN

ZUSAMMENFASSUNG. Einleitung: Komplexität des Produktionsumfeldes in heutigen Maschinenbauunternehmen sowie Bestehen von inneren und äußeren Funktionseinschränkungen beeinflussen heutzutage die Notwendigkeit des Aufbaus von detektierten Planungssystemen innerhalb der Fertigungsströme. Diese Feststellung ist besonders wichtig für die Firmen mit einem breiten Sortiment von hergestellten Erzeugnissen und den verschiedenen Kundenservice-Strategien (mit verschiedenen Standorten des logistischen Verteilungspunktes). Gerade in solchen Bedingungen bedürfen die betreffenden Materialflüsse eines anderen Managements, was als Hauptursache der von den Autoren in diesem Bereich betriebenen Forschungen anzusehen ist.
Methoden: Die einschlägigen Forschungen wurden im einem Maschinenbauunternehmen von einer Mehrbereich-Produktionsstruktur durchgeführt. Das Ziel der Arbeit war es, den Produktionsfluss bei einer reichen Produktpalette (ca. 500 Positionen), die mehrere Wertschöpfungsströme bei unterschiedlichen Marktanforderungen bezügl. Zeit und Kundenservice-Niveau angesichts der einzelnen Sortimentsgruppen bilden, zu vervollkommnen.
Ergebnisse: Im Artikel wurde der Prozess des Aufbaus des detektierten Produktionsfluss-Managementsystems dargestellt. Die Autoren setzen sich theoretisch mit diesem Problem kurz auseinander und stellen die in der Wirtschaftspraxis gewonnenen Erfahrungen vor. Sie zeigen aufgrund der Diagnose des gegenwärtigen Zustandes Faktoren für die Auswahl des Transformationspfades für die Produktionsplanung und dessen Rahmen-Algorithmus sowie den ausgewählten Aspekt für die Abgrenzung der Wertschöpfungsströme mit verschiedenartigen Kundenservice-Strategien (mit verschiedenen Standorten des logistischen Verteilungspunktes) auf.
Fazit: Die Ausarbeitung einer Umsetzungsmethodik für Produktionssysteme stellt eine anspruchsvolle Aufgabe dar. Der vorliegende Artikel setzt sich lediglich mit ausgewählten Aspekten des Entscheidungsprozesses, der die Unternehmungen bei der Transformation des Managementsystem des Produktionsflusses begleiten, auseinander. Gleichwohl zeichnen die Autoren hiermit den Bereich der weiteren betreffenden, seitens der Industriepraxis inspirierten Forschungen ab.

Codewörter: Rekonfiguration des Produktionssystems, logististischer Verteilungspunkt: Make to Order (MTO), Make to Stock - Open to Buy (MTS OTB) and MTS Buffer.

Łukasz Hadaś, Ph.D. Eng.
Faculty of Engineering Management
Poznan University of Technology
e-mail: lukasz.hadas@put.poznan.pl
Piotr Cyplik, Ph.D. Eng.
Faculty of Engineering Management
Poznan University of Technology
e-mail: piotr.cyplik@put.poznan.pl