ALGORITHM OF THE IMPLEMENTATION OF CONTINUOUS FLOW IN UNBALANCED PRODUCTION UNIT CONDITION – CASE STUDY

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Abstract This article shows step by step process of creating general algorithm saying how to implement continuous flow in production companies. Article is based on real environment of medium Polish production company, which produces steel halls. After presenting basic information about TOC and LEAN tools it shows and algorithm showing activities and sequence made in real company. Authors proposed solutions referred to both the material flow changing's and the information flow changing's. Main goal was adapt production process to unchangeable work of bottleneck. After all, results of production flow simulation after implementation of above solutions were presented. Finally, authors created algorithm based on techniques and tools implemented in mentioned company. It shows in general what production engineers should do step by step while implementing continuous flow in production.

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1. INTRODUCTION

TOC is one of the young conceptions of modern management, based on analysis of process bottlenecks. First person, who proposed this way of solving management problems, was Israel physicist PhD Eliyahu M. Goldratt.

Main goal of this conception is to focus all attention on one stage of process named as "bottlenecks". Those are the areas, which are necessary for whole process and also has the greatest importance to the timely obtaining of final goods and total system capacity. Theory of Constrains is based on following tools and management techniques (Hadaś & Karaśkiewicz, 2012):

- Drum – Buffer – Rope tool,
- Continuous Replenishment method,
- Five Focusing Steps tool.

Improvement of production on the basis of this concept is to increase the capacity of bottleneck, i.e. to minimize the negative effects or complete elimination of them. Continuous improvement of manufacturing processes is, in this case, to pass the mentioned stages (Hadas & Cyplik, 2013). While planning to reduce or eliminate the impact of bottleneck, can be done through the use of Drum – Buffer – Rope tool (Gardiner, Blackstone, & Gardiner, 1993). It is a planning technique maximizes the flow of materials in the production system with a strong reduction potential.

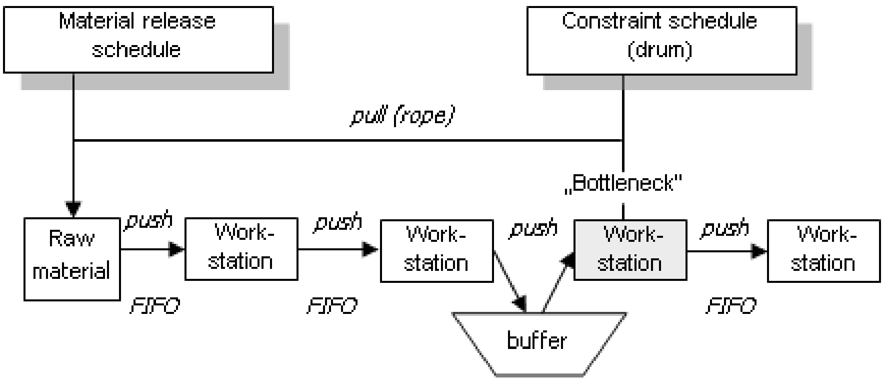

Fig. 1 The idea of Drum-Buffer-Rope methods (Hadaś & Cyplik, 2010)

The concept of lean can be considered as a kind of philosophy of continuous efforts to achieve optimal organization, taking full advantage of the potential which includes the most valuable resource – employees. The process of achieving excellence in the area of lean production can be summed up in five basic principles (Harris & Rother, 2004); (Liker, 2005) called as 5 steps process of lean implementation:

- Step 1. Define value from the point of view of the customer (Specify Value)
- Step 2. Identify the value stream (Identify the Value Stream),

- Step 3. Creating a continuous flow (Flow),
- Step 4. The introduction of the “pull” system (Pull),
- Step 5. Continuous improvement (Perfection).

In summary TOC and LEAN methods are essential for the transformation of the production system. Nevertheless, in practice, specific actions are dependent on identified organizational conditions, with cannot be changed or reorganized in the way that those methods requires.

2. COMPANY REALITY – PLACE OF RESEARCH

The place chosen for the researches is an enterprise from the Wielkopolska region. This company has been in business as an independent entity since 1996, as a limited liability company. The share capital is 100% Polish. The company is privately owned. It specializes in the design, installation and production of modern multi-functional structures. Production is carried out under MTO (make-to-order) that is it depends on the customer needs and is characterized by a high degree of customization. In addition to a wide range of precast tin ware elements, company also undertakes tasks with a high rate of complexity. Production is planned on two shifted workday.

The company has its own production hall of steel structures, the machinery and personnel that is prepared to produce a wide range of products. The company uses only certified raw materials. It has two full lines for automatic welding. Plant is equipped with modern machines and NC equipment, which will significantly expand the range of products and guarantee their quality. The following table shows the course of the stream analyzed taking into account the workload on individual positions.

Table 1 Workload of workstations, (own study)

	Finished beam	**Welded Beam**	**Additional elements**	
	time [min]	time [min]	time [min]	
Sum [min]	126	211	43	53
			<15 mm	>15 mm

Production flow starts at the position of SAW on which the material is transported from the external storage, and ends in a room used to dry painted blanks. Production is made up of three main streams assortment: finished beams, welded and other components separated according to its thickness for: under or equal 15 mm or above 15 mm.

3. IMPLEMENTATION OF MATERIAL CONTINUOUS FLOW CONCEPTION

This section below presents algorithm of activities done in company for optimization.

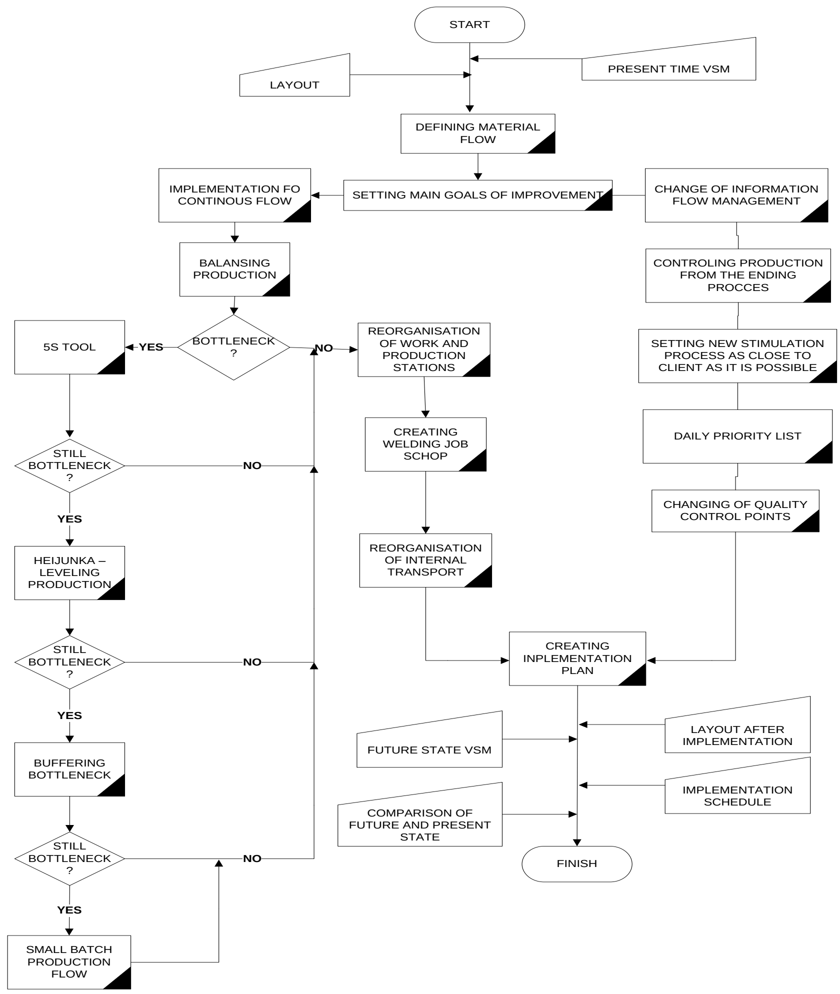

Fig. 2 Algorithm of optimization activities of production system (own study)

It contains four kinds of shapes that mean what's following:

- ellipse shows beginning and ending of process;
- trapeze shows data used as basic information goes inside and outside the whole process;
- rectangles are activities made by authors during process;

- rhombus shows conditional activities;
- arrows as order of activities.

In the beginning authors sets two main goals: change of information flow management and implementation of continues flow. As too a see below both goals were reaching parallel. It gave to company synergy effect of improvements. One of these goals refers to material flow, other one to information flow. Whole algorithm ends with results that are: new layout and VSM, implementation schedule and comparison of present time end effects of implementation. Next two sections (3.1 & 3.2) describes algorithm in details.

3.1. Combining TOC with Lean Management tools in material flow optimization

Based on VSM of present time and Layout of firm authors decided to combine some elements of the logic of the Theory of Constraints and Lean Management. This choice fits the most to character of production. Optimized material streams flow values for each product family is based on the following concept of Lean Management (Gowland, 2005):

- Japanese control tool based on Kanban cards,
- Implementation of a "supermarket" as buffer,
- The use of logic “pull' using small parts flow,
- Implementation of Heijunka - leveling, balancing of production.

Elements of production optimization technology based on Theory of Constraints TOC, applicable in the newly designed system are:

- Drum - Buffer - Rope tool
- 5 Focusing Steps method.

Thanks to the combination of the items listed above, specific tools the authors assume improvement of a parameters characterizing production (e.g. capacity, balanced time of operations, time savings, staff savings etc.) and improvement of the flow of streams. Engineered solutions are presented in the following sections.

3.2. Information flow changes

Previously used "push" method of flow forced scheduling process on "production input". This resulted a high level of storage "in progress" products, and the occurrence of unnecessary production stoppages at different positions. On the other hand optimization of information flow based on:

- scheduling process directly associated with the customer,
- establishing daily priorities list of production,
- changing quality check points.

According to the Theory of Constrains tool Drum-Buffer-Rope, Painting process was chosen as a scheduling process. It was recognized also as a process of stimulating the production, in order to maximize the use of the bottleneck.

Some things also have been changed in, as important as material flow, information flow. According to Lean Management, one process is scheduled – that one which stimulate the whole process. On the other hand, the choice was based on fifth phases of Five Focusing Steps which tells how to identify the bottlenecks limits, and how to eliminate it, according to Theory of Constrains. Localization of constraints was able thanks to analysis of the throughput which was use in area of analyzing each operation time, and retooling time of machines and tools. Identified a "bottleneck" allows then to analyze the cost of the downtime which is always a strong argument for managerial decisions. (Hadaś & Gania, 2007),

When choosing above process, a huge impact had an order of operations and places in where it is possible to implement continuous flow. It was decided that Painting is that process, as it's the process closest to client. In this way we can exclude overproduction. This process is called stimulus because there are sent daily production orders and the list of priorities, and then those information are transferred upstream. So it stimulates the production system and its location prevents the phenomenon of "isolated islands". At the same time it become a drum, whose work is still scheduling, protected by buffer and advised by pull type production line ("rope").

Next step was to establish daily priority list. That was list of semi-products irrefutably needed for creating end product -steel hall. It contains not just a quantity, but also order of production. It can be said that it was daily production schedule (Hadaś, Karaśkiewicz & Jakubik, 2013).

4. EFFICIENCY IMPROVEMENTS - COMPARISON

Numerous improvements proposed by the authors of this work have been thoroughly characterized in previous chapters. In this section they analyses the impact of these changes on the operations times for each product family at every position.

Comparing the data for present and future states, projected effectiveness of the implemented changes is shown. Comparison in the table 2 (Hadaś, Karaśkiewicz & Jakubik, 2013). Above results are presented in three shifts of work. It is worth mentioning, that after implementation of upgrades on third shift there is only one position working – Short-blasting Machine. Thus, not only amount of producing elements were higher, but also almost whole third shift were eliminated, what gives huge costs savings of employment.

It can be concluded, that the proposed changes should increase the production capacity of the company by 50% for finished beams and 33% for welded beams. Summing the two values in order to achieve the level of improvement for the entire company would be a mistake. It is necessary to determine the relative efficiency, which is 43% (estimated). It should be noted that this figure refers only to production and does not include the cost of employment. Considering employment costs on daily shifts and third shifts (night) and taken into account in determining the performance, it could be much higher than 43%.

Table 2 Estimated efficiency of implemented improvements, (own study)

	Present state	**Future state**	**Efficiency**
	3 shifts	3 shifts	
Finished beams	12 (units)	18 (units)	50,0%
Welding beams	9	12	33,3%
Additional elements	27/33	18/22	-33,3%

5. CONCLUSION

Making the conclusion of the work done can try to present a generalized algorithm for on the way to building a continuous flow in the conditions unbalanced production unit. Although work has been done in specific industrial conditions characterized by a variable make to order production, however consists of stages, which can be a repetitive sequence for this type of analysis (Fig. 3).

The first step in the analysis is to create a Visual Stream Mapping of the current situation, which provides information about the physical organization of the shop floor, control information of the flow and the time sequence of technology and batch transfer between the job stations. The classic VSM picture of the according to lean management, it does not provide all the relevant information. Under conditions of high volatility assortment (make to order) is necessary analysis which showing impact of the production plan on:

- the load of machines,
- the possibility of establishing a common tact time,
- changeover sequences.

No satisfactory results in terms of: machines load (idle waiting for work) and the length of the production lead time and the level of work in progress are the starting point for the project of improvements.

Changes are oriented on two main aspects:

- the physical reorganization of the flow of material streams,
- reorganization of the mechanism of production planning and shop floor control.

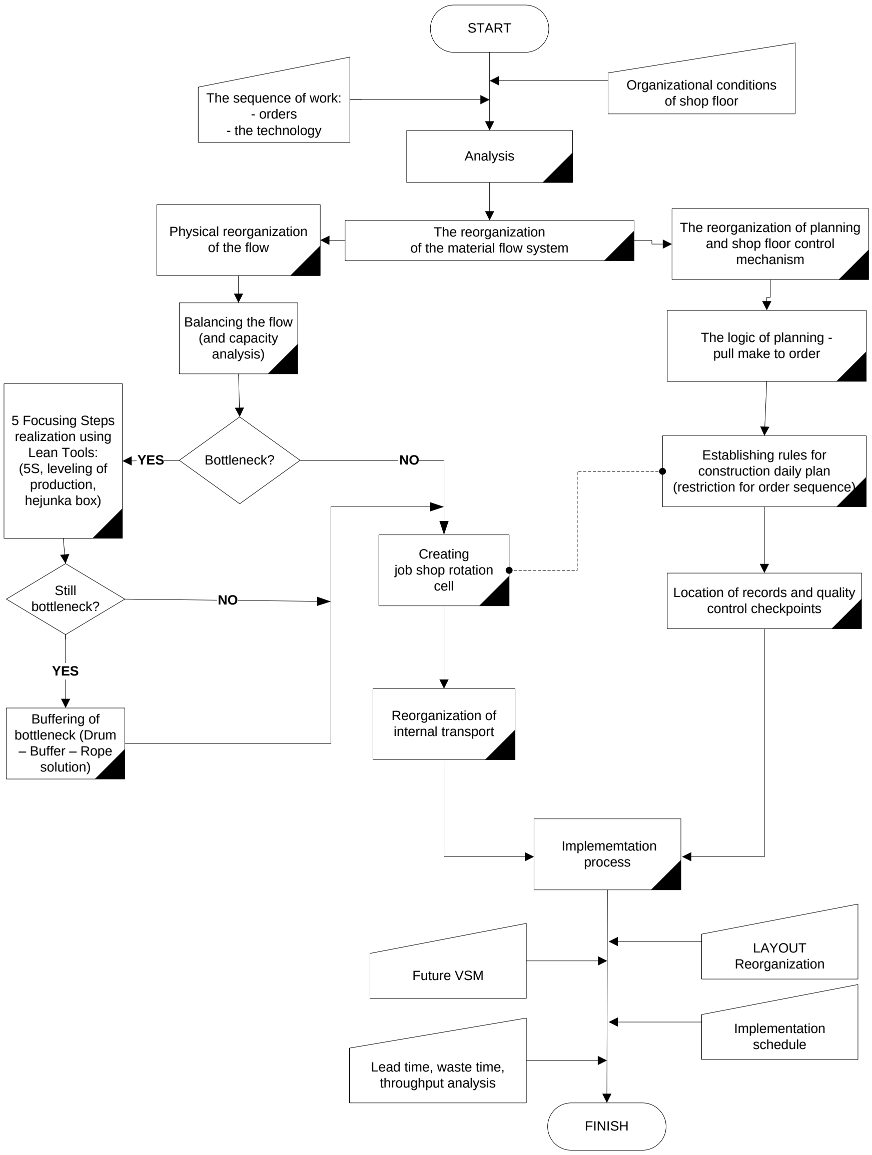

Fig. 3 General algorithm of the transformation unbalanced production unit (own study)

The physical reorganization of material streams beginning an analysis of throughput of specialized technology units to identify potential 'bottlenecks'. If there is any, it is an attempt overcome (it is the realization of 5 Focusing Steps by TOC methodology). The implementation 2nd step (exploit) and 4th step (elevate) is based on lean tools (Fig. 3). The inability of constraint overcome determines the need to implement a mechanism drum-buffer-rope. The main aspect here is the need for buffering critical resource (by the use of a supermarket). In the next step of the analysis we are searching production unit is the most "sensitive" to sequence the work. In this unit (which may be a "bottleneck" or not) there is a need for a load balancing of stations (strong waste as a result of the expected on work, confirmed by load graph of machines).

In the production unit implementation the principle of staff rotation in order to balance the flow. Staff rotation is helps by the establishing the rules of building works sequence for the daily plan (see link in the Figure 3). Improving the flow of the entire production unit usually requires the reorganization of the internal transport system (so that it does not become a "bottleneck" of the process).

The reorganization of the planning mechanism is specific because:

- it initiates the process of physical transformation (change the logic of planning from "push" to "pull"),
- its final form depends on the real possibility of physical transformation.

Thus, there was the strong feedback. The real implementation is to determine:

- rules for building work sequence for daily plan,
- place of location of checkpoints and records in the material streams.

The next step is the work of the implementation process, which consists of determining the future state map (VSM), change the layout, establish a timetable for the implementation of changes, and analysis of the results (in terms of reducing lead time and waste and increase in throughput).

In conclusion it should be noted very clearly that as a result of the work done has not been achieved continuous flow strictly understanding of Lean Management (one – piece flow, continuous flow) because of the characteristics of technological operations in the company. Nevertheless proposed changes have improved the basic parameters of Lean Production as shortening the production lead time and reduced waste (idle waiting for work).

REFERENCES

Gardiner S.C., Blackstone Jr. J.H., & Gardiner L.R. (1993). “Drum-Buffer-Rope and Buffer Management: Impact on Production Management Study and Practices”, International Journal of Operations & Production Management, Vol. 13 Iss. 6, pp. 68-79.

Gowland E. (2005). “Lean Manufacturing and the Theory of Constrains – Focusing Lean, prezentacja multimedialna”, Constrains Management users conference 2005.

Hadaś Ł., & Cyplik P. (2013). Theory of constrains i lean production – Idea, narzędzia, praktyka zastosowania, Politechnika Poznańska, Poznań.

Hadaś Ł., & Cyplik P. (2010). “TOC (Theory of Constraints) w logistyce produkcji – teoria i praktyka zastosowania”, M. Fertsch, Ł. Hadaś, P. Cyplik (Eds.) , Logistyka Produkcji – Teoria i praktyka. ILIM, Poznań.

Hadaś Ł., & Gania I. (2007). “Analiza kosztów przestoju zasobów krytycznych – Case Study”, Skawińska E. (Ed.), Zarządzanie Przedsiębiorstwem, Instytut Inżynierii Zarządzania - Politechnika Poznańska, Poznań, pp. 291-296.

Hadaś Ł., & Karaśkiewicz F. (2012). “Multi-project environment management using the critical chain method”, K. Grzybowska (Ed.), Contemporary management – learning and knowledge in business, Publishing House of Poznan University of Technology, Poznań, pp. 171-192.

Hadaś Ł., Karaśkiewicz F. & Jakubik B., (2013). “Implementation of continuous flow – stimulation by bottleneck aspect”, Enterpice Management – The customer perspective and internal processes management, Wydawnictwo Politechniki Poznńskiej, Poznań, pp. 23-36.

Harris R., & Rother M. (2004). Tworzenie ciągłego przepływu. Przewodnik dla menadżerów, inżynierów i pracowników produkcji, Wrocław Center for Technology Transfer, Wrocław.

Liker J. K. (2005). Droga Toyoty. 14 zasad zarządzania wiodącej firmy produkcyjnej świata, MT Biznes, Warszawa.

BIOGRAPHICAL NOTES

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