RESEARCH IN LOGISTICS & PRODUCTION

LOGISTICS ENGINEERING IN A PRODUCTION COMPANY

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Abstract In the systemic approach, a production company is a complex system of objects and the relations between the objects as well as between the system and its surroundings. The large number of variables and company performance assessment indicators results in the constant search for the methods of formalising the mutual dependencies. The discipline which, through the integration of multiple processes, enables the discovery of practical solutions is logistics engineering. In Poland, the term is not very common, while in the USA (for example), logistics engineering – taking advantage of mathematical methods and cutting edge science is a widely used tool supporting the everyday business activities of companies. The article describes primary tasks of logistics engineering in relation to production companies. Furthermore, original algorithms for the improvements of company productivity are presented.

Paper type: Research Paper

Published online: 19 October 2015
Vol. 5, No. 5, pp. 503-513

ISSN 2083-4942 (Print)
ISSN 2083-4950 (Online)

Keywords: *logistics, production system, logistics engineering, lean methods*

1. INTRODUCTION

The term: logistics engineering in Poland seems hardly known at all – definitely, it is not very commonly used. The popularisation of the term is worth considering, especially when systemic actions in multiple areas (e.g. production and logistics) are planned in order to improve the productivity of the company. Even more so, considering that the understanding of the term: engineering is currently becoming much wider than its traditional definition. Until now, the term engineering has been accepted to mean the activity involving the design, construction, modification and maintenance of cost-effective solutions for practical problems, using scientific and technological knowledge. Nowa Encyklopedia Powszechna PWN (The New Universal Encyclopedia, 2004) provides the most general definition of engineering as: "technological work resulting in an object (prototype), production method (technology) or change in the environment". Therefore, linking engineering with creative activity resulted in the creation of terms, such as: environmental engineering, mechanical engineering, materials engineering, surface engineering and many others. Scientific progress results in the widening of the areas covered by the term engineering. For example, previously unheard of terms, such as: biomedical engineering, genetic engineering or sociology engineering become more and more popular. Generally, it can be said that the engineering of any discipline involves the practical application of mathematics and other sciences in the technical production of this discipline.

In the United States of America, the term logistics engineering is commonly used. There is also an organisation (structurally similar to CSCMPs) – The Council of Logistics Engineering Professionals (CLEP). Interestingly – many renowned universities offer programmes with the same name (e.g. NCSU Course Catalog, 2015). According to the Council of Logistics Engineering Professionals (CLEP):

"Logistics Engineering: The professional engineering discipline responsible for the integration of support considerations in the design and development; test and evaluation; production and/or construction; operation; maintenance; and the ultimate disposal/recycling of systems and equipment. Additionally, this discipline defines and influences the supporting infrastructure for these systems and equipment (i.e., maintenance, personnel, facilities, support equipment, spares, supply chains, and supporting information/data). The practice of logistics engineering is exercised throughout the system life-cycle by conducting the iterative process of supportability analysis and the accomplishment of trade-off studies to optimize costs and system, logistics, and performance requirements."

In Logistics Engineering Handbook (2008) G. Don Taylor wrote: "The fact is, there are few, if any, significant differences between business logistics and engineering logistics except that logistics engineers are often charged with handling the more "mathematical" or "scientific" application in logistics.

An objective and challenge for the future is to address logistics in much broader context, reflecting a total system approach."

2. THE ROLE OF LOGISTICS ENGINEERING

The role of logistics engineering in a production company is the development and preparation of a system of activities which, by the application of the rules and laws of logistics as well as other scientific disciplines, enable the performance of logistic tasks supporting the achievement of the effects specified in the strategy for the company. The primary strategies include:

- high customer service quality,
- World Manufacturing Class,
- achievement of the desired (specified) performance,
- achievement of the specified economic and technical indicators.

The logistic tools and methods useful in the logistics of the company are generally known (Bicheno, 2008, Michlowicz, 2010, Lödding, 2013). Their application depends (besides the adopted strategy) on the abilities, knowledge and skills of the technical and management staff as well as the assumed scope of activities. The selection of the area and methods for task implementation is the first, crucial phase of the activities aimed at achieving the desired goals.

2.1. The logistics system of the company

Figure 1 shows a simplified diagram of a system encompassing the most important areas in which the laws and rules of industrial logistics can be applied.

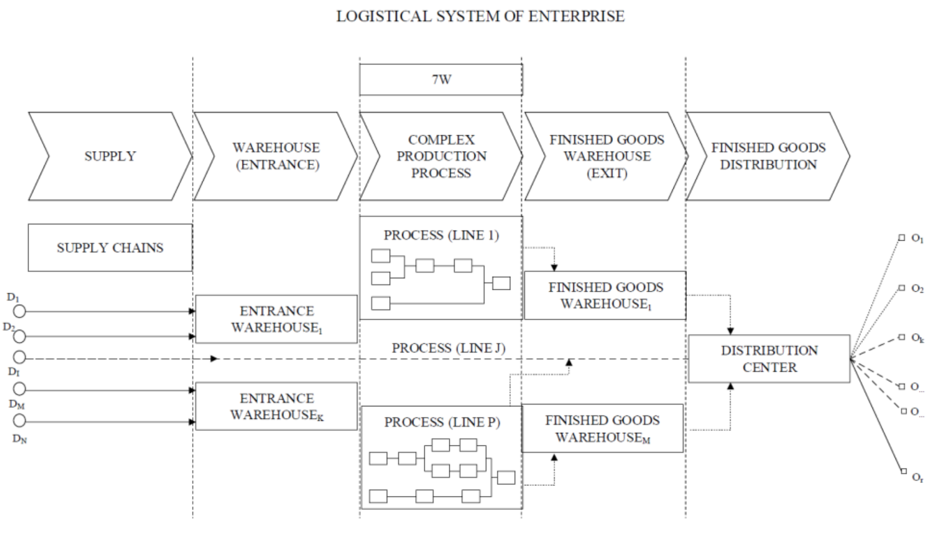


Fig. 1 Logistics System of a Production Company – LSPC

The second stage of the activities aimed at the improvement of the effectiveness of a production company should involve the development of an appropriate process algorithm. The process which involves the largest share of capital and is crucial to the potential success of any production company is manufacturing. Manufacturing moves the main flow of materials through the production departments of the company. This flow depends on multiple factors – the structure of the production system definitely has the largest impact on the flow processes (Michlowicz, 2012) It seems obvious that, from the logistic perspective, the appropriate control of the material flows in the production system should be one of the chief logistic processes. "Appropriate control" should mean the method of control which guarantees the continuity of production processes in accordance with the 7R logistics principles and 9 PLP production logistics principles (Nyhuis, 2009).

Assumption in planning implementation processes:

There is constant monitoring of the effects of company business and key performance indicators are specified for the production area (performance, effectiveness, productivity).

Table 1 shows a list of basic tasks necessary for the improvement of the functioning of the production system

Table 1 Basic tasks to be implemented in the production system

Basic tasks				
Supply strategy (choice of suppliers)	demand for warehouse space	manufacturing strategy (continous material flow)	storage area	distribution strategy
Classification of components (ABC, XYZ, Pareto)	admissions technology (including identification)	Basic Laws of Production Logistics (9 PLP)	stocks analysis	picking
Forecasting	stocks model location (ABC) means of transport	WIP lean toolbox (VSM, TPM) IIS (MRP, ERP)	storage technology	customer service models reverse logistics optimization (VRP)
Computer assistance - common hardware and software platform **Indicators of efficiency evaluation**				

During the selection of methods enabling the improvement of the effectiveness indicators, two groups of methods are available:

- non-logistic methods (according to Taylor (2008) they include mainly: Management Science (MS), Operations Research (OR) and Artificial Intelligence (AI),
- logistic methods (Lean – Enterprise, Production techniques, production logistics principles (Nyhuis, 2009, Michlowicz, 2015).

2.2. Problems of logistics engineering in the production process

Currently, the key to understanding the operations of a company is the awareness, that it functions as a part of a larger system. The development of the SCM concept forces the companies to transform from functionally-oriented to process-oriented organisations. The common element, shared by different approaches to logistics are material flows and their skillful management. Therefore, the means to achieve this goal should be flow control methods. In relation to supply chains, Nyhuis and Wiendhal (2009) said directly that: The fundamental goal of production logistics can thus be formulated as the pursuance of greater delivery capability and reliability with the lowest possible logistic and production cost.

Currently, the integration of production planning and logistics becomes popular in many companies (Kaczmarczyk, 2011). The algorithm enabling the analytical consideration of material flow processes in a production company will be presented below. Figure 2 shows typical rules of controlling material flows.

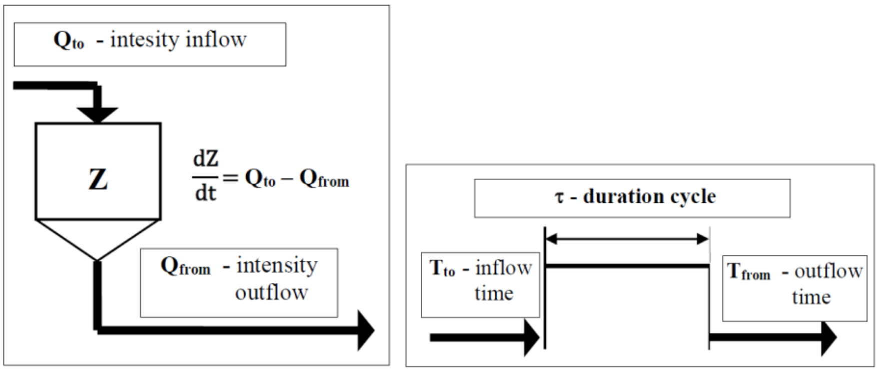


Fig. 2 Rules for controlling the flow Q and time T

The flow of materials through the equipment and warehouses (buffers) can be formulated as follows (according to Tab. 2 and Figs. 3, 4, 5).

If the values describing logistics processes are (Tab. 2):

Table 2 Process-describing values designation

Value designation	Value description
i, j = 1, 2, …n	consecutive numbers of production equipment UP, i.e. $(i \in UP, j \in UP)$
k = 1, 2, …p	batch number of the material MT flowing between the equipment, $(k \in MT)$
s = 1, 2, … st	consecutive numbers of transport equipment UT, $(s \in UT)$

m = 1, 2, … ma	warehouse number MA, ($m \in MA$)
$M^{w}_{i,j}(k)$	shipment moment of the *k* batch of material from point *i* to point *j*
$M^{d}_{i,j}(k)$	delivery moment of the *k* batch of material from point *i* to point *j*
$t^{s}_{i,j}(k)$	total time of transport cycles (loading, transport, unloading, return) of the *k* batch of materials, with transport means *s* from point *i* to point *j*
$\Delta t^{m}_{i,j}(k)$	time spent by the *k* batch of material at warehouse *m*, between points *i* and *j*
$t_j(k)$	time of the *k* batch of material crossing the point *j* (time of *k* batch service on equipment *j*)
$t_{pj}^{(a)}$	time of conversion of the *j* equipment for the production of (*a*) products

then:

- the delivery moment of the k batch of material from point i to point j is given by the formula:

$$M^{d}_{i,j}(k) = M^{w}_{i,j}(k) + t^{s}_{i,j}(k) + \Delta t^{m}_{i,j}(k) \tag{1}$$

- shipment moment of the k batch of material from point i to point j:

$$M^{w}_{i,j}(k) = M^{d}_{i-1,j}(k) + t_i(k) \tag{2}$$

- shipment moment of the k batch of material from point j to point l:

$$M^{w}_{j,l}(k) = M^{d}_{i,j}(k) + t_j(k) \tag{3}$$

however, two cases should be taken into consideration:

- if:

$$M^{d}_{i,j}(k) < M^{w}_{j,l}(k-1); \quad (case\ 1)$$

the moment of delivery of the k batch of material to the j production equipment is earlier (before) than the moment of shipping the previous (k – 1) batch of material from the j production equipment to the l equipment, the material before the j equipment is stored for the period of Δt mi,j (k);

- if:

$$M^{d}_{i,j}(k) > M^{w}_{j,l}(k-1); \quad (case\ 2)$$

the moment of delivery of the k batch of material to the j production equipment is later (after) than the moment of shipping the previous (k – 1) batch of material from the j production equipment to the l equipment, the j equipment awaits (is in "downtime") for the period of $\Delta t_j(k)$.

The flow of materials through the equipment and warehouses (buffers) can be formulated as follows (Figs. 3, 4, 5). Figures 3, 4 and 5 contain a graphical representation of the flows.

Material flows description:

- for UP production equipment

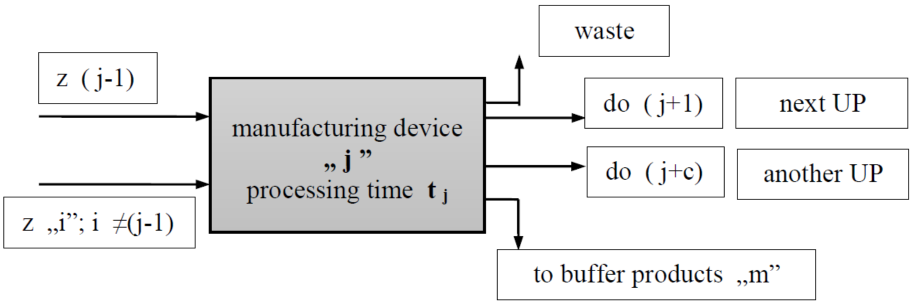


Fig. 3 Diagram of material flow through the UP production equipment

- for transport equipment

a) material transport to the UP production equipment through a buffer

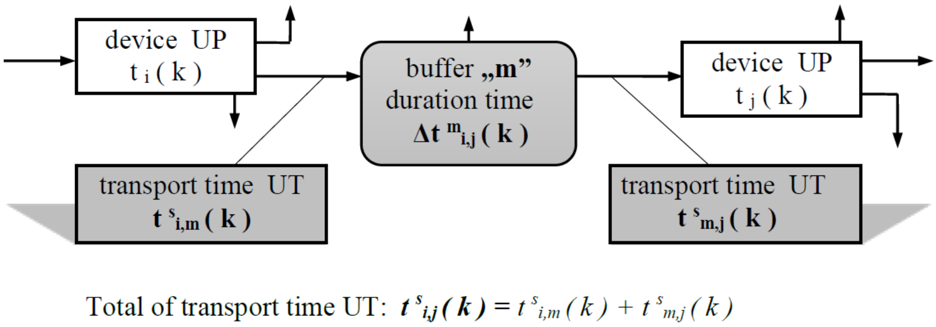


Fig. 4 Diagram of material flow through the buffer

b) transportation of the material between UP units without storage

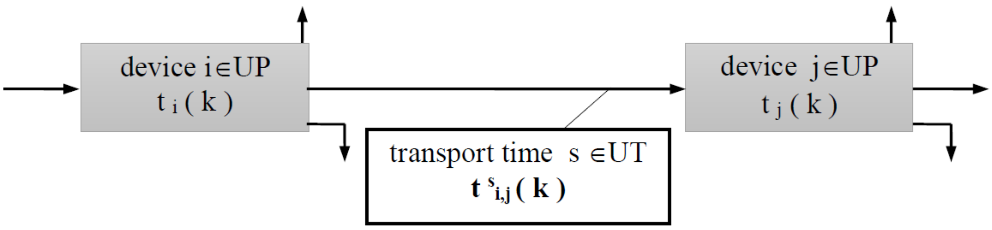


Fig. 5 Diagram of material flow between the UP production equipment units

In practice, professional computer software is more commonly used than analytical deliberations. The authors of this study, for example, use the Witness Process Optimizer (version 13) simulator which enables dynamic modelling, simulation and streamlining of business processes in a production company (production, stock, effectiveness, productivity, process balancing).

3. FLOW TESTING ALGORITHMS

The task of improving flow continuity can be implemented in several phases:

Phase I – Process identification.

Phase II – Selection of improvement methods and tools.

Further phases depend on the selection of methods providing the desired improvement of effectiveness (Michlowicz, 2015). For production companies with broad product portfolios and frequent conversions, it becomes necessary to develop at least two additional algorithms:

- for the SMED (Single Minute Exchange of Die) method in order to reduction the conversion time,
- for the Kanban control system (for selected processes and assortments).

The first stage requires a very accurate identification of all processes related to production and logistics.

Stage I – Process identification – should include the tasks:

1. Selection of process for analysis.
2. Making a detailed diagram of the technological process.
3. Collection of process data, such as: orders, deliveries, stock, etc.
4. Designation of the primary parameters and values describing the process, providing the required time study for the durations of operations.

Phase II – Selection of improvement methods and tools – should involve

5. Description and analysis of losses and waste in the process (e.g. 7 muda, 6 big losses).
6. Selection of the right tool (VSM, TPM,SMED, Kanban).

The time study is a very important element of developing the value stream. It should not be treated solely as measuring the time of specific tasks and operations. A time study implemented at a station structure is frequently a source of information regarding the possibilities of changing the arrangement of elements forming the specific station.

An example of a good time study (fragment) which resulted in the proposition of changing the arrangement of objects is presented in table 3.

In case of selecting the VSM (Value Stream Mapping) method, the algorithm is described by the consecutive phases: IIIVSM, IVVSM and VVSM.

Phase IIIVSM – development of the current status map.

Phase IVVSM – proposed modifications and dates for implementation.

For the TPM method, the algorithm described phases from IIITPM to VITPM.

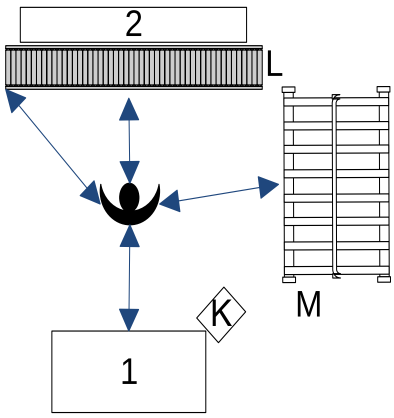
Phase IIITPM – identification of machine operation (failures, Pareto, MTTR, MTBF).

Phase IVTPM – determination of the OEE effectiveness ratio (determination of the availability, performance and quality).

Phase VTPM – implementation of modifications (e.g. reduction of downtimes).

Phase VVSM and Phase VITPM – analyses of effects after the introduction of the modification and continuous improvement by relentless adherence to kaizen principles!

Table 3 Time study for a window frames fitting station – fragment

Frame fitting (operators: 2)			
Station diagram	No	Action description	Time [s]
 M – frames storage, K – computer, 1 – templates station, 2 – rack with fittings, L – assembly line		**Operator 1**	
	1	Approaching the frames	2
	2	Frame collection	3
	3	Frame placement on the assembly line	3
	4	Number scanning	3
	5	Frame stamping	3
	6	Picking up the knife	2
	7	Cutting foil on the edges	20
	8	Laying down the knife	2
	9	Fittings collection	6
	10	Template collection	6
	11	Fittings adjustment	50
	12	Picking up the drill-driver	2
	13	Screws collection	3
	14	Screwing in the fittings	50
	15	Laying down the drill-driver	3
		Total time of operation [s]	**148**

4. CONCLUSION

The broadly defined production management currently proposes many different methods and techniques for the improvement of the functioning of production systems.

Some of these methods have been developed within the framework of the Lean Enterprise (Production) concept. The systems related to the organisation and control of material flows, such as: 5S, 7 Muda, SMED, 5W+1H, JiT, Kanban and integrated IT systems, such as: MRP, ERP are commonly known.

The development of the strategies related to the supply chain and lean thinking involves going outside the scope of own company. This leads to a systemic approach towards production-related problems.

In order to streamline the processes related to material flows, it seems beneficial to additionally apply logistics engineering which integrates multiple business processes in a production company.

Without making any claims as to the importance of different methods of improving effectiveness, the old saying by J. Weber (Michlowicz, 2012) that "it doesn't matter who does a thing, as long as it is done" is worth remembering.

ACKNOWLEDGEMENTS

This work was supported funded by research project AGH University of Science and Technology 15.11.130.965.

REFERENCES

Bicheno J., Hollweg M. (2008), The Lean Toolbox: The essential guide to Lean transformation, Picsie Books, Johannesburg.

Kaczmarczyk W. (2011), Wybrane modele planowania wielkości i szeregowania partii produkcyjnych, Wydawnictwa AGH, Kraków.

Lödding H. (2013), Handbook of Manufacturing Control. Fundamentals, Descrition, Configuration, Springer - Verlag, Berlin Heidelberg.

Michlowicz E. (2010), "New challenges in production logistics", Fertsch M. (Ed.) Innovative and intelligent manufacturing systems, Publishing House of Poznan University of Technology, Poznan, pp. 7-22.

Michlowicz E. (2012), Zarys logistyki przedsiębiorstwa, Wydawnictwa AGH, Kraków.

Michlowicz E., Smolińska K. (2015), "Research on the flow of material in production logistics", [in:] Research in Logistics & Production, Vol. 5, No.1, pp. 21-31.

Nowa Encyklopedia Powszechna PWN (2004), Wydawnictwo Naukowe PWN, Warszawa

Nyhuis P., Wiendhal H.P. (2009), Fundamentals of Production Logistics. Theory, Tools and Applications, Springer – Verlag, Berlin Heidelberg.

Taylor G. D. (2008), Logistics Engineering Handbook, CRC Press Taylor & Francis Group, Boca Raton.

www2.acs.ncsu.edu – North Carolina State University Course Catalog (accessed 10 July 2015)

BIOGRAPHICAL NOTES

Edward Michlowicz is a Professor at AGH University of Science and Technology in Krakow. He works at the Faculty of Mechanical Engineering and Robotics at the Department of Manufacturing Systems. The research deals with the industrial logistics, transport systems, as well as the application of operations research in logistics systems. For many years, prefers the use a systemic approach in terms of general systems theory.

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