PRODUCTION LOGISTICS CONCEPTS AND SYSTEMS IN METALLURGICAL COMPANIES

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Abstract
The article defines operational production logistics and summarises operational production logistics concepts and systems, which are mostly used in engineering production. It discusses specific features of metallurgical productions and limited possibilities of application these concepts and systems in that field. Advanced Planning and Scheduling systems are recommended as a promising approach for eliminating the limitations.

Keywords: operational production logistics, metallurgical production, PPC systems, APS

1. INTRODUCTION
As production systems become more and more complex where many types of machines, workers, and parts are involved, the production logistics activities have become more complicated and harder to execute and coordinate. They become even more difficult when the production system needs to adapt to fast-changing market needs. Nowadays, production logistics has become more challenging as manufacturing companies adapt to a globally competitive environment of fluctuating demand, larger product variety, time-based competition, flexible capability [1]. The known production logistics solutions are built on principles and needs of engineering production. Many specific features are, however, typical for metallurgical production, which significantly limit the possibility of direct application of these concepts and systems. The objective of this article is to present possibilities of application of the operational production logistics concepts and systems in metallurgical companies.

2. OPERATIONAL PRODUCTION LOGISTICS CONCEPTS AND SYSTEMS
Definition of production logistics can be formulated in accordance with Council of Supply Chain Management Professionals definition of logistics management: “Production logistics deals with planning, implementing and controlling efficient and effective flow and storage of materials, semi products, final products and related information in production processes of enterprises for the purpose of conforming to customers’ requirements.” Production logistics concerns not only with flow sections where materials and products are handled, transported and stored but also with technological sections, particularly from viewpoint of their time duration and way of capacity fulfillment. Production logistics is in close connection with the control of technological processes. Production logistics is essentially applied in two management levels- strategic and operational. The strategic level of production logistics includes basic decisions of medium-term to long-term character the general task of which is to create conditions for providing trouble free, economical production process while, at the same time, securing favourable working conditions [2]. The operational level of production logistics aims at medium-term to short-term time horizon. The operational production planning and control are the most commonly used terms in this context.

Production has changed radically. The amount of needed materials, semi finished products, components and parts has been growing sharply and, consequently, so has the complexity of production logistics. It is obvious that bigger and bigger customer requirements cannot be satisfied at acceptable costs, without new solutions in that field. Since the 70s a lot of integral concepts and systems have been created for supporting the production logistics, mainly on operational level of the logistics management. These are mostly called
Production Planning and Control (PPC) systems. There are three approaches which can be considered as groundbreaking. They can be called “MRP way”, “OPT way” and “JIT way”. MRP systems represent the “MRP way”. Their original purpose was developing the material requirements plan respecting master production plan and minimizing emergence of inventories. Development of these systems was carried out in form of extending their functionality to present-day Enterprise Resource Planning (ERP) systems. The “OPT way” started with OPT system, software product for production planning and control taking into account capacity bottlenecks. OPT ideas lead to development of DBR scheduling system and Theory of Constraints (TOC) concept. The “JIT way” started at Toyota Production System (TPS). The basic purpose was maximal shortening of production lead times and in elimination of all losses in production process. TPS ideas lead to development of integral concepts and systems, currently known as kanban, Just-in-Time (JIT) and Lean manufacturing.

3. PRODUCTION LOGISTICS IN CENTRAL AND EASTERN EUROPE METALLURGICAL COMPANIES

Transformation of Central and Eastern European countries to the market economy was that turning point. In planned economy customers felt permanent lack of products. The advantage was on the manufacturer’s side (no competition among producers was allowed). They used it for easy accomplishment of the required economic results, particularly for reducing the costs. Manufacturers could produce relatively limited assortment of standard quality in big production batches.

The conditions for manufacturers changed radically after the transformation of Central and Eastern European countries to market economy:

- Necessity of multiplex extent increase of production assortment
- Pressure to reduce delivery times
- Diminished delivery quantities
- Emphasis on higher quality and products with higher added value etc.

In metallurgical industry, production assortment rose from thousands of items to tens of thousands of combinations of grades, shapes, sizes, heat treatments and surface finishes. From the previous delivery terms of one up to three months the terms of several week or even days became necessity. Order quantities to the extent of several tons are interesting for metallurgical producers nowadays, while in planned economy, there were delivery quantities in hundreds of tons. [7]

Of course, this situation causes frequent adjustments of the manufacturing facilities, a drop in utilization rate of the manufacturing equipment, a growth of inventories of semi and final products and, as a final consequence, production economics is getting worse.

Facing these changes, metallurgical companies of Central and Eastern Europe have started solving the problems connected with production logistics. The first, partial solutions were followed by more and more complex ones. Finally integral logistics concepts and systems have been implemented.

4. THE POTENTIAL FOR USE OF PRODUCTION LOGISTICS CONCEPTS AND SYSTEMS IN A METALLURGICAL COMPANY

The production logistics concepts and systems are built on principles and needs of engineering production, which can be characterized mainly by [8]:

- Relatively complex products with outright description – drawing number and construction and technological documents for each product
- Generally, minimum preparation time and costs in relation to production time
• Assembly production character
• Frequent use of buffer warehouses

Many specific features which can be summarized in the following points are, however, typical for metallurgical production:

• Character of production and its assortment structure – metallurgical products do not consist of components, they are made of refined material of certain shape, size, structure, physical, chemical and other qualities which make their utility value. Despite the illusory simplicity of metallurgical products, their quantity is considerably high. Combinations of grades, shapes, sizes, heat treatments and surface treatments make up as many as tens of thousands of items of rolled products.

• Production batch economy – increasing demand of customers for decrease in order volume and the growth of assortment range in metallurgical plants have their economic limits. If frequent setups necessary for small orders of wide assortment range are accepted it can make production uneconomic. The orders can be put together (sequence of continuous casting machines, campaign on rolling mills) only in case of commonly manufactured assortment. This fact draws even more attention when you realize that, very often, the equipment had originally been designed for mass production of simple assortment.

• Low degree of freedom among the individual processes, parts of the logistics chain – processing liquid metal does not allow any storage which would offset the eventual fluctuation in supply, production or consumption. However, storage possibilities are very limited even if the metal is in solid phase. The economic viewpoints are the main reason here. Cooling molten semi-finished product and its ensuing heating results in very high costs of thermal energy consumption. The eventual storage also leads to high inventory holding costs.

• Various characteristics of follow-up processes – there are processes with different technological character, various cycle times and quantity processed in one cycle in a single chain.

• Great number of production links – variability of production methods is typical for integrated metallurgical companies. There are often more technological methods of steel production, more steel customers (continuous casting machines, forging shops, and foundries), various secondary metallurgical operations, and various treatment operations.

• High capital demands – especially high demand for energy and material (around 2.5 tons of various materials are used for 1 ton of pig iron) and, of course, investment costs and production equipment depreciations.

• Trouble-free supply and removal of material in case of continuous processes, large material flows, and necessity of holding large volume of raw materials in ore storage yard are just a few others.

The defined specific features of metallurgical production significantly limit the possibility of direct application of production logistics concepts and systems.

For the meantime, the most frequent applied solutions are from category MRP / ERP systems. However, these systems do not correspond to recent trends of production and market fully. There was identified complex of requirements which are necessary for effective production logistics and which the MRP / ERP systems don’t offer [10]:

• Possibility of planning, delivery times verification, identification of the closest possible time, proposal of an alternative time or a quantity to be delivered in required time
• System flexibility, a possibility of considering different alternatives
• Possibility of planning and evaluation of impacts connected with including in of priorities
• Possibility to control orders flow and their selection in the case of capacity excess
• Permanent control of inquiries, orders, and contracts processing and information about problems in the processes
5. APS SYSTEMS – PROMISING TOOL FOR OPERATIONAL PRODUCTION LOGISTICS IN METALLURGICAL COMPANIES

APS system can be defined and explained through different perspectives but commonly APS system is viewed as an extension of ERP system. On the other hand, standard APS modules stem from the many in-house developed DSS that aid planners at various levels in the decision hierarchy [11]. Unlike traditional ERP systems, APS systems try to find feasible, near optimal plans across the supply chain as a whole, while potential bottlenecks are considered explicitly [12]. Three main characters of APS system are integral planning, true optimization and hierarchical planning system [11]. APICS Dictionary defines APS system as follows: “Techniques that deal with analysis and planning of logistics and manufacturing over the short, intermediate, and long-term time periods. APS describes any computer program that uses advanced mathematical algorithms of logic to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting, demand management, and others. These techniques simultaneously consider a range of constraints and business rules to provide real-time planning and scheduling, decision support, available-to-promise, and capable-to-promise capabilities. APS often generates and evaluates multiple scenarios. Management then selects one scenario to use as the “official plan”. The five main components of APS systems are demand planning, production planning, production scheduling, distribution planning, and transportation planning” [13]. Stadtler and Kilger categorize different APS modules depending on the length of the planning horizon on the one hand, and the supply chain process that the module supports on the other [12]:

- Strategic network planning – covers all long-term planning processes with extra weight given to plant location and design of the physical distribution structure
- Demand planning – covers the strategic- and mid-term sales planning
- Demand fulfilment and ATP – is used in the short-term sales planning, e.g. when making delivery promises
- Master planning – can be seen as the hub of the planning modules; here the company’s capacities are taken into consideration in the mid-term planning level
- Production planning and scheduling – covers processes such as lot sizing, machine scheduling and shop floor control
- Transport planning and distribution planning – is often covered by two different modules, which together covers the mid- and short-term distribution processes
- Purchasing and material requirements planning – is connected to the mid- and short-term procurement processes

Figure 1 shows the most common standard APS system modules according to these two dimensions. The main objective of the production planning and scheduling module is to support the planner in creating a feasible production plan. Depending on the complexity and the requirements of the business, a feasible plan may be a list of orders per shift or an exact sequence of the operations for each resource [14]. APS systems
are usually designed to cover all classes of scheduling problems and are able to consider many real-world constraints like resource capacity, minimal and maximal constraints between operations, secondary resources and multi-operation resources, shelf life, storage resources, etc. Common options and scheduling algorithms of an APS system to support the creation of a feasible production schedule are [14]:

- Interactive manual planning allows the planner to change the schedule of operations and orders, for example via drag & drop in a Gantt chart – the advantage here is that the impact of a planning step is immediately visible
- Scheduling rules in APS systems enable the use of different kinds of criteria for scheduling operations
- Generic heuristic algorithms for scheduling, which calculate good schedules in an acceptable runtime

![APS system planning structure and modules](modified according to [12] and [15])

### 6. CONCLUSION

APS systems have been already implemented in metallurgical companies. The biggest problem is the applications are used only for a limited part of the metallurgical logistics chain – for example only for steelworks or rolling mill plant. Unfortunately, an optimal production plan and schedule in these two plants is very different. Steelworks works with sequence of continuous casting machines (putting together work orders with the same steel grades) and rolling mills with rolling campaigns (where shapes and sizes of final products are crucial). These applications don't respect basic logistics principle – system approach – and don't allow exploiting the whole potential of APS approach. There is the first, in European scale unique, complex
application of APS system in the Czech metallurgical enterprise TŘINECKÉ ŽELEZÁRNY, a.s., which uses the approach for planning and scheduling the whole metallurgical cycle [16]. However, it is only the first step to integral applications, which allows to plan and schedule production of all members in metallurgical supply chain.

REFERENCES


