SCIENTIFIC PAPERS
OF THE UNIVERSITY OF PARDUBICE
Series A
Faculty of Chemical Technology
17 (2011)

IDENTIFICATION OF MAIN PROBLEMS OF SUPPLY CHAIN MANAGEMENT IN COMPANIES OF CHEMICAL AND METALLURGICAL INDUSTRY

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Received September 30, 2011

In the last two decades, companies have been aiming at creating supply chains on company and inter-company basis. The forms of the individual chains and their management are, however, affected by specific conditions resulting above all from the nature of the production systems that are included in the chain. If the managers want to make an adequate decision regarding the management of material flow in the given chain, they must first identify the specifics of the chain in question and the main problems slowing or stopping the material flow taking place within the chain. This article deals both with the contemporary method of management of material flow in chains with chemical-technological and metallurgical production processes, and with the problems also arising in these chains during management of material flows.

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Introduction

In the last two decades, companies have been aiming at building not only their own supply chains, but also at linking them with supply chains of their suppliers and customers. Since the initial rather coordinating activities, they have been gradually moving towards the implementation of cooperative activities based on the Collaborative Supply Chain Management (CSCM). However, this is not always easy and the companies usually face a number of problems the consequence of which is slower or temporarily complete halt of the flow of materials. The ultimate negative phenomenon is the emergence of stocks in various places of the supply and customer chain. The detection and elimination of these problems is therefore the key element in achieving the primary objective, which is smooth material flow throughout the entire chain. Some of the problems arise no matter what the supply chain is like, i.e., they are of general nature.

Some of the problems are specific and they occur in chains with the involvement of companies of certain industrial branches. Knowing these problems then allows you to set a rational way of managing material flow by the individual companies within the chain, and the chain as a whole. So far, the professional literature has, however, been focusing on describing the ideal material flow on the company and inter-company level, or on the general problems associated with it. It has so far been impossible to find a scientific article on logistic problems inhibiting or interrupting the flow of materials in chains involving chemical and metallurgical companies. These chains are specific mainly due to the nature of the production systems contained in them. When compared to the assembly types of production, they are based on physical and chemical processes taking place within technically and technologically sophisticated apparatus equipment. The metallurgical industry also links physical and chemical processes with mechanical and technological forming processes. The products do not consist of components; they represent heat treated material of certain shape, size, and structure, physical, chemical and other properties that make their utility value. The common features of both the industrial branches are then reflected in similar problems associated with supply management of the company and the supply chain.

That is why the key objective of the article is to develop certain theoretical knowledge of the major problems arising in supply management, namely in chains containing chemical-technological and metallurgical production processes. The starting point for achieving this goal is to understand the real control of material flow on company and inter-company level, contained in the following five research activities:

1. Qualitative research carried out on its own in a selected company engaged in chemical industry (December 2007 - May 2008). The research was focused on mapping of company process systems of the selected SBU (Strategic Business Unit) and their course, the possibility of acceleration based on the Quick

Response method and on barriers of implementation of this method dealing with company process systems. The main aim of the primary research was to map what processes are being realized in the given SBU to provide value to the individual customers, their internal structure and the possibility of their acceleration in order to increase the customer value, and also to identify the barriers of implementation of the Quick Response method. The partial research objectives were:

- To characterize the selected products of the SBU which were used to map which processes take place in the SBU and how they run, including the business strategy used in sales of these selected products.
- To determine whether the company realizes differentiated CRM (whether it segments the customers according to their value and explores what the main differentiating features are) during the sales of the given products.
- To explore the current progress of the individual processes (especially marketing and sales, planning and realization of production, including the provision of energies, procurement, transport and maintenance).
- To explore how it would be possible to accelerate the satisfaction of customers (especially the key ones), (how to adjust the company processes system in general, and how to modify the form of the individual processes) and, within the scope of that, to find out how the new arrangement of information flow would help.
- To determine whether the QR method or its principles have already been implemented in the company, and what conditions must be met for this method to be applied.

The method used for collecting the primary information was based on personal interviews with the aid of scenarios for interviewing company employees (the specification of the sought information was reflected in the questioning scenario). The respondents consisted of SBU manager, product manager responsible for sales of selected products, SBU production manager, SBU head of purchasing, administrative staff of sales and purchasing and other managers of the individual SBU processes. The research was carried out for two selected products.

2. Qualitative research conducted in selected chemical, food and automotive industry companies (June 2008 - October 2008). The main aim of the primary research was to map what information the company collects prior to the decision regarding the delivery method, what logistic strategies it uses (tactics and operation) in relation to its customers and whether it varies with the value of the customer for the company. Further, it aims at exploring the possibility of accelerating the service of the individual segments (niche segments) of customers and the conditions of implementation of the QR and CPFR methods. The partial research objectives were in principle identical with the partial objectives of the previous research, but this research was focused on examining only the logistic processes (unlike the previous one which examined other

selected internal company processes). The research method was the same as the method used in the previous research. The questioned people were in particular the managers of marketing, sales, purchasing and logistics departments of selected companies of the above mentioned industries.

3. Research carried out within the scope of GAČR No. 106/02/0487 project named the Application of Artificial Intelligence in the Logistics of Metallurgical Companies of the Region of North Moravia and Silesia (2002 - 2004). The project included an analysis of production and sales logistics of metallurgical companies leading to identification of the main logistic problems the metallurgical companies face. The basic part of the analysis was performed in VÍTKOVICE STEEL, a.s. (today EVRAZ VÍTKOVICE STEEL a.s.).
4. Research within the scope of the solution of a project of specific research SP/201060 Demand Forecasting as a Key Element of the Application of the DCM Concept (Demand Chain Management) in the industrial and technological chains (2010). The main objectives of the project were to define the possible application of prediction of integrated demand in supply chain management, the possible applications of the principles of DCM in management of industrial and technological chains and the development of an integrated demand forecasting system for metallurgical companies and chains.
5. Research included in the project of specific research SP2011/85 Modern Approaches and Tools for Management of Industrial Systems (2011). The solution to the project includes research on the specific features of metallurgical industry in relation to the possible applications of the lean principles in metallurgical companies and chains. The research was performed among the managers of metallurgical companies and university professionals with long-term involvement in the problems of management of metallurgical companies using the Delphi method.

The collection of the primary information, the processing and content analysis, and the subsequent synthesis of the results of the individual research projects have become the foundation for meeting the main target of this scientific work.

Theory

In the past decade, companies have begun recognizing not only the need for continuous quality improvement and meeting the needs of their immediate customers, but they have also realized the necessity of competing quickly and efficiently in the ever-changing global markets. As a result of that, the Supply Chain Management (SCM) has come to the forefront as a philosophy through which firms can operate on an inter-company level, and merge both the strategic initiatives and upstream and downstream processes in order to achieve business excellence [1]. SCM is a system that contains multiple entities, processes and activities from suppliers to customers. It can be seen that different perspectives of SCM have been proposed, either from the area of product flows, financial flows, and information flows perspectives or from the perspective of relationship among the entities within the chain [2].

The basic concept behind SCM is how the raw materials and information flow from the supplier to the manufacturer, before the final distributions to customers as finished products or services [2]. The material flow management is focused on purchasing, production and distribution activities in which transport, warehousing and packaging operations are used in various rates [3]. The success of a supply chain depends on the efficient and effective flow of goods that insures the right products are in the right place at the right time [4].

SCM arose through the gradual integration of logistics, distribution, marketing, operations, product design, product procurement and operations as the channel members had come to realize that they are part of a value chain extending from raw material extraction to finished goods consumption and that all the channel participants could benefit from smoothing the flow of product, information, and title [4].

Although it has long been obvious that actions taken by one channel member of supply chain can have a positive or negative impact on other channel members, only recently has a spirit of cooperation through SCM been introduced, moderating the historically adversarial relationship between the channels [4]. Firms have strived to achieve greater collaborative advantages with their supply chain partners [5], the task of managing collaboration in business process management becomes increasingly important [6].

The collaborative advantage will be realized when all parties in the supply chain, from suppliers to customers, cooperate [5]. In the supply chain world, “teams” of suppliers, finished goods producers, service providers, and retailers are formed to create and deliver the best products and services possible [7]. The collaboration enables a company to do exceptionally well a few things for which it has unique advantages [7].

The collaborative advantage is defined as strategic benefits gained over competitors in the marketplace through supply chain partnering and partner enabled knowledge creation, and it relates to the desired synergistic outcome of collaborative activity that could not have been achieved by any firm acting alone [5,7].

The research has provided a more accurate definition of supply chain collaborative advantage. The definition contains four components: (1) collaborative advantages are achieved by supply chain partnering activities such as sharing information, synchronizing decisions, sharing complementary resources, and aligning incentives with partners’ costs and risks; (2) benefits are enlarged than acting independently; (3) there are some leverage effects or synergistic outcomes;

and (4) it is not just collaborative transactions but it involves joint knowledge creation and joint innovation as well. This definition puts more emphasis on business synergy and joint value creation and innovation. This emphasis enables firms to see the advantages from a long-term and strategic perspective, shifting from only the cost and short-term focus [5].

The current study has identified five dimensions that make up the supply chain collaborative advantage: process efficiency, offering flexibility, business synergy, quality, and innovation [5].

The collaborative supply chain management (CSCM) is a new strategy that has evolved in the 1990's [8], and is motivated by the earlier approaches such as just-in-time (JIT), electronic data interchange (EDI) and quick response (QR) [2]. CSCM is viewed as one of those SCM strategies that would give significant benefits, including [2]:

- Customer service improvements;
- Cost reduction;
- Efficient use of resources and
- Business process improvement.

These benefits could be achieved through an appropriate planning and designing of the CSCM [2].

The functional areas within the organization also need information that flows through the SCM in order for them to make a decision to manufacture products. The capability of sharing and exchanging information is essential to improve the effectiveness of the SCM. The integration problems that arise in SCM also contribute to the need for redesigning it into the CSCM [2].

Building a collaborative supply chain and its management requires finding a solution to many practical problems and understanding the specific conditions in which the individual activities of a chain take place. This also applies to chains containing the chemical-technological and metallurgical production processes. That is why it is necessary to firstly know the current way of material flow management on company and inter-company level in chains with these production processes and the main problems inhibiting or interrupting the flow of material through the chain in question.

Experimental

At present, the chemical and metallurgical companies are not generally building sophisticated supplier-customer systems, but they are trying to apply the logistic principles on in-house level by linking the sales, production and purchasing activities. The realization of these activities takes place observing the general principles, but their concrete form is influenced by the specific conditions these industries are facing. The starting point for material flow management is the realization of business operations in their traditional way and forecasting of demand and sales. During the realization of business operations, the chemical and metallurgical companies prefer long-term supplier-customer relationships, and they make effort to have consistent suppliers. The main reason for reluctance to change a supplier and a purchased product is the fact that the processing of different raw materials or other materials may cause problems threatening the technical quality of products and / or they can cause additional costs. In companies engaged in chemical industry, switching a supplier is basically impossible is some cases, due to the necessity to comply with the legislative regulations. If there is no certainty that the new supplier will deliver a product that will consistently meet the current legislative arrangements, it is impossible to replace the current supplier. The change of suppliers is extremely difficult in the case of raw materials for validated, usually pharmaceutical productions, which are subject to the necessity of obtaining the certificate of "Good Manufacturing Practice". The approval process of change of supplier is associated with relatively large administrative difficulties and it may take up to two years. Even in metallurgical industry, facing lack of domestic raw material base, Czech (and European) metallurgical companies depend on the purchase of strategic input raw materials from a small number of hardly replaceable suppliers located in relatively remote destinations.

Building long term relationships gives the chemical and metallurgical companies more important positive aspects, such as developing cooperation in research and development, but also managing the material flows. During the realization of the business operations, the long-term partners sometimes accede to consignment warehousing.

The Czech Republic is characterized by a relatively large cohesion of trade relations between companies of the individual industrial branches, i.e. also between companies of the chemical and metallurgical industries. This is due to the historical development of the Czech industry. As a result of central planning before 1989, the Czech chemical and metallurgical companies often have interlinked production systems and many of them have been cooperating together for decades. The changes taking place since the nineties of last century to the present, especially the ongoing restructuring, mergers and acquisitions, as well as the entry of international corporations in the market, have led to establishment of relatively strong property groups. Agrofert holding financial group or PKN Orlen in the chemical industry and the financial group of ArcelorMittal Holdings AG or EVRAZ GROUP S.A. in the metallurgical industry can be presented as examples of this trend. These relatively strong property and business links enable them to realize various interrelated business and manufacturing operations, including the rework of products.

The material flow is not controlled only on the basis of closed business operations, but it is also based on forecasts of demand and sales. In predictions of demand and sales, statistical methods such as exponential compensation or neural networks are frequently used (for manufacturers supplying products for final consumption, such as consumer chemistry or, in case of medium-term planning, metallurgical plants [9,10]) as well as less sophisticated methods, such as simplified forecast, which is used mainly by suppliers of products for industrial markets. Information from plants of customers, which is gathered by the salesmen within the scope of the performed marketing and sales activities, is often used in sales forecasts. It is qualitative information about the intentions in customers' companies, their future needs and the requirements and quantitative information representing the estimates of customers regarding the future purchased volumes. Forecasts of demand are not shared with other business clients, not even with direct suppliers of raw materials and materials used for manufacturing processes.

A plan of sales for the given period is based on current requirements of customers who send orders to the company and on annual or quarterly signed framework agreements. These framework agreements, the execution of which takes place within the given period of time and is based on call-offs or the individual partial orders, enable the stabilization of company plans. If they are not signed with customers, there is usually a significant deviation between the planned and actual sales, to the extent of approximately 30 %. A fluctuation means the necessity of intervention in the production plan or the solution to the problems arising from shortage or surplus of products. Both options bring higher production costs (there are costs caused by lack of stock or costs associated with storing and maintaining inventory) [14].

The company information system is used to support the business activities, The Czech chemical and metallurgical companies very often use SAP R 3. The application of advanced planning systems (APS) still remains an exception. There is the first, in European scale unique, complex application of APS system in the Czech metallurgical enterprise "Třinecké železárny, a.s.", which is used for planning and scheduling the whole metallurgical cycle [11]. The information system is used for the business agenda administration. The standard procedure includes records of the individual customers, in particular the identification data, data on past sales, the established business conditions which are agreed with a customer, etc. Other data, such as company reports drawn up by the salesmen are kept as well. Selected employees of the company have access to the information, especially the salesmen. However, there are other ways of presenting and sharing market information in companies, such as through meetings, sharing marketing information about developments in the individual territories, and informal conversations between the employees who participate in the realization of the processes within one logistic chain. The shared market information can then lead to creation of tasks for other processes. If, for example, a customer plans the innovation of a product, it may indicate the need for innovation of the supplied material input. In this case, there is a task for research and development or it may be necessary to conclude a contract for the realization of the research activities by outsourcing. There is also information link in relation to other corporate activities. There are regular meetings of salesmen and workers of transport or logistics departments on the current and anticipated requirements for transportation. They work together in order to look for ways how to ensure the planned deliveries in terms of physical transfer. The possible transportation strategies are taken into consideration. The aim is to find such a transport strategy that will guarantee compliance with the requirements of customers in terms of delivery date, but, at the same time, that will come at a reasonable cost.

The production plans are based on the sales plans, which are usually refined in regular terms. These are worked up in such a way so as to reflect the current requirements of customers.

Purchase planning is determined by balance of production needs and resources covering them. In essence, it is based on sales predictions that usually arise on the basis of the historical data from previous periods. Purchase planning usually reflects the past sales taking into account the quantity and assortment. Because the Czech chemical and metallurgical companies often focus on suppliers from remote destinations (chemical companies from Asia and metallurgical companies from Asia, South America and Australia), the order times are relatively long, in a matter of months. According to experience from their own primary researches and in compliance with the literary source [12], it is necessary for companies to order up to 6 months in advance.

The activities of an integrated supply chain get under way by taking both call-offs and customer orders. The purpose of the call-offs is to clarify the requirements of customers which were negotiated in the framework agreement. The specification applies both to the delivery time and usually also to the volume of the requested product. The orders that are not linked to the framework agreement are accepted as well. The orders also contain, apart from the main requirements for delivery (the product and its technical parameters, price and payment terms, delivery conditions) other requirements, such as requirement for adjustment. They usually enter the company by telephone (their confirmation by fax is required) or by e-mail. On the basis of an order, the order for production is issued. This order is also forwarded to the technical quality control personnel so that an attest to the supplied product/products can be issued and it also goes to the dispatching warehouse, where it works as a dispatch instruction. In many companies, these processes are not effectively supported by the information systems, and there is no necessary information connection on intra-company or on in-house level.

The final product is manufactured on the basis of the above-mentioned production order. It is adjusted according to customer specifications and then it is prepared for shipment. The necessary documents are issued, the transport is ordered and the date of its realization is agreed. In case of overseas sales, it is usually realized by means of combined transport through intermediaries in the transport and containerization areas. It is followed by loading and dispatch of the products. The customer accepts the product according to the agreed delivery terms, usually based on the advance notice. The product is put in stock and kept in the warehouse, until it is needed in the manufacturing process of the customer. The chain of activities is concluded by issuing new order in customer's company, which is heading for the company of the supplier.

Ideally, each activity should take place in such a way to ensure smooth material flow without delays and unnecessary inventory and, at the same time, also at a reasonable cost. However, this ideal situation usually does not occur in supply chains existing in chemical and metallurgical companies due to many problems arising in the process of management of the material flow at company level.

Results and Discussion

There are many problems on tactical and operational levels arising just because it is necessary to meet the requirements of customers in a quick and flexible manner, but the requirements change very quickly and sometimes very unexpectedly. A company must flexibly respond to these changes and adapt the range and quantity of the individual products to current requirements of customers.

Problems arise as early as during the demand forecasting stage. A forecast is often less reliable, because customers' requirements are highly variable in time, the customers are unwilling to accept a substitute product and, in most cases, they are also unwilling to share information with their suppliers. The problem of sharing information can occur even within a single company, and it is the greater the worse the system for acquiring and storing information is. The less reliable forecasts of demand and sales poses rather serious problem, both for the manufacturers of consumer chemicals, who make about 30 % of their sales through hypermarkets, and for the producers of chemical or metallurgical products intended for further processing which are placed in the middle of the supply chain. They also face the threat of the acceleration effect. The consequence of less reliable predictions of sales are both direct losses, i.e., losses of revenue resulting from inability to meet current orders, and indirect losses, arising for example due to accretion of dispatch stocks. Manufacturers of chemical and metallurgical products are often able to be very flexible and they can cover an extraordinary and unexpected demand very quickly, but usually only at the cost of other production postponement. Generally, the key issue in terms of stability of material flow of a company and the supplier-customer chain is the reliability of demand and sales forecasts. Mistakes and inaccuracies in predicting cause destabilization of the flow of materials, chaos and extra costs arising, for example, as a result of unexpected change of assortment, during extraordinary deliveries when it is necessary to borrow products from a distribution warehouse or from another customer.

De-synchronization of planning conditions between the suppliers and customers represents another problematic area. If a customer completes the planning process for the current year in March, but the contractor completes the plan before the end of the previous calendar year, the suppliers must base their plans on the forecast of demand and sales. That is why it is very difficult to respond to current customer's demands.

Other problems originate in production processes, as elements of the supply chains. More problems arise and are addressed differently in continuous productions, mass (and uninterrupted) productions; there are other and different approaches to solutions used in discontinuous and batch productions. In addition to that, metallurgical production is a combination of both types of productions. Mass production can be represented by blast-furnace and sintering manufacturing process, while batch production takes place in the follow-up manufacturing processes (e.g., in the steel and rolling mill productions).

In continuous, mass (and uninterrupted) production, they use single-purpose production equipment, the individual technological operations are fully synchronized in the given production process, both in time and weight (with the assistance of commonly-used principle of a bottleneck). The product is manufactured to stock and it is subsequently dispatched according to the requirements of customers. These manufacturing processes depend especially on the synchronization of production and withdrawal by customers. The ideal situation would be if the manufacturing systems of suppliers and customers were linked together (in the case of chemical companies, for example, by piping). Raw materials would continuously pass through the manufacturing equipment of the supplier, pipeline between two production systems, and it would continuously enter the customer's production facility. The amount passing through the chain would be adapted to the requirements of the end users.

Of course, such links do not exist in real life. Material flow is usually interrupted, either at the entry and/or at the output from the manufacturing facility. In these production processes, the problems always occur whenever the actual production facility output does not correspond with the withdrawals. In the event that production in the given period shows higher output than the requirements of customers, there is a growth of inventory of finished goods in stock (with simultaneous increase in costs associated with the stock). The output of the production system must be reduced. However, this inflicts a direct economic impact on the economy of the manufacturing process. From an economic point of view, the most beneficial situation occurs if the actual production utilizes the maximum production capacity. Should the volume of production be decreased by a certain percentage, it does not mean the same percentage decrease of costs, which is mainly due to the existence of fixed costs. In chemical industry, it is estimated that a decrease in production volume by 50 % means approximate cost reduction of 20 %.

There will be a problem even in case the output of the manufacturing equipment is not sufficient to cover the actual customer's demand (production capacity is lower than the current requirements of customers). Extremely difficult situation arises in case it is necessary to radically increase the production volume, for example by 50 %, from month to month. This can happen, for example, if you manage to penetrate a new market, at the end of product registration procedures etc. The situation can be solved using three basic ways, with possible combination of more of them, of course. You can:

- Increase the output of production equipment, i.e., increase the production capacity.
- Refuse some of the customers. When implementing this measure, it is necessary to consistently and effectively apply the differentiated CRM, according to the principles described by Lošťáková [13].
- Ensure the required supplies from competing producers, or from customers who do not need their purchased product at the moment.

Companies use all the possibilities, but their realization can sometimes be difficult, or it may bring further problems. The first option is to increase the production capacity in the given period. Generally, the value of production capacity of equipment is determined by the value of two components it consists of, which means the output of production equipment q_t^n [t hr^{-1}] and the usable time fund T^{vf} [hr year^{-1}].

It is difficult to increase the usable time fund due to the fact that these production processes are uninterrupted. The only way to increase the usable time fund is to reduce the time needed for the planned repairs. It may be risky to postpone or make repairs in reduced mode (e.g., only medium repairs instead of general overhaul), given the possibility of accidents which would cause further reduction in the production equipment performance. As a result of these accidents there would be a likely increase in the total maintenance costs and increase in the risk of extraordinary environmental impacts (especially in the case of chemical companies), which also affect the economy of the company (penalties) as well as the goodwill of the company.

Another option is to increase the efficiency of production equipment. The efficiency of the manufacturing equipment in continuous production is determined by the volume of inputs into the production process S_n/t [kg, t hr^{-1}] and by the standardized output w_n [%] and the amount of the theoretical output q_s^{te}.

The performance of production equipment on the tactical-operational level can be increased with the help of the volume of incoming raw materials. However, it is only a theoretical possibility. It should be noted that to increase the performance above the expected production capacity may not be feasible if the company does not have sufficient amount of input raw material and can not obtain it immediately.

Another way of responding to inadequate performance of production equipment is to refuse or postpone part of the orders from customers who are less efficient, provided that the customers are willing to accept a postponement. However, the company will lose part of its sales and profits.

The last option is to obtain the necessary amount of product from competitors or from another customer. Delivery of product purchased from the competitions may involve technological problems on the side of customer with processing the product and the subsequent deterioration of relations with the supplier. In the end, a company may even lose the customer if the technological problems do not occur and a customer finds out that it has another suitable source for ensuring the supplies. Finally, a customer may use the information about the product re-sell to start applying pressure on the price of the product from the original supplier and threatening to leave for the competitors.

The pursuit of higher production volume than the planned production capacity in the given period has further consequences. Higher volume of chemical-technological production means higher volume of waste, waste water and emissions. This might mean exceeding the limits allowed under the integrated waste management, the so called IPPC.

The discontinuous and batch productions, which may be either interrupted or uninterrupted, use the multipurpose production equipment which produces different products in batches. The size of a batch in the chemical-technological production processes is given by the number of the realized batches, while metallurgical companies use the number of production batches and the volume of production from a single batch. When changing a batch, the production equipment must be thoroughly cleaned or setup. Cleaning and setup of production equipment is an activity which is usually both time consuming and financially demanding (in case of metallurgical equipment, the setup and conversion times take several hours). Batch production is driven by demand. When deciding on the sequence of batches and the commencement and termination of production, the customer requirements are of primary importance. Production planning conforms to the requirement of customers to have the right product available at the right moment.

However, it is also necessary to take into account the economy of the manufacturing process. That is why the optimization of batch size is commonly performed. When solving the optimization tasks of this type, the main particularly considered elements are the costs of cleaning or setup of production equipment, loss of unused capacity of manufacturing equipment and the cost of warehousing and maintaining inventory. The higher the cost of cleaning or setup and the losses resulting from unused capacity and the lower the costs of warehousing and maintaining inventories, the more pronounced the tendency to a higher volume of product manufactured within a single batch. In the metallurgical companies, on top of that, the production batches of different processes are developed on the basis of different criteria of optimality. A typical example is the discrepancy between the optimal production batch of steel manufacturing process and rolling mill processes.

The steel works accumulate production orders into continuous casting sequences according to steel grades, but the rolling mills gather production orders into rolling campaigns according to profiles (shape and dimensions). This conflict is usually solved by creating some stock of castings between the two production processes.

The situation is more difficult when sales of products manufactured in batches are forecasted than when you predict sales of products manufactured in continuous or mass productions (and in uninterrupted ones). The higher difficulty stems from the fact that the forecast covers a larger number of product groups, while a mistake may occur during the forecast of each group. This fact is of fundamental importance in metallurgical industry. In the apparent simplicity of metallurgical products, their numbers are significant. The combination of grades, shapes, sizes, heat treatments and surface treatments creates up to tens of thousands of items of rolled products. Another reason behind the difficulty of forecasting demand lies in the fact that consumers often buy products for their own batch productions (realized once or several times a year, depending on how the changing demands of their customers develop). The acceleration effect is much more pronounced in these chains. Planning batch production in the companies of customers brings orders for supplies of raw materials in quantities needed for the entire 'campaign', and the supplier finds it difficult to respond to a request which is sometimes unexpected. Satisfying this requirement can be problematic and even if successful, the delivery time is extended. Both the client and the supplier face problems. That is why there is a strong tendency in these chains to conclude framework agreements as a mean of stabilization of material flows of inter-company level. This measure, however, removes the problems only partially. The framework contracts include the agreement regarding the weight requirements of the customer, but they are formulated with certain tolerance, e.g., 150 $t \pm 20$ t. It also happens that although the customers take the total amount in accordance with this contract, they require different distribution of the supplies in time. There may be a situation that is illustrated in Table I

Table I Planned and real withdrawals of product (t)

	Jan	Feb	Mar	Apr	May
Planned withdrawals based on framework agreements	20	30	25	25	30
Current requirements given by the call-offs	25	25	40	15	25

The changes may even be in tens of percents. This causes huge problems in production planning and its co-ordination in the company of the supplier. There is a problem also if a customer provides information with insufficient technical specifications or changes these specifications with short notice prior to the actual delivery of the product. In this case, the company must again rely on prediction of demand and sales which, however, creates an inventory or the company produces in smaller batches, which makes production more demanding from the economic point of view. Chemical and metallurgical companies generally consider warehousing and maintaining inventory to be economically more efficient than cleaning and setups of manufacturing equipment and therefore they tend to prefer the option of maintaining stocks.

When planning sales, which is the starting point used for the planning the production of the individual products in batch discontinuous production, the companies use this mechanism (Fig. 1)

Quantity specified in call-offs	+	Sales outside the framework agreement based on forecasts	+	Sales according to extraordinary requests (covering inaccuracies of framework agreements and forecast)	=	Sales of a product in the given year

Fig. 1 Mechanism used for calculation of sales plan as the starting point of production plan [14]

Because businesses can not afford risking the potential loss of a customer, they always count on some increase in production volume for each product, which eliminates the need for further batch. Sometimes, however, this is out of the question, with regard to the organization of purchasing, which makes it impossible to provide a flexible material supply. If a buffer is taken into account when purchasing raw materials, usually the final effect is the increase in the total value of company stocks; with all known negatives this fact brings (Fig. 2).

The cost of cleaning or setup of the manufacturing equipment has impact on the way production planning of certain product is made also in the cases when more manufacturing equipment can be used for the specific production. The costs of change in the production of chemical-technological processes (start-up and run down) can be so enormous that the production of a particular product is carried out only in 1 or 2 batches per year. Of course, this affects the purchase of raw materials used for this production. In most cases, the raw materials are purchased at once for the estimated total annual production volume, because to divide the purchase into two stages would be no good in terms of transport costs of raw materials to the company.

Metallurgical companies also maintain high inventory of input raw materials and semi-finished products. However, the main reason rests in the production technology. The stocks in the ore-storage yard, where the homogenization of ore takes place, can serve as a typical example. This process reduces the fluctuation of their chemical composition and lumpiness, thus promoting the regularity of blast furnace operation and its efficiency. To make the list complete, it should be added that in this material flow management system it does not make sense to make allowances for buffer stock of raw materials, but the requirements are growing and the cost of ensuring the storage capacity grows as a result of that as well.

Plan				
60 t Expected withdrawals and quantity specified in call-offs	+	20 t Sales according to extraordinary requests (covering inaccuracies of framework agreements and forecast	=	80 t Sales of a product in the given year
Real sales in the given year			=	30 t
% fulfillment of sales plan of the given product			=	37.5
Increase in value in final product inventory (anticipated price 1000CZK/t)			=	50 000 CZK

Fig. 2 Example of increase in value of stock of the final product as a result of deviation of the planned sales from real sales according to customers' requirements [14]

In the discontinuous batch productions, there can be problems with sufficient number of operational workers. These productions require more versatile workforce, with wider knowledge and skills. In some cases, there is a lack of these skilled workers, especially in the chemical-technological productions with a higher health hazard or even risk of life of these production workers, but the same applies to uninterrupted productions. The lack of workers brings higher complexity of planning and regulation of these production processes.

The discontinuous batch production processes expect production of larger batches and keeping inventory, which will later satisfy the customers' requirements. A problem arises in the case a customer requests a pre-planned, or even higher amount of product than has been negotiated, or predicted, but sooner, i.e., in time when production of the product has not even started yet or it is running, which means the given quantity is not available in the dispatching warehouse yet. In that case, you can consider accelerating the manufacturing process. This can be solved by:

- Finding more time for production, i.e. by increasing the usable time fund,
- Trying to increase production volume from one batch,
- Shortening the duration of one production batch in the chemical-technological production processes, i.e., shortening the sequence of batches.

You can find more time for production either by changing the organization of the working time or by reducing the time originally dedicated to maintenance of production equipment. If production is currently organized as interrupted, it can be changed to continuous one. This will require increasing the number of production equipment operators in the amount of one shift (instead of the original three shifts it will be extended to four shifts). It seems to be the easiest measure but it may fail due to insufficient number of available skilled workers, as described above. The other option is to increase the usable time fund or to cancel or shorten the time required for the maintenance of production equipment and other scheduled stops. This measure may increase the risk of accidents with all the negative consequences, as discussed above. A company can decide to go for this measure, but only in extreme situations. The most complicated situation arises in the case an unexpected customer demand appears when there is a stop for repairs. The company must deal with the dilemma of cancelling planned repairs and starting-up production (which leads to chaos and additional costs) or performing repairs as planned and postponing the satisfaction of unplanned request. It should also be noted that the changes in planning and realization of maintenance cause quite considerable problems in terms of performing maintenance across the company, the use of outsourcing maintenance and the compliance with the terms agreed with the supplier of maintenance work. If the planned repairs are postponed or cancelled, there are more repairs caused by breakdowns, which further undermines the adherence to the repair plan. Of course, it causes subsequent problems in securing the spare parts necessary for realization of the maintenance procedures.

The possibility of increasing the volume of production from one batch is very limited. In principle, the performance of production equipment can be increased only through the volume of incoming raw materials if production equipment allows such a solution. In the chemical-technological production processes, higher performance can be achieved also by reducing the duration of the operation, but this usually means negative effect on the quality and volume of the output from a unit of raw material.

The chemical-technological production processes make it possible to achieve higher production output per unit of time by shortening the sequence of batches (the individual batches come out faster one after the other). This can be achieved, for example, by [14]:

- Removing the gradual way of deploying the individual batches in a row, if used, and asserting the parallel deployment method.
- Using additional production equipment (i.e. apparatus) to perform technological operations with the longest duration.
- Using production equipment (i.e. apparatus) with double (possibly triple) capacity to perform technological operations with the longest duration.

Both in the chemical-technological and in the metallurgical production processes, it is naturally also possible to use the variability of production routes. You can use the equipment which is completely free (if available) at the moment or to change the product manufactured on another production equipment in favour of the desired one. The ideal situation would be, of course, to have the capacity of other production equipment free as a result of fall in sales of the product(s) that are manufactured here. The costs associated with start-up of a production process or with change of assortment (costs of cleaning or setups) which were considered in advance usually turn up here.

Products of batch discontinuous productions do not have to be consumed only by the customers of the company, but they can also serve as material inputs to other production processes in the same company. If the products are further processed in the follow-up production stages and there are changes compared to the plan in terms of quantity and/or time, it usually causes destabilization of material flows in other supply chains, at least on the company level. To maintain the stability of material flow in the other chains, in such cases, means the occurrence of higher production costs. This increase is caused by extra costs associated with more frequent changes of assortment, or costs incurred due to premature exhaustion of stock or costs associated with the storage and maintenance of stock created in defiance of the original presumptions. Of course, it also increases the demands for tactical and operational management of step productions in the company.

Fluctuations in material flows in company supply chains have an impact on the realization of company handling and transport operations between object as well as storage. Other types of stocks may be formed in another time, which can cause chaos in the organization of the handling, transport and storage operations.

Problems related to the management of material flow in chains with both basic types of production processes occur even during purchasing. One of the main problems is that there is a total or partial shortage of some purchased raw materials and it happens at irregular times and usually without any obvious causes. This has impact not only on the management of material flow through the chain, but also on the rise of costs associated with purchase of raw materials. A company may prevent these situations by signing long-term contracts.

Generally, however, the markets of raw materials for chemical-technological and metallurgical processes face a surplus of supply over demand and the trade relations are closely interlinked. A company may sometimes perceive its supplier as a supplier of input for a given company manufacturing process, and sometimes as a competitor in the battle for the favour of customers. These links mean the companies are afraid to establish a deeper collaboration and share information with their suppliers, as it is very likely that the information could be misused and could undermine the commercial interests of the company. Complications may arise not only during the creation and realization of marketing strategies, but also in relations with antitrust authorities, where there is a threat of sanctions due to cartel agreement. The generally known information, with which companies normally operate, is the volume of the European and world markets. However, the information from the individual companies, and it is not only the information of commercial character, but also information on production, such as the size of production capacity is consistently concealed. Great caution when working with information is given by the fact that the price for the misuse or leakage of information can be truly exorbitant.

It can be said that the climate in the markets with products serving as raw materials in production processes of chemical and metallurgical companies does not favour more liberal relations and mutual trust. The business relations rather apply dictate towards the weaker partner. Enterprises of the chemical industry often focus on suppliers from Asia, mainly for cost reasons, when securing inputs for their company supply chains. In some cases, however, they have no other choice because there is no other suitable source of material inputs. Similarly, suppliers in metallurgical industry play the same irreplaceable role. However, the form of business relationships with these suppliers is different. Contrary to the trade relations with European suppliers, these relationships are much more influenced by the different culture and mentality of the supplier, but also by the level of respect that is set between the two trading clients.

If a company uses a supplier from remote destinations, the deliveries must be negotiated long time in advance. Purchases of products in the next year are negotiated mainly during the autumn months of the previous year (it is roughly the period from late October to the end of January next year). For example, the delivery time for supply of raw materials from Asia is about three months and it includes the time necessary to manufacture the product, time of product handling at ports and the time necessary for the following transportation. Its length, however, limits the possibility of flexible response of a company in the case of extraordinary customer requirements, just because of the raw material restrictions.

With increasing territorial distance of suppliers, the risk of delay in delivery increases accordingly. A delay can occur even when loading the ship. Delays can be caused by the hard-pressed north German sea ports, where the unloading waiting time can be up to 1 week. The following transport from the port to the company can be long and it can be delayed as well, especially in the case of transport by rail, because the European rail routes are overloaded as well as the ports. Unfavourable climate conditions may represent another reason for delay. For metallurgical companies, the most critical time comes especially in winter period when the raw materials freeze in trains. Finally, delays may occur due to errors such as errors in the marking of containers (which causes their delay) and due to previously unforeseeable causes.

Transport greatly influences the speed of delivery and its effectiveness not only in transport of raw materials to the company, but during dispatching operations as well. If the loading operation is delayed and the hired freight forwarder has to wait, the company must pay demurrage charges.

If a company does not have synchronized flows of material both on entry and exit, it can get into considerable troubles. If a customer's request lowers withdrawals, and the suppliers deliver materials to the company in line with the forecasts of sales, the inventories of the company are growing. On the other hand, it may happen that a company has not got sufficient quantity of raw materials and supplies and it presses on the suppliers to deliver them or the company promptly (and generally with higher costs) buys raw materials from alternative suppliers. Fluctuations in material flows during this de-synchronization are illustrated in Fig. 3.

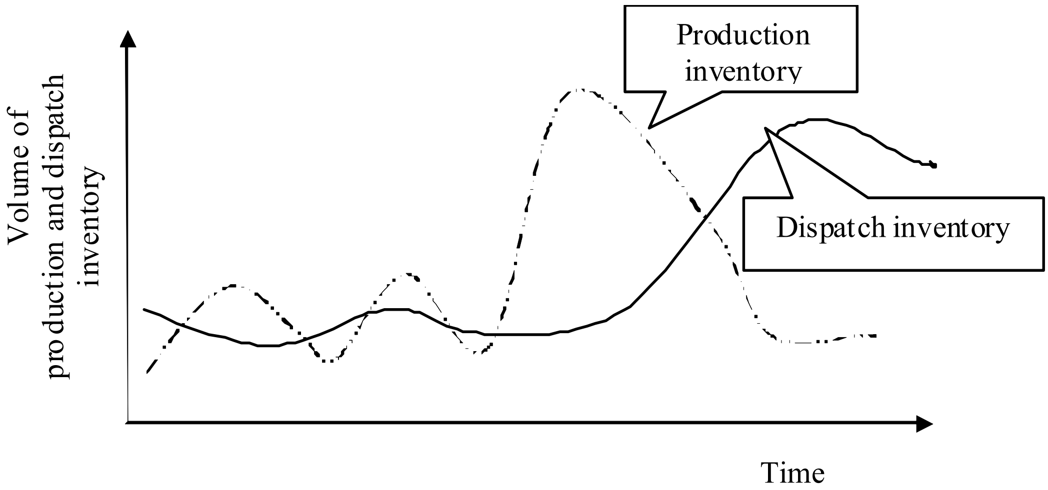

Fig. 3 Development of company inventory as a result of de-synchronization of material flow from suppliers to customers [14]

The consequence of all the aforementioned problems of management of material flows within the chain and the often one-sided efforts of companies to adapt to them, is usually the increased volume of stocks in company supply chain and in the supplier and customers chains as a whole, increasing inventory turnover time as well as extensive time interval from the entry of raw materials into the chain to product output from the chain (failure to respect the links of the supplier and customer chain). The losses of tied financial means are increasing as well. If the average stock of one product in the company is worth hundreds of millions of CZK, then these losses reach hundreds of thousands of CZK. With the increasing average stock, the costs of keeping the inventory increase accordingly. When compared to the losses of tied financial means, these losses are usually much less significant. The growth of costs associated with stock and the efforts to increase the efficiency in creating and delivering value to customers makes companies try to reduce the unacceptably high volume of inventory. However, if a company intends to do this without any radical changes in the logistic processes management system on the in-house and inter-company level, it will probably lead only to the loss of business caused by low flexibility of the company as a supplier [14].

Conclusion

The vast majority of problems arising in the management of material flows in the chains with the involvement of chemical and metallurgical companies results from the fact that the supply systems of the individual customers and suppliers are not linked together. Although these chains show apparent cooperative efforts, the suppliers and customers have so far been building their own supply systems and they have been trying to improve them. The only way to achieve higher logistics performance of these companies and chains is to establish the cooperation within the chain and to apply the new methods of material flow management, such as Quick Response and CPFR (Collaborative planning, forecasting and replenishment). This should radically help to eliminate many existing problems, to improve the fluency of material flow through the company, while maintaining or increasing the economy of the company activities.

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