TOOLS FOR SUPPORT AND ENHANCEMENT OF PRODUCTION PROCESSES IN AN INNOVATIVE COMPANY

Andrzej Szymonik

Abstract: The presented material relates to the production process management in a company that makes a "greenfield" investment with a high-tech manufacturing method by using numerically controlled machinery and equipment and also computer systems supporting management, planning, and direct control of production. The another sections are described contemporary conditions of the production management in modern organization operating in turbulent environment with emphasis on planning process and measures of operational efficiency needed for analysis and improvement all processes in the organization.

Key words: innovative technologies, FMS (Flexible Manufacturing System), CMS (Contract Manufacturing Supplier), CAM (Computer Aided Manufacturing); ERP (Enterprise Resource Planning), IFS (Industrial and Financial Systems), KPI (Key Performance Indicators)

1. Introduction

Nowadays, the functioning of a company depends on the level of flexibility and the possibilities of rapid adaptation to new conditions imposed by the constantly changing environment. As a result of the rapid development of information technology and its versatile applications, the complexity, uncertainty, pressures and threats in the business become constantly more visible. There are more and more companies using automated manufacturing systems, which aim to achieve full integration of all activities related to the functioning of a modern production enterprise. One of the possible ways to achieve success and to meet the requirements imposed by competition is production management, which applies information technology.

2. Innovative technologies in modern companies

The main challenge, faced mostly by small and middle-sized companies, is to adapt to the changes arising in global markets. Executive managers realize that, without immediate reaction to the changing environment, they will not be able to develop their business. However, the entrepreneurs, especially in the developing countries, have an optimistic attitude to the possibilities of growth and so they implement innovative solutions in order to increase the competitiveness of their companies.

In case of an enterprise, the innovations will apply to creating or modification of processes, products, techniques and practices, which are regarded by a particular company as progressive in its branch, if they cause profit increase and strengthen the position of the enterprise on the market.

Modern solutions are implemented mostly in technology, which is the groundwork of increasing company competitiveness by means of new products and services provided to customers.

Modern technology is a method of manufacturing process realization, which allows reaching an increasing added value in comparison with previous results or outcome in comparable branches of the global market.

It is possible by applying the knowledge based on continually extending bases of information, theories developed by science and by practice referring to the objective laws governing economy and technology and to innovative concepts of products and services design, aiming to meet customer expectations in a better way.

In order to reach this goal the following interdisciplinary technologies need to be used:

- telecommunications;
- automation and robotics;
- flexible manufacturing systems;
- material engineering (in particular the development of nanomaterials);
- microelectronics;
- information technology.

Advanced technologies and their commercialization generate sectors in the economy, comparable with those that apply innovative solutions and belong to the best.

Into these areas, we can include the following:

- telecommunications networks digitization;
- optoelectronics, which can be applied in fields such as telecommunications, information technology, robotics, bionics, flexible manufacturing systems (ESP, EMS), medicine;
- electronization of CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) processes;
- lasers, which are applied in e.g. in metrology, medicine or hard materials micromachining;
- computer hardware and software production;
- peripheral devices and computer networks development;
- robots, automation and flexible manufacturing systems production.

The number of companies in Poland with production based on innovative technologies is on the increase. These can include, inter alia, *3M* Poland opened recently in Wroclaw, producing goods for aerospace, aviation and automotive industry, based on the technology which is new among the global solutions, or the PartnerTech company from Myslowice which has started its activities in 2010.

3. Enterprise presentation

This article is the result of a research conducted in Partertech Ltd seated in Myslowice (further called Partertech Myslowice), which is a part of „PartnerTech", the international Swedish group. It has its plants mostly in Scandinavia (Sweden, Norway, and Finland) and also in the USA, Great Britain, Poland and its trade partner in China. The group deals primarily with the production for electronics and in the growing range in mechatronics for sectors such as telecommunications, medicine, electronic banking, recycling. Partnertech group does not offer products of its own brand, therefore, from the supply chain point of

view, the company provides products and services of the latest generation for enterprises located closer to the final consumer.

The Partnertech group is located in top three Scandinavian companies in the segment of mid-size CMS (Contract Manufacturing Supplier) achieving yearly sales is on the level 280-300 mln EUR (based on data from Partnertech Mysłowice - accessed on 20.05.2011).

The researched plant specializes in production of sheet metal components and finished products (in accordance with orders from other companies) together with full customer service, which also includes the following elements:

- pre-transactional (e.g. customer service politics, supply system flexibility and service procedures defined in writing);
- transactional (e.g. stock level settlement, customer service indices and standards measurement);
- post-transactional (e.g. assembly, guarantee service, products monitoring in operation).

Partnertech Myslowice was founded in 2010 as a typical greenfield investment and is located in a modern hall with an area of 12 thousand square meters in the logistics center in Myslowice.

In the plant, there is a state-of-the-art machinery park equipped, inter alia, with the following elements:

- automated punching machine integrated with laser (*Trumpf*);
- press brakes, both manual and automated (*Trumpf*);
- metal plates automated storage system (*Stopa*).

Punching machines, press brakes and storage system compose the Flexible Manufacturing System (FMS) enabling fully automated production of metal components, which means that, starting from loading a metal plate to the storage system, the whole production process is carried out completely by machines and the operators' role is only to check whether the system works properly.

Besides, the plant is also equipped with the following:

- welding robot;
- powder-painting automated line (by Ideal) with the 20-minute time of changeover into another color.

This kind of machinery park enables production of any kind of metal enclosure or a component of any shape and color with the maximum thickness of sheet metal – 8 mm.

The manufacturing process in Partnertech Myslowice is set for the following tasks:

- components production;
- system integration assembly, with the use of manufactured components;
- components and finished goods distribution in accordance with previously signed contracts (orders).

Assembly lines were installed for this purpose, for assembly of both small devices and large cabinets or enclosures too, together with final testing stands.

Such production strategy enables the increase of the company competitiveness on the market and winning more orders. On the other hand, it causes drastic increase of quantity and assortment of materials required for production (in 2010 about 2500 material indices, worth 16 million PLN, were used), which significantly hinders the supply process, more so because the manufacturing process is carried out in accordance with the 'just-in-time' concept.

4. ERP system as a tool supporting production processes management in Partnertech group

Partnertech group has implemented the Swedish ERP class system in all the plants called IFS (Industrial and Financial Systems) – a set of integrated IT solutions, including 50 standard modules, inter alia, finance, distribution, production, equipment maintenance, human resources and planning.

The system also includes the central registry of components, which facilitates material management within the group. At present, the total number of material indices in the group is 9900, of which 3100 in Partnertech Myslowice.

Currently, the biggest IFS challenge is its administration and the optimization (coordination) of databases concerning: production routings, components and material delivery time and the assembly time of finished products in order to run the production process with no conflict based on the so-called pulling processing.

It allows components production planning and finished products assembly in particular time and can limit system reports about shortages on each production level both, on FMS line and in the area providing such elements as cables, circuits, plastic components.

In the Myslowice plant, the IFS has already been implemented in the following areas:

- finance;
- production;
- logistics;
- human resources management.

Finance module maintains all financial records. This module, being part of ERP system, is fully integrated with both Manufacturing and Logistics one. Due to customized setup particular transactions can be initiated and handled directly on production area. All storage movements and stock valuation is done in automatic way without additional paper and manual accounting work that is typical for less developed solutions. It of course drives cost efficiency with significant limitation of mistakes typical for manual processing.

IFS module allows utilization of ERP platform to maintain statutory bookkeeping with respect for Group requirements. It covers all areas like amongst others: fixed assets module, stock handling, control and valuation, current and deferred tax, VAT, payroll and costing. It is worth mentioning that that statutory reporting can be handled directly from IFS. Information is not limited to account balances and transactions behind. Thanks to customized mapping VAT return, CIT documentation and Intrastat reporting are executed directly from the system in a form required by local statutory regulations. Moreover the IFS financial module is not limited to accounting information only.

Controlling part with detailed standard costing information, budgeting and converting production flow into value added process can be monitored almost on-line. This involves non-finance department in the optimizing of process flow with primary focus on plant profitability. IFS allows arranging in order the responsibility grid with seven dimensions of posting chain. Traditional systems focused on tax accounting use usually period and account number and name as posting criteria. With adding cost center, project number, category, currency etc. we receive perfect tool for analyzing the data in order to support business decisions process typical for highly developed management information systems.

Production module allows for optimal production planning by means of materials, technology and human resources. The material structure of each product, divided into material purchased from external suppliers and the components manufactured on site by the FMS line is required for production planning. Apart from that, each product has its routing

list, that is, any activities required for complete assembly of a particular device. Routings belong to particular work center, with rates ascribed to both personnel and machine costs.

After receiving and entering an order into the IFS system, it calculates production abilities, checks the availability of components, machines production capacity and human resources and then confirms whether the order can be produced or suggests another time if any of the resources is insufficient.

At the same time, the system defines the number of operators required for producing the order.

The production module also calculates standard manufacturing cost of each product, which is further used by financial department in the reports.

Logistics module in Partertech Myslowice was implemented mainly in operational purchasing area and consists of the following activities:

- handling purchase req. to order;
  - ✓ verification of purchase requisition;
  - ✓ creation of purchase order;
  - ✓ sending/mailing purchase order;
  - ✓ order confirmation;
- handling supplier schedule;
  - ✓ schedules creation and approval;
  - ✓ sending schedules;
- monitoring purchase;
  - ✓ inventory partp;
  - ✓ purchase replanning;
  - ✓ confirmation monitoring;
  - ✓ delivery monitoring;
  - ✓ deviations confirmation analysis;
- VMI – Vendor Managed Inventory;
  - ✓ supplier responsible for inventory level;
  - ✓ VMI portal;
- sonsignment stock;
  - ✓ supplier owned material;
  - ✓ partnerTech report consumption.

The group-sourcing department is located in Sweden and deals with suppliers' database coordination, valuation and negotiating prices. The sourcing department is also responsible for preparing GPA (Global Purchasing Agreement).

Human resources module consists of work time control recorded by a terminal registering the employees' in and out time. This function allows also to control overtime. Apart from that, the company is now implementing a productivity measurement system, based on measurement of the time efficiently spent on assembly line. There are computers dedicated for this purpose on the lines, where the operators register the beginning and the end of their assembling activities in accordance with routings in the system. It allows calculating how much time employees spend on efficient work and how much on other, non-productive activities, such as meetings, breaks, meals, etc.

5. Specificity of production (basic activity) planning in mid-size CMS segment

Planning is, besides organization, motivation, control, decision-making and coordination, one of the functions of management.

Planning elementary activities is connected directly with products manufacturing and services, and lies in defining tasks and resources required for ensuring customer service quality, fluency, flexibility and price.

Manufacturer's resources can be used efficiently when:

- production planning is based on purchase orders from customers;
- the customer accepts production time;
- production system is carried out according to the plan, with no disturbances or unexpected situations (e.g. recessionary situations caused by force majeure or a human).

Current production realities (especially within contract manufacturing area) are much more complicated since:

- nobody produces for storage (stock must be moving and not lie behind on raks or stockyard);
- finished goods leave the plant on the day when production is finished and go usually directly to final user;
- each customer would like to receive their products as soon as possible, e.g. within 2 weeks since placing order, even if the lead time is 16 weeks;
- nobody wants to invest in any kind of safety stocks.

Additionally, there is vast pressure for production costs optimalization and cheaper purchases and in order to reach lower unit price, purchases shall be done in bulk (MOQ-minimal order quantity).

Partnertech Myslowice is in business on B2B *(Business to Business*) market, where it is difficult to predict precise sales volumes in particular months. Therefore, placing orders in a few months in advance is impossible.

Most customers have only sales forecasts for the nearest 3-6 months and these forecasts are the basis of production planning and material purchases. However, even these forecasts can be unstable and show significant variations. As a result there is need of constant control of production planning in order to meet customer's needs.

Depending on a particular customer the company is trying to work out a particular flexibility concept, which will allow to supply goods in accordance with orders while spreading the risk of having unnecessary material between customer and company.

To sum up, customers are not able to send actual sales orders several months in advance, which would allow stable and smooth production. The only one and long-term plan is the six-month forecast, which is updated every month and is subject to considerable variations. The company cannot produce solely on the basis of the forecast because in short time the stock of finished goods would be filled with unsold products. Thus, how to plan production in order to meet such critical requirements?

First of all, it is necessary to work out a flexibility concept with each customer separately that will define the rules of cooperation and capital responsibility involved in each product.

Secondly, due to long lead time of some components, the orders must be sent adequately in advance and that is why the sales forecast must be sent to suppliers as a base for their planning.

Thirdly, forecasts are updated every month after the last forecast from the supplier (in this way suppliers have the full picture of the situation and know more or less what to expect in the following months).

Eventually, customers cannot send the sales orders at any time because every organization has its own production cycle and consequently its own lead time.

In case of Partnertech Myslowice, this period is 3 weeks, which means that a customer cannot change the order during this time. Here the "frozen period" term can be applied. For external production on the FMS line the period amounts 5 days.

6. Measures and indicators applied in logistics.

Every organization is supposed to measure and monitor its operational efficiency in all the key areas of the activity. The indicators allow controlling the company current condition and, depending on the results, revising improper processes, but on the other hand, observing these trends can be the basis of tactical and strategic decision-making.

Partnertech Myslowice measures and monitors 58 indicators called KPI (*Key Performance Indicators*) in the following areas:

- finance,
- logistics,
- production management,
- human resources management,
- quality assurance,
- customer satisfaction monitoring.

Most indices are measured weekly and analyzed during meetings with lower and higher level of management. The results are presented on a white board dedicated for that purpose, available for all staff, which allows for the transparency of the company situation, not only to the employees but also to guests and customers visiting the company.

Measuring such a great number of indices would be obviously very complicated with no ERP system. Currently 93% indices are measured automatically by IFS system using especially created reports.

The company measures 20 indicators directly in the logistic area and they refer mainly to stock valuation on different production levels and also to the status of open orders and the risks of purchasing unnecessary material. In general, the indicators show volume and structure of capital invested in stock and risks referred to exceeding the acceptable inventory level. Additionally, the mentioned set shows the efficiency of the ERP system operation as well as the capability of purchasers to handle all potential problems and messages appearing during the daily work.

Table 1 presents the set of indicators.

Table 1**.** Delivery and stock indices

Site: Mysłowice Supply and Inventory	
Weekly Metrics	Source definition
Shop order backlog	All Shop Orders in status: Reserved, Released, Started, Planned with Finish date before today (Finish date < sysdate-2)
Inventory (KPLN)	Gross value of inventory (KPLN) and WIP on hand in all stores locations (including shipping and receiving).
Obsolete Inventory (KPLN)	Gross value of Material (KPLN) on Hand and On Order that is obsolete as per Frame Agreement

Excess Inventory (KPLN)	Excess material = sum for all articles(Current inventory (Inventory Part Planning) + sum(all released or planned Purchase orders in inventory part planning) - Sum(all demands in inventory part planning))
WIP Inventory (KPLN)	Material issued on production orders (pre-flush value)
Purchased Parts (KPLN)	Gross value of purchase parts inventory (KPLN) on hand in all stores locations (including shipping and receiving).
Manufactured/Finished Goods (KPLN)	Gross value of manufactured parts inventory (KPLN) on hand in all stores locations (including subassemblies).
Missing material = Negative on hand"	All products with MRP action message = 'Negative on hand'. The data is split into time zones based on negative on hand date (within 1 month)
MRP Performance (% of lines executed)	Log MRP actions on Friday: "Requisition", "Cancel", "Rescheduled-in", "Postponed". Compare following Friday % of actions executed. Sum Total
- Cancelled (% no of line)	Log MRP action "Cancel" on Friday. Compare following Friday % of actions executed.
- Rescheduled-In	Log MRP action "Rescheduled-in" on Friday. Compare following Friday % of actions executed.
- Postponed	Log MRP action "Postpone" on Friday. Compare following Friday % of actions executed.
- Cancelled (% value)	Log MRP action "Cancel" on Friday. Compare following Friday Value of actions executed.
Scrap %	Value cumulative Scrap vs cumalative revenue for quarter. (from financial metrics above)
Supplier Delivery Performance (%)	Number of delivered units at the first confirmed delivery date divided with the total number of units that should have been delivered in the period; window: +1 day (one day late)- 3 days (3 days early)
Part numbers with no std cost	Active part numbers with std cost = 0 with demand or stock
Part numbers with std cost < Last purchase price	Active part numbers with std cost < Last purchase price (Parts with demand or stock)
Products with sales price < Std Cost	Active part numbers with sales price =0 or sales price < std cost (Parts with with demand or stock)
Oldest item in RTV (Return to Vendor - days)	Oldest Item in RTV (days)
RTV Value (Return to Vendor - KPLN)	RTV Value (KPLN)
Cycle Count Results(%)	Total items counted within tolerance / Total Items Counted

The next group of indicators is related to supply and create indices, which present the level of customer satisfaction, in particular: delivery precision and level of goods quality. It is worth mentioning that the company measures both the delivery precision confirmed and required by the customer. Delivery precision required by the customer reflects the company flexibility in servicing of unexpected and express orders. Table no. 2 presents the set of indices.

Table 2. Customer satisfaction indices

Site: Mysłowice Operational Excellence Customers	
Weekly Metrics	Source definition
Delivery Accuracy - Customer request	Prior weeks shipments. Delivery accuracy compared to customer request delivery date. window: 0 day (zero day late)- 3 days (3 days early)
Delivery Accuracy - Customer first confirmed	Prior weeks shipments. Delivery accuracy compared to first confirmed delivery date. window: 0 day (zero day late)- 3 days (3 days early)
Delivery Accuracy - Customer last confirmed	Prior weeks shipments. Delivery accuracy compared to last confirmed delivery date. window: 0 day (zero day late)- 3 days (3 days early)
Backlog Customer Orders	Number of customer orders with promised delivery date before today (Promised delivery date < Sysdate - 1)
Backlog Customer Orders in value (KPLN)	Value of customer orders with promised delivery date before today (Promised delivery date < Sysdate - 1)
Delivery Quality PPM	Accepted claims or rejected product from customer measured in ppm of delivered lines .

Another set of indices related with supply is the financial measures that show material rotation and also the amount of materials for scrap or elimination and purchase price altering from standard prices. These indicators also present the efficiency of capital management. The examples of these indices can be seen in Table 3.

Table 3. Financial indices (costs of logistics)

Site: Mysłowice Financial	
Weekly Metrics	Source definition
Inventory Turns	It is a indicator that shows how many times goods, materials and products rotates during the period. It is calculated as COGS,a difference between sales and gross profit, and divide by average balance of inventory.
Cumulative Scrap (KPLN)	Scrap in receiving, SMT, assembly, rework, etc. Accumulated each week moving forward in the quarter.
Cumulative Inventory Adjustments (KPLN)	Value of favorable and un-favorable inventory adjustments including adjustment from cycle count. Accumulated each week moving forward in the quarter.
Retained Purchase Price Variance (KPLN)	Variance of Purchase spend (KPLN) to standard material cost. Accumulated each week moving forward in the quarter.

7. Planning flexible production using the ERP system

In order to plan the production process the ERP system needs three basic elements:

- what to produce;
- in wchich quantity;
- for when.

The planners, who receive forecasts and sales orders from customers, enter this information into the system. The system can carry out planning only of these goods that had been previously entered, together with full structure of required components (BOM – Bill of Materials), supplier lead time and also the time of finished product assembly.

The product structure is created and entered into system by a product engineer (a person responsible for the product) on the basis of technical documentation. It is divided into components produced internally (any kind of metal elements, which are painted, welded or galvanized) and components ordered from external suppliers.

Then, for every component that is produced internally, a product engineer defines the lead time together with the amount of metal plate required for production and sometimes for the complete assembly of the finished product. For components and materials purchased by operational buyers, the system completes information concerning price, lead time and minimum quantity of each detail.

This information will allow the ERP system to plan and present the optimal production time together with information which components can be critical, how many man-hours on FMS line it will take and how many assembly operators will be required for given production.

Planning is a continuous process. Planners from particular departments, depending on current needs (sometimes even a few times a day), enter to the system data taken from sales

orders and then, at nighttime, between 2 and 4 o'clock the ERP system calculates and analyses the available processing capacity.

Before work, the system is updated with the data from the previous day and depending on the quantity of the changes, it generates reports concerning shortages and delays of component deliveries or suggests changing the production time of some orders.

The master planner, who analyzes and then approves or rejects the suggestions of the system, continuously controls these reports

Approved master schedule works on the basis of everyday production of the FMS line and the orders from external suppliers.

In practice, the system:

- checks whether there are required components available on stock;
- generates production orders for the FMS line with specifying the number of details to be produced during the given day;
- analyses future external deliveries three weeks in advance and if component delivery is confirmed the system accepts it as available.

Internal components production is not a problem, because the production time is shorter than three weeks so the plant is able to meet the customer's needs.

Difficulties arise when we produce goods from external components because the delivery time is usually six weeks and the customer places an order with three weeks production period.

In order to solve the problem, production is planned on the basis of a sales forecast that plans the delivery quantity for the nearest 3-6 months.

Planners divide the forecasted monthly orders into parts for every production week and this data is the basis for the ERP system to plan any resources. Only such operations allow planning and carrying out production on time. Sales orders, which are received later, are entered into the system and verified, in accordance with the previous forecast.

The main disadvantage of such planning is that the orders are:

- lower than the forecast, which results in planning surplus production and thus having unnecessary material or products;
- higher than the forecast, which makes it impossible to produce in accordance with the plan due to shortages of material.

In the first case, the logistics department conducts the analysis of which components were ordered in quantities greater than needed and then, if the customer will not place an order within three months, they are returned to the supplier or sold to the customer. These procedures are governed by the flexibility concept mentioned before.

In the second case, when orders are higher than the forecast, operational buyers analyze the possibilities to speed up deliveries or purchasing from alternative suppliers and then present the total cost of this operation to the customer. Sometimes they need to add the cost of overtime that is necessary to produce extra orders.

8. Conclusion.

The article provides helpful material for further research regarding management of production systems in innovative enterprises with high-end technology and wide range of services. As the result of empirical research we come to the conclusion that in contemporary organizations, in further perspective, there is no room for tactical planning, which was used in the past in the industry. Tactical planning needs to be replaced by daily operational planning supported by modern information technology, such as the ERP

systems, necessary to apply such concepts as Quick Response (QR), Agile Management (AM) or Lean Manufacturing (LM). These methodologies allow the company to exist and have a competitive offer suitable for the current industry

Literature:

1. The Benefits and Disadvantages of Contract Manufacturing, IQS Newsroom, Industrial Quick Search, Inc, 16 Apr 2010.
2. Grudzewski W.M., Hejduk I.K., Zarządzanie technologiami [Management of Technologies], Difin, Warszawa 2008, p. 14.
3. Jasiński Z., Podstawy zarządzania operacyjnego [The basics of operational Management], Oficyna Wolters Kluwer Business, Warszawa 2011, p. 118.
4. Sierpińska M., Jachna T., Ocena przedsiębiorstwa według standardów światowych [Enterprice assesment according to world standards], PWN, Warszawa 2004, p. 183.
5. Szymonik A., Technologie informatyczne w logistyce [Information technologies in logistic], Placet, Warszawa 2010, p. 71.
6. Szymonik A., Logistyka i zarządzanie łańcuchem dostaw [Logistic and supply chain Management], part I, Difin, Warszawa 2010, p. 92.
7. http://biznes.gazetaprawna.pl/artykuly/525732. – accessed on 03.05.2011.
8. http://www.open-source-erp-site.com/work-center.html, – accessed on 03.05 2012.
9. http://b2btarget.pl/co-to-jest-b2b/, – accessed 20.05.2012.
10. http://www.firmaprodukcyjna.pl/s4.html, – accessed on 25.05.2012.
11. http://management.about.com/cs/generalmanagement, – accessed on 28.04.2011.
12. http://www.vendormanagedinventory.com/definition.php, – accessed on 09.06.2012.
13. http://www.investopedia.com/terms/g/greenfield.asp, – accessed on 04.05.2012.
14. http://pcc.imir.agh.edu.pl/poz13/index.htm, – accessed on 28.05.2012.

prof. PŁ dr inż. hab. Andrzej SZYMONIK
Katedra Zarzadzania Produkcją i Logistyki
Politechnika Łódzka
90 -924 Łódź ul. Wólczańska 21545-370
tel. 601 261 602
e-mail: dgw_szymonik@op.pl