LogForum

> Electronic Scientific Journal of Logistics <

http://www.logforum.net

ISSN 1734-459X
2010
Vol. 6
Issue 3
No 6

ANALYSIS OF THE INVENTORY LEVEL IN THE PRODUCTION CELL

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ABSTRACT. Simulation in production management is becoming increasingly important for efficient and competitive manufacturing. Production planners have to focus on several main goals: scheduling the plan efficiently, keeping inventories low, satisfying customer demand and anticipating the impact of every decision on the supply chain. They should understand how much inventory is needed to support demand during the production cycle and how much is needed to support a desired level of customer service. They should know how to reshape plans smoothly and responsively, without breaking the rhythm of the plan. And they should be able to visualize the impact of a planning decision on the entire supply chain. But before making decisions about management of the production they have to organize manufacturing system.

In this article we would like to present example how to organize the level of stock to shorten the time of executing orders and satisfy the needs of any given customer by using simulations in software application Arena.

Key words: production cell, simulations, forecasting, mean requirement, inventory level.

INTRODUCTION

Certain patterns can be observed in the logistics of manufacturing companies. The first is the tendency of production companies to keep the time for the execution of orders as short as possible [Hsu, Lee, Kut 2006]. This is the main tendency that influences how efficiently goods flow out of a manufacturing company. The next tendency that enables more efficient production is to keep the amount of stock on hand as low as possible [Hsu, Lee, Kut 2006]. This allows a manufacturing company to minimize the cost of storing stock. Not the least of these tendencies is how a company individualizes production to satisfy an individual customer's order. Most often, manufacturing companies try to increase responsiveness to satisfy customer needs [Spearman and Zazanis 1992, Lee 1989].

Unquestionably, time is the central issue in organizing logistics processes both for manufacturing and for service enterprises [Bozarth and Handfield 2007]. A production process that takes too much time may cause three negative outcomes: An order not to be delivered on time, the loss of a sale and even the loss of a customer [Coyle, Bardi, Langley 2007]. The company that is forced to back-order stock that was not readily available in its warehouse will have to bear the costs of additional orders and transport. It is possible for some clients to accept delays, but others simply change suppliers. More likely than not, each customer company has many competitors vying for its business. These competitors produce the same or substitutable products. And all competitors lie in wait for the mistakes of their rivals. If we are running a manufacturing company in a competitive market and delay delivery of an order, the customer will probably just cancel the order from our company and place one

Citation: Szozda N., Jakubiak M., 2010, Analysis of the inventory level in the production cell. LogForum 6, 3, 6
URL: http://www.logforum.net/vol6/issue3/no6
Accepted: 12.07.2010, on-line: 10.09.2010.

somewhere else. This will undoubtedly impact the hypothetical profit arising from the sale of the product that could not be manufactured on time. Additionally, our company will have incurred the costs of the initial effort and time spent fulfilling the terms of the order. The third possible negative outcome that can occur due to lack of materials in the warehouse is the loss of the client. The loss of the client means that the customer permanently changes the deliverer of a particular product. Enterprises that run out of clients lose future streams of income.

In order to reap the rewards of maintaining the correct stockpile of materials, and what follows, great customer service, one has to minimize the risk of stock running too low.

In this article we would like to concentrate on the problem of calculating the correct level of stock for the outcome of a given production cell. Our goals are: to shorten the time of executing orders, to organize the levels of stock and to satisfy the needs of any given customer.

DESCRIPTION OF SUBJECT COMPANY AND APPARENT PROBLEMS

The subject of our analyses is a company that produces furniture. Most of the production (about 80%) is custom-made in the pull system. Production is dependent on external orders and is only undertaken after such orders have been placed. This follows the pattern of the so-called demand orientation. The pattern of production in this system for the subject company is shown in the Figure 1.

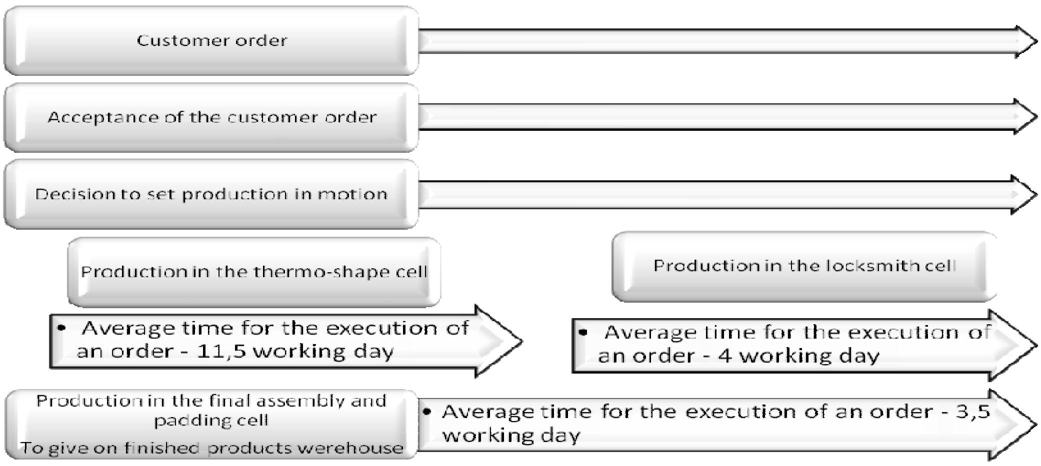
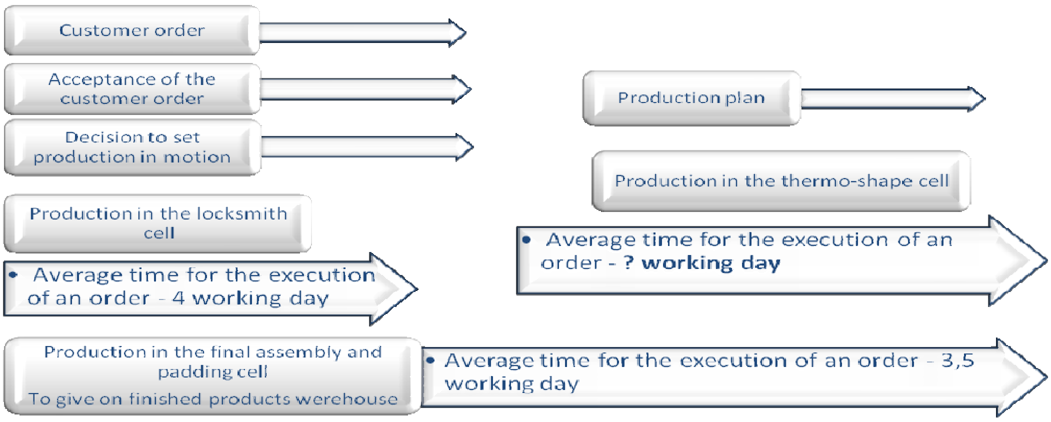


Fig. 1. Production process in the analyzed company
Rys. 1. Proces produkcyjny w analizowanym przedsiębiorstwie

The customer places an order, which should be executed in two weeks - or ten workdays. Once the order is accepted, the execution of production is set in motion in the two given production cells: thermo-form cell and locksmith cell. Work in these two cells is done simultaneously. Semi-finished products are delivered to the next cell, which is the final assembly and padding cell. After assembly and finishing, the final product is transported to the finished product-warehouse. The average time between the customer's order and delivery to the finished product-warehouse is 15 weekdays. This means the customer must wait three weeks for the delivery of an order, equivalent to the order being late by one week - or five workdays. This situation has caused many problems with maintaining agreements between this company and its customers. It has significantly decreased the competitiveness of the company in the marketplace, and the loss orders from possible customers.

The three-cell process described above has the capacity to fill customer orders on time. The organization of the production process is not the reason for the delay. Our observations allowed us to identify the problem. The time to execute orders takes so long because the orders wait for production within each production cell. The lack of available stock means that additionally to the time it takes to produce the semi-finished product, and finished product, one must count the time it takes for stock to be delivered to each cell. This delay-time is the consequence of a lack of inventory and a lack of planning. These times are shown in the Figure 1.

We can see that the bottleneck is the cell with the most stoppages - the thermo-form cell. There is one machine in this cell that executes every order, but there is no stock inventory level of the semi-finished product. Introducing the correct level of inventory at the end of the production process in this cell should bring improvements to the entire enterprise. This solution should allow for production to be executed in a more continuous flow with much shortened mean times for waiting and production. Our proposed solution is presented in Figure 2.



Source: Own study

Fig. 2. Production process in the analyzed company - proposition for the solution of the apparent problem
Rys. 2. Proces produkcyjny w analizowanym przedsiębiorstwie – propozycja rozwiązania występującego problemu

Our proposed solution to the apparent problem is the production of extra stock in the thermo-form cell. This production would be independent of demand and orders so that at the very moment after a customer places an order, semi-finished products are in stock and ready to move on to the next cell.

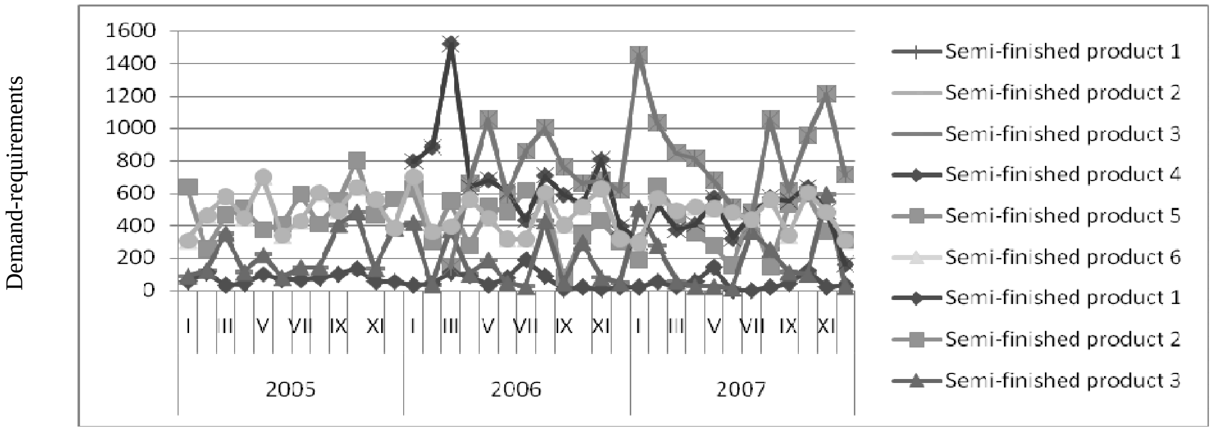
This company operates with one work-shift, 5 days per week, from 7am till 3pm. During one shift, the analyzed thermo-form cell produced ten semi-finished products. Three raw materials were used during this process. The list of semi-finished products, materials used, outlay and the production time is shown in Table 1.

Table 1. The list of produced semi-finished products and materials used in production within the thermo-form cell
Tabela 1. Lista wytwarzanych półproduktów i materiałów używanych w produkcji w jednostce termicznej

Produces semi-finished products	*The time for production [min.]*	*Materials used in production*	*The quantity of materials used [mb/szt.]*
Semi-finished product 1	60	plate – metalic silver 3mm	2.25
Semi-finished product 2	70	plate – metalic silver 3mm	2.9
Semi-finished product 3	35	plate – metalic silver 5 mm	3.25
Semi-finished product 4	10	plate - black 3mm	0.46
Semi-finished product 5	5	plate – metalic silver 3mm	0.08
Semi-finished product 6	5	plate – metalic silver 3mm	0.72
New semi-finished product 1	10	plate – metalic silver 3mm	0.15
New semi-finished product 2	10	plate – metalic silver 3mm	0.7
New semi-finished product 3	10	plate – metalic silver 3mm	0.25
New semi-finished product 4	10	plate – metalic silver 3mm	0.35

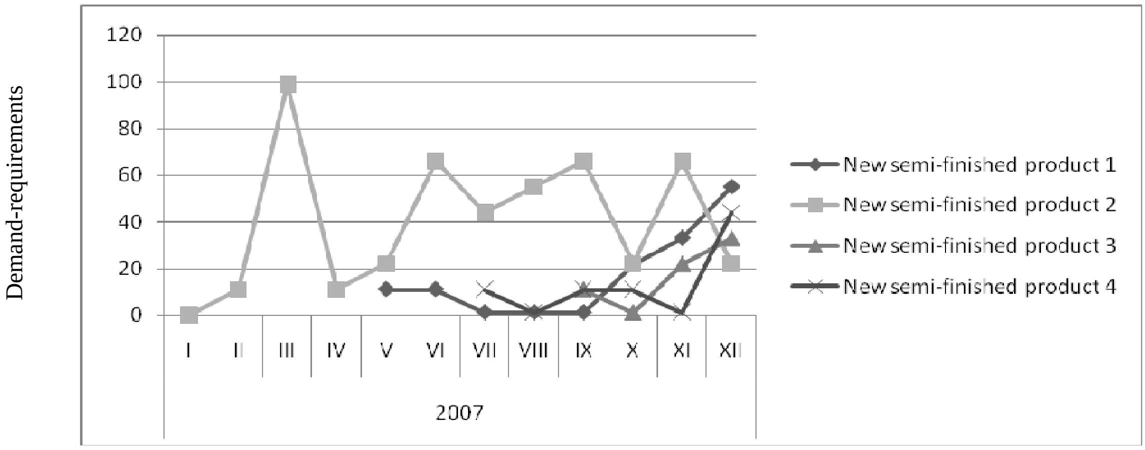
This cell produced two types of products: The first type is made up of old products with established market positions, which had been on offer for at least one year. The second type is made up of new products, introduced to the market in 2007.

With the data above and historical levels of demand for semi-finished products it could be possible to calculate appropriate inventory levels. But we observed one additional problem - irregular demand-requirements. Presented in Figures 3 and 4 is the production plan for semi-finished products (old and new) executed between 2005 and 2007.



Source: Own study

Fig. 3. Historical requirement for old products over three years
Rys. 3. Historyczne zapotrzebowanie na stare produkty w okresie trzech lat



Source: Own study

Fig. 4. Historical requirement for new products in 2007
Rys. 4. Historyczne zapotrzebowanie na nowe produkty w 2007

In these two figures we can observe that the irregularity of the production plan was very high. The changeability coefficient for requirements in the years 2005 - 2007 equals between 0.3167 and 1.6682. This was the case regardless of what type of products were produced in the analyzed production cell - thermo-form cell. We conducted our research on data from 2005 - 2007. We designated 2008 as our test year, for which we have defined a proposition for solving the apparent problem with delays in executing orders.

THE ANALYSIS OF THE PRESENT SITUATION

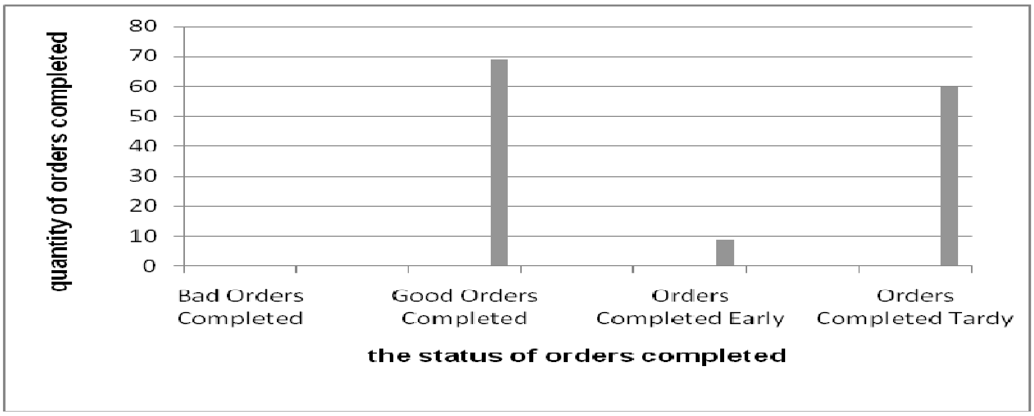
The first analysis that we conducted concerned mapping the current situation. This was necessary because some data in the company, such as the timeliness for implementation of contracts, were not recorded. To confirm our first observations, we carried out the restoration of the production process in 2008. To do this we used the software application Arena made by the Rockwell Software Company [Kelton, Sadowski, Sturrock 2007, Kelton]. In this application we used the special module (Factory Analyzer) which is made to simulate and analyze the various decision-making strategies of a manufacturing company [Altiok, Melamed 2007].

Assumptions of the model:

1. Output data about the production process are taken from Table 1.
2. The company agrees that the duration of the overall process of manufacturing the semi-finished products is two weeks from the moment of the customer's order to the end of all production processes.
3. The production process researched by us in the thermo-form cell starts at the time of notification of an order, and then the production plans are created and production begins.
4. Data about manufacturing orders are taken from Figures 3 and 4.
5. The production process follows the first in first out rule. Orders are filled based on the date they are placed. The earliest orders are completed first.
6. After each production order is completed about 15 minutes is taken to set up input parameters and to rearm the production machine.

Our results are presented in Figures 5 and 6.

Analyzing the results we see that a very large proportion of production orders is delayed. If we take only the products which have been offered by the company for more than one year, we can see that of sixty-nine production orders executed by the thermo-form cell, only nine of them were completed on schedule (this amounts to only 13% of all orders). In the case of semi-finished products that have been offered by the company for less than one year, we can see that of thirty-seven production orders in the thermo-form cell, only seventeen of them were completed on schedule (this amounts to 46% of all orders). The other production orders were characterized by delays an average of about 5.5 workdays. The delays that are presented caused the time lags for completing orders (as was mentioned earlier in this article).



Source: Own study

Fig. 5. The result of the simulation for old semi-finished products - those at market for over a year
Rys. 5. Wyniki symulacji dla starych półfabrykatów, które istnieją na rynku ponad rok

Source: Own study

Fig. 6. The result of the simulation for new semi-finished products
Rys. 6. Wyniki symulacji dla nowych półfabrykatów

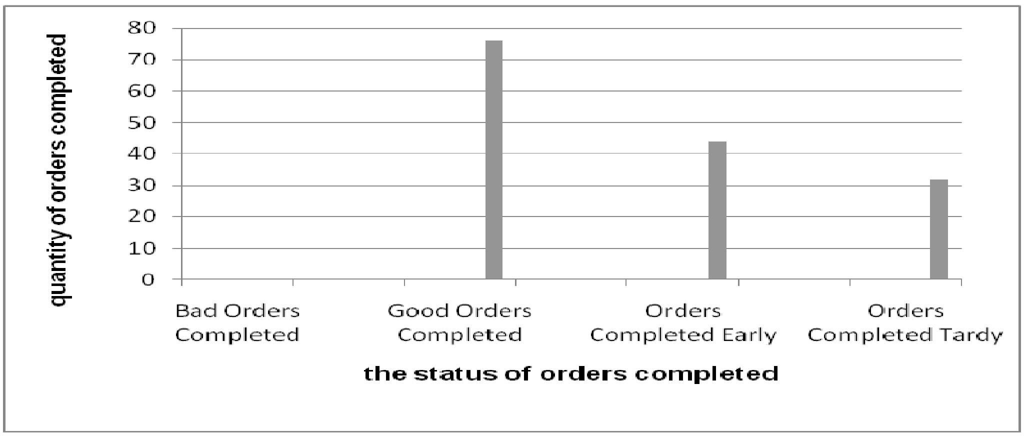
SOLUTION 1 - PRODUCTION OF STOCK IN TERMS OF AVERAGE DEMAND

The results obtained by our analysis of the present situation of this company led us to think-through two variant options for decision-making that could improve the process in the thermo-form cell. In both variants we change over from the pull production system to the push production system. In the first test case, the size of a production batch is determined in advance on the basis of orders from the previous two years.

Production orders are triggered in two cases:

- for stock - the goal of this production plan is to create a state whereby the final size of the stock at the end of every month equals the average size of orders from the previous 24 months.
- on demand of the "customer" - this is additional production in the case where there is an insufficient quantity of semi-finished products in stock.

All other conditions are the same as in the base situation. The results of this option are presented in Figures numbered 7 and 8.



Source: Own study

Fig. 7. The result of the simulation for old semi-finished products that have been at market for over a year by taking into account production in terms of average sales

Rys. 7. Wyniki symulacji dla starych półfabrykatów, które są na rynku ponad rok przy uwzględnieniu średniej sprzedaży do planowania produkcji

Source: Own study

Fig. 8. The result of the simulation for new semi-finished products that have been at market for under one year by taking into account production in terms of average sales
Rys. 8. Wyniki symulacji dla nowych półfabrykatów, które są na rynku ponad rok przy uwzględnieniu średniej sprzedaży do planowania produkcji

In this variant, the number of production orders is increased to seventy-six when we consider the semi-finished products that have been offered by the company for over a year, and fifty-five in the case of semi-finished products that have been offered by the company under one year. For the first type of products 57% of all orders are completed on schedule. For the second group of products, this number fluctuates within the limits up to 70%. This approach (production of stock in terms of average demand) makes it possible to substantially improve the level of customer service. This improvement is especially noticeable in the case of semi-finished products that have been offered by the company for under one year.

SOLUTION 2 - PRODUCTION OF STOCK BY USING FORECASTING

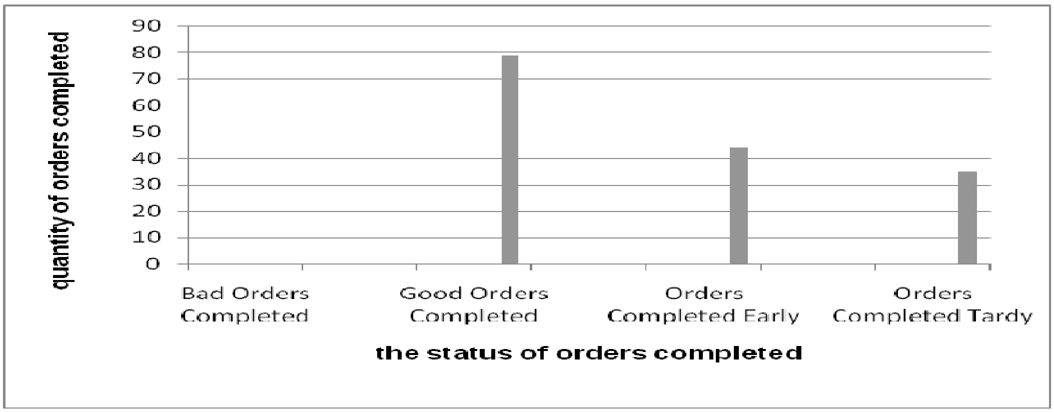
In the second variant option, the level of the production batch is calculated by forecasting the necessary level of stock in the future. For the first type of products, old products, the forecast is calculated by using adaptations for a time-sensitive data series. Because these special methods are designed for a series characterized by trends, seasonality etc., they apply to furniture, where sales are higher in some parts of the year and lower in others [Zeliaś, Pawełek, Wanat 2003]. For the second type of products, new products, we were not able to use standard time-series forecasting methods. The standard forecasting methods require some historical data, which were unavailable at the time when the forecasts were being calculated. In this case we created our forecasts by analogy [Cieślak 1998, Cieślak 2000]. We used the data based on orders of semi-finished products placed in the past for old products. We then compared the size of past orders for semi-finished products produced by the thermo-form cell with the orders for semi-finished products for the new products.

Production orders, as in our first test scenario, are triggered in two cases:

– for stock - the goal of this production plan is to create a state whereby the final size of the stock at the end of every month equals the average size of orders from the previous 24 months.

– on demand of the "customer" - this is additional production in the case where there is an insufficient quantity of semi-finished products in stock.

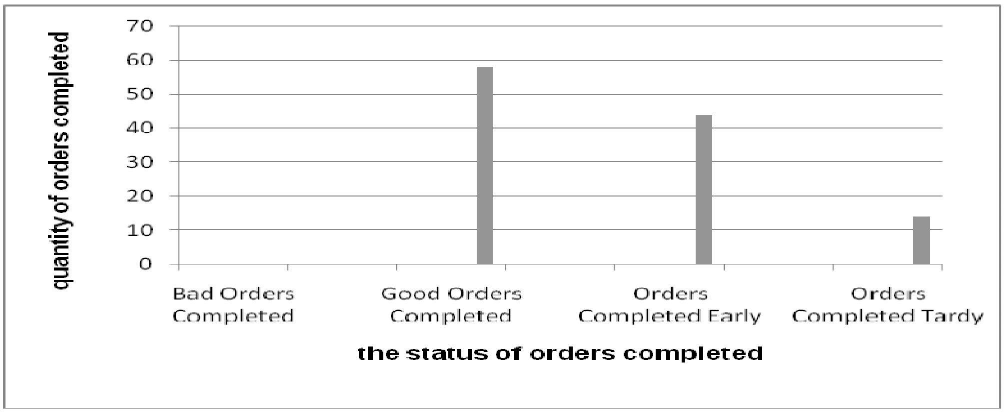
All other conditions are the same as in the base situation. The results of this option are presented in Figures numbered 9 and 10.



Source: Own study

Fig. 9. The result of the simulation for semi-finished products that have been at market for over a year by taking into account production using forecasting

Rys. 9. Wyniki symulacji dla półfabrykatów, które są na rynku ponad rok przy uwzględnieniu szacunków do planowania produkcji



Source: Own study

Fig. 10. The result of simulation for semi-finished products that have been at market for under a year by taking into account production using forecasting

Rys. 10. Wyniki symulacji dla półfabrykatów, które są na rynku poniżej roku przy uwzględnieniu szacunków do planowania produkcji

The number of production orders in this variant is increased to ninety-four when we consider the semi -finished products that were offered by the company over a year, and fifty-eight in the case of semi -finished products that are offered by the company under one year. For the first group of products, the number of production orders which were performed punctually was forty-four (this is about 48% of all orders). For the second group of products, the number of production orders which were performed punctually was also forty-four (which represents 76% of all new product production orders).

This approach (production of stock by using forecasting) gives very good results, especially in the second group of products. A summary of the percentage of orders filled punctually in the three cases which were researched is shown in Table 2.

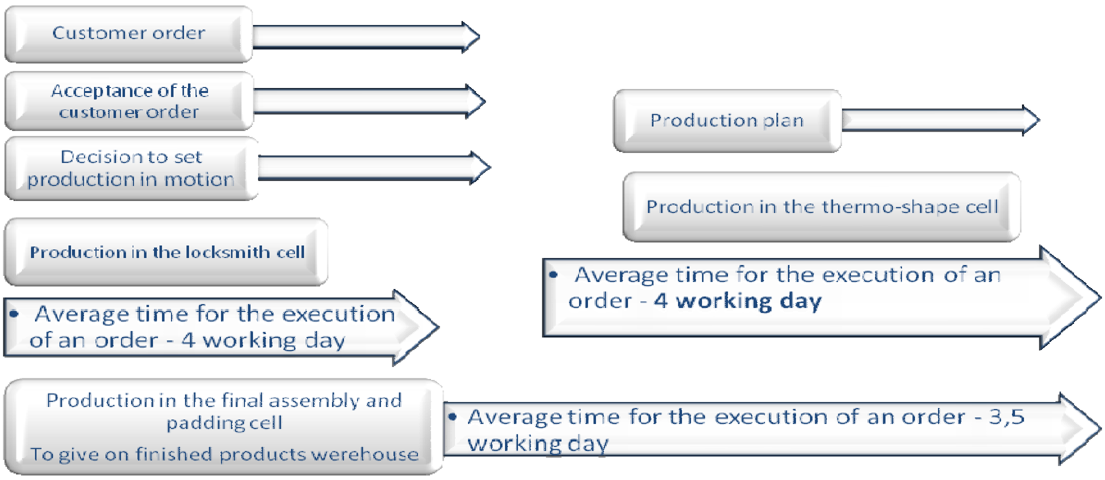
Table 2. Summary of times for the manufacturing process, for the analyzed options
Tabela 2. Sumaryczne czasy procesu wytwórczego w analizowanych wariantach

	Products with strong market position – 95% of semi-finished products manufactured	*New products – 5% of semi-finished products manufactured*
Option	*The average time of waiting for the completion of the semi-finished products in the thermo-forming cell [working day]*	
Customer Order	11,5 working day	6,6 working day
Average	4 working day	3,5 working day
Forecast	5,1 working day	3,1 working day

Source: Own study

The time of waiting to complete an order for semi-finished products which have been produced by the company for over a year is shortened by 7.5 working days after determining the level of stock based on the average level of past orders. When we use the forecasting method, the wait-time is shortened by 6.4 working days.

The time of waiting to complete an order for a semi-finished product which have been made by the company for under a year is shortened by 3.1 working days after determining the level of stock based on the average level of past orders. When we use the forecasting method, the wait-time is shortened by 3.5 working days.



Source: Own study

Fig. 11. Production process in the analyzed company - solution to the problem
Rys.11. Proces produkcyjny w analizowanym przedsiębiorstwie – rozwiązanie problemu

Analyzing the entire process of manufacturing the finished product, it can be concluded that the average time of execution of a production order is now 7.5 working days after determining the level of stock based on the average level of past orders. When we use the forecasting method, the wait-time is shortened by 8.6 working days. At first it would appear that the better approach is to use the averaging method, but with deeper analysis of the results we can see that stocks are much lower by using the forecasting method. The results of this analysis are shown in the Table 3.

Table 3. Summary of indicators for the stock levels for the two options presented in the article
Tabela 3. Sumaryczne wskaźniki dotyczące poziomu zapasów dla dwóch wariantów przedstawionych w pracy

	The average level of stock which is counted as an indicator – the average stock in the warehouse/average order size [%]
Customer Order	0%
Average	81 %
Forecast	46 %

Source: Own study

When the forecasting method is applied, the average level of stock used as an indicator (the average stock in the warehouse/average order size) is 35% lower than the average. In the case of the company studied by us, there is a very good argument for the introduction of the forecasting method over using the method determining the level of stock based on the average level of past orders.

Table 4. Comparison for the time of the entire production process for the two options which are presented in the article
Tabela 4. Porównanie czasu sumarycznego produkcji dla dwóch wariantów przedstawionych w pracy

	The duration of the entire manufacturing process [in days]	***The duration of the entire manufacturing process [in weeks]***	***Stock – how much stock left as reserve [in weeks]***
Before	15 working days	3 weeks	- 1 week
After– average **After – forecast**	7,5 working days 8,6 working days	1,5 week 1,72 week	0,5 week 0,28 week

Source: Own study

CONCLUSIONS

In the 1950s producing to order was common to almost every trade and industry [Hulten, Dubois, Gadde 2000]. However, industrialization introduced methods of mass production, and with it standardization and decrease in costs (especially due to the effects of scale). Since that time, made-to-order production continued only for niche products characterized by high value and small turnover. In this category of consumption goods were luxury and craft goods. In last few years technological advances in production and information technologies have produced the effect that even high rotation/mass produced products have been made to order. But it is not the case that this option is always appropriate. It is characterized by many weaknesses, about which companies should be aware. One of the biggest disadvantages of this make-to-order pull system is the long time it takes to execute an order. Because time has such a high value these days it may save time and money to switch from a pull system to a push system of production. This is the so-called switch from customization to standardization. The main cause of this is the desire to keep existing customers and attract new customers. The example presented above confirms this hypothesis.

REFERENCES

Altiok T., Melamed D., 2007, Simulation Modeling and Analysis with ARENA Elsevier Science & Technology Books, 2007.

Bozarth C., Handfield R.B., 2007, Wprowadzenie do zarządzania operacjami i łańcuchem dostaw, Helion, One Press Exclusive, Gliwice.

Cieślak M., 1998, Prognozowanie popytu na nowy produkt, Prace Naukowe Akademii Ekonomicznej we Wrocławiu, nr 808, Wrocław, 202 - 210.

Cieślak M. (red.), 2000, Prognozowanie gospodarcze. Metody i zastosowania, Wydawnictwo Naukowe PWN, Warszawa.

Coyle J.J., Bardi E.J., Langley C.J., 2007, Zarządzanie logistyczne, PWE, Warszawa.

Hsu V.N., Lee Ch.Y., Kut C. So, 2006, Optimal Component Stocking Policy for Assemble-to-Order Systems with Lead-Time-Dependent Component and Product Pricing, Management Science, 52 (3), March 2006, 337-351.

Hulten K., Dubois A., Gadde L.-E., 2000, Developments in Distribution Networks - A framework for understanding variety, Paper presented at the 16th IMP conference, Bath, UK Sept. 7-9.

Kelton W. Sadowski P. Sturrock D., 2007, Simulation with Arena, 4th edition, McGraw-Hill.

Kelton W., Arena Factory Analyzer, Rockwell Software User's Guide.

Lee L.C., 1989, A Comparative Study of the Push and Pull Production Systems, International Journal of Operations & Production Management, 9, (4), 5 - 18.

Spearman M.L., Zazanis M.A., 1992, Push and Pull Production Systems: Issues and Comparison, Operations Research, 40 (3), May - June, 521 - 532.

Zeliaś A., Pawełek B., Wanat S., 2003, Prognozowanie ekonomiczne. Teoria, przykłady, zadania, Wydawnictwo Naukowe PWN, Warszawa.

ANALIZA POZIOMU ZAPASÓW W PRODUKCYJNEJ JEDNOSTCE ORGANIZACYJNEJ

STRESZCZENIE. Symulacje w zarządzaniu produkcją stały się bardzo istotnym narzędziem w celu osiągnięcia efektywnego i konkurencyjnego systemu produkcyjnego. Planiści produkcji powinni się skupiać na kilku głównych celach: efektywnym harmonogramowaniu produkcji, utrzymywaniu niskich poziomów zapasów oraz spełnianiu wymagań klienta przy uwzględnieniu, jaki wpływ te decyzje będą miały na łańcuch dostaw. Muszą oni rozumieć w jaki sposób zapasy wpływają na zaspokajanie zapotrzebowań w czasie cyklu produkcyjnego oraz jaki ich poziom jest potrzebny dla zapewnienia wymaganego poziomu obsługi klienta. Powinni posiadać umiejętność dokonywania korekt planów w płynny i odpowiedzialny sposób bez naruszania rytmu tego planu. Powinni również rozumieć wpływ decyzji planistycznych na całość łańcucha dostaw. Jednak zanim zaczną podejmować decyzje dotyczące zarządzania produkcją, wpierw powinni zorganizować system produkcyjny.
W pracy przedstawiono przykład zarządzania poziomem zapasów umożliwiający skrócenie czasów realizacji zamówień oraz zaspokojenia potrzeb każdego klienta poprzez zastosowanie symulacji oprogramowania komputerowego ARENA.

Słowa kluczowe: jednostka produkcyjna, symulacje, szacunki, średnie zapotrzebowanie, poziom zapasów.

ANALYSE DES LAGERBESTAND IN DER FERTIGUNGSZELLE

ZUSAMMENFASSUNG. Simulationen in der Produktionsverwaltung werden immer wichtige Werkzeuge sein, um das effiziente und wettbewerbsfähige Fertigungssystem zu erreichen. Die Fertigungsplaner müssen auf mehrere wichtige Ziele konzentrieren: die Produktion effizient planen, Lagerbestände niedrig halten, Kundenanforderungen erfüllen, unter Berücksichtigung der Auswirkungen, die diese Entscheidungen auf der Lieferkette haben. Sie sollen verstehen, wie und welche Lagerbestände nötig sind um die Nachfrage während des Produktionszyklus zu unterstützen und welche sind nötig um ein gewünschtes Niveau des Kundenservice zu halten. Sie sollen die Fähigkeit haben, Anpassungen der Pläne in einer glatte und verantwortungsvolle Weise zu machen, ohne den Rhythmus des Plans zu brechen. Sie sollen auch verstehen, welche Auswirkungen für die gesamte Lieferkette haben diese die Planungsentscheidungen. Aber bevor können sie die Entscheidungen über die Verwaltung der Fertigung machen, müssen sie das Produktionssytem organisieren. Ein Beispiel von der Verwaltung von Lagerbeständen wurde in diesem Artikel präsentiert, mit dem Ziel die Ausführungszeit von Aufträgen zu verkürzen und die Bedürfnisse des jeweiligen Kunden zu erfüllen durch den Simulationen in der Software Anwendung ARENA.

Codewörter: Fertigunszelle, Simulationen, Prognosen, durchschnittliche Nachfrage, Lagerbestand.

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