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Method of Buffering Critical Resources in Make-to-Order Shop Floor Control in Manufacturing Complex Products

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Abstract: The article presents the results of research on creating a dedicated planning system and shop floor control in the conditions of make-to-order in manufacturing complex products. The research was done in Marine Diesel Engines Factory, HCP S.A. Poznan conditions. HCP S.A. Poznan is the biggest producer of high-power marine engines in Europe. The result of the research is a method for buffering critical resources shop floor control. These methods of buffering critical resources include procedures of buffer management, (buffer configuration and optimization), a system of disruption compensation and feedback protecting from destructive influence of “wandering bottlenecks.” The simulations show that this method is more effective than the classical drum-buffer-rope production solution, according to TOC, using the FIFO rule. Finally, the lead-time and the level of work-in-process were about 20% lower than the solution recommended to TOC. In the last part of the article a place and a method of implementing the solution in a planning system of an enterprise are discussed.

Keywords: Make-to-order company, Long lead time, A-plant (V-A-T analysis) TOC – (Theory of Constraints)

1. Introduction

Many companies face a difficult choice between make-to-stock (MTS) and make-to-order (MTO) production. Such a decision depends on various factors connected with not only demand in the market (customers), but also with internal conditions, such as the way of organizing production or the complexity of manufactured products. On the one hand, there is a problem of CTT (Customer Tolerance Time) and customer service level (e.g. Schragenheim *et al.* 1994, Sox *et al.* 1997). On the other hand, there is a classic issue of production batch size and machines setup times, which is further complicated by limited production capacity. This leads to lengthening production time through congestion, which, in turn, requires raising levels of safety stocks to maintain the targeted service level (e.g. Li 1992, Rajagopalan 2002). Attempts to solve the complex trade-off issue are the springboard to make decisions to choose between the MTO or MTS strategy (Rajagopalan 2002). In the production environment in which strictly customized high-power marine engines are the finished product, the necessity to choose between MTO and MTS is limited to a certain number of component parts. They constitute a group of common parts which are used to realize a great number of orders for finished products. MTS production is connected with accumulation of orders for these components to reduce the number of setups of a machine.

In MTO conditions of complex product what also plays an important role is to ensure fast and cost-effective deliveries of parts and components from suppliers. The role of suppliers is crucial here because of the extent of competition in the area of realization and the influence the reliability of deliveries has on meeting deadlines when fulfilling orders. Decisions taken to choose suppliers regarding their time of delivery also have an impact on total production

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costs. Usually such a decision is made on the basis of the price and the time as well as the quality (e.g. Easton and Moodie 1999, Verma and Pullman 1998). The effectiveness of these decisions depends on creating the right negotiation model which takes into account purchase, production and marketing conditions (Moodie and Bobrowski 1999, Cakravastlat and Nakamuraji 2002). In the case of making complex products with long manufacturing lead time, their reliability and coordination, rather than short delivery times, gains significance. What is key here is the coordination of delivery chains and production process as well as the final assembly. For a very limited number of suppliers of major parts (e.g. crankshafts or pistons), also the price is less prone to negotiations than the quality and reliability of supplies.

One key issue in making to order is production planning and scheduling, assessed on the basis of customers' satisfaction and production costs. A typical way of measuring client's level of satisfaction is the service level, understood as the percentage of customers' orders realized on time. On the other hand, there is the aim to reach the low unit production cost by reducing the time that materials have to wait before processing begins, decreasing the length of processing and the amount of time that ready products have to wait before they are dispatched.

The environment of making to order is dynamic in its nature, because customers can modify, annul or add orders during the planning horizon (e.g. Muda and Hendry 2002, Sawik 2006). As a result of this, production planning and scheduling may become inefficient and require modification in response to unexpected changes in customers' orders. In practice, reactive scheduling is undertaken according to the relevant algorithm (Vieira *et al.* 2003, Sawik 2007). The key issue here is to meet due dates when it comes to using the production capacity at the disposal (e.g. Vieira *et al.* 2003, Corti *et al.* 2006)

In the environment of producing high-power marine engines, the production process is extremely expensive and long. Making manufacturing lead time shorter by appropriate configuration of values of time buffer is critical from the perspective of decreasing the value of work in progress, and consequently, the amount of the capital employed. In case of a strong bottleneck, what is the most important, apart from a shipping buffer, is to shape the value of constraint buffer, which is the object of this paper.

2. Literature review

The system of scheduling in the theory of constraints (TOC) is a drum-buffer rope (DBR), (Goldratt and Fox 1986), which in practice consists in realizing the idea of five focusing steps) (Goldratt and Cox 1984) in the area of flowing of the production stream. What is key here is to subject materials and machines to the rhythm of work of a critical resource in order to ensure the maximum level of exploitation and, at the same time, the control of work in progress as well the length of the manufacturing lead time. The basis of this logic is identification of the main critical resource and construction of the optimal work schedule (Drum). Another element of the method is to combine work constraints schedule with materials schedule (Rope) in order to include the material in the production system through working critical resources, according to the "pull" flow logic. The last part of the method is the time buffer, being the time from release materials to the moment of the treatment start in the critical resource. Its aim is to ensure uninterrupted work of the critical resource based on the principle that it is the constraint of the production system that influences its flow capacity (Goldratt and Cox 1984).

For the DBR system to function properly, some excess capacity of production in non-critical resources is needed. It is the so called protective capacity (APICS 1995), being the DBR system's integral part. This protective excess capacity is used together with the time

buffer to absorb time delays in case of production flow stream disruption towards the critical capacity as well as the possibility of not meeting the deadline of a given order.

Many authors (Goldratt 1990, Umble and Srikanth 1996, Atwater and Chakravorty 2002, Blackstone and Cox 2002) stress the importance the protective excess plays in the way the DBR functions, which is also connected with how statistical fluctuation influences on a production process. This needed excess of power is the reason why imbalanced systems of production are built to ensure optimal performance.

DBR is a logical and clear mechanism which allows managing the flow of material streams in imbalanced production systems with a critical resource. Nevertheless, the functioning of DRUM and ROPE may be obvious, but in implementing it is calculation and improvement of the time buffer which require the most attention (Woepfel 2001, Goldratt School 2004).

The calculation of buffers, the process of its monitoring and improvement as well as guidelines as to its location make up a buffer management system. The basic aim of buffer management is: to protect the flow capacity, to reduce the level of stocks and to decrease operating expenses. The aim is in line with operational measures used by TOC to assess the efficiency of optimization actions that are taken (Goldratt and Cox 1984). In the area of production, TOC concentrates on increasing throughput and, consequently, the whole production process. The increase in the flow capacity is treated as the main way of increasing profits. To enable assessing the efficiency of actions taken, TOC suggests categorizing what a company does with its money in three ways, introducing the following operational measures (Goldratt and Cox 1984):

- Throughput - T
- Inventory - I
- Operating Expense – OE

All these three measures are interdependent. This means that changing any of these will affect the second one, or the other two. Because of that, if we want to improve the result according to the TOC philosophy, it is necessary to implement the formula consisting in maximizing Throughput as well as decreasing levels of Inventory and Operating Expenses. These three measures are key to assess the relation between local facilitating decisions and the whole system's results. Despite the interdependence of these three measures, Throughput is regarded as the most important one. Expenses are of course to be decreased, but TOC's practitioners believe that an increase is not caused by concentrating on what should be limited, but rather on what should be increased (Woepfel 2001, Goldratt School 2004). In other words, one should concentrate on actions that increase processing. This importance of processing is called Throughput World Thinking as opposed to Cost World Thinking (Goldratt 1997).

The decision to localize buffers in the production process is facilitated by the VAT-analysis (Umble 1992, Umble and Srikanth 1995, 1997). The analysis divides companies into so called "V", "A" and "T" plants and their possible combinations. Guidelines concerning the location of time buffers and stock buffers also depend on market conditions as well as the MTO, MTS or ATO (Assemble-to-order) strategies, or the location of the decoupling point, also known as Order Penetration Point (OPP). The location of global buffers in critical points of production system also means the absolute necessity to dispose of local buffers in order to increase the efficiency of buffering (Hadas 2006). Operational management of buffers consists in shaping their sizes and monitoring their wear. One very well-known method is based on the so called Traffic Light Analogy, which allows both monitoring and constant improving of buffers' sizes. The method divided the buffer into three zones: green, yellow and red.

Figure 1. Managing the constraint buffer according to Traffic Lights Analogy

If an order is in the green zone, there is no need to take action; if it is in the yellow zone, one should be prepared to take action; and if it is in the red zone, it is imperative that one take action immediately, to avoid delays, which can lead to a loss of the constraint buffer or shipping buffer (see figure 1). Improving the size of the buffer is based on observing subsequent production orders. If subsequent orders use up not more than 1/3 of the buffer (the green zone), it means that the buffer is too big and it needs decreasing. If orders use up more than 2/3 of the buffer (the red zone), it means the buffer is too small and needs enlarging. If the buffer is used up regularly in the green zone, it means its size is appropriate. Monitoring how the buffer changes also allows to analyze a potential upward or downward trend, which, in turn, allows to lengthen or shorten the fulfillment time. Analyzing why buffers are used up in the red zone allows to take action to eliminate disruptions in the flow and stabilize the production system. Therefore, the method used in the correct way may be a tool of continuous improvement of the production process.

Buffer management has many variations, as for example, dividing a buffer into two zones – a green buffer zone and a safety buffer zone and management bases on a Re-order point (Yuan *et al.* 2003). The practice of the DBR mechanism is also improved in the context of, e.g., a workload control (Riezebosy *et al.* 2003) or the influence that the so called free goods in a critical resource have on its results (Satya *et al.* 2005). In conditions of great changeability of the process time, the DBR mechanism has also been modified – MOD DBR (Sirikrai and Yenradee 2006) and complemented with an algorithm of a detailed scheduling of all resources.

Determining the right buffer size and its improvement requires, however, multiple iterations. Collecting information on the size of penetration of the buffer is possible in case of many regular orders. In case of high-power marine engines, where the manufacturing lead time lasts from 9 to 12 months and 30 items can be produced in one year, the amount of data of how the buffer is used up is very limited. The analysis is also made difficult because of changes in labor intensity of particular orders, which results from individual customization for particular customers. So if the buffer size is to be specified in the right way, a mechanism should be used, which will allow to estimate each single order in a more precise way, rather than in the process of subsequent iterations.

3. Business Process Perspective

3.1. HCP S.A. Poznan production background

Introduction

The subject of the analysis is a manufacturing company which deals with producing single machines and devices in the area of mechanical engineering. It is H. CEGIELSKI-POZNAN S.A. – a marine engines manufacturer (W2). The company is a major producer of marine engines in Poland and their biggest producer in Europe.

The number of engines produced yearly amounts to about 30. The labor intensity of producing one item amounts to 40 000 working hours. The final product is characterized by a long manufacturing lead time. A theoretical manufacturing lead time of a single item is about 9 months long. In practice, due to various interruptions, it may be 12 months long or longer. It results in increasing capital (the capital-intensive nature of production), so typical for the branch and single-production conditions. The level of the products' customization can be

classified as Versatile Manufacturing Companies (VMC) (Stevenson *et al.* 2005), and an Order Penetration Point (OPP) can be determined as Engineer-To-Order (ETO).

The system of production planning and control

The company’s planning system for Marine Engines Company (W2) is a typical hierarchical system. A sales plan is devised at the level of finished products. Because of the fact that the branch is highly specific and the finished lead time is very long, the plan has a horizon of at least 2 years. A typical issue here is specifications of what a marine engine should be like, what its description should be like and what certificates it should have. An offer enquiry is directed to be consulted in the company’s key departments. The Department of Technical Production Department expresses its opinions as to whether a particular order can be handled from the construction’s and technology’s point of view. Special offer enquiries for highly customized products (uniqueness of construction solutions) are carefully evaluated by the construction department and the technological department. The Production Department evaluates whether a potential order can be fulfilled from the production capacities’ point of view in given periods of time. The key dates are “the date of the product’s trial” and “the date of the engine’s shipment”. On this particular stage, what is evaluated is whether the order can be fulfilled in line with critical resources load, according to treatment anticipation against the date of the product’s final trial. The balancing of the potential consists in assessing the available flow capacities on critical resources, which considerably limit the company’s production capacities. The yearly production volume is established on the basis of the production capacity in the intersection of products. Priority is given to orders of basic production (engines), and then components, parts other than engines and services are taken into consideration. One additional criterion is to aim at spreading load evenly in particular periods of production.

Accepted orders for finished goods form the basis of creating a periodical production plan. Initially, production capacity for critical resources and the intersection of construction groups are specified, then they are complemented with production capacity according to professional groups of workers. On the basis of the results of balancing, the number of workers needed to fulfill the order is specified. For the following six months demand for additional employees is determined; what is also analyzed is the ability of moving people across departments and/or outsourcing a part of work to other companies.

On the stage of components devised cyclographs are used – plans of building an engine. These are typical framework cyclographs which do not reflect the complexity of the product – all its components, but only basic criteria of main components, so called leading parts. The framework cyclographs help create next parts of the production plans variants. The production plans are then used to start up orders for works in particular workshops (production plans of the first stage of complexity).

On the operational level, given workshops work as new orders flow in. It does not lead to a detailed planning of particular workstations' load. The sequence and delegation of work to particular workstations is determined by foremen of particular production entities. If work piles up, there are problems with prioritizing what should be done first, because foremen in particular production entities do not have information on the global work progress for particular orders. It is usually the case that what is done first depends on what is received from previous entities. Work advancement in particular production entities is controlled on the basis of employees' reports on how many hours have been spent on a particular order. "The number of hours" is compared to normative guidelines for a given order, which allows to assess the percentage rate of project fulfillment. Due to the fact that reporting of workers on

the number of hours spent is inherently delayed against the real work progress, the information that the planner receives is only approximate and, therefore, it is of little use in current control. The Main Planner has knowledge of whether a component order has been started or finished. More often than not, he or she does not know the fulfillment progress of a given order. Lack of this knowledge makes it difficult to modify the sequence of orders to speed up the inflow of particular components, according to the priority of the shortest possible period of treatment.

3.2. The proposed model

A simple application of the DBR mechanism based on the FIFO rule in conditions of big changeability of tasks and the nine-month manufacturing lead time has proved inefficient. What influences the efficiency of using FIFO in companies for a production system with a critical resource most is the amount and labor intensity of works competing for resources. As the number of works competing for resources is increases, lead time lengthens (see figure 2). At the same time, as it does, the constraint buffer is limited. The continuity of work is threatened, so the sequence of treated parts has to be changed. First, additional FIFO sequence has to be prioritized; yet another step will be to stop production of parts. It is one of the main reasons why this method of flow cannot be used for single production conditions of manufacturing products with a long manufacturing lead time.

Full scheduling of the flow of non-critical resources has proved necessary – i.e. detailed planning of their work. An idea algorithm is shown in figure 3. The first step of the method is to choose orders that are a load to a critical resource in a planning horizon not shorter than 1 year. Then a schedule of work of the critical resource (DRUM) is devised, which takes into account the order fulfillment deadline. A key step is to calculate the size of the constraint buffer in order to ensure loading the critical resource and shortening the manufacturing lead time. On the basis of the data from the MRP system, a theoretical lead time of production is calculated, which is the sum of operations' period and setup times and nothing more. The theoretical lead time therefore provides for full availability of the machines and lack of the process fluctuation.

Then the real lead time of performance is set. Lengthening of a theoretical lead time depends on a synergy of many factors such as: the period of awaiting treatment (availability of resources when the task arrives), changeability of time and amount of work (lack of synchronizing times), the influence of fluctuation, breakdown, etc.

Figure 2. The effectiveness of applying FIFO rule in the materials flows in the critical resources.

All these factors contribute to the fact that setting the real lead time of performance is not easy. In order to do that, one simplification is used based on the assumption that lengthening the theoretical lead time has an influence on overloading machines (Fertsch 2003) and the amount of fluctuation characteristic of each production system as well as on lack of synchronization between operations.

The real lead time needed to calculate the constraint buffer is calculated on the basis of (3.1).

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$$T_r = \frac{T_t}{x} \quad (3.1)$$

where:

- T_r - real lead time,
- T_t - theoretical lead time,
- x - production capacity excess on non-critical resources.

Figure 3. An idea algorithm of how the buffering method of critical resources works.

The length of the real lead time (T_r) is calculated on the basis of the theoretical lead time (T_t) through production capacity excess on non-critical resources (x). The value of production capacity excess is calculated as a difference between workstations' total production capacity, being one, and the average workstations' load on non-critical resources (η - eta) (3.2).

$$x = 1 - \eta \quad (3.2)$$

where:

- η - average workstations' load on non-critical resources,
- x - production capacity excess on non-critical resources.

Therefore, the coefficient of lengthening the theoretical lead time (α – alpha) is as follows (3.3):

$$\alpha = \frac{1}{x} \quad (3.3)$$

where:

- α - the coefficient of lengthening the theoretical lead time,
- x - production capacity excess on non-critical resources.

Using the formula above (3.3) – the value of the coefficient of lengthening the theoretical lead time is directly dependent on the average workstations' load (see figure 4).

Figure 4. The coefficient of lengthening the theoretical lead time directly depends on the average workstations' load.

It is worth noting that the value of the coefficient of lengthening the theoretical lead time for a small load of workstations (up to 40%) rises slightly to the value of about 1.5 length of the

theoretical lead time. When it comes to HCP S.A.'s workstations load which on average amounts to between 40% and 60%, it grows faster reaching 60% load for 2.5.

The suggested coefficient of lengthening the theoretical lead time depending on the average workstations' load is an acceptable simplification here, because it reflects the most important correlation – the bigger load, the longer period of time of waiting for treatment and the smaller stocks of non-critical resources. The second essential element of lengthening the lead time is characteristic of a given material stream - it is the lack of time synchronization of particular operations and the influence of fluctuation. What is indispensable here is the correcting coefficient (k), which will play an adapting function here, taking into account the specific nature of a given production system or, in more complicated cases, a given stream of values. Its volume should be specified on the basis of the empirical verification of the real lengthening of the production lead time.

$$\alpha = \frac{1}{x} \cdot k \quad (3.4)$$

where:

α - the coefficient of the average lengthening of the theoretical lead time,

x - production excess on non-critical resources,

k - correcting coefficient characteristic of a given production stream.

An empirical analysis at HCP S.A. for a material stream from the moment of the material release to the moment of treatment on critical resources has shown that the k coefficient stands at 0.7.

Figure 5. Distribution of tasks for forwards and backwards scheduling.

The stability coefficient allows accepting it as a constant quantity, so the variable quantity in calculating the size of a buffer is an average load of non-critical resources. Finally the constraint buffer's size is equal to theoretical lead time of process corrected by α - the coefficient.

After determining the size of the constraint buffer, operations are scheduled according to the "forward" rule from the moment of the material being released for production. Forwards scheduling is characterized by a more advantageous layout of tasks against a critical resource than scheduling "backwards" (Fertsch 2003). For forwards scheduling the layout is characterized by longer continuity, without stoppages, which is in line with the TOC guidelines on maintaining continuity flow towards the critical resource (see figure 5).

Other stages of the algorithm are to monitor how the buffer is used up. The classical method of "Traffic Light Analogy" is used here. The method is supplemented with monitoring non-critical resources, whose load in the planning process amounted to more than 80%. Monitoring of the load of these machines prevents the effect of "wandering bottleneck". When the throughput of the critical resource is at risk, tasks are rescheduled. Rescheduling consists in taking a decision about overtime hours or cooperation to realize an urgent order and to dispose of the system's congestion. What is taken into consideration in order to realize the outside part of works in the decision making process, is the calculated cost of hours of stoppages of the critical resource.

3.3. Implementation of the model

Localization of buffers

There were no problems whatsoever with identifying the limits of a production system. The fact that they exist is confirmed by both an analysis of load and a physical sequence of tasks waiting to be processed in the company’s production hall. The two strongest constraints are the treatment centre “Coburg 3” and a machine tool drill-milling machine “4” CNC – especially for sleeves”. The machining centre of the “Coburg 3” type treats a stator which, together with its casing and fundamental framework, forms a crankcase. The “4” CNC drill-milling machine workstation helps produce a cylinder liner. Operation carried out on them concern key and leading construction elements of the produced marine engines. These parts are produced only in the company and do not have an alternative possibility of cooperation. The chosen resources meet all the criteria required for them to be named critical resources. Because of the fact that the critical resource in the form of the “4” CNC drill-milling machine will be "strengthened" (step 4 of the 5 Focusing steps) in the investment process, the key production constraint will be the "Coburg 3" machining centre. For each order (a marine engine) at the "Coburg 3" machining centre about 300 working hours are realized. Taking into account the average size of the labor-intensity nature of building a marine engine which amounts to 40 000 working hours on the critical resource, it means that about 1% of all works (0.75%, to be more precise) is realized. The labor intensity on conducting an operation on the critical resource is in line with the 99/1 principle (Woepfel 2001).

The carried out V-A-T analysis shows that the analyzed production environment has a structure of type “A” (“A”-plants). In the structure of type “A”, a constraints buffer or an assembly buffer is used (Figure 6). The assembly buffer is to buffer the main assembly process (the final assembly), where various value streams of components converge. Usually, a shipping buffer is used to fulfill the order on time.

Figure 6. Buffers localization in HCP Poznan S.A.

The value stream aiming at constraints, namely “Coburg 3”, is a very complex one. In the technological card of the crankcase there are 98 technological operations before treatment on a critical resource. The labor intensity of particular operations amounts to from 6 to 90 hours, and the limit advance of the treatment in a critical buffer is about 6 months.

Calculating the cost of stoppage in a critical buffer

Determining the real costs of stoppages of a critical resource is based on the Theory of Constraints Accounting. In line with it, costs of stoppages in a critical buffer can be calculated as follows (Woepfel 2001):

The cost of stoppages in a critical buffer = the total operational costs/the period of time of constraint

In the analyzed conditions of the HCP S.A. W2 company, one significant critical resource is “Coburg 3”. It is so because it has an overload of tasks (the balancing of the potential) and it has a specific range of tasks to be carried out (the technological potential). Because of the fact that the total operational costs of the company are not connected only with realizing the

current critical resources of finished products (marine engines), there have been attempts to estimate the costs on the basis of the costs of realizing these tasks.

Calculations have been made on the basis of the following data:

The company's data:

Value of one order (costs): about 7.5 million USD

Total labor intensity (for one order): 40 000 hours/engine

"Bottleneck" load per one order: 300 hours/engine

Calculations:

Costs of a bottleneck's stoppages: $7.5 \text{ million} / 300\text{h} = \mathbf{25.000 \text{ USD/hour}}$

The calculated cost form the basis for calculating cost-efficiency of using the reserve in the form of overtime hours as well as outsourcing, if deadlines are at risk (using up the constraint buffer too much).

Embedding the method in the production flow planning and control system

The next step in the studies places the developed method in the production planning and management system. The suggested method of the critical resources buffering fills the existing "gap" in the planning system (figure 7). At the level of elements it combines information about the critical resources load with the planning level according to operation. It is a combination of data from two key documents in the planning system of the company: the plan of engine building (framework schedule) and the schedule of critical resources load.

Figure 7. The planning system of HCP SA Marine Diesel Engines Factory (W2) and the position of the suggested method of buffering critical resources.

Such a way of positioning the method in the planning system enables solving the problem of the sequence of tasks for non-critical resources and, at the same time, ensuring the "bottleneck" work continuity. Therefore the buffering method is a practical application of the step of exploit (step 2) and the step of subordination (step 3) belonging to the 5 focusing steps. Since the existing planning system of the company is the system of MRPII class after positioning the buffering method in it a hybrid MRP/TOC system was created.

Measuring results

Because of the key role of the level of work in process and the length of manufacturing lead time in decreasing company's costs, the measure of these values is considered to be the most important.

The current level of work in process amounts to 78 million USD, and that means that any decrease, but with maintaining the company's flow capacity, is extremely significant.

Using the constraint capacity at the level of 95% is absolutely essential because of the full portfolio of orders in the planning period of 2 years. 5% of production capacities of the critical resource is a reserve indispensable for technical service and potential faults.

4. Conclusions

The proposed method of calculating the buffer is a part of work on an integrated information system realized within the framework of the "Neo" project. The aim of the project is to create an information system which facilitates planning and controlling a production flow in an analyzed production environment. At the same time, work is performed to improve the process of designing and customizing products by means of the Critical Chain Project Management concept (CCPM).

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Figure 1. Managing the constraint buffer according to Traffic Lights Analogy

Figure 2. The effectiveness of applying FIFO rule in the materials flows in the critical resources.

Figure 3. An idea algorithm of how the buffering method of critical resources works.

Figure 4. The coefficient of lengthening the theoretical lead time directly depends on the average workstations' load.

Figure 5. Distribution of tasks for forwards and backwards scheduling.

Figure 6. Buffers localization in HCP Poznan S.A.

Figure 7. The planning system of HCP SA Marine Diesel Engines Factory (W2) and the position of the suggested method of buffering critical resources.