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USING THE THEORY OF CONSTRAINTS TO PRODUCTION PROCESSES IMPROVEMENT

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Abstract: *This article shows how important is production processes improvement and discuss using Theory of Constraints to this purpose. According to the Plan-Do-Check-Act cycle processes should be improvement constantly. In purpose to observing effects at once of implemented changes authors propose to begin the process of improving in that place which is the weakest point on the production line.*
The main part of the article is to suggesting the way of the identification of constraints of the system. To this purpose value stream mapping was applied.
Key words: theory of constraints, value stream mapping, multi-agent systems, production improvement

1. INTRODUCTION

Improvement of production processes is necessary in time when we can observe constant development of technology and free competition. Continuous analyze and improve existing processes is essential if company want to satisfy still changing needs of customers. Improvement of production processes is also associated with growing quality requirements of products.
How important is continuous improvement shows also Plan-Do-Check-Act cycle (Fig.1) which is used to manage a process. It shows four steps which still iterate make the process better and better. This systematic process management methodology assures that processes are maintained at the best performance level achievable, given the present design of the process. Plan-Do-Check-Act cycle is similar to Theory of Constraints steps.

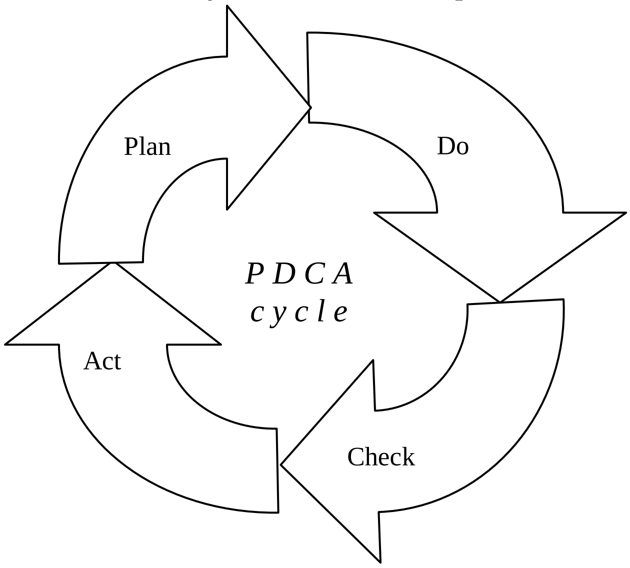


Fig. 1. Plan-Do-Check-Act cycle

For production processes improvement we can use Theory of Constraints. Theory of Constraints was created in 70s of XX century by an Israel physicist Doctor Eliyahu Moshe Goldratt, and introduced in his book (in 1984) titled “The Goal: Excellence In Manufacturing”. TOC is an overall management philosophy that is geared to help organizations continually achieve their goal. The underlying assumption of Theory of Constraints is that organizations can be measured and controlled by variations on three measures: throughput, operating expense, and inventory. Theory of Constraints is based on the premise that the rate of goal achievement is limited by at least one constraining process. Only by increasing flow through the constraint can overall throughput be increased [3].

2. THEORY OF CONSTRAINTS

2.1 Main measure

Following Theory of Constraints organizations can be measured and controlled by three measures [1]:

• Throughput – is defined as the rate at which the organization generates money through sales.

• Operating expense – is defined as all of the money the organization spends in order to turn inventory into throughput.

• Inventory – is defined as the money that the system spends on things it intends to turn into throughput.

Measures are connected together (Fig.2)

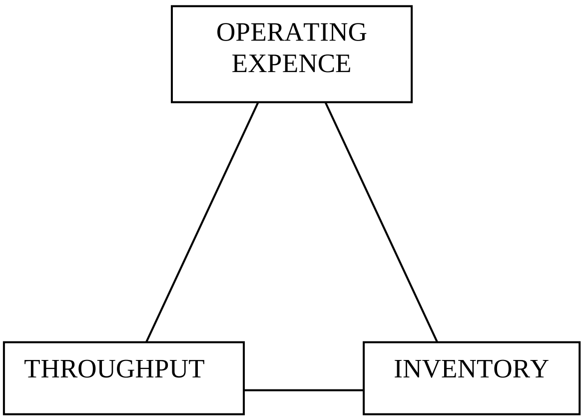


Fig.2. Main measures of Theory of Constraints

As Eliyahu Goldratt said the main goal of organization is not an effectiveness production or high quality products, but it is to "make more money now as well as in the future" [1]. And that is why all three measures are determine by money. If we want to check whether conducted action caused the positive effect it is necessary to check whether at least two measures are improved.

2.2 Focusing steps

The TOC process seeks to identify the constraint and restructure the rest of the organization around it, through the use of the Five Focusing Steps. TOC's five-steps process offers a systematic and focused process which organizations use to successfully pursue ongoing improvement [3].

The Five Focusing Steps [1]:

1. Identify the system's constraint.
2. Exploit the system's constraint.
3. Subordinate everything else to the above decision.
4. Elevate the system's constraint.
5. If in previous steps a constraint has been broken, go back to step 1, but do not allow inertia to cause a system's constraint.

Identify the system's constraint. The constraint can be located in one of three places:

- the market – not enough sales,
- the vendors – not enough materials,
- an internal resource – not enough resource.

It is good for organization when the constraint is in an internal resource, because then the company can manage this constraint and regulate production by using it.

The constraint can be identified through various methods, for example a classic indicator is the amount of work in queue ahead of a process operation.

Exploit the system's constraint. Once the constraint is identified, we should improve the process or support it to achieve its utmost capacity without major expensive upgrades or changes. For example eliminate the wasted activity performed by the constraint or ensure that only good material is processed by it by added inspection steps in front of the constraint.

Subordinate everything else to the above decision. When the constraining process is working at maximum capacity, the speeds of other subordinate processes are paced to the speed or capacity of the constraint. This means that sometimes we need to sacrifice individual productivity of some processes for the benefit of the entire system.

Elevate the system's constraint. Another step of improvement is necessary, if the output of the overall system is not satisfactory. The company may now contemplate major changes to the constraint and should taking whatever action is necessary to eliminate the constraint, for example expenditures of money for buying new machines.

Go back to step 1. This step remind us that Theory of Constraints is the process of ongoing improvement. When one constraint is broken we need to find another constraint in different part of the system or process chain. We need to remember to ensure there is sufficient protective capacity surrounding the constraint which we discovered in first step and, what is high important, don't allow inertia to become the system's constraint.

Now it is obvious how similar are steps of the Theory of Constraints and Plan-Do-Check-Act cycle presented in the introduction (Table 1).

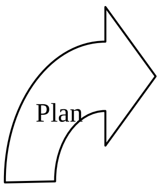
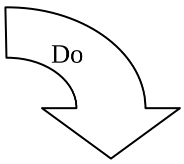
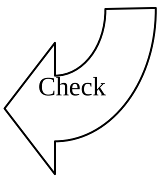
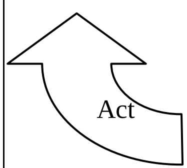
Cycle	*Steps of theory*
	Identify the system's constraint
	Exploit the system's constraint
	Subordinate everything else to the above decision
	Elevate the system's constraint

Table 1. Plan-Do-check-Act cycle and steps of Theory of Constraints compare.

2.3 Drum-Buffer-Rope

Drum-Buffer-Rope is a technique of production planning, based on the Theory of Constraints. The primary goal of the drum-buffer-rope technique is to facilitate the business enterprise to optimize the use of a capacity constrained resource and use time buffers to create schedules that help deliver products on time.

Generally the Drum is the constraint that is the weakest link in the production planning system, the Buffer is the material release duration and the Rope is the releasing time.

The particulars definitions of drum, buffer and rope are [7]:

Drum - the rate at which the constraint resource is able to process. A correctly set 'drum beat' will ensure that the constraint resource always has just the right amount of work - neither too little nor too much - to process.

Buffer - A protection against Murphy, i.e. the assumption that if something can go wrong, it will! Buffers are measured in time rather than quantity of material and ensure that process flow is prioritised according to the time an order is expected to be at the crucial, buffer-protected areas - namely the constraint resource, the assembly of constraint parts with non-constraint parts, and shipping.

Rope- this is an information 'link' from the Drum to the raw material release schedule, so that the constraint is always kept supplied with just the right amount of work.

A major part of subordination in a DBR system is the idea of limiting the release of material into the system to avoid overloading the constraint[6].

The aim of the solution is to protect the weakest link in the system, and therefore the system as a whole, against process dependency and variation and thus maximize the systems' overall effectiveness. The outcome is a robust and dependable process that will allow us to produce more, with less inventory, less rework/defects, and better on-time delivery – always [5].

As in an example [8] of boy scouts hiking, those who are bottlenecks are positioned at the beginning and a rope is used for subordinating (synchronizing) the speed of followers with that of the bottleneck persons (Fig.3).

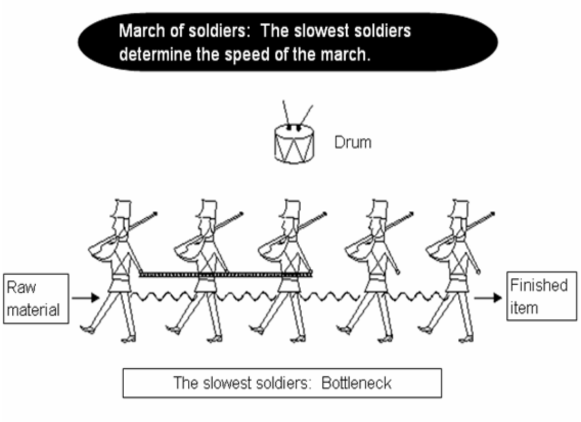


Fig.3 Drum-Buffer-Rope

This enables preventing the march (work-in-process inventory) from expanding. In other words, to eliminate work-in-process inventory is to reduce costs. Also, in preventing the front ones of the bottleneck group who determine the marching speed of the entire team from slowing down, a rope plays an important role as a buffer to absorb the changes in the marching speed of the front ones of the bottleneck group. A drum plays a role of conveying the information about the speed of the slowest bottleneck persons to everyone in the group and cheering up the bottleneck persons to raise their speed up.

3. IDENTIFY THE SYSTEMS'S CONSTRAINT

3.1 Constraint of the system

Identify the system's constraint is the first step of Theory of Constraints and it is the most important thing in whole improvement process. Constraints of the system mean the element about the smallest bandwidth, limiting bandwidth of entire system.

We can divide constraints of the production system on: technical constraints, for example insufficient bandwidth of machines or technologies, and organizational constraints, like as associated with the bad labour organization, with inappropriate company policy, with badly organized production process. It is good situation for company when constraints are inside the company (not outside, it is for example when the market is a constraint) because then the enterprise controlling the bottleneck and is able to use it in the function of the valve. That means company can have the bigger control over the processing. Therefore if a bottleneck is regulations, company policy, bad organization of a production process – one should change them. However the bottleneck can sometimes repeat itself, then one should manage it so that it acts as the valve.

When the constraint is correctly identified it mean that our problem is solving in a half. However making a mistake at this stage is sentencing our action at once to the defeat. It caused that identification the weak point of system is the most important problem when using Theory of Constraints. Value stream mapping can be one of tools of seeking the constraints.

3.2 Value stream mapping

Value stream mapping is a lean manufacturing technique used to analyze the flow of materials and information currently required to bring a product or service to a consumer. Example of value stream mapping shows fig.4.

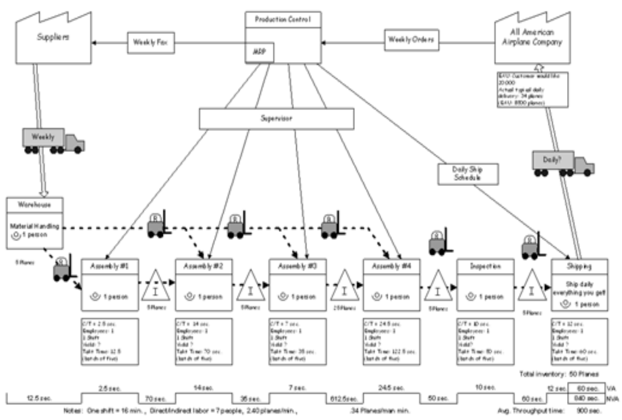


Fig.4 Value stream mapping.

At Toyota, where the technique originated, it is known as "material and information flow mapping"[2].

Value Stream Mapping (Fig.4) helps to understand and streamline work processes. The goal of VSM is to identify, demonstrate and decrease waste in the process. Waste being any activity that does not add value to the final product, often used to demonstrate and decrease the amount of ‘waste’ in a manufacturing system. VSM can thus serve as a starting point to help management, engineers, production associates, schedulers, suppliers, and customers recognize waste and identify its causes. As a result, Value Stream Mapping is primarily a communication tool, but is also used as a strategic planning tool, and a change management tool.

In order to do this, the Value Stream Mapping method visually maps the flow of materials and information from the time products come in the back door as raw material, through all manufacturing process steps, and off the loading dock as finished products.

Mapping out the activities in the manufacturing process with cycle times, down times, in-process inventory, material moves, information flow paths, helps to visualize the current state of the process activities and guides towards the future desired state. That is why we recommend using value stream mapping like a tool of seeking the constrains. That kind of map could show as where the inventory are biggest. It means that the position situated behind this magazine work in progress can constitute a constraints of whole system. But before we finally said that this is the system constraint it must be carefully check. It could turn out that the position before this inventory produced too quickly or too much, and it can be effect of the company policy incorrectly taken on. Then the politics, rather than the specific position, could turn out the constraints of the system.

3.3 Constraint management

When the constraint will be identified it is possible to liquidate them or to manage it. As tools which could eliminating the constraints it is possible to use tools coming from the low-cost lean management conception. However for flow control was suggested application of the multiagent system (Fig.5) which cause using constraint in the function of valve, with aim of increasing the control over the throughput.

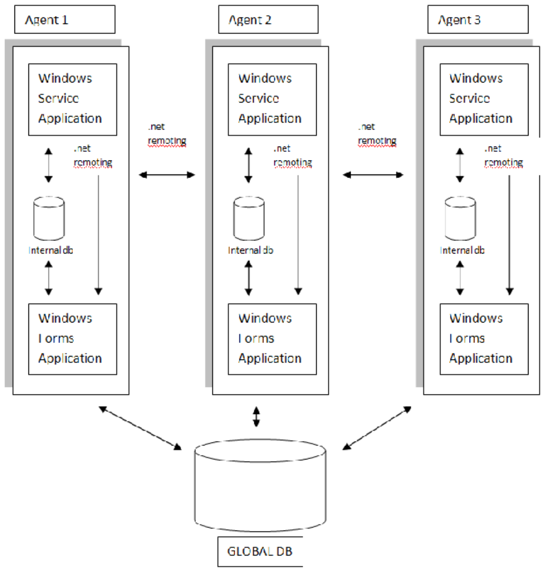


Fig.5 Example of multi-agent system structure.

A multi-agent system is a system composed of multiple interacting intelligent agents. Multi-agent systems can be used to solve problems which are difficult or impossible for an individual agent or monolithic system to solve. The agents in a multi-agent system have several important characteristics [4]:

– autonomy - the agents are at least partially autonomous.

– local views - no agent has a full global view of the system, or the system is too complex for an agent to make practical use of such knowledge

– decentralization - there is no designated controlling agent (or the system is effectively reduced to a monolithic system).

Typically multi-agent systems research refers to software agents. However, the agents in a multi-agent system could equally well be robots, humans or human teams. A multi-agent system may contain combined human-agent teams.
Multi-agent systems can manifest self-organization and complex behaviors even when the individual strategies of all their agents are simple.
Agents can share knowledge using any agreed language, within the constraints of the system's communication protocol. Example languages are Knowledge Query Manipulation Language or Agent Communication Language.
For managing constraints, and controlling the flow of production, it is proposed creating the network of agents. Single agent should be connected with individual positions and gather information from them. This information should be made available to the major agent. Because of this information, the main agent could show the place where is constraint and offer the appropriate flow to the production.

4. CONCLUSION

Implementing Theory of Constraints to production processes improvement is leading to using accessible sources. No need to incur financial costs on improving investments is probably the most important advantages of the discussed theory. The identification of constraint, being the most important component of the improvement process is also being carried out by value stream mapping which is the tool of low-cost conception of lean management.
Apply the multiagent system causes using constraint in the function of valve what is leading to increasing the control on the throughput, being the very important measure in theory of constraints.
Proper managing of bottlenecks or their liquidation where it is necessary will allow for reducing operating costs, reducing the inventory, improvement of the quality of products and services, better flow of materials on the production line. By reducing flow time, we improve cash flow, what means faster restore the money which is invested.

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