THEORY OF CONSTRAINS APPLYING IN OPTIMIZATION OF PRODUCTION MANAGEMENT SYSTEMS AND AUTOMATION OF PRODUCTION SYSTEMS

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Abstract. The goal of present research is to determine how and in what way the effectiveness of the production process in theory and practical in the wake of the built organizational structure in a middle large Bulgarian mineral water bottling company with 4% market quota in this industry can influence over the whole organization in production aspect, how far the effective management and material resources contribute to the success of the analyzed company, as well as the opportunities for systematical analysis making in basic production and organizational activities, priorities and trends of development in the concrete company environment. The main aspects in the production activity management are considered on the base of the practical and theoretical formulations as a strategy of management, company policy, motivation and complete process of a definite management philosophy adoption, connected with the specific character of every particular company. On the ground of the considered project is the decision finding for improving of the capacity of the company on the base of high level automated technological equipment adoption.

Keywords: TOC; logical thinking; cause and effect connect

1. Introduction

Today the companies in Bulgaria stand against great number of difficulties and provocations. On the one hand is the years continued depression, on the other hand is the reality of an increasing competition in conditions of world economic space globalization, as well as opportunities for building of a competitive to the west standards private production sector. The globalization of management and work itself is possible due to the great development of information technologies. The modern market must be comprehended not as a place of a products comparison, but as an opportunity for competition of potentials and production and labour management systems, as well as a diagnostics of the complete activity, because the building of properly functioning priority activities in the separate companies depends on development of the certain effective sections in every one of companies. All this requires toward the management of every one of organizations as whole. Through this there is formed with more and more growing intensity of the necessity of a new model of development and management on the micro level i.e. on the level of the separate business unit. Today's world is a world of organizations. In its matter organization is a union of people, which are set a common goal, coordinating their efforts to its realization. To motivate the collaborators of organization for creating of possibilities of revealing their physical, intellectual and creative potential – for achievement of all this it is necessary a modern management philosophy. The actuality of the problem of the production activity management is in a long-term perspective. The strategic thinking and action are a key element in the whole management organization of the production processes in company. Without active presence of the strategic perspective, concrete management aspects in every functional area – quality, prime cost, human resources, materials etc., in the last it is get to unsystematic and chaotic management. All this decreases the possibilities make the most of effectiveness of organizational interactions. Problems in production and planned process in the company have to connect with the economic transition from a planned to a market economy, as well as with the core and special features of this transition.

2. Expose

The goal of this research is to consider and determine the modern aspects of the separate production management in the company on the base of real example of production process management in a Bulgarian mineral water bottling company, as well as the difficulties and the provocations towards the managers and personnel. On the base of the considered and analyzed practical problems regarding to the production organization in the company they are looked for possible alternatives and decisions with a view to develop an effective production process on the maximal stage. This is possible through the development and elaboration

of a total integrated strategic and operative system for production activity management in industrial companies, appropriate with the economic situation in the country. They are considered the possibilities of production cycles optimization with a view to achieve an internal and external competitive power on the market. The bottling company is specialized in the mineral water bottling. Its taste and characteristics are similar to these of the famous all over the world trade marks of mineral water. The maintenance and service in the company are on high European level, as the firm politics is oriented to permanent technology development and introduction in production process, enabling a quality bottling in new, convenient packing, imposing on the market due to the requirements and trend on the world market. The company is imposed as a sale leader in Bulgaria for years of its existence. The ambition is to achieve a full satisfy of costumer needs.

2.1. Theory of Constraints (TOC) as a methodology of optimization of production processes

The Theory of Constraints (TOC) is a management philosophy, where the organization may be considered as an interdependent series of processes rather than an independent business unit. TOC offers a methodology for achieving system optimization rather than process optimization. The theory can be characterized as a set of concepts, principles, and measurements that focus on the ultimate output of the whole system, not just that of a component part of it. TOC views any organization as a system, as an integrated whole instead of a collection of related parts with the primary emphasis on the output of the entire system, i.e., "Throughput." Throughput is defined as the difference between the value of output (sales) and direct cost (variables such as raw material, parts, etc.) and thus as the rate at which the system generates money through sales. The focus of the TOC philosophy is that any organization (or system) has a constraint that dominates the entire system. The secret to success lies with managing these constraints and the system. On the other hand, TOC moves the performance measurement from a cost-oriented to a throughput-oriented paradigm. Throughput provides a more meaningful and effective measure of improving organizational performance, and does not necessarily prescribe cost cutting and downsizing strategies. Deming [2] described the danger of suboptimization as follows: Anything less than optimization of the whole system will bring eventual loss to every component of the system. He noted that the obligation of any component is to contribute its best to the system, not to maximize its own production, profit, sales, or any other competitive measure. Some components may operate at a loss themselves in order to optimize the whole system. Sub-optimization may result from a lack of awareness or an assumption that maximizing the performance of each component part of the system will automatically maximize the performance of the system as a whole. According to Deming, this is not a valid assumption. Another reason cited for sub-optimization is analytical thinking [3]. Analytical thinking breaks complex problems into smaller, more manageable sub-problems that may be analyzed separately. After solving each sub-problem, often in isolation from the rest, the pieces are reassembled into a whole again. This analytical thinking is based on the assumption that if we make each part of a system perform to its maximum capability, the system as a whole will benefit. This approach may be useful in analyzing sub-components and, thus, there may be a certain appeal to the idea of disassembling and reassembling again. However, as systems become more complex, the interaction and interdependencies of components would define the performance of the system as a whole, and the effectiveness of analytical thinking become questionable. In TOC, an organization is viewed as a system and components of the system under management subordinate their efforts to the larger system of which they are a part. The primary focus is on the constraints that hinder the organization from achieving its goal. More specifically, the organization is compared to a chain or a network of chains. In this analogy, one weak link limits the performance of the entire chain. This weakest link is the system's constraint that has to be targeted for improvement, be carefully examined, and efficiently addressed. Once the weakest link is strengthened, the next weakest link becomes the constraint that limits overall system performance. Therefore, at each stage, improving the performance (throughput) of the chain requires strengthening the weakest link at that stage. It may be relatively less complex to locate physical constraints, such as limitation of resources or technology to support production / operation / distribution processes, because they are tangible. In most cases, however, the real constraints to improving a system's

performance are not physical but policy constraints. They are rules, plans, procedures, measurements, or other guidelines that are less tangible and at the same time prescribe the framework for operations and management of the internal organization, and its interface with external environment. In Goldratt's view, the policy constraints are usually much more devastating than physical constraints, and nearly every physical constraint results from some policy constraint. It is also more difficult and challenging to identify the exact policy constraints, as it requires a complex chain of cause and effect that can be traced back to a root cause. Furthermore, in larger organizations, the policy constraints often go across multiple functional units and require addressing those constraints and breaking them at higher levels of the organization. Therefore, due to the relative complexity of policy constraints, [4] proposes a more elaborate process, requiring three major steps:

1. What to change? Where is the constraint?
2. What to change? What should be done with the constraint? (Develop and validate new ideas to break the constraint that would deliver the desired results, and at the same time minimize the adverse side effects.)
3. How to change? (Convert those ideas into effective action and reality.)

These three questions provide the framework for the TOC Thinking Process. Furthermore, this thinking process is logic based, and thus not confined only to physical constraints, manufacturing systems, or for-profit organizations. It is applicable to any system as long as the goals of the system can be defined clearly. In order to apply this thinking process, there are four criteria [3] to be satisfied:

1. Motivation to improve the system,
2. Thorough knowledge of the system that needs to be improved
3. Some degree of authority, or at least influence, to initiate change, and
4. Understanding the TOC Thinking Process methodology.

2.2. TOC Thinking Process

Using the rigor and logic of cause-and effect, the five-step thinking process would enable the management team to solve a problem and develop an integrated strategy, beginning with the symptoms and ending with a detailed action plan that coordinates the activities of all those involved in implementing the solution.

There are five logical processes in TOC [4]: Current Reality Tree (CRT), Evaporating cloud (Cloud), Future Reality Tree (FRT), Prerequisite Tree (PrT) Transition Tree (TrT). CRT, FRT and TrT use cause and effect thinking.

CRT: This step examines the cause and effect logic behind the undesirable effects in the system. The CRT process starts with the observed Undesirable Effects (UDEs), and builds, with strict logical rules, a model of the system. It helps management to identify the system constraint or what to change.

Evaporating Cloud or Conflict Resolution The Cloud is used partly to finalize what needs to change and to surface the breakthrough that is the base of the solutions.

FRT: The FRT step is used to confirm the solution and to identify potential negative side effects. FRT construction starts with the Injection from the CRD step, and uses the logic and UDEs from the CRT to develop the future system. This would enable management to remove negative effects and see if a solution will work.

PRT is used to break the solution down into smaller logical steps. This step is used to outline how to cause the change.

TT is used to identify detailed actions needed to reach each steps identified by the PrT. This is a detailed stepby step implementation of the solution. This is used to cause the change.

CRT shows the symptoms, root causes and a core problem.

TOC considers a project as a network of required tasks that move toward a set of clear objectives intended to be completed under budget and on schedule. For a project with goals such as developing a new technological line for mineral water bottling are necessary certain prerequisites.

These prerequisites are the precedents for the goal. In order to achieve the goal from the prerequisites, there may be some underlying assumptions to clarify all needed dependencies between the predecessor and the successor. This process is repeated a number of times until the start task is reached. The result is a network that describes what must be in place in what order and what is the logic behind these successive tasks. For the concrete case in the bottling company on the base of the official annual report on the soft drinks production and consumption during year 2005 they are done the following conclusions for bottled water:

- The bottled water consumption is increased with 21.4% or total with 90.0 million litres in

comparison with the previous period under review.

- In year 2005 they are bottled total 507.8 millions litres mineral, spring, table, soda-water and spice water.
- The nature bottled waters get ahead the aerated drinks in a market quota.
- The natural mineral waters consumption is increased most highly – with 22.2%.
- The natural mineral waters consumption per capita of the population has reached to 66 litres, which is with 12 litres more in comparison with the previous year.
- The soda-water takes up only 8.7% from the whole volume of waters.
- The volume of the spice waters during the year is 3.8 million litres.
- The volume of the waters in gallons is 59.7 million litres and has a growth of 37.2%.
- The water in gallons has already 11.8% market quota.
- The glass packing to 300 millilitres have only 4.4% quota.
- The quota of the waters, bottled in PET packings is 84.0%.
- The packings larger than 2.00 litres (3*l*, 5*l*, *6l*, *8l*, 10*l*) with natural water increase their quota to 39.1%.
- The volume of the realized quantities of water in large packings is doubled in comparison with year 1999.
- The sales of waters in packings of 1.5*l* decreased with 0.5%.
- The prices of the bottled waters in 2005 are increased with an average of 5%.
- The mostly realized water is in the third quarter – 31.8%, the least – in the first quarter – 14.4%.
- The value of the realized bottled water on the home market in 2005 is 239 millions leva (BGL).

On the base of analysis it is imposed the conclusion that for keeping and hardening the positions of the company on the market it is necessary to improve the capacity of the equipment. The capacity of the existing equipment is almost fully used and it can't take up the fast rates of increasing of the bottled mineral water demand on the market. It has got to make an investigation the possibilities of new automated production line adoption, which replaces an existing one – line 2. The using of TOC as a method of project processes management accelerates the project actions and leads to practical optimization choice with necessary stage of automation without a essential restructure in production in the space and in the time and without to increase the number of service personnel. On the ground of all this is developed Table of analysis results „Cause and effect relationships" and „Building of a purpose tree" (Table 1). The manager team, guiding by the basic TOC principles and cause and effect thinking develops two projects for increasing the capacity of mineral water bottling line by bottles of 5*l* and 10*l*. By the both projects are kept the market quotas of the separate volumes of mineral water at the present moment, as well as the current personnel and shift system of work. Through the TOC logical processes applying into the current situation in the bottling company it is visible that Project 1 is more profitable than Project 2 regarding to the capacity, investment, retrieval and work flexibility. It removes the production constrain, imposed from the weakest link – the insufficient capacity of the technological line 2 without causing of considerable effects.

3. Conclusion

Traditionally there are many accents, directed to achieving project management effectiveness. CPM, PERT and Gant diagrams are developed to make easier and execute the projects in time within the framework of budget. On the other hand the project managers pay attention to project planning and execution. In other words there aren't satisfying accents, directed to achieving of project management effectiveness. Separately the project manager needs clearly to determine the project purposes and objects in servicing of organization mission and visual condition, so as the project team to can focus on the effectiveness of the project planning and execution before to look for the effective measures. SWOT analysis is an effective method of the strong and weak sides' determination as well as a control of the possibilities and risks in the project management. TOC uses the systematic approach in the project management, accepting the capacity as effective estimation and execution measure. All this determines constrains, which dominate over the whole project at any time and the connected with it resources for a removal constrains and for the project purposes achieving. In this way, TOC technique of time management contributes to effectiveness of the project management. Moreover, TOC is extended to the resources for the complex projects, which determine the common resources. This application maximizes the number of projects,

which the organization can support, observing principles of project duration decreasing. TOC can be also effective applied in other areas as project risk management and project cost management.

Table 1. Table of analysis results „Cause and effect relationships" and „Building of a purpose tree"

<table>
<tr><td><u>Complex cause</u>:</td><td>Small capacity of the current bottling equipment.
<table>
<tr><th colspan="8">Bottled waters</th></tr>
<tr><th>quarter / year</th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th></tr>
<tr><td>first</td><td>18.5</td><td>18.6</td><td>19.0</td><td>17.2</td><td>17.6</td><td>16.0</td><td>14.4</td></tr>
<tr><td>second</td><td>32.8</td><td>31.1</td><td>30.7</td><td>31.8</td><td>30.4</td><td>30.1</td><td>28.2</td></tr>
<tr><td>third</td><td>33.3</td><td>33.2</td><td>32.8</td><td>34.5</td><td>33.2</td><td>32.2</td><td>31.8</td></tr>
<tr><td>fourth</td><td>15.4</td><td>17.1</td><td>17.5</td><td>16.5</td><td>18.8</td><td>21.7</td><td>25.6</td></tr>
</table></td></tr>
<tr><td><u>Concrete purpose</u>:</td><td>Increasing of capacity through preservation of the personnel on hand and existing parameters of the relative market quotas to the present moment:
<table>
<tr><th>Relative market quota of the sales in liters</th><th>%</th></tr>
<tr><td>0.5 l</td><td>18</td></tr>
<tr><td>1.5 l</td><td>28</td></tr>
<tr><td>5 l</td><td>18</td></tr>
<tr><td>10 l</td><td>23</td></tr>
<tr><td>19 l</td><td>13</td></tr>
<tr><td>Total</td><td>100</td></tr>
</table></td></tr>
<tr><td><u>Basic reasons:</u>

<u>Task:</u>
Acceptance

Execution

<u>Direct achievements:</u>

<u>Indirect achievements:</u></td><td>• The increased consumption of bottled mineral water;
• Impossibility to readjust the existing equipment for different bottled volumes;

• Provided finances through bank credit.
• Prepared strategy for branch programs in accordance with the market changes.
• Created section for work on the innovation equipment development

• Provided proposal financing for activities on market changing
• Provided financing for investigation and consultation, connected with the execution estimation
• Regulated rights and obligations of all participants, taking place in the investigation
• Improved coordination between the parties concerned
• Built system for information exchange between the parties concerned

• The plan of action of reaction to the market changing is prepared and it is partiality applied in practice

• Scientific potential on hand
• The reaction to market changing is a priority in the company's politics
• The company's strategy of output increasing is actualized</td></tr>
<tr><td><u>Undesirable Effects:</u>

<u>Disadvantageous effects:</u>

<u>End desirable results or new condition:</u></td><td>• Impossibility of reaction on the market changing
•
• Accept orders, which wouldn't execute

• Preparing and implementation of an adequate firm politics on the market changing
• Implementation of the obligations of contracts with costumers
• Taking apart the progress, which the firm reaches</td></tr>
</table>

Current condition

THEORETICAL PLAN												
concerning maximum attainable levels			Capacity of the flow lines - bottles/hour									
of mineral water capacity												
Number of personel in production	26		LINE 1 - 0,5 l	2200								
Number of shifts in twenty-four-hour period	3		LINE 1 - 1,5 l	1800								
Work time mountly - hours	495		LINE 2 - 5 l	200								
Possibility of overtime work - hours	72		LINE 2 - 10 l	120								
Average work-load - %	70*		LINE 3 - 19 l	300								
* includes the technological idle time - changing of formats, adjustments failures etc.												
Relative quotas of sales in litres - %												
0,5 l	18											
1,5 l	28											
5 l	18											
10 l	23											
19 l	13			for 495 hours					for 567 hours			
Total	**100**											
				Relative quota	Relative quota	Maximum attainable levels of production, bottles			Relative quota	Relative quota	Maximum attainable levels of production, bottles	
maximum attainable levels of production, bottles		for 495 hours	for 567 hours	of production time/1 l	of equipment loading - %				of production time/1 l	equipment loading - %		
						Calculated	Accepted				Calculated	Accepted
on adherence to the correlation	0,5	270 000	310 000	8,1	24,57	267 575	270 000		9,3	24,57	306 495	310 000
between separate packings	1,5	140 000	160 000	5,1	15,57	138 743	140 000		5,9	15,57	158 924	160 000
as it is taken for granted that it is the demand	5	30 000	34 000	10,1	30,78	30 474	30 000		11,6	30,78	34 906	34 000
on the market of this product - l	10	15 000	17 000	8,5	25,65	15 237	15 000		9,7	25,65	17 453	17 000
	19	5 000	5 700	1,1	3,42	5 085	5 000		1,3	3,42	5 825	5 700
Total		**460 000**	**526 700**	**33,0**	**100,00**	**457 115**	**460 000**		**37,8**	**100,00**	**523 604**	**526 700**
Coefficient of effectiveness				3,033					2,648			

Future condition - Project 1

THEORETICAL PLAN			In the future							
concerning maximum attainable levels		through using of new automoted production equipment in the new market conditions								
of mineral water capacity		Capacity								
Number of personel in production	26	2200								
Number of shifts in twenty-four-hour period	3	1800								
Work time mountly - hours	495	1000								
Possibility of overtime work - hours	72	600								
Average work-load - %	70*	300								
* includes the technological idle time - changing of formats, adjustments failures etc.										
Relative quotas of sales in litres - %										
0,5 l	18									
1,5 l	28									
5 l	18									
10 l	23									
19 l	13	for 495 hours					for 567 hours			
Total	**100**									
		Relative quota	Relative quota	Maximum attainable levels of production, bottles			Relative quota	Relative quota	Maximum attainable levels of production, bottles	
maximum attainable levels of production, bottles		of production time/1 l	of equipment loading - %				of production time/1 l	of equipment loading - %		
				Calculated	Accepted				Calculated	Accepted
on adherence to the correlation	0,5	8,1	44,79	487 800	490 000		9,3	44,79	558 753	560 000
between separate packings	1,5	5,1	28,39	252 933	253 000		5,9	28,39	289 724	290 000
as it is taken for granted that it is the demand	5	2,0	11,22	55 555	56 000		2,3	11,22	63 636	64 000
on the market of this product - l	10	1,7	9,35	27 777	28 000		1,9	9,35	31 818	32 000
	19	1,1	6,24	9 271	10 000		1,3	6,24	10 620	11 000
Total		**18,1**	**100,00**	**833 337**	**837 000**		**20,7**	**100,00**	**954 549**	**957 000**
Coefficient of effectiveness		5,530					4,828			

Future condition - Project 2

THEORETICAL PLAN			In the future							
concerning maximum attainable levels		through using of new automoted production equipment in the new market conditions								
of mineral water capacity		Capacity								
Number of personel in production	26	2200								
Number of shifts in twenty-four-hour period	3	1800								
Work time mountly - hours	495	500								
Possibility of overtime work - hours	72	500								
Average work-load - %	70*	300								
* includes the technological idle time - changing of formats, adjustments failures etc.										
Relative quotas of sales in litres - %										
0,5 l	18									
1,5 l	28									
5 l	18									
10 l	23									
19 l	13	for 495 hours					for 567 hours			
Total	**100**									
		Relative quota	Relative quota	Maximum attainable levels of production, bottles			Relative quota	Relative quota	Maximum attainable levels of production, bottles	
maximum attainable levels of production, bottles		of production time/1 l	of equipment loading - %				of production time/1 l	of equipment loading - %		
				Calculated	Accepted				Calculated	Accepted
on adherence to the correlation	0,5	8,1	39,61	431 323	432 000		9,3	39,61	494 061	495 000
between separate packings	1,5	5,1	25,10	223 649	224 000		5,9	25,10	256 180	256 000
as it is taken for granted that it is the demand	5	4,1	19,85	49 123	50 000		4,6	19,85	56 268	56 000
on the market of this product - l	10	2,0	9,92	24 561	25 000		2,3	9,92	28 134	28 000
	19	1,1	5,52	8 198	9 000		1,3	5,52	9 390	9 000
Total		**20,5**	**100,00**	**736 855**	**740 000**		**23,4**	**100,00**	**844 033**	**844 000**
Coefficient of effectiveness		4,890					4,269			

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