THE USAGE OF THE THEORY OF CONSTRAINTS ON EXAMPLE OF THE SHAFT WORKING CELL

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¶***Abstract:*** *There is presented the practical application example of the theory of constraints, in the paper. There are described principles and stages of the production system improvement, which are based on the mentioned above theory. The particular stages will be illustrated by the example of analysis of the whole production system, which was the aim the bottle-neck finding, and examples of changes, which are executed in the shaft working cell, which magnificent oneself the bottle-neck of the analysed factory.*
Key words: *modelling, simulation, theory of constraints.*

1. METHODS AND TECHNIQUES OF THE PRODUCTION PROCESS MANAGEMENT

At production planning, it is not enough to determine how, what and when we should produce something but also to determine what, where and for whom we should produce it. Production planning is realized by starting with long-term tasks and short-term tasks planning and ending with the planning realization of the operation tasks. The planning of production can be understood as a creation of conditions for fluent and effective run of the production processes coming into existence. We should remember here about costs and realization time, which should be made broadly optimal.
Development of the system aiding control of production results from the targets, which are to be fulfilled by production systems. These targets were often quite different but if they were the same, they differed from each other with the assigned priorities.
Activity of the company in the free market economy conditions force managers to undertake more and more complex and complicated tasks. In the consequence there is necessity for synchronisation of increasing quantities of the technological factors, what brings looking for more effective methods of control of the production processes. Control of the production is one of the most important task in the company. The target of these activities is to manufacture the products at the planned time. Furthermore, they have to fulfil the qualitative requirements and their manufacture costs should be as low as possible.
New tendencies within the company organisational field, which have also influence on the computer systems, have a meaningful influence on development of the production planning and control. Among them, the most important are: Material Requirements Planning (MRP I), Manufacturing Resource Planning (MRP II), Enterprise Requirements Planning (ERP or MRP III), Just in Time (JIT), Kanban and Theory of Constraints (TOC).

Furthermore, modelling and simulation becomes more and more substantial method, which aids the production management mainly in conditions of long-series production.

2. MODELLING AND SIMULATION IN THEORY OF CONSTRAINTS

The theory of constraints directs main attention on the bottle-neck of the production system, that is this element, which decides about efficiency of the whole system. Production process is the chain of workings, which are realized on mutually related resources and only several units (constrains) in this system have influence on achieved results [3]. Understanding of this dependence makes possible to find solution also even very complicated problems [1,2,4].
The theory of constraints and the modelling and simulation method are connected directly with changes. The Goldratt's theory of constraints gives us answer for three questions:
- What to change?
- In what to change?
- How to cause changes?

However modelling and simulation answers on question:
- What will be, if we will change …?

The theory of constraints in production management means orientation on critical points of the system (the critical chain), what assures the maximization results of the system. The improvement of achieved results, it should can reach introducing different improvements in cyclic way in 5 following stages [5]:
1. identifying of the constraint (bottle-neck) of the system,
2. maximum exploitation of the present possibilities of the bottle-neck,
3. subordination of all to the maximum utilization (exploitation) of the bottle-neck,
4. elevation of the bottle-neck possibility (throughput),
5. return to stage 1.

In every stage, there is possible to use simulation, for example to identify the system limitation, to check the present bottle-neck possibilities and to plan properly uncritical tasks practically. All unlimited (uncritical) resources should support constraints and improve their exploitation.
By the simulation we can execute analyses of different investments and enlarge possibilities (throughput) of the bottle-neck for example by purchase of new machines, modernization of existing machines and devices or by enlargement of the employment.

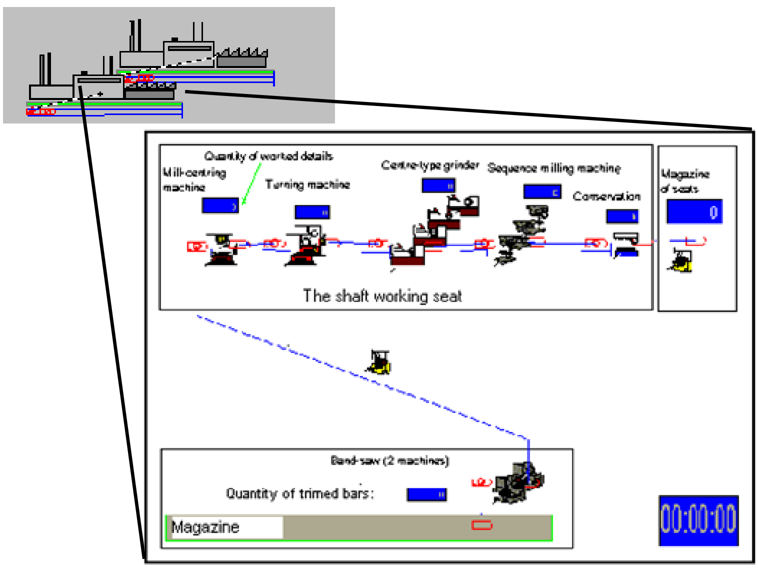

Fig.1. *Simulation model of the shaft working seat*

3. EXAMPLE OF IMPROVEMENT OF THE SHAFT WORKING SEAT

The firm producing electric motors intends to enlarge production. The constrain was outside the firm - firm possesses means of production, which are not used maximally. Production abilities are higher than existing sale. However planned enlargement sale crosses production abilities (about several percentage). The aim of introduced below analyses was the checking of possibilities for improvement of the present system.

After preliminary analysis of the manufacturing process of electric motors it turned out, that the shaft working seat is the limitation of the whole system. The process of working of shafts is the main process in the analysed firm, and one workplace in this seat is the bottle-neck of the whole production system. Therefore, there was executed more detailed analysis of this seat using the method of modelling and simulation.

3.1. Identifying of the constraint

After modelling of the shaft working seat and simulation of the monthly production we obtained information about duty of workplaces, about size of queues before workplaces and the time of realization of planned production. It made possible identifying of the bottle-neck.

Table 1. Report from first simulation

REPORT FROM SIMULATION		
Volume of production 1355 pieces.		
Utilization of workplaces (simulation time:168 hours)		
Workplace (quantity of machines)	**Work time [hours]**	**Duty of machines [%]**
Band-saw (2)	63.84	38
Mill-centring machine (1)	97.44	58
Turning machine (2)	164.64	98
Centre-type grinder (4)	90.64	54
Sequence milling machine (3)	57.12	34
Conservation (1)	6.77	4

Conclusions from the first simulation:

- workplaces with the highest duty are two turning machines – there is the bottle-neck of the modelled seat;
- duty of the workplace for conservation of working shafts is 4%. This operation can be executed immediately at milling workplace after operation of milling.

3.2. Maximum exploitation of the present possibilities of turning machines

To enlarge the efficiency of turning machines there were proposed organizational changes. The creation of conditions for continuous production on these workplaces was the effect of these changes. There were established different hours of pauses on both turning workplaces, so as to always work there the least one operator. The turners' work will be supported additionally by the operator of neighbouring mill-centring machine.

Above mentioned changes were introduced in the second simulation model. Additionally the operation of conservation was shifted on milling workplace. From the conducted simulation there were drawn out following conclusions:

- duty of all workplaces of the seat grew up - average about 2%. Bottle-neck was loaded almost 100%;
- the volume of production grew up similarly - from 1355 to 1380 pieces (about 2%);
- the connection of the operation of conservation with milling, it did not influence on change of production volume.

3.3 Subordination of all to exploitation of the bottle-neck

This principle was realized by the proper scheduling of production orders. In first simulation the size of batches of material was established on the level of 400 parts per week. From simulation we obtained information, that we are not able to process such quantity of material and we should to enlarge queues before turning workplaces. On the basis of results from simulation there was established, that 380 pieces will be the suitable size of week's batch. With such level of production the average week's size of the queue before bottle-neck will be constant.

3.4. Elevation of the bottle-neck throughput

The possibility of turning workplaces should be enlarged by purchase of a new machine. This solution was rejected - too large costs. The next proposed solution was the modernization, which makes possible the shortening the necessary time for handling of shafts. There is possible shortening of the operation time from 15 to 12 minutes. This change was taken into account in next simulation model. To check the possibility of the seat after such improvement, there was defined the same size of batches identically like in first simulations (400 pieces).
From simulation there was turned out, that only after such changes we will be able to execute whole orders accepted to realization. The achieved volume of production carries out 1615 pieces. The duty of workplaces was enlarged average about 20%. Turning workplaces are the bottle-neck still - duty carries out 98% what means.

4. CONCLUSIONS

In the last stage of analysis there was turned out, that turning workplaces are the bottle-neck still, and we should still improve the operation of turning. Thanks to simulation we can check every proposed changes, their influence on constrain and other elements of the analysed system. If after changes other workplace will be the bottle-neck, we should back to stage 2, that is to search of possibility the maximum utilization of a new constrain.
Every improvement of the bottle-neck gives the advantage for the enterprise, but they are the most often short-lived. Projects of improvements we should not realize "once on some time", but they should be the basis of continuous improvement of production system.
The disadvantage of the modelling and simulation is labour-consuming of building models. Having it (the first model) we can comparatively easily to change his parameters and to create next models taking into account other variants of different improvements of the identified constraints.
The introduced example confirms, that modelling and simulation of production processes becomes more and more important aiding technique not only for designing of new production systems but also for continuous improving of already functioning production systems.

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