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STEPS AND IMPLEMENTATION OF THE CONSTRAINTS THEORY

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Abstract: Theory of Constraint (TOC) is a management philosophy that advocates that every system has at least one constraint which limits the system from achieving high level performance. General principles of TOC can be applied successfully to improve performance of manufacturing and service organizations. The implementing steps of the constraints theory consist, first, in the optimization of their system. Considering that all activities are constant, the outputs maximization is tried on, paying attention to the constraints. The system limits being imposed by constraints the interest consists in synchronizing any activity with these.

1. INTRODUCTION

The implementing steps of the constraints theory consist, first, in the optimization of their system. Considering that all activities are constant, the outputs maximization is tried on, paying attention to the constraints.

Than, a step, which varies the progressive rejection of constraints and the sequence of the optimization efforts is convenient. It is a process trying to exploit at maximum the constraints (constraints have to be always active) and to bond the influence of all other resources to this constraint (constraints impose the rhythm) because otherwise, the resources not adapting themselves, will produce either an increase of stocks or an increase of operating costs.

This process may be resumed to four steps:

- identification of constraints
- designation of the using manner of these constraints and information of protagonists
- synchronization of the production and subordination of all other activity to the constraints described
- rejection of limits for constraints

The first three points are corresponding to the investigation step, the last one to the improving step [1, 4]. It may be remarked that the existence of constraints produces a limitation of the production flow. Restrictive resources determine the stocks level and the global flow. Any over-activation of non-limited resources will be counter-producing.

The system limits being imposed by constraints the interest consists in synchronizing any activity with these constraints.

2. THE CASE OF A COMPANY

A company assembles lamps for mineworkers with reference (M10), starting from two subassemblies SE1 and SE2. These last ones come from two raw materials MP1 and MP2. The production schedule and technical data of the product are as follows:

- Production schedule: it gives the manufacturing combination: the weekly request is of order 100 M10 and of 50 SE2. This last article may be sold directly on the market. This example is adapted from [1].
- Nomenclature (figure 1);
- Sorts (table 1);
- Production capacity (table 1).

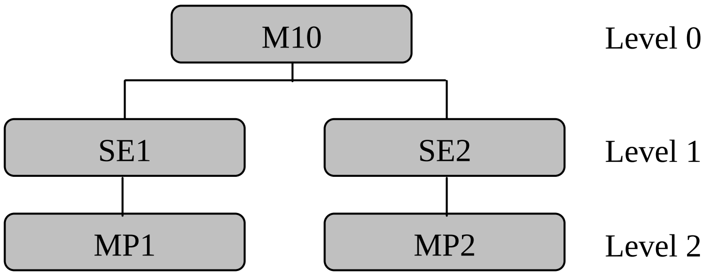

Fig.1. Product nomenclatures

Tab.1. Table sorts

Item	Name of operation	Unitary time	Machine
SE 1	Op 1 Op 2	28 minutes 10 minutes	Machine 1 Machine 2
SE 2	Op 3	22 minutes	Machine 2
M 10	Op 4, assemble SE 1 and SE 2	15 minutes	Machine 3

Tab. 2. Table production capacity

Machine	Machine 1	Machine 2	Machine 3
Production capacity / week	4000 min.	4000 min.	3000 min.

The production capacities indicated here are corresponding to the real production time (deducted from usual and predictable stops). Sometimes, the analysis of random phenomena appearing the most often at one of the stations interposing in the treatment of subassembly SE1 on machine 1, shows that incident is always solved within less than 1 hour.

Stage 1: Identification of constraints

For identifying restrictions, first of all, different occupation times of machines shall be reviewed, according to the item produced on them (Table 3). These values are obtained by analysis of sorts. The calculation of the test resulted from the combination is the following (table 4).

Tab.3. Occupation times

Item	Machine 1	Machine 2	Machine 3
SE 1	28	10	0
SE 2	0	22	0
M 10	28+0	10+22	15

Tab.4. Calculation of tests

Item	Machine 1	Machine 2	Machine 3
SE 1	0	0	0
1 x SE 2	0	22 min.	0
2 x M 10	56 min.	64 min.	30 min.
Sum of times	56 min.	86 min.	30 min.

Different resources have neither the same opening time, nor the same production capacity. For taking into account this consideration, we are calculating a test rate (table 5):
Test rate = Test / Capacity

Tab.5. Comparing tests and capacities

	Machine 1	Machine 2	Machine 3
Test	5600 minutes	8600 minutes	3000 minutes
Capacity	4000 minutes	4000 minutes	3000 minutes
Test rate	1,4	2, 15	1

The most occupied resource for the production within the production schedule is machine 2 with 2.15.

Remark: It is interesting to remark that having the same nomenclature, the same sorts and the same machines, the constraint may "slide" according to the request and thus, according to the production schedule. Thus, in our case, if the request was of 2M10 for 1 SE1, the restriction should pass on Machine 1.

Stage 2: Description of the operating manner of restrictions and information of protagonists

We shall make mention, first off all, of the rule saying that the restriction determines in the same time, the output flow and the stocks level (table 6). Knowing the restrictive resource, we may determine its opportunities, i.e. its weekly rhythm or production. Starting from the previous calculation, a combination uses 86 minutes of the restrictive resource Machine 2, for a capacity amounting 4000/86 = 46 combinations.

The production will be thus 46 x 2 = 92 M10 and 46 SE2 per week. The information for different persons of the company is mainly the output flow of the restrictive resource: 92 M10 and 46 SE2 per week (table 7).

Information from the commercial and selling department. By communicating the possible weekly production, the commercial department knows that if the sum of firm orders is less than or equal to this volume, clients shall be satisfied this week.

Information about clients and supply. The information of these departments is based on a nomenclature analysis.

Tab. 6. Global purchases

	MP 1	MP 2
1 M 10	1	0
1 SE 2	0	1

Tab.7. Weekly purchases

	MP 1	MP 2
M 10	92	92
SE 2	0	46

Thus, weekly 92 MP1 and 138 MP2 are needed. The supplies have to follow these data and the material output sheets from the storage. Any additional raw material (excepting those provided for remedying and spoilages) couldn't be transformed by the restrictive resource and will complicate the additional processing.

Information of the workshop responsible. All persons of the workshop staff shall be informed "related to the objective outputs" of each machine, i.e. related to the occupation foreseen for each station, such as indicated in table 8.

Tab. 8. Objective outputs as per machine

Machine	Time for a combination	Number of combinations	Occupation times	Capacity time (min.)	Test rate
Machine 1	56	46	2576	4000	64 %
Machine 2	86	46	3956	4000	99 %
Machine 3	30	46	1380	3000	46 %

Obvious that only one of the stations is of 99%: the restrictive one. The other stations are ok from this point of view and the wish of increasing the occupation rate should signify an increase of the number of intermediary operations, causing delays, because the restrictive station couldn't assimilate their overproduction.

Stage 3: Production synchronization and protection of restrictive stations

Starting from the rule showing that an hour lost at a restrictive station is an hour lost for the whole system, it may be said that Machine 2 determines the production rhythm of the company. A direct consequence of this fact is that any random phenomena on Machine 2 has direct consequences on the number of items manufactured and thus, on the sales.

A terms analysis allows the protection of the critical route (here, critical resource) of other routes, by using temporary margins able to cover all these random phenomena. The protection of the restrictive resource is made by programming the previous stage by a feed equal to the sum of possible delays in the upstream part of the restrictive station (blocking moment). Thus, it's about an indication which is retrieved directly in the plan. More generally, the third stage of implementing a buffer against random phenomena, in the form of the stock or the time, represents the DBR-Drum-Buffer-Rope model (imposed synchronization) system. In this case, product launchings are depending on capacities of the restrictive stations. In this system only what restrictive station may treat comes back. Nonrestrictive resources will be periodically stopped for lack of material, this being not only normal, but also planned.

Capacity restrictive resources CCR are conditioning the whole activity. Their stopping means a stopping of the whole activity. Thus, it's reasonable to be protected against flow breakings - and thus, to synchronize the entire activity – approving a protective stock, the buffer.

In the Drum-Buffer-Rope model (DBR) system charges to be executed arrives on time or with delay, excepting the buffers. The cycle time and the number of intermediary processing are reduced, thus only a single charge should be available in the same time. When this charge is available, it has to be treated as fast as possible.

The operating manner related to the third stage may be summarized as follows:

- sequencing restrictive stations according to the market request and their capacity
- protecting global flow and dispatches as per buffers
- forestalling the launch of buffer value
- producing as fast as possible

Obligations to be observed are as follows:

- to observe the launching data
- to observe all proceedings (quality …)
- to survey attentively the sequence imposed. Interdiction of batches regrouping.

The following steps will make production more stable and predicable, therefore allowing for a greater level of confidence in the impact of removing the most significant constraint: a. Measuring process and machine capacity and output in order to define the constraint point; b. Creating clearly defined production procedures and processes; c. Implementing the 5S system at shop floor level; d. Synchronizing the production layout to better arrange workstations so as to minimize transportation bottlenecks.

3. CALCULATION OF THE LOSS PER MINUTE AT A RESTRICTIVE STATION

This calculation has as aim to determine the circumstantial hourly cost of a production station and, especially, the restrictive resources. This calculation passes through a time and costs accumulation, for the hourly tests and rate, as it results from the next example.

3.1 The case of a company

We shall study the case of a subsidiary company of a big numeric decoding construction trust. This company, profit center, sells these items (RW, WC5, P) to an other company of the group, which engage itself to assembly and to dispatch. The workshop is organized on three manufacturing lines, flexible enough to accept one or two item families, with all their versions. The market request is often higher than the offer, which is limited by the capacity of some machines, represented by a serious investment. The company responsible has as aim to estimate the losses, due to production breakdowns of the restrictive machines.

Stage 1: Collection of times and costs

Data concerning the yearly rates of turnover are represented in table 9.

Tab.9. Yearly rates of turnover

Restrictive station	Item family	Yearly rates of turnover
Industrial robot for welding (RW)	Connection	14000 k€
Work center with 5 axles (WC 5)	Electronic card	10000 k€
Press (P)		
	Front and tools	5000 k€
	Yearly rates of turnover = 29000 k€ / year	

Supplies are representing 10% of rates of turnover and the yearly capacity of the restrictive stations amounts 1800 hours.

Stage 2: Calculation of tests and added values

The material, appliances and other supplies are representing 10% of rates of turnover the added value is equal to 90% of rates of turnover (table 10).

Tab.10. Tests and added value

Restrictive station	Rates of turnover (RT)	Supply chain	Added value (AV)
RW	14000 k€	1400 k€	12600 k€
WC 5	10000 k€	1000 k€	9000 k€
P	5000 k€	500 k€	4500 k€

Stage 3: Calculation of hourly rates

We should remember some rules coming from the management method by constraints:

- An hour lost at a restrictive station is an hour lost for the whole system;
- The restrictive station determines simultaneously the output flow and the stocks level.

Because the restrictive station limits the quantity produced and the sales, its breakdown punishes the whole production associated to it. We may deduce from this, that the loss resulted from a breakdown of an hour on a restrictive resource is equal to the added value, which should generate the whole subassembly of the company, depending on this, within this respective hour. Starting from the yearly capacity of 1800 hours for each restrictive resource, we shall obtain (table 11, table 12):

Tab.11. Hourly rates

Restrictive resource	Added value (AV) / year	Capacity	Hourly rates
RW	12600 k€	1800 h	7000 k€ / h
WC 5	9000 k€	1800 h	5000 k€ / h
P	4500 k€	1800 h	2500 k€ / h

Tab.12. Losses as per minutes

Restrictive resource	Hourly rate	Losses as per minute in the restrictive resource breaking
RW	7000 k€ / h	117 € / min.
WC 5	5000 k€ / h	83 € / min.
P	2500 k€ / h	42 € / min.

Now, the responsible knows the economic importance of restrictive resources and is able to take preventive measures:

- Control at 100% of items before the constraint;
- Preventive maintenance during the work;
- Flexibility of the operators of this station.

3. CONCLUSION

Theory of Constraints (TOC) brings in the powerful 'five focusing step' methodology to identify the constraint in the company and systematically attack the associated problems. The result is dramatic improvements of throughput (or contribution) and customer order due date performance, and inventory reduction. One simple way of using constraint theory is to reduce throughput time by reviewing the processes in the factory and office from the time an order is received until it is produced and shipped. By identifying the bottleneck operations that are constraining fast throughput, and discovering where the problems are, several solutions may be found. Sometimes, it may be desirable to arrange the factory around the main constraint and balance production around the Tact time of the constraint. In other cases, it may be desirable to increase the capacity of the constraint, and then test for adequate output. If output is inadequate, then the same process can be repeated for the operation that has become the new bottleneck.

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