METHOD AND ANALYZE OF THE PRODUCTION CAPACITY CALCULATION

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Abstract. The capacity analysis shows the shortages for enabling a request for necessary investments. This paper follows to present the creation of a capacity analysis for business units, product lines and plants of company at the work center level, and the handling and the content of capacity statements made by the customers (sample, volume production and capacity statements in enquiry process). The target group for this paper is all employees who create or approve capacity analysis and request investments for production machines. This may include employees engaged in production scheduling, facility planning, investment planning, budgeting and controlling.

Keywords: capacity, cost, production, budgeting, cycle time

1. Introduction

Capacity management is a significant issue in the high-tech industries such as semiconductor, telecommunications devices, and optoelectronics. In this environment, manufacturers are confronted with capital intensive facilities and highly skilled labour, operating under long manufacturing lead-time, short product life-cycle, and near-continuous technological innovation [1].

Changes in the nature of production and the enhanced significance of auxiliary processes made calculations necessary for production and service systems where processes are difficult to quantify. To perform a capacity calculation, we have to know the ratio of the costs of the machine, equipment, plant or division depending on, and independent of the output. These costs are closely related to the resource where they appear. The operated resources can be divided into groups on the basis whether they are provided according to their usage needs or in advance, without the prior knowledge of these needs [2].

2. Capacity analysis

2.1. Calculation of the Capacity Requirements (CR)

The capacity requirement – relative to one work center – is calculated by the following formula:

$$CR = \sum_{1}^{n} \left(Td \cdot Trct\right) + \left(S - t\frac{Td}{Ls}\right), \qquad (1)$$

where:

Td – total demand,
Trct – total running cycle time,
S – setup,
t – time,
Ls – lot size,
n – number of materials.

The total demand is generated from the direct primary demand and the secondary demand from other product lines – relative to the reporting period of time. The reporting period of time is tow years for the budget process (budget + forecast). For analysis between the reporting time periods, the data from operation planning should be used.

The total cycle time for a work centre is derived from sum of the cycle time and the standard down time of each material. It is to be based on the current process and not to include measures for reducing standard cycle time.

2.2. Calculation of the Capacity Offered (CO)

The available Capacity Offered of one machine is calculated with the following standardized formula:

$$CO = DM \cdot WN \cdot CU, \qquad (2)$$

where:

DM – day minutes, maximum factory utilization time is 1.440 min. per workday,
WN – workdays number, according to capacity hierarchy (Figure 1) is 235, 250, 280 or 325 workdays per year,
CU – capacity utilization, according to capacity hierarchy (Figure 1).

The capacity of machine group or machining centre is comprised of the sum of the capacity of machines group per technology or cost centre.

2.3. Calculation of the Capacity Efficiency (CE)

The degrees of capacity utilization may be determined by using the above incremental hierarchy derived capacity offered by the following basic formula:

$$CE = \frac{CR}{CO} \cdot 100\% . \qquad (3)$$

The capacity offered according to the hierarchy (Figure 1) can vary in size.

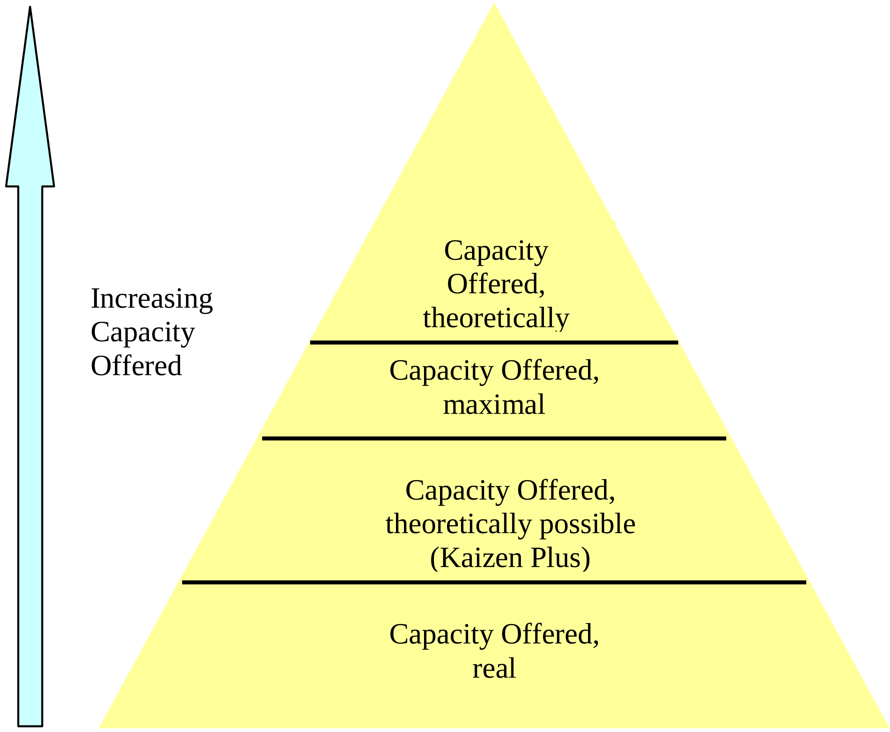

Figure 1. Hierarchy of the Capacity Offered

3. Data presentation

3.1. Capacity Offered, real (COr)

The capacity offered, real is calculated according to the equation (2), using the real capacity utilization from the work centre and 235 workdays:

$$COr = 1440\,\text{min} \cdot 235 \cdot CUr , \qquad (4)$$

where CUr is capacity utilization, real.

The real capacity utilization is taken from past efficiencies according to the following formula:

$$CUr = \frac{PT + ST + ASDt}{Pt - \sum DtALtB} , \qquad (5)$$

where:

- PT - production time,
- ST - setup time,
- $ASDt$ - article specific downtime,
- Pt – planned time,
- $DtALtB$ – downtime avoidable on a long term basis.

Article specific downtimes consist of all order-specific machine downtimes. Real capacity utilization provides information on the real capacity offered of the work centre. The capacity efficiency with use of the real capacity offered shows how the machine works to full capacity under present organizational and technical conditions. At this point any existing optimization potentials for rising capacity offered should be examined.

3.2. Capacity Offered, technically possible (COtp)

The capacity offered, technically possible is calculated according to the equation (2), with the capacity utilization, technically possible and with 250 workdays:

$$COtp = 1440\,\text{min} \cdot 250 \cdot CUtp , \qquad (6)$$

where $CUtp$ is capacity utilization, technically possible.

The capacity utilization, technically possible comes from past efficiencies according to the following formula:

$$CUtp = \frac{PT + ST + ASDT}{Pt - \left(\sum DtALtB + \sum OADt\right)} , \qquad (7)$$

where $OADt$ is organizes avoidable downtime.

In calculations of the capacity utilization, technically possible of areas where the reset and non-productive-times are not part of the total running cycle time the article specific downtimes are not to be considered in the numerator.

In the area to be considered, work centres which are technological comparable are to be checked: at the level of elementary work places (derive from adjustments of work plans and production versions), at the level of plant/plant alliances (derive from production transfers). The capacity utilization with use of the technically possible capacity offered shows how the machine works to full capacity under improved organizational and technical conditions.

In the case that the technically possible capacity is not enough for an intermediate-term according to the profitability, capacity extensions are warranted by existing work centres or new investments. According to the lead time of the plants the capacity extension has to be initiated within time. Before the capacity requirement is higher than the capacity offered, technically possible the additional capacities should be ready to use.

3.3. Capacity Offered, maximal (COm)

The capacity offered, maximal is calculated as follows:

$$COm = DM \cdot (WN + AD)CUtp\,, \qquad (8)$$

where *AD* is additional day.

The capacity offered, maximal is calculated with the capacity utilization, technically possible and with 280 workdays:

$$COm = 1440\,\text{min} \cdot 280 \cdot CUtp\,. \qquad (9)$$

The capacity efficiency with use of the technically possible capacity offered shows how the machine works to full capacity under improved organizational and technical conditions as well as a work time of 18 shifts per week. Compared with the technically possible efficiency is shown by how much capacity reserves the work centre has, e.g. for short term additional requirement.

3.4. Capacity Offered, theoretically possible (COthp)

The capacity offered, theoretically possible is calculated according to the equation (2), with 100% capacity utilization in connection with a maximum shift model:

$$COthp = 1440\,\text{min} \cdot 325 workdays \cdot 100\%\,. \qquad (10)$$

The capacity efficiency with use of the theoretically possible capacity offered shows how the machine works with a capacity utilization of 100% as well as a work time of 21 shifts per week. Compared with the other capacity efficiencies this theoretical view shows how many losses will appear in general operational conditions.

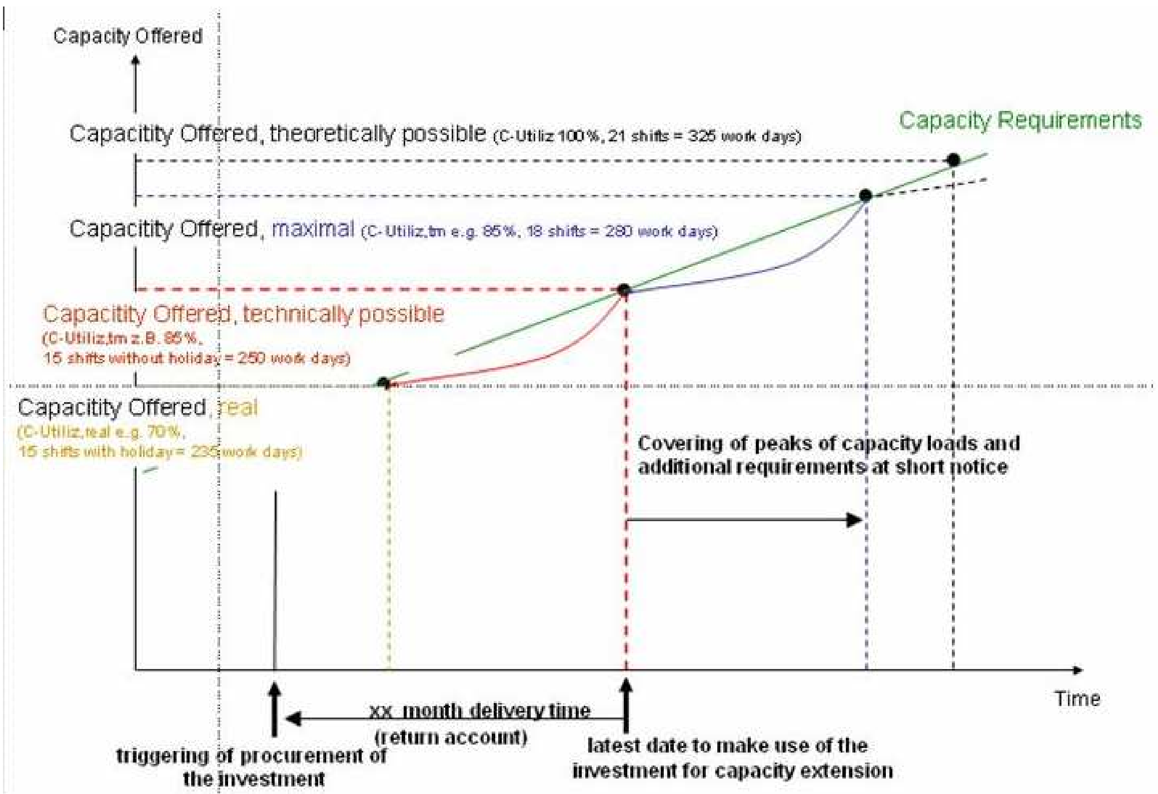

Figure 2. Connection between the different kinds of Capacity Offered

The delivery time also consists of the installation, the initial operation and the acceptance of the plant. The yearly requirements of the operative planning are taken from demand planning. For capacity planning within the framework of the budget process the relevant requirements from the budgeting and planning system are available in the product-line controlling. By the controlling process quantity structure are budget quantities for sailable products as well as for components in access. That way the budget yearly requirement and the yearly requirement are exploded.

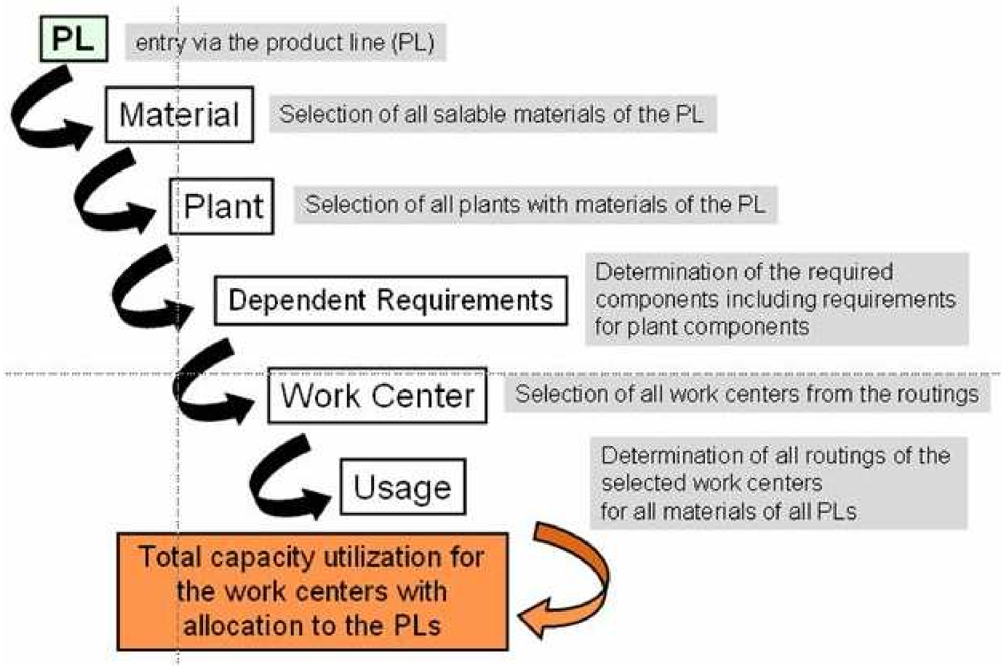

Figure 3. Procedure of the capacity calculation per work center

This diagram illustrates the process of data determination, presentation and data analysis for a product line. The assignment of the materials to the product line is followed by the product hierarchy in the material master. The product line is entered in the work center classification, in the category product line.

The assignment of the work centers to the product line are followed by the same rules of the corporate controlling – plant reporting, like the segments in a plant are assigned to the product lines and business units. Every product is provided with a product hierarchy when creating the material master.

When several different products with different PL assignments are produced in one segment, the assignment follows after predominant proportion, i.e. rule of majority (rule of majority works after delivery performance, i.e. delivery quantity):

- assignment full possibility (100% delivery performance for one PL);
- assignment of maximum principle possible (> 50% delivery performance for one PL);
- assignment manual (e.g. 33% delivery performance for 3 product lines each time);
- assignment individual, by utilization of several product lines, especially by segments of services to a product line or a plant.

4. Capacity evidence

For some time, customers have been requesting statements from suppliers in the case of new products and also for products already in volume production on machine utilization, cycle times and shift patterns, in order to draw conclusions on productivity and manufacturing capacity in the supply chain. A capacity statement is only introduced once the contractual terms valid for the specific customer have been reviewed.

In all cases, capacity statements should be handled restrictively and processed in accordance with level 1 where possible. Customer forms should not be put into circulation by Sales. If capacity statements cannot be processed in accordance with level 1, then level 2 is used. The data determined in level 2 can be transferred into customer forms at the customer’s request (level 3). This course of action should ensure that the statements forwarded to the customer are uniform in terms of their content. This is of particular importance if a customer sends enquiries from different plants.

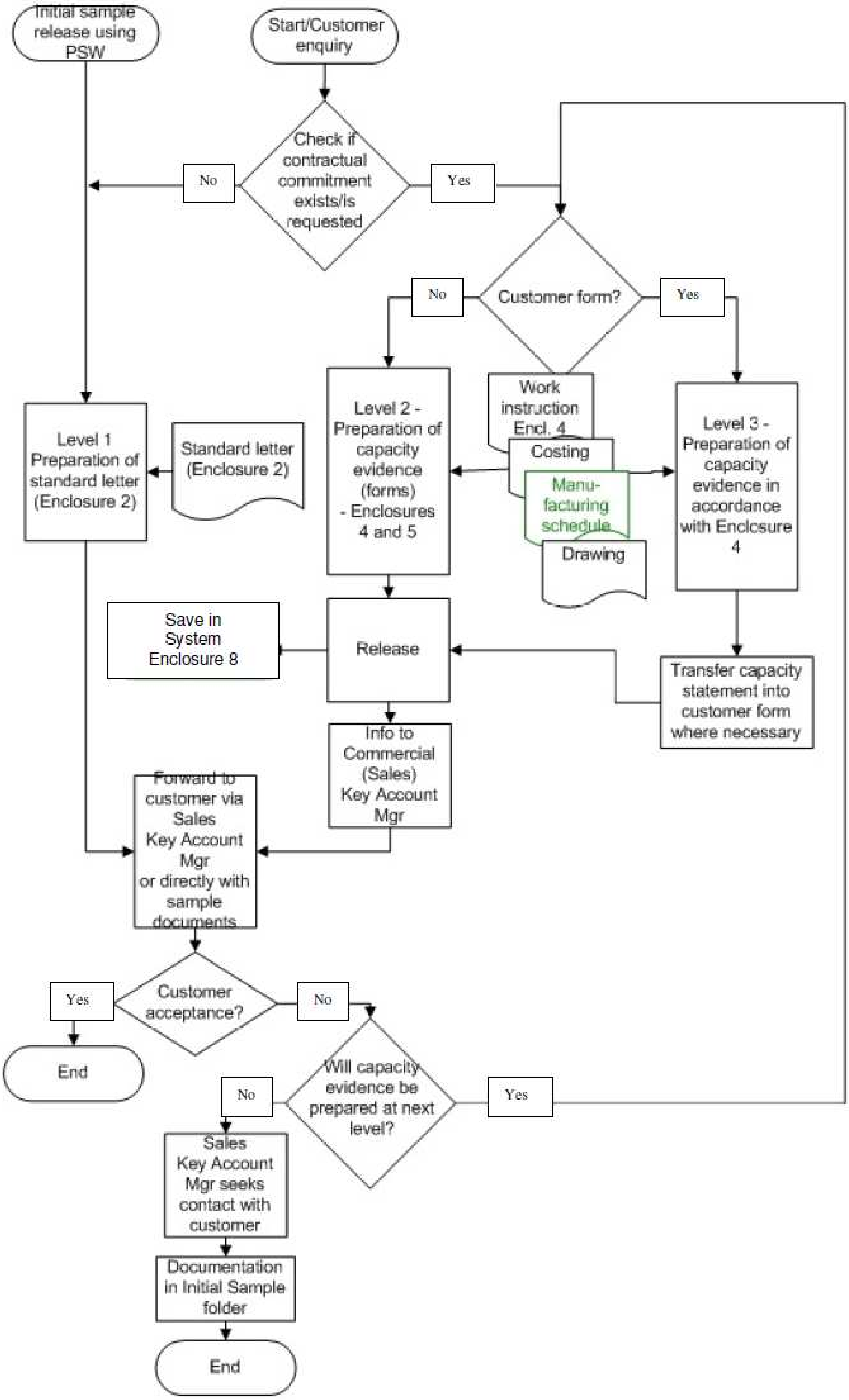

Figure 4. Enquiries on capacity evidence

4.1. Level 1 – Standard letter in text form (Enclosure 2)

The standard letter is used to give general information in level 1. No specific capacity statements, e.g. parts, hours, output in machine/time unit or parts/shift, etc. may be entered. If the customer is not satisfied with the standard response, it must be clarified whether a more specific response in accordance with level 2 can be given in the circumstances.

For capacity statements which are required within the framework of initial sample release using the part submission warrant form or product and process release, the only response in principle is with reference to this standard letter (see Enclosure 3 with reference to Enclosure 1). Responsible for the standard letter in accordance with Enclosure 2 is sales department.

4.2. Level 2 – Capacity statement with calculation (Enclosure 5)

If the customer does not accept the capacity statement in accordance with level 1, a capacity calculation is carried out in accordance with Enclosure 5. In this case we refer only to the assembly and single-purpose/bottleneck machines involved in the manufacturing process (not to standard machines and not to component manufacture or purchase). Only the completed form shown in Enclosure 7 (to be prepared in accordance with Enclosure 4) is passed to the customer. Responsible for completing the form is the production planning.

4.3. Level 3 – Capacity statement with calculation (individual customer form)

If the customer does not accept the form in accordance with level 2, the data can be copied into the customer form exactly where necessary. Responsible for transferring data from the form shown in Enclosure 5 into the customer form is sales department.

5. Conclusions

Capacity is one of the most important measures of resources used in production. Its definition and analysis is therefore one of the key areas of production management [2].

Physical expansion of manufacturing capacity involves enormous risk. This involves building new facilities, purchasing new equipment, and/or automating existing production processes, all of which translate into significant capital investment. In the case where demands are not sufficient to cover revenue projections, or to recover the investment, significant consequences follow [1].

In calculating the real capacity utilization of areas where the reset and non-productive-times are not part of the total running cycle time, the specific downtimes are not to be considered in the numerator. Long-term downtimes can be taken into account during capacity planning because they are known and may be scheduled.

The capacity, technically possible is set in calculations of optimizations (Kaizen actions, work shop technology benchmark) instead of real capacity utilization. A further variable is the total capacity demand over time (years). From the calculation of the capacity efficiency the need for investments derived from utilization calculations.

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