Techniques for Planning and Control Dependent on Different Types of Flexibility

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Abstract
The implementation of a particular technique for planning and control of capacities, materials, and other resources for production is strongly dependent on what type of flexibility, in a strategic, tactical, or operations view, is the center of attention. For decision making, two-dimensional visualizations, with the horizontal axis and the vertical axis each representing a certain type of flexibility, have proved practical. This decision aid proves advantageous especially when the decision is made jointly and the reasons for the decision need to be communicated to other persons – in the job shop, for example. The paper presents examples of concepts and techniques for capacity and materials planning, and further areas where the decision aids can be used.

Keywords:
Flexibility, Decision Making, Operations Management

1 INTRODUCTION

Flexibility is the capability to adapt to new, different, or changing requirements [1].

In the literature, the above very general definition is specialized in various directions:

- Various subtypes of flexibility. [2] distinguishes mix flexibility, design changeover flexibility, modification flexibility, volume flexibility, rerouting flexibility, and material flexibility. [3] provides a comprehensive list of types of flexibility; [4] provides a literature review.
- Aspects of flexibility that mostly are meant to describe the company. It is common to use adjectives like lean, agile, adaptable, transformable, reconfigurable, changeable, resilient, and the corresponding nouns. The examples that are given for these terms are all quite similar, and they can be understood as flexibility potentials. See here [5], [6], [7], [8], and [9].

The implementation of a particular technique for planning and control of resources for production is strongly dependent on what type of flexibility, in a strategic, tactical, or operations view, is the center of attention. For decision making, two-dimensional visualizations, with the horizontal axis and the vertical axis each representing a certain type of flexibility, have proved practical. Most people can (intuitively) understand logical connections better if they can be represented in two dimensions, on a plane, for example on a piece of paper. Using the visualization, a team in a job shop, for instance, can reach a common understanding, which is a requirement for successful collaboration.

The paper presents examples of concepts and techniques for capacity and materials planning.

2 TECHNIQUES FOR CAPACITY PLANNING IN DEPENDENCY UPON FLEXIBILITY OF CAPACITY AND FLEXIBILITY OF ORDER DUE DATE

2.1 Characteristic Features that Indicate Flexibility, and Classes for Capacity Planning and Control

Depending on the main objectives of the enterprise, the values for some of the characteristic features of planning and control will differ.

- The *quantitative flexibility of capacity* describes its temporal flexibility. If maximum capacity utilization is required, there will be no quantitative flexibility of capacity.
- The *flexibility of the order due date* indicates whether customers (internal or external) are flexible when stipulating the delivery due date. If maximum fill rate and delivery reliability rate are required, there will be no *flexibility of the order due date* of the production or procurement order.

There are various techniques for capacity planning. Figure 1 groups them into two classes, in dependency upon the two types of flexibility just mentioned before.

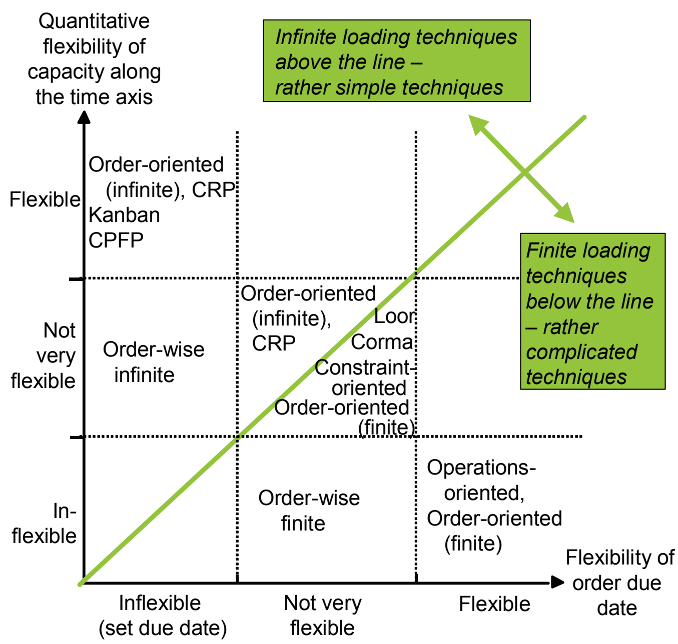

Figure 1: Classes of techniques for capacity planning in dependency upon quantitative flexibility of capacity and flexibility of order due date.

- *Infinite loading* means calculating the work center loads by time period, at first without regard to

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capacity. The primary objective of infinite loading is to meet dates as scheduled, with greatest possible control of fluctuations in capacity requirements. Therefore, infinite loading is important when meeting due dates must take priority *over* high capacity utilization, such as is the case in customer order production in a job shop production environment. The planning techniques are rather simple.

- *Finite loading* considers capacity from the start and does not permit overloads. To prevent overloads, the planner changes start dates or completion dates. The primary objective of finite loading is good use of the capacity available through the course of time, with greatest possible avoidance of delays in order processing. Therefore, finite loading is most useful if limited capacity is the major planning problem, such as in the process industry in a continuous production environment. Often, this condition is given in very short-term planning, in execution and control. The planning techniques are rather complicated.

In addition to quantitative flexibility of capacity, there is also qualitative flexibility of capacity:

- The *qualitative flexibility of capacity* determines whether capacity can be implemented for various or for particular processes only. If a company puts the focus on flexibility in the utilization of resources, then qualitative flexibility of capacity (employees and the production infrastructure) is absolutely necessary.

If there is qualitative flexibility in capacity, this can increase its quantitative flexibility. For example, if employees can be moved from one work center to another, this is the same as if each work center showed quantitative flexibility in assigning employees.

2.2 Techniques for Capacity Planning

In addition to these *two classes of techniques*, Figure 1 groups techniques for scheduling and capacity management in *nine sectors* in dependency upon quantitative flexibility of capacity and flexibility of the order due date. The techniques shown were chosen because they are readily available today, in many cases also in software packages such as SAP. The task is to identify the correct technique in accord with the desired type of flexibility.

For details of the different techniques, see [10] or [11]. CRP stands for *capacity requirements planning*, particularly in connection with software (there exist also some variations of CRP). CPFP is the abbreviation of *cumulative production figures principle*, Loor for *load-oriented order release* (see also [12]), Corma for c*apacity-oriented materials management*.

The techniques can be compared with respect to their overall capacity planning flexibility.

Overall capacity planning flexibility is defined as the "sum" of the quantitative flexibility of capacity along the time axis and the flexibility of the order due date.

- Note that there is no technique in the three sectors at top right of the figure: Here, the overall capacity planning flexibility is high enough to accept and execute any order at any time. This case is very advantageous with regard to capacity planning, but it is usually too expensive due to overcapacity.
- Note the numerous techniques in the three sectors from top left to bottom right. Here, there is *sufficient* overall capacity planning flexibility in order to allow a computer algorithm to plan all the orders without intervention by the planner. After completion, the computer program presents unusual situations to the planner. The planner will intervene in order to execute appropriate planning measures – perhaps daily or weekly.
- Note that there are few techniques in the two sectors above and to the right of the bottom left sector. Here, there is no flexibility on one axis and only low flexibility on the other. Thus, there is *little* overall capacity planning flexibility. Planning takes place "order for order" (order-wise). Each new order must be integrated individually into the already planned orders. In extreme cases, the planner may have to intervene following each operation and change set values for planning (completion date or capacity). Already planned orders may have to be re-planned. This procedure is usually very time consuming and is therefore efficient only for orders with considerable added value.
- Finally, note that there is no technique in the sector at bottom left. Here, there is no flexibility of capacity or due date. As a consequence, there can be none of the required balancing, and the planning problem cannot be resolved.

3 TECHNIQUES FOR MATERIALS PLANNING IN DEPENDENCY UPON THE FREQUENCY OF CUSTOMER DEMAND, THE ITEM'S UNIT COST, AND THE ORDER PENETRATION POINT (OPP)

3.1 Characteristic Features that Indicate Flexibility, and Classes for Materials Planning and Control

Depending on the main objectives of the enterprise, the values for some of the characteristic features of planning and control will differ.

- *Frequency of customer demand* means the number of times within defined observation time periods that the entirety of the (internal or external) customers demand a product or product family. If the company puts the focus on adaptation of the product to the customer's specific requirements, then the demand pattern of a product (family) will be discontinuous.
- An item's *unit cost* is defined as the total cost for producing or purchasing one unit of measure of the item, e.g., one part, one gallon, one pound. It includes labor, material, and overhead cost. For low-cost items, the quality of materials planning is less important than for high-cost items. Thus, there is more flexibility in the choice of a planning technique.
- The *(customer) order penetration point (OPP)* is a key variable in a logistics configuration. It is the point in time at which a product becomes earmarked for a particular customer. Downstream from this point, the system is driven by customer orders; upstream processes are driven by forecasts and plans (see [2]). Thus, the OPP indicates the flexibility in order fulfillment. If the customer tolerance time is at least as long as the cumulative lead time, the product can be engineered, procured, produced, or delivered when actual demand in the form of a customer order is placed. Otherwise, all goods (such as semifinished goods, single parts, raw materials, and information) from which the end product cannot be manufactured and delivered within the customer tolerance time must be ordered *before* there is known demand. The goods must all be procured and stocked on the basis of demand forecast. If the customer tolerance time is zero, the end product must be procured before demand is known. This is the same as stocking the end product in a warehouse.

In materials planning, there are two different classifications to consider. *Classification of demand according to accuracy* is defined as follows: