THE PRODUCTION CAPACITY PLANING MODEL IN TERM OF SUPPLY CHAIN MANAGEMENT

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Abstract

The paper describes the custom oriented approach to capacity planning model design, if the company is one of the elements of the SCM. The model of the capacity planning is designed on the heuristic principles. Model was created for RS Ltd.. The model in the paper is presented in algorithms form.

Keywords: Supply chain management (SCM), KANBAN, capacity planning, order logistics, information system

1. INTRODUCTION

The capacity planning of the production (CPP) is one level of operative planning. The main targets of CPP are:

- The records of customer orders and production tasks for the next planning period (some weeks) and production department.
- The order assignment to time unit of the capacity plan (weeks)
- Capacity smoothing for machine and time unit.
- Creation of the internal orders – cumulated orders from the real customer orders.
- Creation of the production batches,

And by these activities it is created capacity plan of production department, which is the input to the next step of operative planning to production scheduling. [4].

Each company is original from the point of production processes. Application of standard enterprise information system (SAP, proAlpha, etc.) needs difficult adaptation especially for conditions of small or medium enterprises (SMEs) and the price of that system is relatively high. Therefore, the proposed model of capacity planning is much more suitable for the conditions, requirements and demands of SMEs. [1, 2, 3, 11]

What are the advantages and disadvantages for company and its capacity planning model when company is a part of SCM or not. In this cause the RS Ltd. is a daughter company of big foreign company – Mother Company. Inside one company, between two subjects (mother, daughter) is applied the SCM, which can be understand as a KANBAN[4].

Model for CPP uses the information from SCM – KANBAN. KANBAN store can be used as a regulator element (buffer) in CPP model.
2. METHODOLOGY OF CPP MODEL CREATION

Both models are created on the heuristic approach i.e. there were analysed rules and limitations, which were applied to algorithms of the models. By this approach applied in the model, there were included all activities, know-how, knowledge of the experts and people, who works in the company for a long time [3, 8].

2.1. Approaches to CPP design

In the theory and practice were formed two basic approaches[4].

Customer oriented model of CPP - This approach is influenced from idea to satisfy all customers by their order (due date, order amount, etc.) without consideration of the capacity possibilities of machines and workplaces. Each order – product has technological prescription for your manufacturing, where is defined sequence of operations as $S_i$ and operational time this product $I$ on machine $J$ $t_{i,j}$. From the set of the orders it is created order sequence by definition of priority (due date, cost, profit, etc.). The products are assignment on the machine by the technological prescription applying the pull system. Result of this assignment is initial variant of CPP, which goes to next step to capacity smoothing process.

$$CN(J) = \sum M_{i,j} \cdot t_{i,j}$$

$CN(J)$-capacity needs and $CP(J)$-capacity possibilities machine $J$

$M_{i,j}$ - order amount of product

$t_{i,j}$ – operation time

Following the capacity smoothing, i.e. harmonisation of $CN(J) \equiv CP(J)$. Manufacturing oriented model of CPP - But also different approach is possible. Ordered products will be not allocated in planning periods, but product sequence will be developed in accordance with delivery term. From this sequence we should take such part of products, which will maximize capacity exploitation of production processes bottle neck. So we can avoid capacity smoothing. It is necessary to realise that the bottle neck of production process can be changed in accordance to assortment and amount of ordered products.
2.2. Strategies of CPP

Very often manufacturing process is realized in some production departments. By the optimising criteria and technological, economical, environmental constrains, we can select two basic strategies. [8, 9, 11]

A) The open system of CPP – open system means that product in one planning period (week) pass through some production department. Capacity planning in this case has to coordinate operation amount this production department to keep DD. The creation CPP model on this strategy is very complicated.

B) The closed system of CPP – this strategy define that operations on some product is realized in one planning period (week) only in one production department.

The selection of the strategy is influenced from the production cycle, delivery cycle and from type dominant optimization criterion. Where is dominant technological optimization criterion, in this case is better apply close strategy. Opposite: where is dominant economic and trade optimization criterions, in this case are commanded open system.

2.3. Utilization SCM – KANBAN in CPP

There can be defined free basic SCM system:

A) The SCM established of exchange of information about forecast or manufacturing plan among the member of the SCM agreement. The forecast is the only information for supplier is not binding, it has only information character.

B) enterprise N1 receives or gains the manufacturing plan forecast of enterprise N2 and N2 enterprise will specify, how big the stock produced by N1 should be e.g. in T₁, T₂ ......Tₙ period in the exit warehouse of N1 company. The same will apply for N3 enterprise, which will specify the volume of inventory for the same T₁, T₂ ......Tₙ period as in N2 enterprise etc. (see the Chyba! Nenalezen zdroj odkazů.

C) Demand chain - This philosophy has recently let mainly bigger pressure from chain dominant enterprises that specify, for their sub-suppliers, the volume of products and the period (T₁, T₂ ......Tₙ), in which the given volume should be either in a warehouse close to their premises or directly in entry i.e. disposition warehouses. The above-mentioned goods will be owned by the supplier up to the moment of their release from the disposition warehouse. Once released the following will take place: deal – order – invoice – payment to the sub-supplier. We would like to emphasize once more, that the goods in disposition warehouses are owned by sub-suppliers, which forces each enterprise in the

Fig. 4 The principle of SCM-KANBAN

I₁, I₂, I₃ – the entry warehouse of N1, N2, N3 enterprises
S₁, S₂, S₃ – the exit warehouse of N1, N2, N3 enterprises
chain to make its sub-suppliers create I0, I1, I2 dispatch stocks in their warehouses (see the Chyba! Nenalezen zdroj odkazů.).

I0, I1, I2 – the disposition warehouse of N1, N2, N3 enterprises

S1, S2, S3 – the exit warehouse of N1, N2, N3 enterprises

**Fig. 2** The principle of demand chain application

If subject of SCM N1 and N2 are member of one company (N1 is daughter, N2 is mother company) in this case SCM is KANBAN.

Now we take a case, if the N1 and N2 are in second type of SCM, i.e. N2 define the level of storage products in the KANBAN (output buffer) for N1 and levels of product are define to the end of planning period (month).

The model of capacity planning company N1 must respect this information – regulation – limitation. The model of CPP utilized this KANBAN buffer as regulation element it means: in the case, when it is not enough order capacity possibilities of the machine workshop utilization information about level of the product in the KANBAN buffer as virtual order which is assignment to capacity plan \( CP_{i} > CN_{i} \).

In the case, when \( CP_{i} < CN_{i} \) in the beginning of the planning period we utilized product from the KANBAN buffer for fulfilling the orders of the customer and by this way are decreased \( CN_{i} \) on the planning period.

Disadvantage to create the KANBAN buffer and its maintenance become advantage when model of CPP has assemble the regulation element describe on fig.6.

**Fig. 3** Utilization of KANBAN- buffer for capacity regulation

3. DESCRIPTION MANUFACTURING PROCESS AND MATERIAL FLOWS OF RS LIMITED

The enterprise RS Ltd.. is producer of stator and rotors for industrial ventilation and air conditioning system and is conformed to German mother company. The basic production process starts at cutting of dynamo plates and their welding or riveting (PP1), its casting to aluminium alloys (PP2), finishing (PP3) and surface treatment (PP4), see figure 1.

The file of recorded orders (FRO) is continuously actualised by adding new incoming orders, while planner can open the file anytime but on mentioned date he will receive the file through e-mail. By this step the actualisation of this file is finished and it is ready for planner to create new production plans.

The plan is created separately for these divisions:
1. for cutting (CNC machines)
2. for casting
3. for finishing (CNC machines), however this is not detailed plan given to a supervisor but it is a list of products and due dates and delivery dates.

The first set of information input is in-process production itself, which was planned in previous periods “N-1” for present period “N” (e.g. cut dynamo plates are not already casted in to aluminium body, casted are not finished and finished are not surfaced etc.)

The second set of information input is store levels of finished products, so called “KANBAN”, where the certain levels are need to be kept (levels represent quantity) by the end of a month. The decree, from the mother company which defined the certain levels of finished products, is actualised regularly, sometimes also when there is unexpected increase of orders of standard (often ordered) products. store and then the missing items are planned first as a priority.

Some of the semi-products (e.g. riveted stators and welded rotors) are not produced in this enterprise but they have to be ordered. This idea is used as a flexible item in capacity planning model. These purchased semi-products are also a reserve for smoothing of material flow especially between cutting and casting (figure 1). The second task of purchased semi-products is a capacity balance of production process. The capacity calculation is done first with all incoming unproduced orders.

Then it shows the “bottle neck” (usually it is welding and riveting) of the process by its calculation which also shows the ratio of possible and impossible produced orders and thus it is possible to enlarge capacity of welding and riveting by purchasing of these semi-products.

Purchased semi-products represent standard products, which are parts of best selling products. They are even with better quality and in many cases cheaper in comparing with self-produced semi-products.
4. **PROPOSAL OF CAPACITY PLANNING MODEL**

The CPP model is designed on the heuristic approach. [1, 12] Source of input information is the file of all orders. Each order has the certain quantity of ordered assortment and due dates. Present capacity planning consists of planning of all orders backwards from due date to first operation. There are calculated latest times of beginning of production and capacity need of each machine by this way, supposed that all income orders are put into production. Next, there is calculated in-process production and purchasing of semi-products, which can relieve capacity need at PP 1. In each production company, including RS Ltd., the capacity calculation have to include unexpected influences (lost times) i.e. breakdowns, increased time of setting etc., which is 10 – 15% of all times. That is why the machines are planned at about between 85 – 90% of their capacity, so this created a kind of time reserve.[10]

The capacity planning comes out from known workload – orders to certain planning period. Its aim is to choose orders from the aggregated orders (file of incoming orders) and to put them into a production plan, into a certain planning period by keeping the following:

- to fulfil required ordered quantities and due-dates for customers,
- to give in balance capacity demands to machines, equipments, workplaces with their capacity possibilities,
- to keep the prescribed store level limits of products in KANBAN warehouse,
- to purchase material, semi-products or sub-deliveries based on capacity plan of production,
- to have the capacity plan as a basis for creation production scheduling, in which there is no need to take care about capacity.

4.1. **Parameters and criteria for capacity planning**

1. The capacity plan is created for all company and it is divided to:
   - U1 – cutting, welding, riveting,
   - U2 – casting and production of aluminium (Al) alloys,
   - U3 – surfacing, finishing and other finalising.

![Planning periods of defined divisions (U1 - U3)](image)

2. Planning period will be at minimum 8 weeks. Planning point is between 10:00am – 12:00pm on Thursday./fig.8/

3. There is used the principle of sliding planning, which is performed each Thursday at noon (12.00 o'clock).

4. There is a different obligation in weeks (1st week is definite, 2nd week is preliminary – set at approx. 80%, 3rd week – 8th week is forecasted). The exact authorisation of doing changes have to be defined, e.g. changes for 1st week – only general director can provide changes, for 2nd week – only delegated
production supervisors or planner can provide changes, other weeks planner and other entitled persons can provide changes.

5. Planning by PULL system – it means from the end to beginning.


7. Closed system of capacity planning (phase production) besides the products with priority “S” and “SS” (defined by general director) will be kept, i.e. what is produced at U1 in week N will be processed at U2 in week N+1 and at U3 in week N+2. It results to defined production time, which for “B” products is three weeks, for “S” products two weeks and for “SS” products is one week or orders are completed from KANBAN.

8. The capacity plan will be created at 90% of maximum capacity (10% is left for unexpected, unaware changes and interactions).

9. Initial variant of plan is created in the way that:
   a) Inputting “S” and “SS” orders into weeks according to DD to division U3.
b) New “B” orders are assorted by: LRT – Longest Remaining Time, i.e. maximum time to their production is:
\[
\sum_{j} M_{N_j} * t_{ij} = \max \text{ respectively according to DD to division U3.} \tag{1}
\]

c) Orders are inserted to certain weeks from the end of U3 through U2 up to U1.

d) The capacity calculation is provided and there are calculated CN_{j} (capacity needs) in certain periods of weeks N+1 - N+8, but planning dead times, compulsory maintenance and in-process production have to be taken into calculation.

11. Solution of bottle-neck through KANBAN stock levels, and point 10 is again repeated.

12. Calculation of sub-deliveries of welded and riveted parts and point 10 is again repeated.

13. The capacity smoothing is possible to reach:
   a) By using KAIZEN,  b) By moving forward,

By dividing one big order to 2, 3 smaller batches (internal work orders) and moving two, three batches a period back.

CONCLUSION

The real system for the company RS Ltd. is not only the model for capacity planning itself. It was also created the model cumulating of orders and production scheduling with the evidence of work in progress and finished products for the each machine. The system, in this state, is already similar to the professional information systems for production management, with the difference, that there are integrated all the features and tools they really need and will use them as it is required from their production practice. Description of such a system would have far exceeded scope of this article and further description of this model is omitted.

The proposed model of capacity planning itself is a key activity of the whole system, because in this model it is created a file of possible workload that is possible to process, in the certain week with the given capacity potential of machines. This file is important for the operation of the further model of cumulating of orders and production schedules preparation and faults in that file would cause malfunction of the system.

LITERATURE


