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Analysis of order release rules and implementation in a PPC simulation module

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Abstract

Throughout the years a number of methods have been developed with the intention of optimizing the work of Production planning and control (PPC) systems. PPC systems represent a set of decisions on the acquisition, utilization and allocation of resources with the ultimate goal to satisfy customer requirements in the most effective and efficient way. It involves a considerable amount of parameters and synchronizing of high number of components is a complex process, especially in present business environment where everything has to be decided fast and precisely under an enormous pressure of external factor that undergo through constant change. One of the methods for optimizing PPC systems which is also used in this case is simulation module for PPC which integrates the parameters involved offering the opportunity of experimenting and analyzing the different possible scenarios in order to find the one that delivers the best possible results without affecting the current actual system and with that reducing the cost and time needed to identify the most optimal solution.

Key words: *Experiment, Order release rule, PPC, Simulation*

1. INTRODUCTION

Offering desirable customer service at a reasonable cost requires an efficient flow of materials and services while simultaneously managing the organization’s resources that direct and transform these flows. Effective planning and coordination ensures that all resources required to deliver services or produce goods are available in the right quantity and quality at the right time. Such planning and coordination, however, is often very complex. For example, a typical manufacturer is required to track hundreds or thousands of raw materials, components, and subassemblies for effective production. In a similar way, a service provider must ensure the appropriate employees and range of necessary materials are available to fill the needs of multiple market segments, often on very short notice. Effective internal planning and control represents the fundamental “block and tackling” underlying an organization’s efficient and effective operations. Planning and control is one of the foundational blocks that contribute to the management of broader operational systems. Forecasting customer demand based on a wide range of business factors is one critical input. Planning for operations then must cover both the long-term planning horizon for overall capacity and process-related resources, such as facilities, equipment, and personnel, as well as detailed schedules to match these to customer needs. And once plans are in place, management must actively control the use of resources to meet customer demands and against budgets. In practice, planning and control is a multistage process, often with iteration to refine the development or acquisition of particular resources.

Production planning and control is one of the most important elements of a successful production system, through which key questions like what to produce, how to produce, where, when, how much to produce and who will produce are answered, [1, 2]. The answers are obtained as a result of processes that include product mix planning, material requirement planning, determining quantity and batch size, planning of capacities and deadlines, managing production, [3]. All these planning steps have to be controlled in order for the production flow to go as it is foreseen.

In a static environment where we can make precise forecast of our production and there will not be any external or internal factors that will influence the course, circumstance or result of the production process we would only need to focus on production planning once and the established plans would be valid for long period of time. Since companies around the world operate in a dynamic environment that continuously changes; costumer needs modify, technology improves, competition is always pressuring us, suppliers are not often consistent in quality or delivery time and more global factors that are nearly impossible to have effect on like political, judicial, economic and social policies impose the need of feedback from data analysis gained throughout analyzing and evaluating the data secured during control process. The feedback link is supposed to provide information about the difference in what was planned and what has been achieved in order to gain insight about why didn't our plan go as predicted so the needed adjustments are made for the future production planning to match with the achieved outcome more closely. This in practice is not an easy task, which has resulted in production planning and control developing into a field that is being researched more and more in order to find optimal and improved methods that will result in more thriving achievements, [4, 5].

One of the key elements in the PPC is the order release rule under which the company operates. This is in line with the dynamics of the PPC and how the company achieves/manages the deadlines set by the customers. The rules dictate what (the number of the order) and when (the time the order will be activated). The consequences of the choice of rule are huge and affect every subsequent order. These rules are not limited only to production processes, but are also found in project management, IT services etc. Table 1 shows the most frequently used rules. The ones marked with (*) are found in the simulation software, discussed later.

Table 1. Different order release rules [6]

Rule	**Full form**	**Description of the rule**
SPT*	Shortest processing time	Select a job with minimum processing time.
EDD	Earlier Due Date	Select a job which is due first.
FCFS*	First Come, First Served	Select a job that has been in workstations queue the longest.
FISFS*	First in System, First Served	Select a job that has been on the shop floor the longest.
S/RO	Slack per Remaining Operation	Select a job with the smallest ratio of slack to operations remaining to be performed.
Covert		Order jobs based on ratio-based priority to processing time.
LTWK	Least Total Work	Select a job with smallest total processing time (SPT).
LWKR*	Least Work Remaining	Select a job with smallest total processing time for unfinished operations.
MOPNR	Most Operations Remaining	Select a job with the most operations remaining in its processing sequence.
MWKR*	Most Work Remaining	Select a job with the most total processing time remaining.
RANDOM*	Random	Select a job at random.
WINQ	Work in Next Queue	Select a job whose subsequent machine currently has the shortest queue.

1. WHAT IS A PRODUCTION PLANNING AND CONTROL MODULE?

Production planning and control is a complex process and such as that involves a huge number of elements that have to be synchronized and that is not an easy mission. A small inaccurate step can cause the whole process to go wrong.

One of the methods for optimizing production planning and control is using the benefit of software for modeling and simulation such as Tecnomatix Plant Simulation, [7]. It can create a module for PPC which could facilitate the process and make it possible to experiment with different parameters of the system, like production scheduling or numbers of machines and the infinite other parameters that are part of the system. The effect of the change in parameters on the outcome of the system is determined, without changing anything in the real system which would lead to a lot of costs and actually the number of experiments that can be simulated with the module are nearly impossible to achieve in the real system without damaging the system, [8].

Modeling is the process of gaining a deeper understanding of a system through imitation [9]. Models imitate the system and reflect properties of the system. Models specify what a system does; that is, how it reacts to stimulus from its environment, and how it evolves over time. Simulation shows how models behave in a particular environment. Simulation is a simple form of design analysis; its goal is to lend insight into the properties of the model and to enable testing of the model, [10, 11].

The module shown in Figure 1 is a real example of how the long list of objects and options offered with Tecnomatix can be used to model the production planning and control of a production plant. Creating the

account for the work order of the machine, product name, batch size, start time of the production as well as setup time, processing time and end time of the production.

3.2. Material requirements planning (MRP)

The MRP object includes three sub-objects: Master data, forecast and planning.

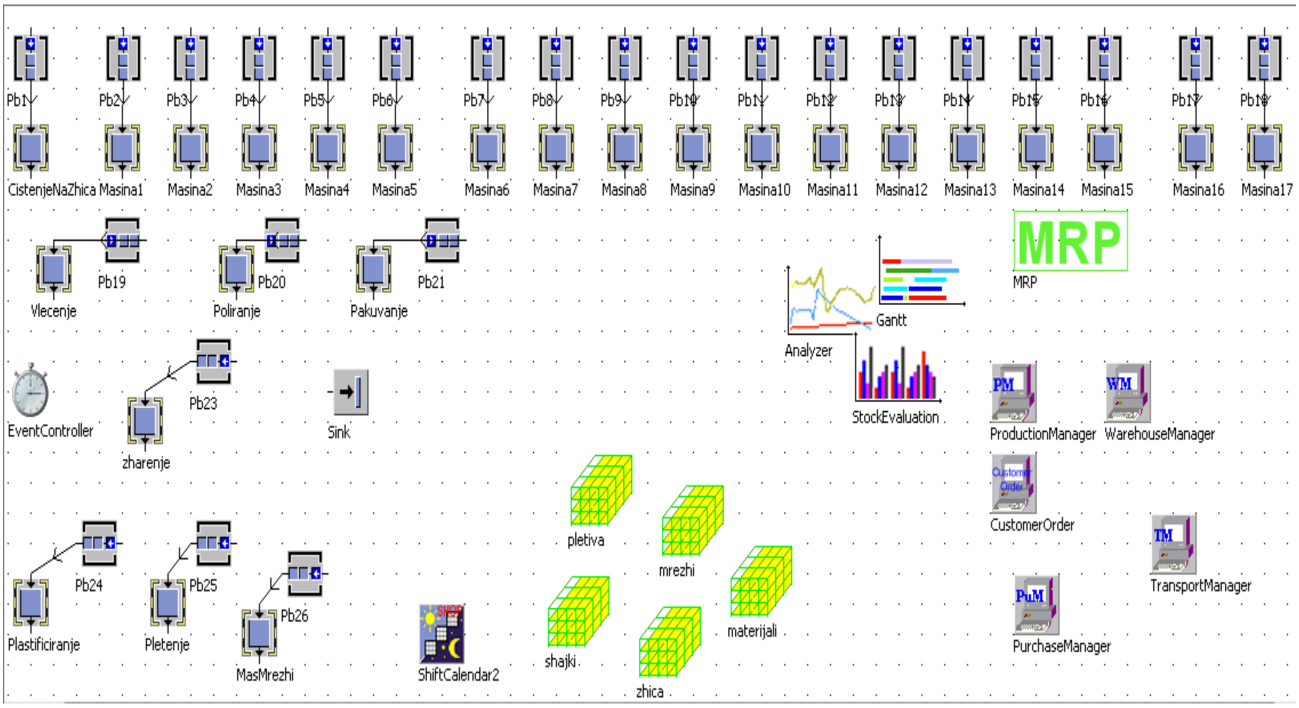


Figure 1. PPC module

module of any system even the simplest one requires a deep understanding of the work flow, even though our main focus is on the phase of production planning and control in order to express that phase using the principles of modeling and simulation we have to get sense of how the complete company production process functions.

2. STEPS OF CREATING THE MODULE

Much the same as most of process simulation the first part is to model the actual system with all its parameters, constraints and resources which (for this model) is done through the following steps[7]:

3.1. Modeling the machines as object station

This object offers the possibility to model the name of the machine, the operations that occur in it, the cost of the machine per hour for every machine in particular or in groups of cost centers, the availability of the machine in percentage, the mean time for repair, mean time between failures. The protocol of the object takes

With the option of forecast we model the expected sales of products if we have the data of probability the module has an integrated algorithm that translates the submitted probability based on our estimations into calculating the expected sales in the future periods according the mathematical principles of probability theory.

With the help of master data the biggest number of information are defined, including all the products, parts that are produced in the company, as well as the ones that are supplied from other companies. Components of every product/part are defined, also the operations through which there are processed and the processing time of the operations.

The information that are modeled in this phase are grouped into the following columns:

1. productId
2. product name of the product/part
3. PT (procurement type)

4. BOM (bill of material) - the bill of materials of the product/part is modeled into the module through defining position of the part during assembly, defining the product/part into which is being assembled, factor respectively the number of same parts that are assembled into the product/part and unit.

5. Operation plan - the operation list is a table that withholds information about the operations through which the product/part is processed using operation number, operation name, setup time, processing time and personal time (additional time that is not foreseen with setup time nor with processing time)

6. Inhouse production time – notes the production time of the parts that are produced in the company

7. Calculated production time – this column is automatically estimated using the data from the operation list we have fulfilled for the product/part we are modeling, respectively it adds up the processing time of the different operations through which the product/part is produced

8. Calculated setup time – this column as well as the previous one is automatically estimated using data from the operation list but this one adds up the setup time of the different operations through which the product/part is processed

9. Lot size data – models information about the batch size which can be:

   - fixed: according to this rule (option) we model a production system that can only produce a fixed number of product in a batch and every order bigger than this fixed number is split into two or more batches depending on the number we can produce at once
   - exact: according to this rule every order is processed in the way that the batch size is equal to the ordered number of products
   - replenish: modeling a production system that when deciding the batch size focuses on maximum utilization of the capacity of the system
   - profile: choosing this rule means that we choose to create a table in which we appoint a batch size for the appropriate order (the table that we create has only three column for maximum value of the order size, minimum value of the order size and the batch size into which the appropriate rang is translated into)
   - kanban: even though it is listed as a rule for batch size it actually represents and functions as a strategy for production management, but because it has influence on the batch size it is listed here, [12]

10. Delivery Time – notes the time for delivery of the products that are produced by external suppliers

11. Warehouse - the table for the warehouse has the information about the name of the warehouse, unit of the product, security stock (this is the value under which the stock for product should never go below),

12. Costs - the table for costs enlists information for the price by which we supply the part (if we purchase it form a supplier) or the production cost (if we produce it into the company), number of parts for which these costs are spent on.

13. Fixed inhouse productionTime – since we don't have data all the time about the processing time of every operation, we can model a system by listing an approximate value for the duration of the production.

14. Shift calendar – this column is fulfilled only in the case when for producing a certain product/part we work with a different shift than with standard products/parts

4. RESULTS AND DISCUSSION

The number of different experiments that can be conducted with this module are closely related to the number of the parameters ergo the complexity of the system, meaning the more parameters the production system the more elements can be changed and combined the bigger the number of the experiments. This in no way means that if the module is used for simpler systems with fewer parameters we can conduct only a small number of different experiments, but that with complex systems the number is huge and the time to conduct all the experiments we have in mind is considerable.

When working through the steps of creating the module, one starts to get sense of the experiments that can be conducted, for example simple variation with the number of machines and seeing the effect it has on the outcome.

Experiments can be conducted with replacing more machines with a work station of newer technology to see if its profitable to go for the new work station, changing the number of shifts adding or subtracting a shift, changing the number of transport vehicles, the layout of the machines/work stations, the capacity and the number of warehouses, changing the rules of order of production, combining them. When we list them like this it sounds like actually there isn't much experiments that can be conducted but if you take into consideration that with only combining the production rules you get 560 combinations that would have different effect on the results of our production system.

For the experiments to make sense, we have to have tools that show the variations that are produced depending on the changes we make in our experiments, the module offers the following tools for analyzing the system:

Analyzer

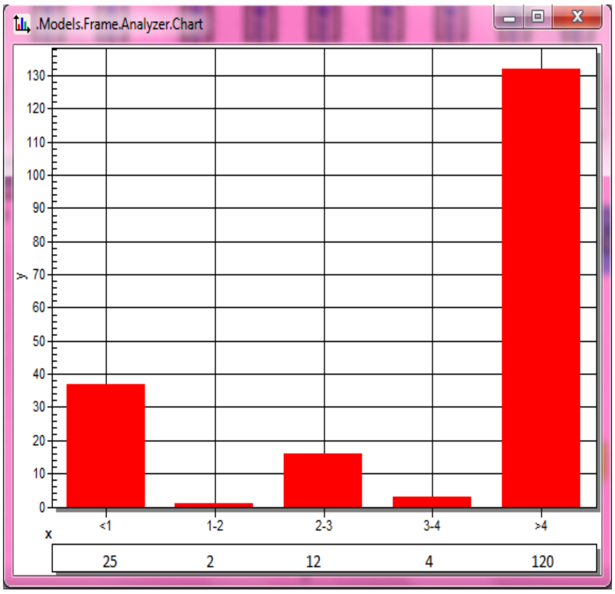
- Lists late orders

- Costs with cost center and cost groups split up by: Order costs, set-up costs, and processing costs
- Statistics of the individual stations: Utilization, set-up times and processing times
- Throughput times

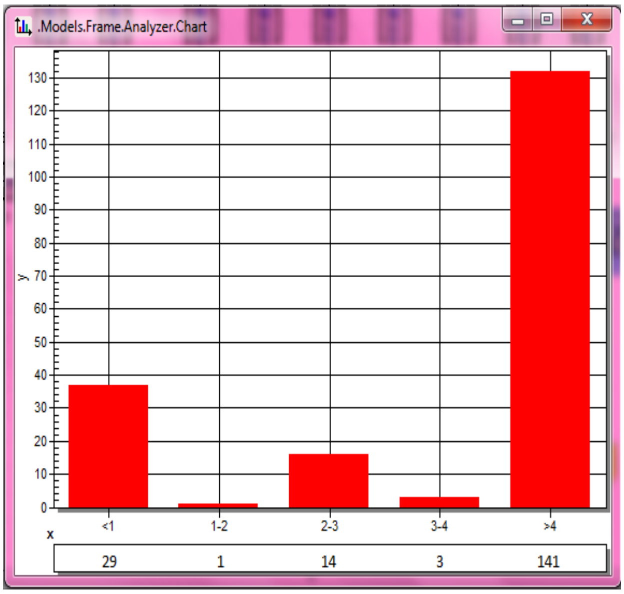
Figure 2 shows the number of late orders we get during the following combinations of the entry queuing rules:

a) Order disposition: Due date
Process disposition: Longest waiting time
Station disposition: Minimum available capacity

b) Order disposition: Order in the sequence
Process disposition: Delivery time
Station disposition: First suitable



a)



b)

Figure 2. List of late orders

If we compare only the late orders for these two combinations it's clear that the first combination produces a smaller number of late orders ergo the first combination would be a better choice. But making decisions about the entry queuing should not be based on only one comparison, this is simple a small example of what can be analyzed through the module.

Another ways to analyze the scenario and its worthyness is through:

a) Stock Evaluation

- Shows the circulating stock and the total stock.
- Total or interval-related
- Product-specific

b) Gantt chart
- Start date
- Shows data as graphics or in lists.
- Start time and end time of the operations.
- Shows the utilization of resources.

c) Histogram
- Shows data as graphics or in lists
- Can manage/show different types of elements in the model – machines, workers, entities etc. (Figure 3 presents the utilization of the machines).

5. CONCLUSION

Most of the benefits are already pointed out through explaining the possibilities of the experiments and the analyzing tools but in general the benefits of the module can be grouped in four main points:

1. Optimizing the system of production planning and control
2. Testing the feasibility of the production plan
3. Experimenting with different scenarios
4. Creating detailed production plans based on existing data.

Creating a module of production planning and control is not easy, its time and energy consuming, it generates considerable costs, but as they say nothing worth comes easy and the perspective we get from how changing different parameters affects our production system and getting an insight for improving our system through the module is surely worth having.

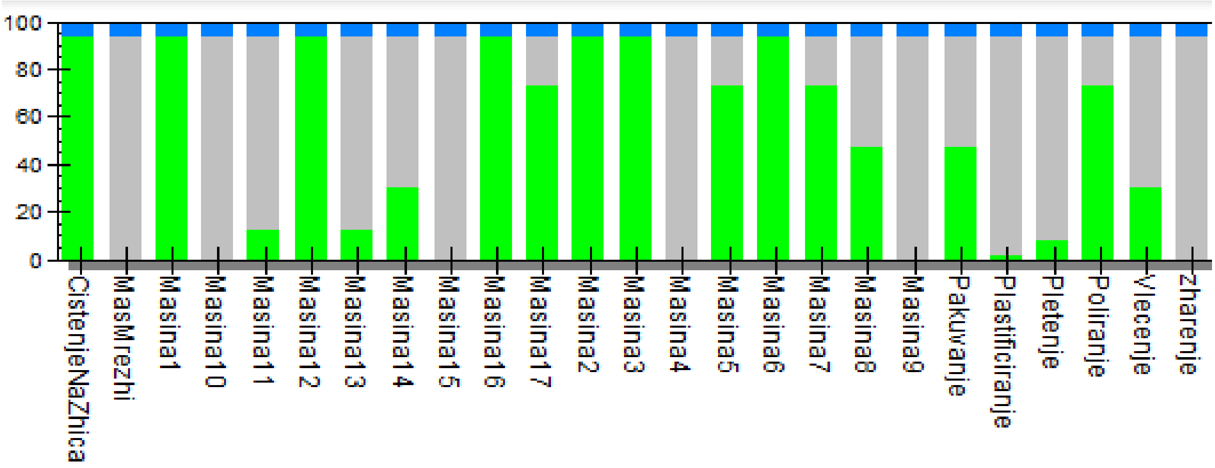


Figure 3. Histogram chart for machine utilization

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