World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:3, No:11, 2009

Individual Configuration of Production Control to Suit Requirements

Ben Muenzberg, Prof. Peter Nyhuis

***Abstract*—**The logistical requirements placed on industrial manufacturing companies are steadily increasing. In order to meet those requirements, a consistent and efficient concept is necessary for production control. Set up properly, production control offers considerable potential with respect to achieving the logistical targets. As experience with the many production control methods already in existence and their compatibility is, however, often inadequate, this article describes a systematic approach to the configuration of production control based on the Lödding model. This model enables production control to be set up individually to suit a company and the requirements. It therefore permits today's demands regarding logistical performance to be met.

***Keywords*—** Production, Planning, Control, Configuration

I. Production Control as a Lever in a Company's Success

A company's command of its own logistics is not just a possibility for a manufacturing company to stand out from its competitors. More than that, it is increasingly becoming a necessity in order to survive in a global market [1]. Companies with successful logistics grow faster and are more profitable than their competitors. Besides intelligent networking with suppliers and customers, a company must realize that organizing its own internal production logistics as efficiently as possible, in order to be able to turn it into an intrinsic success factor, is an important task.

Production control is an important lever within internal logistics, enabling an efficient relationship between logistical performance, in the form of shorter throughput times and a high date reliability, and the cost of logistics, which are characterized by the variables work in process (WIP) and utilization. The difficulty lies in the partly conflicting nature of the four target variables, known as the "dilemma of operations planning" [2]. For example, under real conditions minimum throughput time and maximum performance cannot be achieved simultaneously in one work system. The causes and effects can be mapped by means of production operating curves according to Nyhuis [3], as the qualitative diagram in Fig. 1 shows. So production should not be expected to achieve maximum goal attainment in all four areas, but rather a sensible positioning within the lines of conflict drawn up and tailored to the strategic objectives of the company.

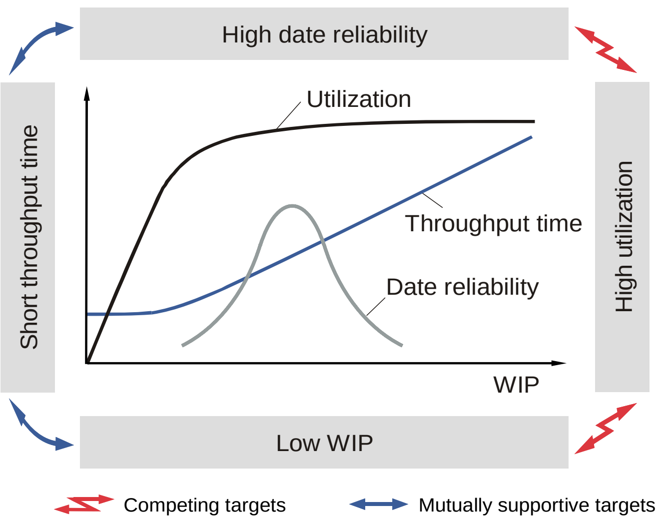

Fig. 1: The "dilemma of operations planning" [3]

To do this, it must be possible to configure the various tasks of production control to suit the goals, using suitable methods and taking into account their interactions. The new approach described in this article enables this process, known as configuration, to be carried out systematically and holistically. The intention is to place companies in the position of being able to configure their production control to suit the requirements with respect to typical corporate logistical conditions, taking into account customer requirements, strategic objectives, capabilities and other influences.

The steps required for the individual configuration of production control are described below based on a conception for the production control model developed at the IFA according to Lödding [4]. A corresponding practical example is also described.

II. The Production Control Model

The production control should implement the stipulations of production planning despite unavoidable changes with respect to quantities and schedule plus disruptions caused by absent personnel and machine breakdowns in production [5]. The production control model according to Lödding shown in

Ben Muenzberg is research associate at the Institute of Production Systems and Logistics (IFA), Leibniz University of Hanover, Garbsen, 30823 Germany (corresponding author to provide phone: 0049-511-762-18183; fax: 0049-511-762-3814; e-mail: muenzberg@ifa.uni-hannover.de).

Prof. Peter Nyhuis is director of the Institute of Production Systems and Logistics, Leibniz University of Hanover, Garbsen, 30823 Germany (e-mail: nyhuis@ifa.uni-hannover.de).

Fig. 2 brings together the IFA's knowledge of the modeling of logistical target variables and the development and application of production control methods [4]. It describes the interactions between the tasks of production control on the one hand and the logistical target variables on the other. In doing so, it follows the logic that every one of the four tasks influences plan and actual figures, which function as command variables in the model. The deviations that occur between each pair of corresponding command variables in real operations have an effect on the control variables. These in turn influence the four logistical target variables date *reliability*, *throughput time*, *WIP* and *utilization*.

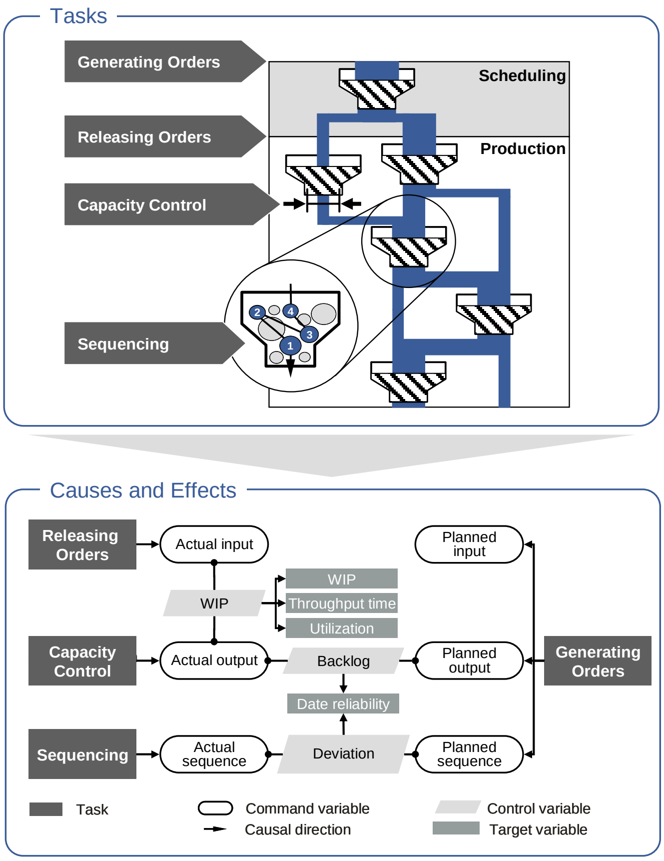

Fig. 2: The production control model [4]

For example, the key variable "WIP" has both a target and a control character and has a direct influence on the target variables throughput time and utilization, or rather performance, as can be seen in the qualitative presentation of the production operating curves in Fig. 1. The date reliability of an order is influenced by the size of the average backlog in production. If the First In – First Out principle is applied rigorously in the individual work systems, this backlog is always present for the entire spectrum of orders. If other sequencing methods are used, prioritizing is the outcome and this results in changes to the sequence when processing the orders. The ensuing advancing or delaying of orders has an influence on the date reliability for the corresponding order and also determines the scatter of date reliability with respect to the entire spectrum of orders. Production control comprises, in detail, the tasks of *order generation, order release, capacity control* and *sequencing*.

Order generation specifies the planned figures for inflow and outflow of orders to be processed and hence the WIP and the sequence of order processing. The feasibility of these plan figures influences the potential date reliability. The basis for order generation is either customer orders or depletion of stocks. Typical methods are the MRP II (Manufacturing Resource Planning) method [6, 7] and made-to-stock methods such as Kanban [8, 9], the Order Point Method [10] and Basestock [11].

Order release determines the time at which the orders can be released for production, i.e. their processing can begin. Many order release methods delay or accelerate the order release, with the aim of regulating WIP or balancing workloads [4]. They are mainly employed in order to coordinate the workload with the current WIP and hence influence, among other things, the throughput times for orders. Besides order release according to the schedule, Conwip [12, 13], Workload Control [14] and Workload-oriented Order Release [15] represent further typical methods.

Sequencing determines the succession in which the orders in the queue are processed by the work system [16]. To do this it sorts the orders according to criteria that are specified depending on the logistical objectives. Sequencing rules have an effect on, above all, the date reliability of production and the degree of service in a storage area, and hence an effect on the date reliability of a company. The sequencing rules include First In – First Out, least slack time (LST) [4] and setup time-optimized sequencing.

Capacity control regulates the short-term capacities of the work systems. The aim of capacity control is to avoid an impending production backlog or to enable quick capacity increases to deal with a production backlog, e.g. by reducing a build-up of overtime as quickly and cost-effectively as possible [17]. This enables good date reliability even in the case of deviations from the plan.

III. Configuration of Production Control

The principles outlined above represent the starting point for configuring the production. Numerous methods are available for each production control task concerned (see Fig. 3). These differ with respect to the goals supported, the requirements placed on data availability, their compatibility with other methods and many other factors.

Up until now the choice of suitable methods for fulfilling the production control tasks described was based on the considerable experience of the persons doing the work. But as considerable experience in this field cannot always be presumed, it is necessary to apply a concept that supports the production configuration systematically. In order to achieve a holistic improvement in the accomplishment of logistical goals, achieving excellent results in just one area of production control is not enough.

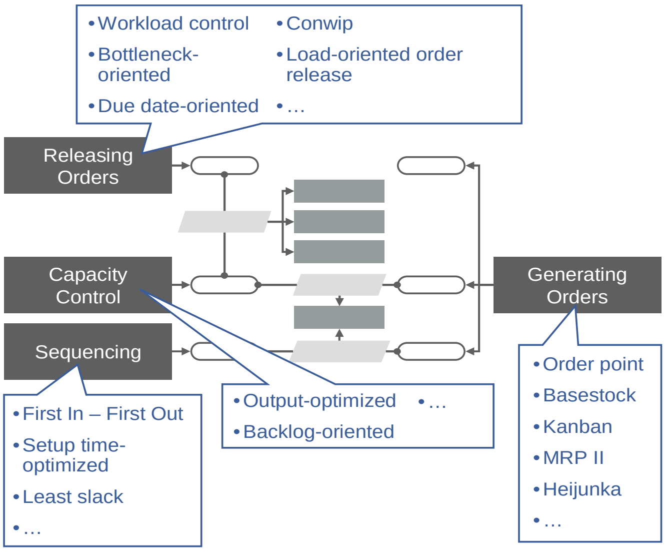

Fig. 3: Production control methods

It is far more important to configure the production control through a specific and systematic design process that takes into account the interactions between the tasks, the command and control variables and the logistical target variables.

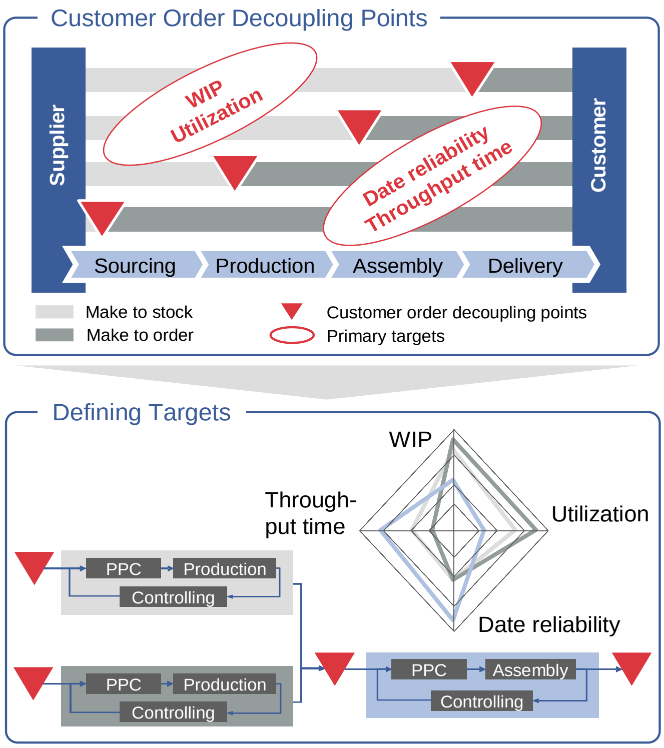

Fig. 4: Process analysis and definition of targets

As the target priorities and hence the choice of suitable methods for reaching these goals can vary across the entire range of production, it is first necessary to identify suitable control or regulating areas for which specific targets can be defined. Market- and product-related requirements, or rather boundary conditions, are collated for the area under consideration and the capabilities for dealing with these requirements are determined. Based on this it is possible to select production control methods that are in the position of being able to utilize the available capabilities in order to handle the requirements.

A. Process Analysis and Definition of Targets

In companies with multi-stage production it is not possible to specify any universally applicable logistical targets for the shop floor. Instead, it is more important to identify specific targets for each different area and to support these with methods. For example, it would appear sensible that, for reasons of cost, a desired high utilization for a production area handling universal intermediate products should be considered in conjunction with the aims of short throughput times and high date reliability in an order-related final assembly. In this case intermediate storage functions as a customer order decoupling point (CODP). Like the aforementioned example shows, the need for CODPs might lie, for example, in the demands of the market. This is generally the case when the required delivery times for order-specific products are shorter than the minimum throughput time possible in production. Production and subsequent storage of universal intermediate products is then necessary. After an order is received, these then only have to pass through a part of the total process, e.g. final assembly.

After possible CODPs have been identified, various control areas with specific logistical target weighting can be specified, as shown in Fig. 4.This is where priorities for the logistical key variables *utilization*, *WIP*, *throughput time* and *date reliability* are determined within the scope of a target definition workshop. In doing so, a positioning is necessary that takes into account the mutual dependencies, as described above. This can be carried out with the theory of logistical operating curves developed at the IFA [3].

B. Analysis of Requirements and Capabilities

In order to design a consistent production control it is essential to analyze the requirements placed on production and the capabilities of the individual areas for the various control areas identified and with respect to the logistical objectives etc. (see Fig. 5).

Requirements result from, on the one hand, the market environment; such factors include, for example, demand fluctuations and the competitive situation. On the other hand, requirements also result from the characteristics of the product, e.g. material value, physical properties and number of variants produced. In addition, the type of production is important because in the end a one-off order places totally different requirements on the control of the processes than is the case with mass production.

Besides market and product, it is also essential to consider the configuration of the processes in the analysis. Here, the respective process category and the production principle implemented are the main factors. Requirements are placed on the four production control tasks for each attribute of a criterion. These can be grouped together in one requirements profile which depends on the characteristics of the area under consideration.

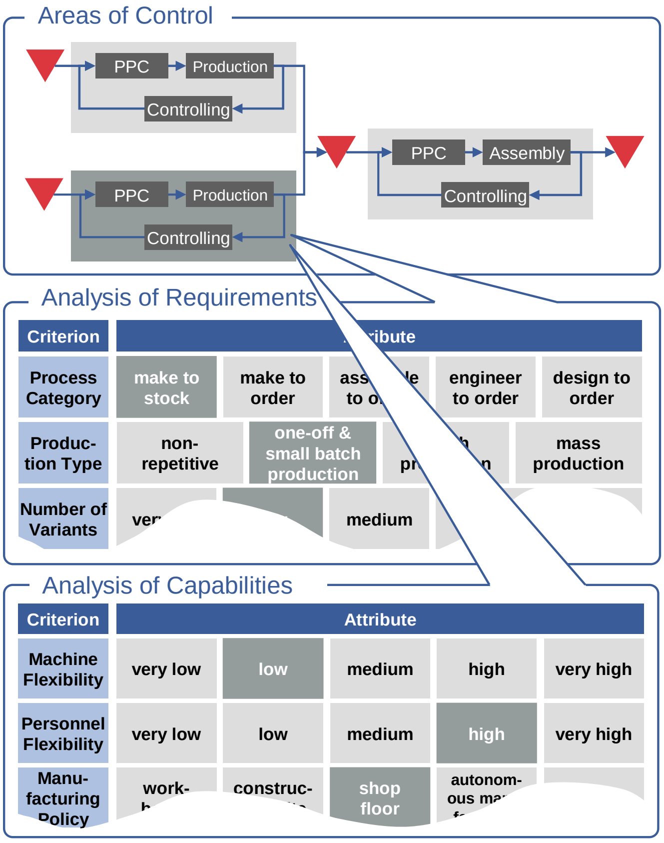

Fig. 5: Systematic analysis of requirements and capabilities

The capabilities of a certain area of the production control are investigated at the same time as determining the requirements placed on the area. Such capabilities include, for example, short- and medium-term personnel and machine flexibilities and the options for outsourcing orders or individual operations. In addition, the granularity and quality of the master and transaction data available plus the work schedules and the possibility of forecasting future demand are decisive for the later choice of suitable methods.

"Soft" factors such as the qualifications and motivation of personnel should not be ignored because different demands are placed on these depending on the method chosen [18].

C. *Choosing a Method*

Once the control areas have been established and the corresponding requirements and capabilities analyzed, it is necessary to choose a suitable method for the four production control tasks and their link with a total system.

A catalog provides profiles for methods known and acknowledged in practice; it contains criteria such as the prerequisites necessary, the main target variables supported, strengths and weaknesses. Using the example of the Kanban order generation method, the following list represents an extract from the catalog:

- *Prerequisites:*
  made-to-stock, controlled processes, short throughput times, high and generally constant demand rate, limited number of variants to be produced
- *Target variables supported:*
  high delivery capacity, limiting the batch and minimum stock levels
- *Strengths:*
  simplicity, transparency
- *Weaknesses:*
  high WIP costs for a high number of variants, low customization options, possibly high WIP fluctuations in production

The requirements and capabilities determined for an area to be configured are compared with the catalog contents in order to identify suitable methods (Fig. 6).

To do this, the known production control methods are assessed with respect to each criterion attribute of the targets, capabilities and requirements using a scale from 0 to 4 points, where "0" is to be understood as disqualification.

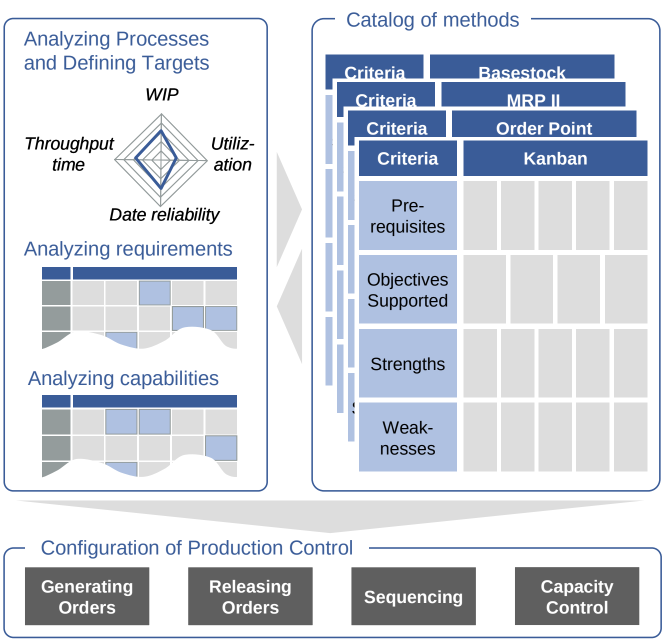

Fig. 6: Consistent selection of suitable methods

A tool based on Microsoft Excel determines the maximum number of points a method can achieve corresponding to the given criteria and the attribute selected and outputs the methods that attract a high relative number of points.

Afterwards it is necessary to check various combination options for their compatibility and consistent target alignment within the scope of these prioritized methods. For example, combining a WIP-regulating order release method with a due date-oriented sequencing rule might seem to be a good choice. In that case although changes to the sequence would be carried out upon order release, with the aim of reducing WIP, the date reliability would not be ignored in this situation because of the sequencing rule then applied. At the same time, however, due date-oriented sequencing rules, which prioritize the orders according to their planned start or finish dates at the work systems, require operations-related scheduling during order generation. But mapping these relationships and considerations automatically by way of appropriate algorithms appears less sensible in the opinion of the authors because the decisions to be made would be very complex and in the end the result less comprehensible to the user. On this detailed level of production control configuration the user is required to combine and arrange the methods that have been determined in advance and are suitable in principle. The morphological boxes with the requirements and capabilities criteria, the production control method profiles and the evaluation logic of the Excel tool are useful in helping to limit the configuration options. As a further help, action guidelines and method characteristics are provided in written and graphic form.

IV. The Application in Practice

The production control at an automotive supplier was reconfigured with the help of the approach described above within the scope of a project carried out by the IFA together with a business consultant; this improved the plant's attainment of its logistical targets.

In accordance with section 3, first of all the production process was analyzed and the logistical targets defined for an area selected beforehand. The logistical targets for the area were determined by key persons from various departments in a target definition workshop. Reducing the WIP was formulated as a target in addition to improving the date reliability.

These targets and further boundary conditions led to the derivation of the requirements that a reconfigured production control had to satisfy. The production in the plant was characterized by a high number of variants (approx. 3000), which were manufactured to customer specification as one-offs or in small batches on about 120 work systems using the shop floor principle. Hitherto, the high demands placed on date reliability had been met by large stocks of finished products. These stocks were to be essentially eliminated by the new target stipulations. An analysis of the capabilities of the area investigated revealed, above all, the high quality of the master and transaction data and the high flexibility of the personnel and machine capacities, which, however, owing to customer requirements were offset by a very low workload flexibility.

Once the analysis of requirements and capabilities was finished, it was necessary to choose a method for the production control and adapt it to the specific boundary conditions. Fig. 7 shows the result of the configuration. Essentially, there were two factors that influenced the configuration of the order generation. The automotive supplier was provided with accurate demand information in good time because the customer orders were fixed up to a year in advance. However, the workload flexibility was extremely low because the automotive supplier was supplying directly to the customer's assembly lines without any intermediate storage. Therefore, in the reconfiguration of the order generation, operations-related schedule and capacity planning, with the steps *throughput scheduling*, *capacity demand calculation* and *capacity alignment*, was proposed, which follows the classical MRP logic.

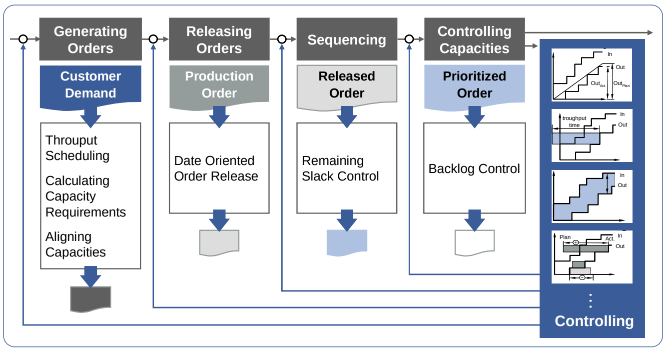

Fig. 7: Example of the application for an automotive supplier

Fixed delivery dates was another main factor influencing the order release. For this reason, systematic order release according to the planned start date was recommended. This sends the orders to production upon reaching the start dates without checking with respect to workload and/or capacity. The main factor influencing the choice of a sequencing rule was the demand for a high date reliability. Therefore, remaining slack control was chosen, a method that prioritizes the orders in production according to the length of their remaining transit times, the remaining slack. This achieves a systematic orientation of the sequencing to match the operations schedule. The basis for selecting the method was the granularity and high quality of the data, which allowed a reliable calculation of the planned throughput and execution times per operation.

One criterion for the configuration of the capacity control was the anticipated cost of execution. Therefore, the introduction of backlog control was proposed. This guarantees the required adherence to the timetable with a simple method at every work system.

In order to ensure the successful operation of this revised production control configuration, it was necessary to implement controlling with real-time capability. This enabled a closed control loop (see Fig. 7) to be set up with which it is possible to respond to deviations between plan and actual values quickly and in line with the targets by changing the control variables.

V. Checking the Attainment of Targets

A (re)configured production control should achieve the targets agreed beforehand as fully as possible. However, the quality of the result cannot always be traced back to the actual choice of method and parameters. In the end, capabilities arising from the process and the production environment, requirements due to the boundary conditions and the production structure itself represent degrees of freedom for the configuration and limit the possibilities accordingly.

If the production control concept selected does not fully achieve the targets, various amendments are possible (see Fig. 8), which the newly developed tool supports by way of a transparent and consistent preselection. The first of these is to recheck and, if necessary, adapt the production control method selected and its parameters. However, this will only bring about improvements when not all aspects were given sufficient consideration in the first place.

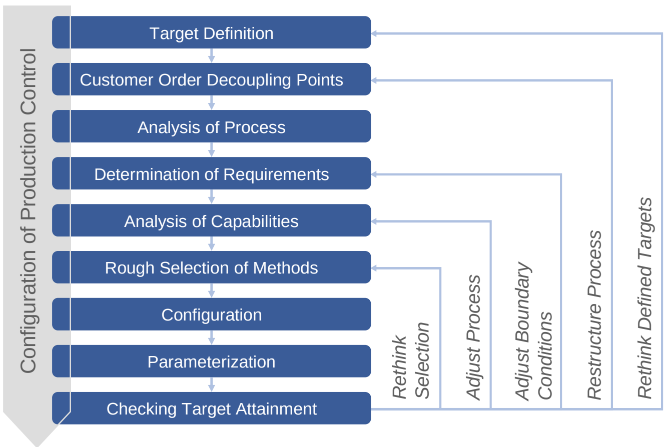

Fig. 8: Checking the attainment of targets and adapting the influencing variables if necessary

Otherwise, improving the attainment of targets presumes adapting the capabilities provided by the production (e.g. increasing capacity flexibility) or the existing boundary conditions due to the corporate environment, the market and other influencing factors. The latter would be possible if, for example, the number of variants could be reduced.

If these measures do not release any further potential with respect to the attainment of targets, the process structure, characterized by the customer order decoupling points, should be revised before the definition of targets is questioned critically and, if necessary, is adjusted downwards.

VI. Summary and Outlook

Companies with a high attainment of logistical targets are more successful than their competitors who are slower, less punctual and have a high WIP. Production control can take on a key role in this context. With the right configuration, production control is in the position of being able to exert a considerable positive influence on the logistical target variables. A manufacturing company therefore needs to support the various tasks of production control with suitable methods, taking into account their interactions. A new approach to the planning of production control, a process known as configuration, enables a holistic design. The main steps here are the identification of control areas and their logistical goals, the analysis of requirements and capabilities in these areas, and the systematic selection and functional combination of suitable methods. This can be decisively supported by a newly developed tool that provides the user with case-specific suitable methods and numerous data about these. An example of a project undertaken in the automotive industry shows a successful application.

In order to do justice to the dynamic displacement of the logistical targets in production areas, transferring the mostly static production control to a dynamic production control is to be recommended. To do this, however, a close intermeshing of methods of production control and approaches from control engineering is necessary.

References

[1] K. K. B. Hon, “Performance and Evaluation of Manufacturing Systems”, *Annals of the CIRP*, vol. 54, no. 2, 2005, pp. 675-690.
[2] E. Gutenberg, *Grundlagen der Betriebswirtschaftslehre. Band 1: Die Produktion*. Vol. 1, Berlin: Springer-Verlag, 1951.
[3] P. Nyhuis and H.-P. Wiendahl, *Fundamentals of production logistics : theory, tools and applications*. Berlin: Springer-Verlag, 2008.
[4] H. Lödding, *Verfahren der Fertigungssteuerung. Grundlagen, Beschreibung, Konfiguration*. 2 ed., Berlin: Springer-Verlag, 2008.
[5] H.-P. Wiendahl, *Betriebsorganisation für Ingenieure*. 5 ed., Munich: Hanser-Verlag, 2005.
[6] T.-E. Vollmann, W.-L. Berry, and D. C. Whybark, *Manufacturing Planning and Control Systems*. Vol. 3, Burr Ridge: Irwin, 1992.
[7] J. Orlicky, *Material Requirements Plannung: The New Way of Life in Production and Inventory Management*. New York: McGrwa-Hill, 1975.
[8] T. Ohno, *Toyota Production System: Beyound Large Scale Production*. Cambridge: Productivity Press, 1988.
[9] H. Hirano and M. Furuya, *JIT is flow: practice and principles of lean manufacturing*. Vancouver, WA: PCS Press, 2006.
[10] E. A. Silver, D. F. Pyke, and R. Peterson, *Inventory Management and Production Planning and Scheduling*. New York: John Wiley & Sons, 1998.
[11] J. E. Kimball, “General Principles of Inventory Control,” *International Journal of Manufacturing and Operations Management*, 1988, 1(1): pp. 119-130.
[12] W. J. Hopp and M. L. Spearman, *Factory Physics*. Vol. 2, Chicago: Irwin/McGraw-Hill, 2000.
[13] M. L. Spearman, W. J. Hopp, and D. L. Woodruff, “A Hierachical Control Architecture for Constant Work in Process Production Systems,” *Journal of Manufacturing and Operations Management*, 1989, 2: pp. 147-171.
[14] T. M. Chang, and Y. Yih, “Generic Kanban Systems for Dynamic Environments,” *International Journal of Production Research*, 1994, 32: pp. 889-902.
[15] H.-P. Wiendahl, *Load-Oriented Manufacturing Control*. Berlin: Springer-Verlag, 1995.
[16] R. W. Conway, W. L. Maxwell, and L. W. Miller, *Theory of Scheduling*, Massachusetts: Addison-Wesley Publishing Company, 1967.
[17] C. Begemann, *Terminorientierte Kapazitätssteuerung in der Fertigung*. Hanover: University of Hanover, 2005.
[18] H.-H. Wiendahl and S. Behringer, „Stolpersteine der Lieferterminermittlung und -erfüllung, in Liefertreue im Maschinen- und Anlagenbau: Stand - Potenziale – Trends,“ *G. Schuh and E. Westkämper, Editors*. 2006, pp. 19-32.