Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management
Bali, Indonesia, January 7 – 9, 2014

Improving Decision Making within Production Control

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Abstract

Companies are facing more and more the challenge to achieve a high production logistic performance in order to stay competitive. The task of production control is to ensure high adherence to delivery dates, short throughput times and low costs by using adequate control principles. Production control is in general characterized by many decisions which have to be made in order to achieve a good production control performance. Wrong decisions about order release and prioritization, however, lead to poor logistic performance. In order to achieve short throughput times and therefore a high adherence to delivery dates, employees of production control for example tend to change orders' priorities very often which leads to big internal turbulences within production and to a high spread of throughput times. The aim of this paper is to develop decisions guidelines in order to improve employees decisions within production control to achieve better logistic performance.

Keywords
Production Control, Logistic Targets, Decision Making

1. Introduction

In last decades, the challenges of production control is characterized by individual customer requirements and short delivery times. Especially the short delivery times are getting to a decisions criteria for customers (Schuh, Stich 2011). To respond to the individual customer requirements and short delivery times, product life cycles are getting shorter and at the same time the range of product variants increases. Within the machine and plant construction branch for example, the delivery times decreased by nearly 50% in past years. This influences the order fulfilment process drastically and requires flexible capacities of manufacturers (Wiendahl, Behringer, 2006).

Despite of dynamic influences, the task of production control is to realise the best possible achievement of logistic targets (Schuh et al. 2011). The logistic targets consists of short throughput times, short delivery times, low inventory and low costs. The production control determines the way of order release, order prioritization and capacity planning. Production control is therefore a central lever to obtain a high adherence to logistic targets. Since the importance of meeting logistic targets is obvious and undisputed, the way how to meet these logistic targets is more of an issue (Münzberg, Nyhuis 2009)

2. Motivation

This paper addresses the problems of production control configuration, which are explained in the following.

In many companies, there is a transparency lack of understanding how production control principles work. Employees do often not understand the logistic interdependencies and it is not really possible to anticipate which consequences occur when using a certain control principle (Wiendahl, Behringer 2006). Besides, the variety of production control principles rather confuses employees since it leads to a selection problem with high probability of taking the wrong control decisions (Schuh et al. 2010). Another reason for complex control situations of employees is an increasing work load: while employees were in the past only responsible for single machine operation, today their tasks expanded by carrying out quality tests for products, too (Bullinger 2003).

The result of the task expansion is a worsening of understanding of particular processes. As a consequence, many not incomprehensible decisions are made within production which leads to a poor production performance. The installation of understandable and easy rules, however, leads to better performance: in a case study by the Laboratory for Machine Tools and Production Engineering (WZL) of Aachen University, the realization of a simple first-in-first-out prioritization of orders turned out to achieve better results than the prioritization by complicated algorithms (Schuh et al. 2011a).

During the past decades, various IT Tools were developed such as Supply Chain Management (SCM), Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (Milberg, Neise 2006). Main function of these is the support of employees' decisions within the field of production control. However, it turns out that these IT solutions are not sufficient for many users as essential constraints are disregarded. The neglect of organizational structure and of the need of high data quality is a reason for this dissatisfaction. An additional reason arises from the intransparent control logic within the systems which causes mistrust of the employees on the shop floor. Consequently, employees rather determine their own production plans assuming that due dates of orders can be saved by this and do not trust in the correctness of the new order priorities calculated by the system on daily basis.

Furthermore, the objectives between production and employees are often not coordinated and thus, inconsistent. For example, whereas the production management focusses on its logistic target, namely the good adherence to delivery dates, employees on the shop floor attempt to stabilize the capacity utilization of their machine on a high level. Performance-related payment systems strengthen the inconsistency between the objectives. This can have a negative effect on the introduction of a new system: for example, a company failed to introduce a Kanban-system since the employees' habits and methods of payment were not compatible with the idea of Kanban (Wiendahl 2008).

The performance of production control is also influenced by organizational effects like the cooperation and communication between employees. Proactive and failure-avoiding actions are based on organizational forms that favor self-reliance and a sense of responsibility. Besides this, the possibility for employees to contribute their experience and knowledge to the production process supports innovative ideas and continual improvement (Beck et al. 1996). Since there is the need of many decisions within production control based on production information and communication, the communication with other departments and the use of external knowledge according to the production system plays an important role for employees of this field. An industry project of WZL revealed in cooperation with a machine manufacturer that a decision had to be made for almost any fulfillment of tasks. Typical tasks were changing order plans, capacity plans, order release or material scheduling.

3. State of the Art

According to Lödding, the configuration of production control requires a structure of the scope of duties. In the following, the four tasks introduced by Lödding and existing approaches for configuration are elaborated. Further, research deficits are clarified.

3.1 Task of production control

As can be seen in Fig. 1, order generation, order release, sequencing and capacity control are the four tasks of production control (Lödding, 2012).

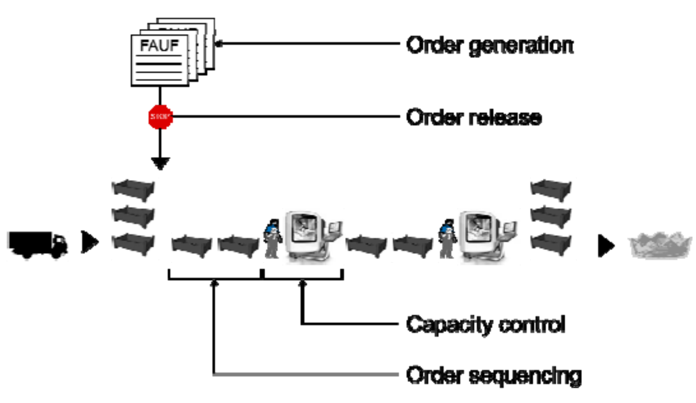

Fig. 1: Four tasks of production control

To commence the order fulfillment process, an order has to be generated and hence order generation is the initial step. By doing so, the lot size is determined by order generation and as a consequence, work in process (WIP) level and scattering of throughput are also affected. This impact of order generation was shown by an industry project of

WZL: Throughput times were reduced up to 20% caused by halving the top 5% of the greatest lot sizes. Different order generation principles can be selected based on customer order, predicting or inventory levels.

Subsequently, the production of an order is started by order release. The setting of the starting point influences the WIP level and thus capacity utilization and throughput times. Although limiting of WIP is seen as an essential part of production control by many scientists like Lödding, Goldratt, Spearman, most of the existing IT Systems still neglect WIP limitation (Münzberg, Nyuis 2008; Lödding 2012; Goldratt 1990; Hopp, Spearmann 2008).

The order sequencing determines the sequence of the production orders waiting for the next step of procedure in front of a machine. Logistic objectives like throughput time and adherence to delivery dates are affected by sequencing. In order to meet the logistic targets, often complex algorithms within IT Tools are used. However, a simpler method of sequencing like first-in-first-out can support the stabilization of the production and improves understanding of the employees (Schuh et al. 2011).

Further, capacity control is needed for a proper occupancy of machines and allocation of employees. This task of production control has an impact on productivity and production costs. On the one hand bottlenecks should be expanded if needed, on the other hand more flexibility through separation of the machine-operator-assignment should be gained.

3.2 Current approaches for configuration of production control

Approaches for configuration of production control have been developed and debated for decades. The discussion of logistic target interdependencies and targeting of production control led to the formulation of Little's Law and the funnel formula by Kettner and Bechte (Little 1981, Bechte 1984). For the first time, the values production inventory, production capacity and lead times of orders were linked. In funnel formula, Kettner and Bechte underline that every element of the process requiring capacity can be characterized by material input, WIP and material output. Thereby, many principles of order release were developed considering that the control of throughput times can be reached by limiting WIP.

Feedback as a basic principle of controlling production was utilized by H.-P. Wiendahl by reducing the differences between production plan and real production output. By comparing the plan- and as-is-values, the outcome of this comparison influences the choice of appropriate measures (Wiendahl, Nyhuis 2009). By doing so, the approach of H.-P. Wiendahl can be used in order to react faster to upcoming disturbances.

In order to define the correlation between the logistic targets mathematically, Logistic Operating Curves were established by H.-P. Wiendahl and Nyhuis (Wiendahl, Nyhuis 2009). Basis for further modifications of a production system is the current operating point which can be calculated with the help of Logistic Operating Curves. Thus, an adequate level of WIP can be defined and the systematic determination of process parameters is simplified.

Other scientists like Lödding and H.-H. Wiendahl also developed approaches for the configuration of production control. Whereas Lödding focusses on the structure of four tasks of the production control within his approach, H.-H. Wiendahl configured the production control itself. This configuration procedure commences with the determination of design and methodology aspects followed by the setting of derived method. In further researches by H.-H. Wiendahl, the order fulfillment process is introduced. This approach stresses the significance of socio-emotional aspects such as the organizational structure. Although socio-emotional aspects are considered, the scheme rather relates these aspects to the introduction of an order fulfillment process than to the operative production control.

A further approach is the three layer model of value stream oriented production control developed by Schuh. Referring to the approach of Lödding, Schuh's layer model contains value stream, production control and master data management. In consideration of finding segments with equal production processes, the approach aims to simplifies production control by smaller control segments within production (Schuh et al. 2010).

In addition to the mentioned approaches, simulation is an efficient and easy tool in order to test different production control strategies (Schuh et al. 2010, Baumann, Dimitrov 2011). Due to the possibility of simulating various scenarios without affecting the business activities it supports the configuration of production control.

3.1 Research deficit

Although many approaches exist, the sufficient configuration of production control still causes numerous difficulties for companies. The problem settings reveal that deterministic control rules alone are not satisfactory for this configuration since many problems are caused by misunderstandings, overload of alternatives and a lack of communication. Despite the great number of configuration approaches, almost none of these considers the socio-technical influences. Furthermore, the work and decision situation of a production controller is neglected within existing approaches. Hence, the efficient design of task setting of a production controller has to be investigated to ensure that he has the chance of making right decisions.

4. Approach for Configuration of Production Control

The new approach to configure production control faces the described research deficit. In production control different decision need to be made. Thereby, the decisions can be assigned to three hierarchical levels. The highest level is the so called production controller. The production controller creates orders, chooses orders for job release, prioritizes them and adjusts capacities in production. In addition, the production controller determines the production starts of orders, checks the progress towards completion and communicates with production foremen about needed capacities. The production foreman constitutes the second level in production control. Here the responsibility for selection of orders for production sections, prioritizing of orders and adjustment of load with capacities is placed. The machine operator can only influence, for instance, the order prioritization and composes thus the third level of production control. As shown, there are a huge number and diversity of decisions in production control. In the following, requirements to ease the decision-making process are introduced so that the probability of wrong control decisions can be reduced.

4.1 Requirements for good decisions within production control

A decision can be structured by three issues:

- What do I want (aims)
- What can I do (action alternatives)
- What can happen (consequences)

The decision situations will be discussed below according to these three key questions to ultimately derive design recommendations.

For a high achievement of objectives, the employee’s goals and the company’s goals need a high conformity. In case of low goal conformity the employee does not decide in the company’s interests. In the space of production that causes a poor performance related to the logistic goals. For example if the company defines short throughput times as its most important logistic goal but the machine operator tries to use the machine to full capacity, the company’s logistic goal is imperiled. That implies that the higher the conformity of logistic goals between employee and company, the better the quality of decision-making. There are a few determining factors influencing goal conformity in production control. First of all the company needs to ensure the employee’s knowledge of logistic goals. Just with this knowledge it is possible for employees to make constructive decisions. Also the form of organization influences the goal conformity. Thereby process-orientated forms often achieves higher goal conformity than a function-orientated forms, because of accurate defined process owners and thus better communication. In addition the incentive system of monetary and nonmonetary benefits affects the goal conformity. Monetary benefits for instance can be a goal-oriented wage which increases if logistic goals are achieved over a fixed period. Nonmonetary benefits are job securities, advanced trainings and awards for special achievements.

The number of possible options also influences the quality of decision-making. If there are only a few alternatives the probability to achieve the best solution for the system with one of the given alternatives is low. Up to a certain point an increasing number of alternatives gain the probability of a best-solution-alternative. In this connection it needs to be ensured that the number of alternatives is bounded so that there is no overload of choice for the employee. Humans tend to choose worse if there are too many possibilities. Thereby the quantity of alternatives correlates with the expenditure of time needed to make a decision. To derive a design recommendation for production control principles, the number of orders in front of a machine and the time to identify the adequate next order are taken into account. Thereby the relation between these two factors differs according to the sequencing rules (see Figure 2).

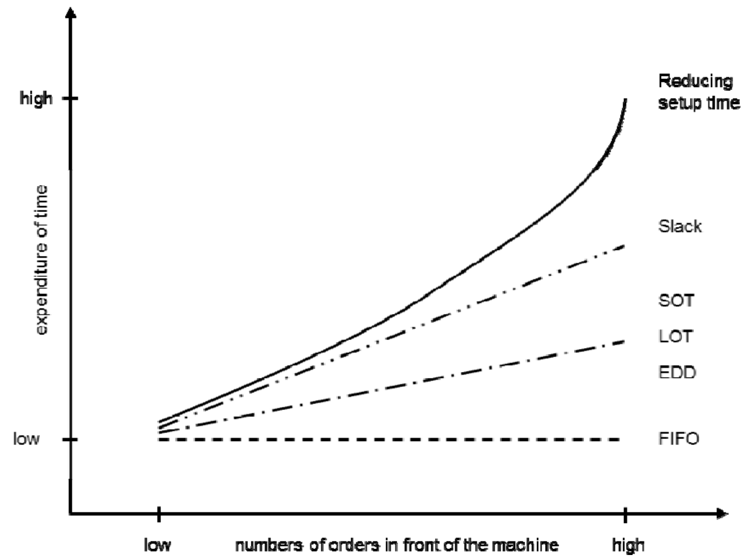

Figure 2: Connection between numbers of orders and expenditure of time choosing the follow-up order

The sequencing rule first-in-first-out (FIFO) does not have any connection between the number of orders in front of the machine and the expenditure choosing the right follow-up order. The machine operator only takes the order which is in front of the FIFO lines. The order sequencing earliest due date (EDD), longest operation time (LOT) and shortest operation time (SOT) combine the number of orders and the expenditure in a linear way. To choose the right follow-up order in this case, it is necessary to compare one value each order: For EDD the earliest due date value and for LOT as well as for SOT the operation time. The sequencing rule Slack also builds up a linear connection. The slope of this straight line is twice as high as for the mentioned sequencing rules before, because the employee needs to compare two values each order to figure out the follow-up order. The sequencing rule according to reduce setup times delivers an exponential course. Since the machine operator needs to check every order about the necessary tool for production, abstract orders with the same tool for production and afterwards compare the number of orders for each tool. So the expenditure gets higher above average the higher the numbers of orders in front of the machine.

As mentioned before, the quality of decision-making has a close connection to the expenditure of time. Thus the sequencing rules can be associated with the quality of the made decision (see Figure 3). The more calculation parameter are given within a sequencing rule, the lower the decision quality.

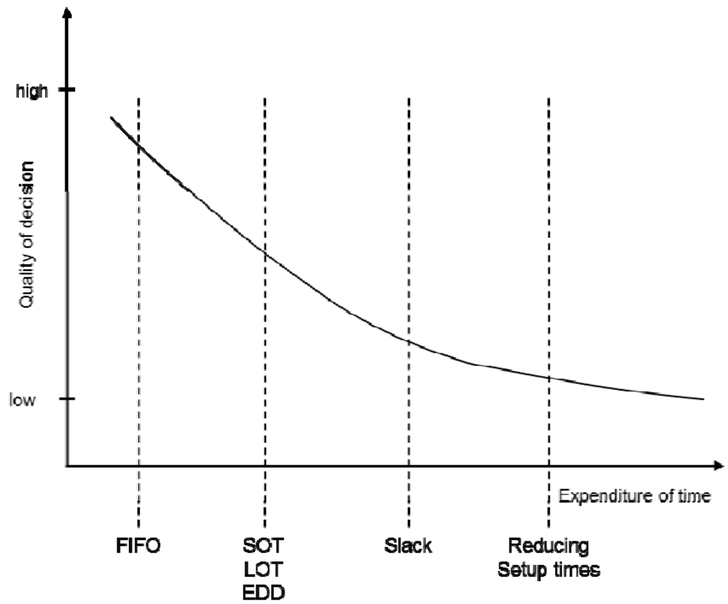

Figure 3: Quality of decision making regarding expenditure of decision time

The decision quality in figure 3 can be understood as a probability for the compliance of the giving sequencing rule. It considers the feasibility of the different sequencing rules for the machine operator in order to reduce the no added value interactions in production. In general, a minimum numbers of orders in front of the machine is required for good efficiency.

Further it is important to know about the consequences of the decisions. In order to know the consequences, employees need an overview of the whole production system, the interactions of production processes and so on. The machine operator, however, has no chance to appraise the effect of sequencing changes for instance for following machines in the material flow. Therefore, decision on the machine operator level are always decisions under risk. It implies for decision-making in production control, that only the production foreman or the production controller is able to make decisions focusing on the achievement of objectives in logistic goals.

4.2 Design of decision making within production control

The requirements for high quality decision-making (see Figure 4) lead to improved logistic goals like low throughput times, high adherence to delivery dates, high efficiency of the machines and low stock.

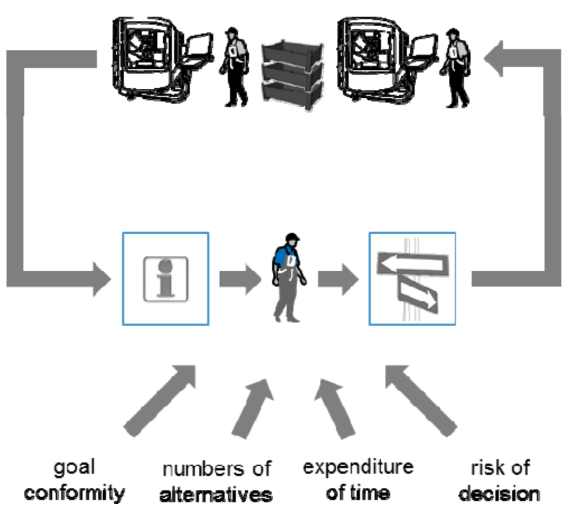

Figure 4: Requirements for high quality decision-making in production control

Employee's decisions are within the focus of the in figure 4 displayed loop: his decisions influence the performance on shopfloor. The decision quality is determined by four aspects: goal conformity, number of alternatives, expenditure of time and the risk of decision. Considering production controler's tasks, the quality of decisions can be influenced for example by the WIP level, the prioritization rule and the given information:

- The higher WIP level within production, the more possible options are given for machine operator when choosing the follow up order
- The easier the prioritization rule, measured by amount of relevant operation values, the higher the probability to make failures.
- The better the information basis meaning meeting the employee's requirements, the lower the decision risk.

5. Implementation within the Manufacturing Industry

The introduced decision guidelines for production control have been already implemented to several industry projects. One typical project is described in the following.

A company with job shop manufacturing and around 150 machines had problems with adherence to delivery dates. This was mainly caused by high scattering throughput times. When making detailed process analysis, it turned out that many machine operators optimized their own work space by changing order sequencing all the time. By making use of the introduced guidelines a new order release and sequencing concept was installed. First, the order release was affected by limiting the WIP. To define a proper level of WIP, the focus was on the order queue in front of the bottleneck machines. Secondly, the freedom of choice for the follow up order was replaced by a strict FIFO rule in order to stabilise throughput times. Thirdly, an information board with upcoming workload was installed in order to show the work burden for the next days. The result of this rearrangements are displayed in figure 5.

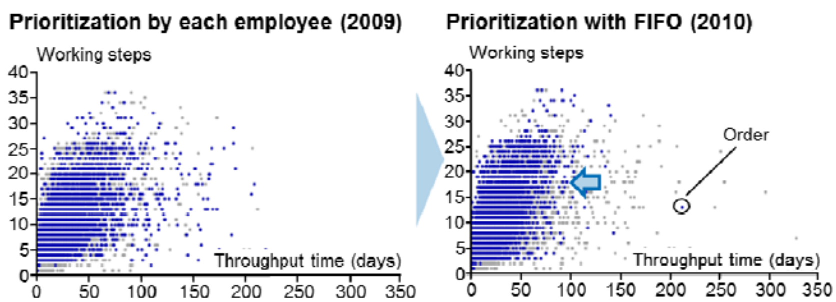

Figure 5: Development of throughput times after rearrangement of production control

As can be seen in the figure, the scattering of throughput times decreased drastically. As a result, the average throughput times could be reduced by 25%. The implementation of the design recommendations for decision-making in production control ensures a creation of stable production processes. The employee's work gets simplified and simultaneously the susceptibility to trouble decreases.

6. Summary

This paper introduces an approach to design employee's decision making process within production control. This is necessary since production control is characterized by many decisions which are made on different hierarchical levels. Therefore, not only technical influences have to be considered when configuring production control, but also social aspects like the decision process. Within this paper, four main aspects of employee's decision making process have been identified: the goal conformity, the number of alternatives (or within production orders), the expenditure of time to identify the next order and the knowledge about the consequences. For each aspect, decision guidelines have been developed which helps production controller to find a suitable configuration of production control. Thus, this approach represents a new perspective of production control's configuration process with a high relevance for practice. Further research is needed, however, to quantify the mentioned aspects in regarding their quantitative impact on production control.

Acknowledgements

The new approach of improving decision making within production control is being investigated by the Laboratory of Machine Tools and Production Engineering (WZL) within the publicly funded research and development project: "Cluster of Excellence - Integrative Production Technology for High Wage Countries" (German Research Foundation, DFG).

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Biography

Günther Schuh studied mechanical engineering and economics at the RWTH Aachen from 1978 until 1985. He received his doctorate in 1988 following his research fellowship at the WZL, where he was also head engineer until 1990, under Professor Eversheim. He lectured manufacturing economics and industrial management at the University of St. Gallen (HSG) from 1990 until becoming Professor for Economic Production Management and co-director of the Institute for Technology Management in 1993. Professor Schuh succeeded Professor Eversheim in September 2002 as Chair of Production Systems at the RWTH Aachen and as co-director of the WZL and the Fraunhofer IPT in Aachen. His most important research work includes various methods and instruments related to complexity management, resource-oriented process cost calculations, participative change management and the virtual factory concept. Professor Schuh is also a member of several boards of directors and councils.

Till Potente is currently chief engineer at WZL. He studied mechanical engineering at the RWTH Aachen University in the field of manufacturing engineering. Since 2006 he is a research associate at the Chair of Production Engineering (WZL) of the RWTH Aachen. His work focuses on the development of new planning and control concepts for internal logistics. Since November 2008, he took over the management of the group production logistics. Since January 2011, Mr. Potente is chief engineer for the Department of Production Management.

Christina Thomas studied industrial engineering mechanical engineering at the RWTH Aachen University and industrial engineering at Tsinghua University in Beijing. Since 2010 she has been working as a research assistant at the Chair of Production Engineering (WZL), RWTH Aachen, of Prof. Schuh and since 2012 she leads the research group of production logistics at WZL. Her current work focuses the field of production planning and control as well as in the design of internal logistics processes.

Paul Zeller is currently a research student at the Chair of Production Engineering (WZL). He studies mechanical engineering with focus of manufacturing process at the RWTH Aachen university. His current work focuses on production control and internal production logistic processes.