Self-optimizing Production Program Planning for Product Ramp-ups

A. Günther Schuh¹, and B. Maik Schürmeyer¹

¹Institute for Industrial Management (FIR), RWTH Aachen, Germany

Abstract - Because of decreasing product life cycles and increasing product diversity, producing companies are confronted with a growing number of product ramp-ups. The associated high effort in the production planning and control (PPC) for ramp-up products can only insufficiently be reduced using existing planning algorithms, because of a lack of reliable historical information. This problem is highly significant for the production program planning (PPP): as the first step of PPC, its lack of information is exceptionally high. The goal of current research activities is to establish a concept for reliable and fast PPP for companies with numerous ramp-ups. To reach this goal, a model for a cybernetic PPP is currently developed. For this interdisciplinary and cybernetic design of the PPP, the Viable System Model (VSM) is used as frame of reference. It enables a transparent and efficient handling of highly complex and interdisciplinary structures, processes and information flow.

Keywords: Information Management, Cybernetics, Production Planning and Control

1 Introduction

The last decades showed a clearly trend to rising product variety as well as to steadily decreasing product life cycles [1, 2, 3]. This results in a drastic increase of production ramp-ups.

According to WACK, the average number of ramp-ups at car manufacturer Mercedes-Benz Cars has increased more than three times a year for the last two decades [4]. A study, in which 225 ramp-up situations of 100 car manufacturers and suppliers were inspected, showed that the serial production ramp-up is still burdened with major problems. In 33% of cases the economic goal could not be achieved and in 50% of them the technical goal was missing [5, 6].

1.1 Production Planning and Control

One of the reasons behind the poor performance in ramp-up projects are the problems in production planning and controlling (PPC). The PPC for ramp-up products are particularly challenging, because the information needed for planning (e.g. product structure, sales projection etc.) is either missing or is not of sufficient quality in terms of actuality, accurateness or granularity.

---

Figure 1: PPC process for make-to-stock production [8]
Reasons for this are the dynamic environment changes on the one hand and changes in the production process in this phase of product life cycle on the other hand. Furthermore, the underlying target system and other restrictions of PPC in serial production can vary from those in stable serial production. For example, the ramp-up restrictions could be the uncertain effectiveness of resources, the limited purchasing volume or the quality of externally procured greige [7].

1.2 Production Program Planning

The production program planning (PPP) is the initial step of PPC, see Figure 1 [8]. Therefore, PPP plays a specific role for the entire PPC process. STICH emphasizes this particular role of PPP as follows: “The different conditions in the ramp-up phase compared to serial production are exceptionally affecting the production program planning.” [7]

Since PPP as the initial step of PPC does not have any input information from preceding PPC-processes, there is a higher lack of information compared to other PPC-processes. The following list shows the potential information deficit in PPP regarding the information availability and quality (actuality, correctness, and granularity).

- Sales history, composition of product characteristics
- Evaluation of forecasting method and its parameterization
- Practical inquiry and orders, reserved in- and outflows, internal demands
- Capacity and error rates of resources (personnel, assets, utilities)
- Bill of Material, work plans, different cost rates

These information deficits can have a negative impact on the quality of the production program. Possible effects of insufficient information availability or quality are:

- Faultiness of production program
- Late completion of the production program
- Limitation of production program to predictable products

According to the law of error propagation, these faults, delays and limitations may partially increase in the following steps of the PPC process [9]. As a result of planning insecurity and error propagation, the PPC is confronted with several risks:

- Overproduction or underproduction
- Loss of market shares by unmet customer requirements
- Faulty purchase quantity in general agreement with suppliers

These risks may involve a concrete financial loss. Overproduction affects the capital commitment costs, obsolescence expenses and inventory costs. In case of underproduction, the opportunity costs for unused production resources occur. Loss of market shares can lead to loss in revenue. Too high purchase quantity in general agreement with suppliers may lead to high carrying costs for capital commitment, obsolescence and warehousing. Too low purchase quantity leads to production downtimes and therefore to possible contract penalties.

To suppress the low quality of planning, particularly the high-wage countries are incorporating extremely sophisticated and time-demanding planning methods [10]. Higher planning complexity induces not only higher personnel costs but also brings about the risk of time setback. Especially in the case of a new product, the “time-to-market” can influence the success of an innovation. These conflicting goals are the first main problem of PPP at ramp-ups and will be depicted as “Dichotomy Stability vs. Speed”.

It is possible to reduce the “Dichotomy Stability vs. Speed” by limiting the production program. With such a limitation of production and vending amount of goods, the planning quality can be improved by specialization and its accompanied economies of scale. However, if the production program is kept low because of planning, it may be that certain customer requirements cannot be met which in turn may influence the company’s success negatively. This conflicting goal is the second main problem of PPP in ramp-up situations and it will be depicted as “Dichotomy Scale vs. Scope”. In the following, both of these goal conflicts will be depicted as the “Polylemma of Production Program Planning at Product Ramp-ups”, see Figure 2.
2 Objective

The objective of this research is to develop a methodology to reduce the “Polylemma of Production Program Planning at Product Ramp-ups”, which consists of the following dichotomized dimensions:

- Stability: High planning quality should warrant a stable production program.
- Speed: Low planning complexity should anticipate the product-to-market introduction delays and high personnel costs.
- Scale: With the use of specialization and learning effects, the economies of scale should be used in planning.
- Scope: With a strong focus on customer needs, the diversification effects should be used.

To achieve this goal, a model that allows a self-optimizing PPP is being developed. In order for PPP to be self-optimizing, it must be able to learn from earlier planning cycles. It also has to be able to automatically recognize and compensate inner and outer faults. To be able to do so, high resolution information must be available in adequate granularity, correctness and actuality; for fault compensation, the system must be able to adapt itself to the new circumstances without much effort.

Since cybernetics fulfills these requirements completely, it will be used as the main principle for the creation of the self-optimizing PPP. The model “Cybernetic Management of Versatile Production Systems” by BROSZE investigates cybernetic forms of production systems intensively. It serves as the reference model for this research [11].

3 Conceptual approach

The conceptual approach is split into three solution segments

- Information demand analysis
- Sensitivity analysis for evaluation of information criticality
- Creation and design of a VSM-based cybernetic PPP

3.1 Information demand analysis

The aim of the information demand analysis is a detailed display of information-flow in the conventional PPP. For this purpose the main tasks of intermediate PPP are identified and broken down into several planning processes. For every identified step of the process, methods, formulas and algorithms needed for the solution will be composed. Based on these methods, formulas and algorithms, the needed (input-) information and the generated (output-) information will be passed to PPP and consolidated in the following steps.
The base of this research is the definition of boundaries of PPP system according to system theory. The result is a detailed map of the overall required information in PPP. To avoid unnecessary calculations and to warrant completeness of the information map, the analysis uses the pull-principle: depending on the aspired result (intermediate production program) the process will be backtracked to the predefined boundary of PPP or rather PPC.

The modeling steps are done by means of IDEF-Standard, cf. Figure 4. This systematic approach allows to generate a transparent model with high complexity.

One temporary result is shown in Figure 3. It shows an information map of PPP referring to Aachen PPS-model. Future research results will concentrate to drill down those information flows in terms of granularity. By that means a “high resolution PPP” is to be created.

---

**Figure 4: Modelling of the information flow by means of IDEF-standard [12]**

The base of this research is the definition of boundaries of PPP system according to system theory. The result is a detailed map of the overall required information in PPP. To avoid unnecessary calculations and to warrant completeness of the information map, the analysis uses the pull-principle:

---

**Figure 5: Extended model of PPC-tasks, cf. [11]**

<table>
<thead>
<tr>
<th>normative level</th>
<th>Identity creation</th>
<th>definition of objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>strategic level</td>
<td>monitoring of enviroment and changes</td>
<td>development of production strategy</td>
</tr>
<tr>
<td>tactical level</td>
<td>process monitoring</td>
<td>process configuration and control</td>
</tr>
<tr>
<td>operative level</td>
<td>supply chain sales planning</td>
<td>production program planning</td>
</tr>
<tr>
<td></td>
<td>supply chain requirement planning</td>
<td>production requirement planning</td>
</tr>
<tr>
<td></td>
<td>procurement planning and scheduling</td>
<td>inhouse production planning and scheduling</td>
</tr>
<tr>
<td></td>
<td>data management</td>
<td></td>
</tr>
</tbody>
</table>

---

**Figure 4: Modelling of the information flow by means of IDEF-standard [12]**

The base of this research is the definition of boundaries of PPP system according to system theory. The result is a detailed map of the overall required information in PPP. To avoid unnecessary calculations and to warrant completeness of the information map, the analysis uses the pull-principle:
3.2 Sensivity analysis

The aim of sensitivity analysis is to identify the criticality of the input information. This evaluation is carried out in the following steps:

- Definition of a ramp-up specific target system for PPP
- Construction of a quantitative evaluation scheme for the quality of input information based on the predefined characteristics (availability, correctness, actuality and level of detail).
- Explanation of the correlation between the quality of respective input information and its effects on the target system and derivation of a sensitivity-index for the necessary input information.

3.3 VSM-based cybernetic PPP

Creation and design of a VSM-based cybernetic PPP aims on a PPP as a part of the Cybernetic Management Model for Versatile Production Systems according to BROSZE, see Figure 5 (The highlighted labels affect the resent research activities). For this purpose, the VSM-systems 1 to 5 of PPP and ramp-up management are defined and integrated into the reference model. Additionally, the necessary communication infrastructure comprised of process routing centers, process control centers and process coordination centers is formed. Furthermore, the operational VSM-systems are identified as alternative sources of information and integrated in the existent VSM-structure. The possible information sources are for example the different entities of ramp-up management or a person as an individual part of the entire system. Special attention is turned on creation of knowledge base to warrant interdisciplinary communication and the use of learn effects.

4 Conclusions

The paper in hand describes a way to form a cybernetic production program planning for companies with numerous ramp-ups. The first step describes the complete information flow that warrants a high quality production program in terms of actuality, correctness and granularity. In the second step the sensitivity of necessary input information on the result of the PPP is analyzed in order to evaluate the information criticality. In the third step, the information flow is arranged in such a way that an automatic and qualitative high-grade planning is made possible. Additional information sources for particularly critical information are identified and integrated into the process of planning. By that means the planning quality in ramp-up situations is improved. Furthermore, the information flow is arranged according to principles of cybernetics so that the faults can be compensated in best possible way and learn effects can be used reasonably. The results of the explained research activities can allow the ramp-up intensive companies to create reliable production programs in short time. Learn effects can be used without neglecting diversification. In conjunction with cybernetic arrangement of other parts of production planning and control, the development of cybernetic-operational ERP-systems is strongly pressed ahead.

5 References


