Suggested Alignment Process of the Production Planning and Control (PPC) with Prognostics and Health Management (PHM)

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ABSTRACT

Any manufacturing company’s core function is production planning and control (PPC), which includes activities like capacity control, sequencing, and resource planning. The best production plan becomes more difficult to determine as production becomes more complex, but PHM advancements and the rise of predictive maintenance also present new opportunities to maximise PPC. Despite a large body of research on PHM and PPC, not much has been done to bring the two fields together. Different PPC decisions, like extending production, stopping a machine, or lowering its workload, can be elevated by a remaining useful life (RUL) estimation through post-prognostics decision-making. The purpose of this work is to examine how advanced PPC can result from organisational, technological, and process changes brought about by PHM.

Keywords: Production Planning and Control (PPC), Prognostics and Health Management (PHM), Remaining Useful Life (RUL)

1. INTRODUCTION

Prognostics and health management, or PHM, improves machine availability and reliability while facilitating better maintenance decisions and ultimately lowering costs. PHM can, however, also enhance PPC through information integration, for example, in post-prognostics decision-making; by enhancing the maintenance procedure by implementing smart-assistance systems; or by enhancing the production process by modifying welding parameters via PHM insights. Overall, PHM alignment could be used to improve PPC without the need for new machinery. PHM can offer vital information to modify the production schedule and prevent any and all consequences from arising from a breakdown.

2. LITERATURE REVIEW

The PPC process typically starts with master production scheduling which transforms the sales plan into an aggregate plan for producing products that regards customer orders and order promises from demand management (Jacobs et al., 2011). From the master production schedule, sourcing and production requirements can be derived within requirements planning. Here, net requirements are determined for which a make-or-buy decision is made (Schmidt & Schäfers, 2017). External requirements are forwarded to source planning, where they are procured; for internal requirements, a tactical production program is set up and sent to production planning (Kistner & Steven, 2001). Here, the initial plan is coordinated with available resources (material, machines, personnel), and a schedule is created (International Electrotechnical Commission, 2016). Subsequently, production control defines concrete sequences, dispatches the production, and controls capacities (International Electrotechnical Commission, 2016; Schmidt & Schäfers, 2017).

The Role of Information Systems (IS) are crucial to control the performance of business processes (O’Brien, 2003). They are sociotechnical systems that
"collect, process, store, and distribute information" (Piccoli & Pigni, 2016, p. 56). Through the alignment with PHM, existing IS must be adapted or newly integrated into the PPC process.

### 3. METHODOLOGY

In contrast, this work aims to analyze how PHM can be aligned with PPC on a processual, technological and organizational level while incorporating a practitioner’s perspective through literature review. This is achieved by answering the following research questions: 1) “Which PPC processes can benefit from PHM, and what information systems and organizational units are involved?” 2) “How must the PPC process be aligned to achieve the benefits?” and 3) “How is it currently done in practice, and what is the disparity to research?” Following process are used to align PPC with PHM:

- **Master production scheduling**: Because master production scheduling has a long-term planning horizon, no improvements can be made with PHM.
- **Requirements planning (general)**: Here, the maintenance threshold and production quantity are jointly determined to satisfy the demand. From the incoming master production schedule, a net requirements calculation is done, and it is defined whether the production requirements should be produced in-house or sourced externally.
- **Production planning**: Afterward, the tactical production program is forwarded to operational production planning, typically done in ERP by the production department. ‘Traditional’ production planning is hierarchical and tries to achieve cost-optimal production plans. Through an alignment with PHM, the process is made more flexible.
- **Production Control**: After a final production plan is devised, production control is the next process category. It is typically done in an MES and starts with sequencing, where, based on the lead time schedule and the determined dates, the concrete production sequences are defined. PHM can lead to better sequencing quality, load balancing, and optimization of production control.
- **Production monitoring**: Here, the adjustments made are continuously monitored and checked against a cost model.
- **Demand management**: The process starts with customer order receipts, which are then considered in order-specific capacity planning. Here, different quantities are tested to calculate all possible variants that do not cause a delivery interruption.
- **Inventory management**: After production is completed, material consumption and manufactured goods are forwarded to inventory management. Finally, they can be issued and shipped to the customer, which concludes the PPC process.
- **Source planning**: In the latter case, source planning is conducted. Besides raw materials planning, spare parts planning must also be done. Through PHM, spare parts can be ordered just in time. Here, the RUL and information from ERP (e.g., costs, lead times) are balanced and jointly optimized to minimize the total cost.

#### 3.1. A PHM-ALIGNED PPC PROCESS

Considering the processual, technological, and organizational changes introduced, an aligned PPC process is proposed in Figure 3.
Here, the process categories depicted in Figure 2 are picked up again and split into multiple process elements. In the following, the former is written in bold, the latter in italic letters. Additionally, process elements where PHM alignment is possible are marked with a bold frame in Figure 3.

5. RESEARCH-PRACTICE GAPS

All in all, it could be shown that aligning PPC with PHM holds much potential to improve performance because production can be made more flexible and efficient.

6. CONCLUSION

A PHM-aligned PPC process was introduced in this work by demonstrating how PPC benefits from PHM. To summarize, the research questions raised at the beginning can be answered as follows. 1) “Which PPC processes can benefit from PHM, and what information systems and organizational units are involved?” Seven of the eight presented PPC process categories can benefit from PHM to different extents. However, the benefits can only be attained by integrating different information systems (e.g., CPPS, PHM, ERP systems) and collaborating between production, maintenance, and information technology departments. 2) “How must the PPC process be aligned to achieve the benefits?” The analysis showed that PHM is beneficial for short-term production planning and production control, moderately prevalent in requirements and source planning, and applicable to production monitoring and inventory management. A PPC process with 18 process elements was developed, which shows how benefits can be achieved through the alignment of PHM. 3) “How is it currently done in practice, and what is the disparity to research?” A research-practice comparison revealed that PHM for production control is highly relevant. Further, production and requirements planning are underrepresented in practice, while a research gap exists for source planning. There is no single best way to align PPC and PHM. Its success can depend on many things, such as the maturity of PHM, PPC process, organization, or the firm’s technological and data quality. An empirical analysis could shine a light on these aspects. Lastly, it was also demonstrated that real-time production and capacity control adds much flexibility to PPC. In the future, more focus should be on hierarchical, autonomous production control.
REFERENCES


