УДК 332.1

NECESSITY AND APPLICATION ADVANTAGES OF LINKED MASTER PRODUCTION SCHEDULING AND HUMAN RESOURCES REQUIREMENTS PLANNING

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The following article considers the need to integrate social aspects into the Master Production Scheduling. This is justified by the demand for sustainable business processes and the previously neglected social dimension, which is also reflected in the development of working conditions. The linear optimization model for Master Production Scheduling outlined in connection with aspects of Human Resource Requirements Planning offers an approach to reduce this research gap and underlines the urgency of long-term planning and control of employee burdens. For companies, this results in a Decision Support System through the evaluation of measures to improve working conditions.

Introduction

A concept of Production Planning and Control that is often used in science and practice is the Hierarchical Production Planning with consideration of limited capacities, as proposed by Drexl et al. (1994). In the original concept, however, mainly economic aspects are in the foreground. In view of current political and social demands, the sustainability aspect is becoming more important in current research (Andriolo et al. 2014). Production Planning and Control provides considerable potential for improvement in this respect (Haasis 2008; Vorderwinkler and Hei. 2011; Trost et al. 2016), so that numerous papers now exist that extend the classic economically oriented models to include aspects of sustainability. Nevertheless, the social dimension is often ignored. Therefore, the following article reviews the state of the art in research and underlines the need for further research. Based on this, a linear optimization model is outlined, which establishes a link between Production and Human Resources Requirements Planning at the level of the Master Production Scheduling and enables the planning and control of employee utilization. In addition, results from the investigation of exhaustionrelated employee utilization-specific processing times are presented. From the presented application advantages it becomes clear that decision support can be developed with the help of the established model, which shed light on the consequences of an improvement of the working conditions and thus open up scope for suitable measures. This enables companies to respond better to future events, such as fluctuations in demand or a shortage of skilled workers.

STATE OF RESEARCH AND THE NEED TO INTEGRATE SOCIAL ASPECTS INTO PRODUCTION PLANNING AND CONTROL

There are various definitions of the term sustainability. Common definitions agree that sustainability must meet economic, ecological and social criteria (Rogall 2009). However, the social dimension in the area of Production Planning and Control in particular is less researched (Trost et al. 2016). Science, for its part, is divided on the concrete understanding of the social dimension. For more information on this discourse, please refer to the relevant literature (see for example Empacher and Wehling 2002; Schmucker 2014; BMAS 2015; Allmendinger 2016). For instance, appropriate income, meaningful work content, a good working atmosphere or the compatibility of career and family are mentioned as requirements (BMAS 2015). At the same time, more specific requirements can be defined. The "DGB Index Gute Arbeit 2013", for example, distinguishes 11 characteristics (Schmucker 2014). Contributions that integrate social aspects into Production Planning and Control can be found primarily in the areas of Lot-sizing and Scheduling. At the level of Lot-Sizing Arslan and Turkay (2013), for example, aim to minimize personnel hours, and Jaber and Bonney (2007) integrate a two-phase learning and forgetting effect. In the Scheduling area, the papers by Boysen and Fliedner (2011), which reduce the burden on airport ground staff, which can be transferred to a production environment, and by Lai and Lee (2013), which integrate learning and forgetting effects into a single-machine environment, should be mentioned. These results are supported by the paper by Grosse et al. (2017). In it, relevant papers were classified in a self-developed framework. It became clear that despite an increase in contributions taking the social dimension into account, there is still great research potential. Relevant contributions include the paper by Khan et al. (2014), which considers cognitive factors in Lot-Sizing and the paper by Andriolo et al. (2016), which deals with ergonomic Lot-Sizing. In addition, the contribution of Otto and Scholl (2011) is mentioned, which enable a performance comparison taking ergonomic risk factors into account.

Nevertheless, it should be noted that working conditions are hardly improving despite various measures (Schmucker 2014). Among other things, in addition to a too low income, the physical strain and work intensity are rated as too high (Schmucker 2014). Short-term reactions to increased demands are, for example, an increased heart rate, frustration, increased errors or aggressive behavior. In the long-term, this leads to resignation and psychosomatic diseases (Nerdinger et al. 2014). In addition, taking into account the continuing shortage of skilled workers, the need for a stronger social orientation of production processes increases. The demographic change and the expected transformation of jobs and tasks in the context of Industry 4.0, which requires even more specialized workers, makes this need even more urgent. Within the framework of Production Planning and Control, the burdens on employees are directly determined by the production schedules created, resulting in considerable potential for improvement. As can be seen from the foregoing overview of the relevant literature, previous work concentrates on the levels of Lot-Sizing and Scheduling. The level of the Master Production Scheduling has not yet been linked to social aspects, so that no long-term consideration of social aspects is possible. One consequence is, for example, that the total burden cannot be controlled, since consideration of exhaustion effects in operative planning levels only enables an optimal distribution of the total burden to the employees. The linear optimization model for the Master Production Scheduling outlined briefly in the next chapter was created to enable longterm control of employee workload.

DEVELOPED SOCIAL EXTENSIONS TO THE MASTER PRODUCTION SCHEDULING AND THEIR APPLICATION BENEFITS

For the mathematical description of the optimization model outlined below, reference is made to Trost et al. (2017a). Classical models for the Master Production Scheduling as by Claus et al. (2015) are economically oriented. The production program to be created is restricted by fixed capacity limits, whereby the possibility is given to expand these by using additional capacities. The objective is to minimize the total costs of storage costs and costs for the use of additional capacities. The essential extension in the model presented in Trost et al. (2017a) is the linking of the classical model with aspects of Human Resources Requirements Planning. The number of employees required is determined by the model, which means that the rigid capacity limitation is replaced by a variable available capacity. Costs and lead times for capacity adjustment, the determination of the effects of necessary shift models and a maximum number of work places are taken into account. In addition, different groups of employees are distinguished for each production segment, so that a differentiation between experience and qualification of the employees is possible. Conditions of the labor market regarding the availability of suitably qualified and experienced employees are also taken into account. As an objective, the total costs, consisting of storage costs, employee costs, costs for capacity expansion and reduction, and costs for shift bonuses, are minimized. Previous studies (see Trost et al. 2017a and Trost et al.2017b) dealt with the consideration of employee utilization-specific processing times. This is based on the assumption that manual processing times are influenced by the exhaustion of employees, whereby the exhaustion is measured in terms of employee utilization. Accordingly, an employee utilization was integrated in the model for each production segment as the ratio between capacity requirements and available capacity. In the case studies, various employee utilization intervals and dependent processing times, product requirement sequences and exhaustion sequences are examined. One expected result is that the greater the exhaustion effects, the lower the capacity utilization of employees should be. In addition, however, it became clear that regardless of the assumed course of exhaustion and contrary to common assumptions, maximizing capacity utilization does not necessarily lead to a cost-optimized production program. This result underlines the need to control employee utilization. This allows cost advantages as well as a reduction of the employee burden to be achieved. However, it should be mentioned that the concrete quantification of exhaustion effects is a research gap.

Application benefits result from the use of the model for improved decision support with regard to combined Master Production Scheduling and Human Resources Requirements Planning. This makes it possible to assess the consequences of highly fluctuating demand and sudden slumps in demand. Decision guidance is provided on how to react to corresponding scenarios. For example, whether a reduction in capacity utilization or the reduction in available capacity is expedient, which is gaining in importance, especially in view of the expected shortage of skilled workers described above. Furthermore, application possibilities for the determination and evaluation of measures to improve working conditions arise. For companies, this issue is becoming increasingly important due to the shortage of skilled workers described and the political and social demands of sustainable business processes. For example, competitive advantages can be achieved by recruiting employees with attractive working conditions. This is countered by the pressure to make production systems more flexible, which also has an effect on the working conditions of employees. As decision support, different scenarios can be compared, which, for example, specify reduced or fixed employee utilization intervals, whereby the economic requirements for the production program must always be met. As a support for decision-making, companies can identify scope for action from which measures to improve working conditions can be derived and evaluated while complying with economic requirements.

CONCLUSION

This article makes it clear that the integration of social aspects into Production Planning and Control has not yet taken place sufficiently, despite great potential and increasing pressure on sustainably oriented business processes. Especially the long-term planning and control of workloads is a research gap. The then briefly outlined linear optimization model for Master Production Scheduling represents a link between Production Planning and Human Resources Requirements Planning. The studies show that maximizing employee capacity utilization does not necessarily lead to optimal production schedules, but requires long-term planning and control of capacity utilization. This reduces the burden on employees. In addition, there are various application possibilities for decision support of companies. Consequences of various scenarios for improving working conditions can be evaluated, from which room for maneuver arises that enable competitive advantages in employee recruitment due to reduced and constant workloads.

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