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Dynamic bid pricing for an optimized resource utilization in small and medium sized enterprises

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Abstract

Sales revenues of small and medium-sized enterprises are subject to seasonal fluctuation. This leads often to overloaded or underutilized manufacturing resources. Either way, this results in revenue losses. Therefore, companies have to optimize their resource utilization. This paper describes a new methodology for a dynamic bid price system by using correlations of revenue management in production planning to level the resource utilization. The methodology supports especially small and medium-sized enterprises, which are often affected by additional work shifts across seasons. Furthermore, the proposed method points out dependencies between costs and capacity to avoid financial losses. The method has been developed and is being tested in collaboration with two small and medium-sized enterprises.

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Keywords: Production Planning; Manufacturing Resource Utilization; Dynamic Bid Price.

1. Introduction

In production, the economic success of companies is based on the highest possible utilization of manufacturing resources while maintaining flexibility and responsiveness to demand fluctuations. The majority of small and medium sized enterprises (SME) accepts the highest possible number of customer orders aiming to ensure a high production utilization. Commonly, a systematic evaluation of customer orders based on capacitive criteria (e.g. utilization of work stations) does not happen due to a lack of information and decision-making. Consequently, the production is overloaded, which causes overtime, quality problems, delays and the risk of economic losses. The fluctuating demand from customers forces manufacturers to plan available capacities under a dynamic demand over a long period. Capacities for regular customers or for the production of standard products must be kept available. At the same time, spontaneous orders and orders with a high proportion of own development as customized brackets, must also be included in capacity planning. Many manufacturing companies already provide information on resource utilization in manufacturing execution systems. Nevertheless, customer orders are not rejected even when manufacturing resources are fully utilized. Instead, the date of delivery is shifted depending on the order priority. In order to overcome this issue, this article presents a methodology for capacity-based production planning and control, which prognoses the long-term capacity of manufacturing resource as well as the short-term deviations, as shown in figure 1.

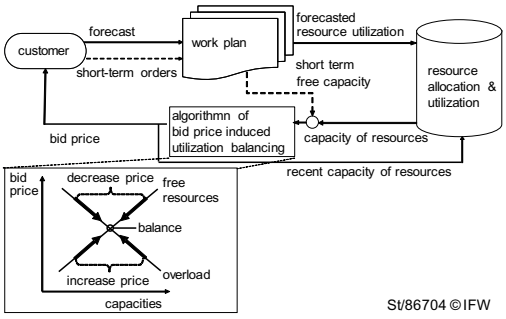

Fig. 1. Resource utilization equilibrium by bid prices.

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Within the method, the necessary capacities for a production order are determined based on the predicted demand. Furthermore, the current utilization (e.g. operating resources, machine hours) and a dynamic bid price are used to determine individual manufacturing costs for each customer order using a mathematic cost model. If a resource is busier than planned, the increased production costs must be taken into account by starting a new work shift or by switching machine classes. The dynamic bid price influences the demand and thus the resource utilization. The methodology has access to the scheduling, which enables the integration of relevant information on the current and the expected resource utilization. The method has been developed and is currently being tested at two SMEs.

2. State of the art of capacity planning and revenue management

Production planning and control (PPC) contains the planning of the production program, the material and the monitoring of all production stages. Production control on the one hand, includes functions that enable the execution of specific orders in terms of time, quantity, quality and cost. Production planning on the other hand, covers the activities that comprise the service creation process, e.g. the creating part list and the work plan in advance. Order release, capacity control, scheduling and order monitoring are the main tasks of production control. The order release sets the earliest starting time for processing at a particular work station. Within the scope of capacity control, the capacity requirement is matched with the capacity availability of every manufacturing resource. The order monitoring records and visualizes the progress of a production order with regard to the planned quantity, the completion date and the quality [1].

In PPC, methods like workload control (WLC), order review and release (ORR) or bottleneck load oriented release (BLOR) are main research targets as presented in [2]. The objective is to level order releases (input), work in progress and capacity adjustment (output) of manufacturing work stations or networks.

Customer inquiry and job entry stages are a sub objective of WLC research. As mentioned in [2], the LUMS approach deals with the decision-making problem in an early stage of the manufacturing process. Starting with a customer request, the manufacturer has to decide whether the order is accepted or rejected. Furthermore, in this stage the delivery date and the bid price have to be determined. Kingsman [3] refers to an “analytical model of dynamic capacity planning at the stage of customer inquiry” by using the flexible capacity of single work stations. In this case, capacity is an output rate of PPC. Moreover, Kingsman transferred the methodology of single work stations to shop floor networks, which shows the decision-making problem in orders requiring processing on work stations. By controlling the order release, the observance to delivery dates is managed. Main part of managing order releases is a job pool, which includes all accepted orders. In addition, Kingsman explained the planning problem of bidding and order acceptance. The capacity of each work station in future is defined as the main decision variable. Kingsman emphasis the importance of the delivery date and the price in this early stage of the manufacturing process. Nevertheless, only the delivery dates are taken into account, because the companies try to keep the price as low as possible [3]. In [4] an “overall decision support system for dealing with inquiries” is developed. It is divided in three modules: the estimation module, the capacity planning module and the marketing module. The estimation of the bid price is mainly influenced by a database of past prices and won bids. Regarding to [2], the main research target in PPC is the order release. At this time, the order is already priced and the price communicated to the customer without considering the future resource utilization.

According to VDI Guideline 2234 [5], the quotation calculation can be divided into the preliminary costing, the accompanying costing (intermediate costing) and the post-calculation. The availability of information on calculation-relevant data increases with the production progress, when accurate information on the production and preparation of the work as well as the exact descriptions of the product and the required processing times are available over time [5]. The calculation methods can be divided into expert estimates as well as parametric, analog and analytical calculations. Basic descriptions and general conditions of these procedures can be found in [6, 7]. The lower and upper boundary of the price are determined by the total cost of production and the customer’s willingness to pay for the product, respectively neglecting strategical reasons for lower prices [8]. The challenge of bid price calculation is to determine costs of the product development and the production process quickly and at an early stage, although the necessary calculation basis is often incomplete [6].

Within the service sector, enterprises (e.g. aviation industry, car sharing, hotels [8, 9]) already sell free capacities at a time-dependent price using revenue management (RM) approaches. If the current demand exceeds or underruns the expected demand, the price increases or decreases and thus regulates the demand [10]. It refers to a price-quantity control. Quantitative methods are used to quantify the assumption or rejection of uncertain, chronologically distributed demand of different values. The aim is to use the inflexible available capacity in a limited time as efficiently as possible [8]. Within the framework of the RM, a heterogeneous demand behavior represents a major application requirement [11]. A consequence of the heterogeneity is that the demand for the available capacities in a period is not constant and uncertain. The capacity control is a stochastically dynamic decision-making problem. If a company accepts an order, it will decide whether the order is accepted or rejected, even if the order is still available. At the time of the decision, future incoming orders are uncertain [8]. Instead of appointed prices for capacity units, dynamic pricing is increasingly known, as a revolution in RM [12]. As mentioned in [12] dynamic pricing alters the opportunity to bring RM from stable business environments to real-time competition.

For the service sector, e.g. in ticket sales, converted systems are commercially available (for example, ISO software systems: Skyfly Revenue, Lufthansa systems). With respect to their complexity, these systems cannot be transferred to the manufacturing sector without adapting to SME needs. A large number of resources have to be taken into account in production. In addition, RM's mathematical models refer to a short-term period and inflexible capacities [8].