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Procedia CIRP 3 (2012) 20 – 25

www.elsevier.com/locate/procedia

45th CIRP Conference on Manufacturing Systems 2012

Model of a Decision Support System for a Least-Cost and Harmonized Capacity Adjustment in the Short- and Medium-Term Planning Horizon

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Abstract

Because fluctuations in demand will increase in future, producing companies will have to adapt their available capacity regularly, always taking the total production costs into account.
In practice, planning of available capacity is being realised without a comprehensive evaluation of changeover costs of total costs. The aim of the presented approach is to support companies in choosing an adequate strategy for a least-cost and harmonized capacity adjustment in the short- and medium-term planning horizon. This also represents a first step towards a new planning approach, enabling not only the systematic utilization of flexibilities of orders, but also of manufacturing resources.

Keywords: Capacity planing ; Capacity adjustment ; Decision-support system ; Flexibility-options ; Adjustment costs

1. Introduction

Over the last years, high fluctuation in demand forced companies to adjust their capacities gradually. According to many experts, this phenomenon will show a significant increase [1]. Due to increasing globalization of business competition and demand, companies will have to adapt their capacity level to the customer demand more often, while giving full thought to efficient cost structures.

SMEs (=small and medium sized enterprises) in particular are going to face greater challenges, since they are more vulnerable to “cost-pressure”, because of their relatively insignificant market-share [2]. In addition, they are strongly limited in taking actions and adjusting a different strategy, due to their narrowed and confined financial and human resources [3]. This hypothesis was confirmed through a survey in machinery and plant engineering industry, conducted and carried out by Grundmann und Reinisch [4].

Since one can expect that fluctuations in demand cannot be levelled totally [5], those turbulences have to be handled somehow [6]. This shows that a continuous adaption of production volume and mix is necessary to fulfil the requirements of the international markets [7].

2. Problem Statement

The capacity adjustment mainly deals with deciding and planning problems which have to consider different adaption strategies on given fluctuations in demand. In practice, capacity planning is supported by IT, whereby ERP-systems (=Enterprise Resource Planning systems) are the most used and common ones. ERP-systems use MRP II (= Manufacturing Resource Planning) Logic, in which under-utilized resources or unfulfilled customer orders are visualized and then manually and iteratively optimized [8]. Therefore, the short and medium term capacity planning strongly depends on the experience and ability of the responsible employees. Hence, the achievement of a global optimum is very unlikely. Furthermore the planning process takes place without the consideration of adjustment costs, and as a result without a total cost analysis. In addition, there is no outline of all possible capacity adjustment measures. To

doi:10.1016/j.procir.2012.07.005

find an appropriate solution (a global optimum) under these general conditions, a decision support system for manufacturing companies will be developed.

3. State-of-the-art

3.1. Adjustments related to demand fluctuation

How to react on fluctuations in demand is dependent from different parameters, e.g. storage costs, shelf life of products, accuracy of demand forecasts, liquidity of the company, quantity of product variants, and of course the flexibility of each resource [9]. Therefore, it is obvious that the flexibility of a company is not only a function of its ability to shift working hours, but is influenced by multiple parameters.

Buzacott has listed capacity adjustment measures and points out that each of those depends from its situational applicability for capacity levelling and likewise from the measures' related costs [10], but there is no assistance in choosing the right capacity measure. Other authors [11], [12] define capacity adjustment measures more detailed, but they do not deliver selection criteria as well. In comparison to that, Asl and Ulsoy [13] have presented approaches to the capacity management problem based on Markov decision process and feedback control. In this approaches, the decision process itself is focussed, but neither the calculation of adaption costs and adjustment measures nor a practical application in a decision support system.

The concept of capacity envelopes, which is discussed by many different authors [14-18], seems the most promising approach for defining the ideal capacity adaption strategy. In this concept, the x-axis represents the reaction time or the minimum installation time respectively. The y-axis represents the capacity level and shows especially additional or less capacity caused by a certain adaption measure. By interleaving envelope curves of all possible measures for capacity adjustment of a working system, flexibility profiles can be generated. They show the maximum capacity adjustment ability of a production system, but do not factor the related costs.

The existing scientific literature does not deal with operative short and medium term capacity planning in detail; therefore there is no support for identifying the adaption strategy which causes the lowest overall costs. Although an interesting modelling approach for evaluating capacity flexibilities in uncertain markets was presented by Zaeh and Mueller [19]. This approach focuses on evaluating the configuration of Value Streams by their ability to handle the expected market volatility. Furthermore it calculates which changes in fixed costs or profit occurs if different investment strategies or process changes are applied. Therefore, it can be used as a decision support system in long term capacity planning.

Currently, the medium term capacity planning gets along with capacity corridors. The capacity of a resource can be adjusted within such a corridor; exceeding manufacturing orders are shifted [20]. Furthermore, general selection criteria to adapt capacities to the demand cannot be found. However, Gottschalk [15] claims that a sufficient understanding for flexibility at all production stages and a detailed capacity planning lay a foundation for successful capacity adjustments.

In order to identify the need for capacity adaption, Lödding [16] suggests developing capacity profiles for all relevant resources in a first step. In a second step, the bottleneck-resource can be identified, for which specific measures have to be elaborated and proofed. These measures adapt the previous plan and should finally improve the performance of the total system. Nevertheless, Lödding does not discuss how to choose and evaluate adjustment measures and related costs remain again disregarded. Single [21] describes reaction and action methods for companies as well, which struggle with demand fluctuations. Similar to the bottleneck-search at Lödding [16] he looks for weaknesses, and establishes counter-measures and reaction strategies respectively.

In operational practice, capacity planning is generally done with capacity and PPS (= Production Planning and Scheduling) -software's. They are used for staff planning and complete resource planning and are usually integrated in ERP-systems. Generally, they support the flexibility of companies by considering costs in planning. However, adjustment costs are not observed. Some examples are:

- Production von abas [22].
- Fast/pro [23].
- enviso optiCAP [24].
- GANTTPLAN [25].
- WINLine PROD [26].

SAP APO (Advanced Planning and Optimizer) is the production planning component within the mySAP SCM solution. It is probably the most used planning and optimization tool for customer order processing and therefore a closer look is appropriate. It contains 7 modules, whereby Production Planning and Detailed Scheduling (PP/DS) has the biggest relevance for the topic of this paper. Generally, it delivers feasible schedules, optimizes order sequences under consideration of resource capacities, set-up and delay costs, and also matches customer demand with free capacities along the supply chain. However, capacities are treated as fixed constraints and are only adaptable manually.