Optimal Usage of Flexibility Instruments in Automotive Plants

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Summary. Scope of this work is the development of an optimization approach to find the optimal configuration of automotive plant capacities for a time horizon of one to seven years regarding market demand, planning premises, and dependencies between the shops (body shop, paint shop, final assembly) and between planning periods (e.g. learning curves). The methodology has been implemented in a planning tool and includes production and workforce planning. The optimization algorithm is based on a dynamic programming approach.

1 Introduction

In the past years the automotive market is characterized by increasing diversification and shortened lifecycles, which leads to an enhanced fluctuation of demand. This trend is enforced by seasonal effects and a rising uncertainty in demand forecast. In order to achieve a high utilization OEMs implement a high degree of flexibility in their plants. Many approaches for planning and optimizing the degree and structure of flexibility in production facilities have been considered (see for example [6], [5]). The next nontrivial but important planning task is the optimal use of flexibility instruments for adapting capacities to demand. In particular, industries with a high proportion of personnel costs like the automotive sector use organizational flexibility instruments just as technical flexibility so that these two aspects can not be treated separately or successively. Regarding these requirements we emphasize an integration of workforce and production planning with a focus on changing demands using given flexibility instruments (see Fig. 1).

The simultaneous medium-term planning of production and workforce capacities is not self-evident. The subject first arose in the late 80s when the general economic situation led to a broad public and scientific discussion of the topic. On the scientific side pioneering work was conducted by [4] and [3]. In practice the combination of production and workforce planning is rare, although there is a urgent need to manage available flexibility efficiently ([2], [7]). Due to special requirements regarding the

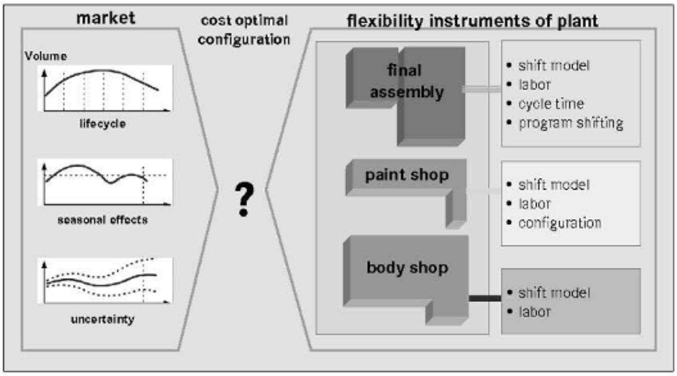

Fig. 1. Demand of flexibility and flexibility instruments

flexible workforce planning and an enormously rising complexity of the planning problem it is still not common that labor aspects are considered in the context of production planning.

2 Modeling an Automotive Plant

The manufacturing of a car is divided in three shops. The first step is welding the car body in the highly automated body shop. Workforce is mainly required for programming and maintenance of the machines. In the succeeding paint shop the surface of the car body is prepared and lacquered. In general, the painting process is fully automated. Only handling and rework is done manually. In the last step the coated car body is composed with all modules and parts in the final assembly. The low degree of automation leads to a high degree of flexibility in this shop, but also to a high integration of workforce and production planning. Hence, these two planning tasks have to be considered simultaneously together with planning of working time and an evaluation of costs in order to find an optimal adaptation of automotive plants to given demands. Additionally, there has to be a coordination among the different shops, which are uncoupled. The main functions of the buffers between succeeding shops are catching breakdowns and sorting the cars for the production process. Only a small part of each buffer remains for working with different production rates and shift lengths in successive shops.

As described above final assembly possesses most of flexibility instruments. The production is organized by an assembly line with constant speed. All assembling