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# Complexity-focused planning and operating of mixed-model assembly lines in automotive manufacturing

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**Abstract**

Nowadays manufacturing companies face an ever increasing variety of their product range and produce in a highly turbulent environment. As a result the production department has to handle a large number of varying production processes and a fast changing production program. In particular the assembly lines in mass customized production are burdened with this complexity, as they handle a high number of different parts resulting in numerous and varying assembly operations. In order to satisfy the market demands, those mixed-model assembly lines have to adopt methods to assemble both in an efficient and flexible way.
To address this situation, an approach is presented that focuses on assembly operations of the product components and the complexity's impact on those operations. To do so, an analysis is given that differentiates work operations regarding their possibility to handle complexity process-related. Based on this analysis principles are presented to manage complexity, in particular for flow mixed-model assembly lines. The principles focus on the modification of assembly configurations and consider both planning and operating methods supported by information systems.


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## 1. Introduction

Since several years manufacturing companies face markets that demand more and more individualized products and are highly volatile both in quantity and in type of the demanded products [1,2]. This situation leads to a large variety of the companies' product program and shorter lifecycles. As a consequence, production faces a variety of its manufacturing processes resulting in several challenges especially for serial production.

Focusing on gaining economical advantages, production lines were applied to standardized and similar products, that were produced in flow and in a large number [3]. A small quantity of particular work operations was executed by workers along the production line, therefore a lower qualification was required and learning effects could be realized quickly. Those production lines were able to produce a large number of products efficiently by achieving a high productivity in its work processes and a high average workload utilization.

As the variety of the product program increased, work operations varied, leading to inefficiency for the production lines [4,5]: The lack of similar work operations make realizing learning effects more difficult, require different work equipment and resources, create bottle necks for the flow production line and require different production time based on the product variant. Those inefficiencies have a particular impact on the assembly lines, as they handle a large number of different work operations and different parts, especially when assembling complex products, like in the automotive industry. The complexity within the production program must be matched with a highly flexible production


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system, that is still able to produce a large number of products [5]. The major challenge for manufacturing companies is establishing flexibility in production to handle a complex production program and still operate efficiently.

This paper presents a methodology to increase the effectiveness and efficiency of mixed-model assembly lines. Its focus is on planning and operating steps in order to diminish the negative influences of complexity on the assembling process.

## 2. Basics

This section presents an explanation of the fundamental terms used in this paper and gives an understanding of the field of application.

### 2.1 Complexity

The meaning of the term complexity is vague and differently interpreted depending on the subject it is related to [6]. In the area of manufacturing, complexity is often referred to the concurrent appearance of the dimensions variety and change [7]. Complex systems can be characterized as highly dynamic and its outcomes are uncertain to predict [9]. Complexity is considered as something that manufacturing companies have to deal with in order to be successful; the goal of manufacturing companies is to avoid, diminish or control complexity and its results [8].

### 2.2 Flexibility

As manufacturing companies operate in a highly dynamic and instable environment, they are confronted with variety and change: As a result they need the ability to react to the complex situation. This ability is related to flexibility. As for the term complexity, there are many different definitions of flexibility in the manufacturing area [11,12]. Widely common of the definitions is the ability of reaching different conditions of a system and the ability to do so in a certain predefined time [9]. The adaption to different and changing situation, however, occur in a predefined scope [10].

### 2.3 Field of application

In the following section the field of application is given, which are mixed-model assembly lines and its planning and operating steps.

#### 2.3.1 Mixed-model assembly line

As mentioned in the introduction, manufacturing companies and assembly lines in particular face an ever increasing variety of their product range. As a result assembly lines that were once established for a single product in order to gain economical advantages have transferred into so called mixed-model assembly lines. Mixed-model assembly lines assemble different product variants in batch size one and in flow. To do so, the product variants need to have a certain similarity [11]. Therefore mixed-model assembly lines provide flexibility and efficiency despite a varying product range; nevertheless the product variety leads to varying assembly processes, resulting in inefficiency that have to dealt with.

#### 2.3.2 Planning and operating

Planning and operating steps of assembly lines can be differentiated by phases according to their level of detail, task and time [12]. The sooner the actual production process is the more detailed becomes the structure of the assembly line and the assignment of the resources to the product features.

While the planning steps contain framework conditions for the assembly, the operating phase is focused on executing the actual assembly process. It's task refers to staff planning, resource monitoring, adaption of equipment and enhancing the manufacturing process.

### 2.5 Structure of product and assembly system

In order to establish improvements in a system, it is inevitable to gain a deeper understanding of the focused systems with its relations and interactions. Manufacturing companies operate in a turbulent system, that contains a high variety of elements and interactions, facing steady change. To describe such a complex system, the system theory provides an applicable approach [13]. The system theory contains three aspects to describe the system, which are functional, structural and hierarchical (see Fig.1).

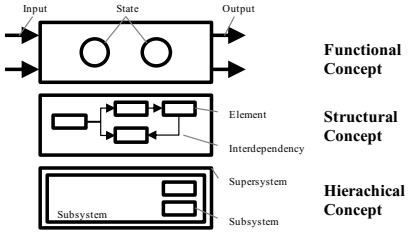


Fig.1. Conceptual aspects of the system theory [14]

Based on the conception of the system theory, the product and assembly system can be characterized. The product system represents the task of the assembly and therefore the assembly has to adapt to the specifications of the product system.

The hierarchical characteristic of the product details the different level of the product, which represents the highest level. The product can be differentiated in single parts, that cannot be divided in a non-destructive way. The assembly system's level reaches from the line to the actual assembly process at the workstation. The structural characteristics of the assembly and product system are represented by the procedure of the different processes and derived from the priority chart [15]. Functional aspects refer to the tasks of each systems and describe the objective of the regarded elements in order to fulfill a certain purpose.

## 3. State of the art

In the following section a short outline of approaches is represented that aim on increasing the flexibility and efficiency of production and assembly lines in particular.