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Method for a cross-architecture assembly line planning in the automotive industry with focus on modularized, order flexible, economical and adaptable assembly processes

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Abstract

In the last years the number of offered vehicle derivatives increased. In respect of series vehicle production by means of high efficiency each assembly line normally can realize only one vehicle architecture with a defined number of vehicle derivatives. This is the reason, why additional derivatives or new designed vehicles only can be managed within the production network for specific derivatives and different working-time models in the factories, if even. The demand of increasing flexibility and low investment rates can be faced by enabling assembly lines to realize more than one vehicle architecture. The developed method uses degrees of freedom in the assembly order to configure economical cross-architectural assembly lines - by taking in account the most important product specification and assembly design premises.

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Keywords: assembly; planning methode; flexibility; automotive industry

1. Introduction

In the last years, the number of offered vehicle derivatives increased. In the serial production of the automotive industry, normally a defined number of vehicle derivatives can be assembled on one line. These vehicle derivatives mostly have to be based on the same car architecture. The main reason therefore is that it would not be efficient to realize several architectures at once. The assembly times would be too different and it would lead to an efficiency loss. Assembling a larger number of vehicle derivatives is not the only challenge automotive factories have to deal with. They also need to manage the variant mix and quantity changes within the vehicle derivatives economically. The flexibility of single assembly lines and also the flexibility of the production network can be increased if more than one vehicle architecture could be realized on the same line. The highest theoretical flexibility would have an assembly line, which is able to realize all vehicle architectures and their derivatives.

An analysis in the automotive industry has shown that not only between different architectures even within the same architecture, the order of the assembly steps in existing assembly lines differ. That means that there are degrees of freedom in the assembly order. These degrees of freedom can be used to satisfy the requirement of reducing the throughput time of assembly lines. The method presented here can be used to harmonize different vehicle architectures. This is the precondition to assemble them on the same line (greenfield-planning) or to integrate other/new architectures on an existing assembly line (brownfield-planning) by using these degrees of freedom.

The fundamental idea behind is the modularisation of the products and assembly lines. In the fractal factory, a company is seen as the summation of autonomous organized company modules [1]. In the modular factory, the focus is on the degree

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of modularisation of the products and the company [2]. The target of the developed method is to modularize the final assembly line and to use the degrees of freedom to get all possible configurations which can realize more than one vehicle architecture. The result is a generated order of the assembly modules. Finally, the modules have to be harmonized on the timeline. The result is a configuration, which allows, that all vehicle derivatives, which are assembled on the assembly line, using the same assembly modules. The assembly modules of the vehicles can be harmonized with further architectures or existing assembly lines. The degrees of freedom of an assembly line are the possibilities to change the order of different assembly modules.

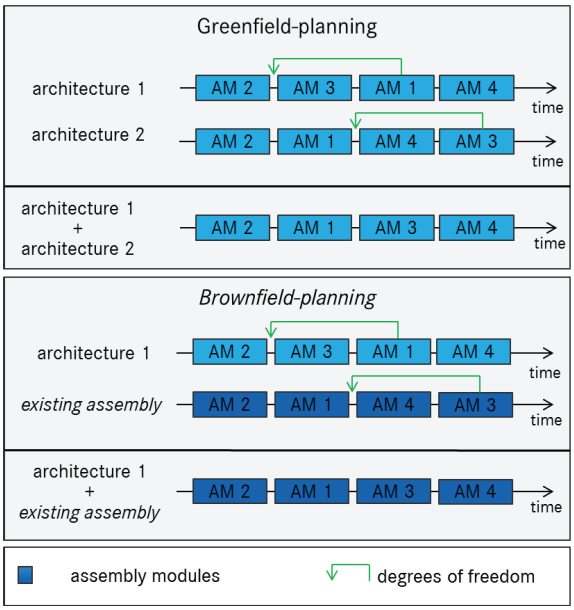

Figure 1: Target of the developed planning method

In the next chapter the developed method for planning cross-architecture assembly lines in the automotive industry, is explained.

2. Method for a cross-architecture assembly line planning

This method is used to increase the flexibility of assembly lines. There are numerous definitions of flexibility. In this paper the definition of flexibility follows the view of Westkämper. A system is called flexible, if it is reversible adaptable to changing circumstances in the context of a principle preconceived scope of features [3]. In this context flexibility is the ability to assemble a preconceived number of vehicle architectures/derivatives and to manage the requirements of changes in quantity and derivatives in a specific scope.

The method uses the degrees of freedom in the assembly order to harmonize different vehicle architectures by defining requirement specific assembly configurations. The following figure shows the main steps of this method.

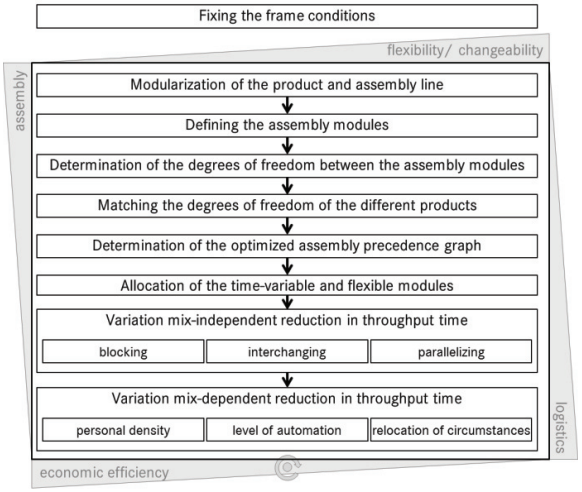

Figure 2: Overview of the developed method and the different steps

These steps will be detailed in the next chapters.

2.1. Fixing the frame conditions

Often new car generations are launched or there is a higher market demand than the capacity of the production network offers. That leads to the necessity to improve existing or planning new assembly lines. If an existing line is improved it is called a brownfield planning, else it is a greenfield planning. The decision depends on the needed vehicle derivatives and the requested quantity. The location has an impact on the available area and the local legislation defines the maximum business operating time. In a greenfield the cycle time can be defined. In the brownfield normally it is already fixed. Further on, it has to be ensured that the conveyor system can handle the architecture-dependent attachment points, weight and dimensions of the different vehicle derivatives/architectures. The developed method enables to extend these premises to manage future changes. The variation mix, the different engineered hours per vehicle and the variation mix will not be a restriction anymore.

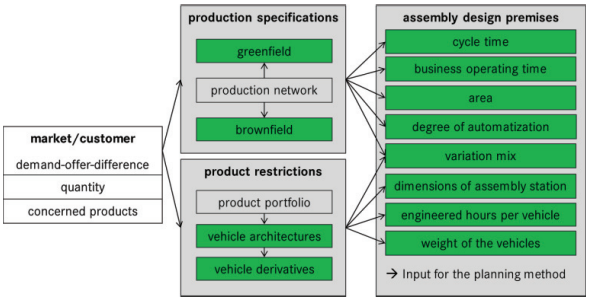

Figure 3: Assembly design premises

After the definition of the frame conditions, the assembly line can be planned in detail.