Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 54 (2016) 215 – 220

www.elsevier.com/locate/procedia

6th CLF - 6th CIRP Conference on Learning Factories

Method for configuring product and order flexible assembly lines in the automotive industry

Christian Küber[a,]*, Engelbert Westkämper[b], Bernd Keller[c], Hans-Friedrich Jacobi[d] *

[a, b ,d]*Graduate School of Excellence advanced Manufacturing Engineering, Nobelstr. 12, Stuttgart 70569, Germany*

[a ,c]*DaimlerAG, Mercedesstr. 162, Stuttgart 70546, Germany*

* Corresponding author. Tel.: +49 (0) 176/30922128. *E-mail address:* Christian.Kueber@gsame.uni-stuttgart.de; christian.kueber@daimler.com

Abstract

In the last few years the number of offered vehicle derivatives in the multi variant serial production of the automotive industry increased. The existing assembly lines have to manage many ramp ups. It is necessary to increase the product and order flexibility of existing assembly lines to manage these challenges. This paper details the preconditions to learn, which assembly configurations fulfill the requirements of existing, further and future products. Therefore the developed method uses degrees of freedom in the assembly order.

Peer-review under responsibility of the scientific committee of the 6th CIRP Conference on Learning Factories

Keywords: automotive industry; assembly; requirements; planning; flexibility; strategy

1. Introduction

The multi variant serial assembly of the automotive industry is confronted with different challenges like a growing number of car models and global demand changes. It can be managed within the production network but only in a restricted corridor. Therefore, it is necessary to have product and order flexible assembly lines.

Today normally one vehicle architecture can be realized on an assembly line. Vehicle architectures are the platform for different cars, like a front or rear driven architecture. The different car models, also called vehicle derivatives, are based on these architectures. But even the number of the vehicle derivatives, which can be assembled on the same line, is restricted. There are different reasons, like different assembly times between the car models, so they cannot be assembled on the same line economically [1]. The same assembly processes would be located at different positions in the line.

An assembly line normally is planned and configured for one vehicle architecture and their derivatives. The product changes and the ramp-up of new products have an impact on the existing assembly configuration. It has to be analyzed, if they can be assembled on the same line and which reconfigurations are necessary. Each reconfiguration causes costs. These costs can be reduced, if a strategic configuration can be detected, which will allow to assemble different cars with different ramp-up dates.

This paper is based on the modularization of factories and products, synchronizing of the assembly and product life cycle and harmonizing of different assembly configurations [2, 3, 4]. The target is to learn, how existing assembly lines have to be reconfigured, that they can fulfill future product requirements. This is based on already existing learning factory approaches, which allow changing the order of different assembly elements [5, 6].

Before detailing the developed method to increase the flexibility of assembly lines, flexibility has to be defined. In this paper the definition follows the view of WESTKÄMPER. A system is called flexible, when it is reversible adaptable to changing circumstances in the context of a principle preconceived scope of features [2].

In this context flexibility is the ability of an assembly line to be able to react to demand changes in quantity and derivatives in a specific scope.

An analysis in the automotive industry has shown that the same vehicles can be assembled in a different order. These

Peer-review under responsibility of the scientific committee of the 6th CIRP Conference on Learning Factories
doi:10.1016/j.procir.2016.03.051

degrees of freedom can be used to harmonize the assembly processes of vehicle architectures and an existing assembly configuration. A precondition to configure such product flexible lines is the vehicle independent modularization of the assembly processes. The results are assembly modules, which are identical for all the architectures and assembly lines (figure 1).

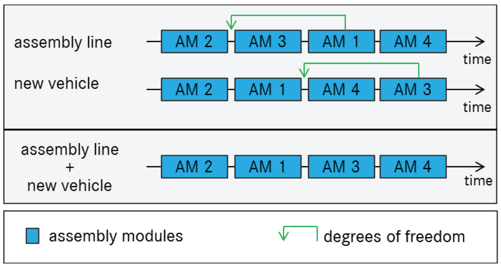

Figure 1: Using degrees of freedom to enable the planning of product-flexible assembly lines

In the following chapters, the preconditions for an adaptable assembly line will be discussed. Further on the method to modularize and configure assembly lines, which are able to handle future products, will be detailed.

2. Preconditions of future assembly lines

An assembly line is comparable with the human immune system. An immunization allows reacting to unknown threats. Also an assembly line can be immunized. A company has to learn how an assembly line has to be configured to increase the product flexibility [7]. Therefore it is necessary to reconsider today´s preconditions (figure 2).

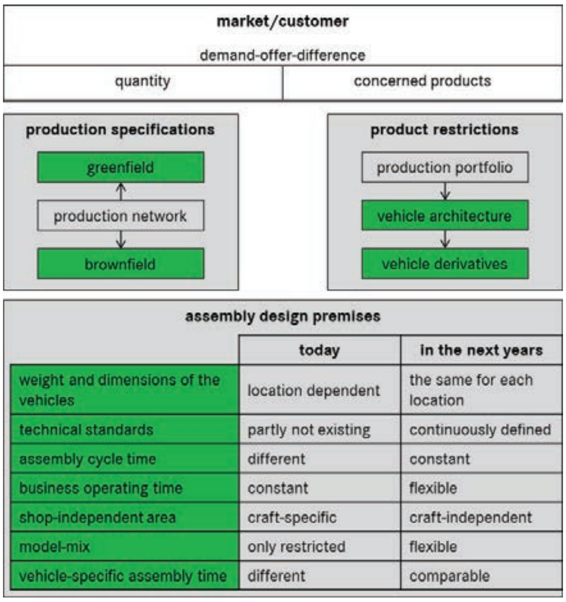

Figure 2: Preconditions of future assembly lines

At the beginning, the market demand has to be determined. Afterwards it can be analyzed, which quantities of the different vehicle derivatives are needed. Based on this information, decisions can be made, whether it has to be planned in a green- or in a brownfield.

A greenfield planning means to plan a new assembly line. That is necessary, if there is not enough capacity in the production network or a new vehicle cannot be integrated in an existing line. Otherwise it is a brownfield planning.

In a brownfield, the assembly time, the business operating time and the area are already defined. Instead of adopting the current conditions of the existing line, they can also be further developed. In this paper, a brownfield planning is focused.

Before starting the planning of an assembly line, the basic requirements need to be defined, which are shown in figure 2. Those were considered in the past. But in the future, there is a need to rethink them. The further development of today's preconditions will be amplified in the following chapters.

2.1. Weight and dimensions of the vehicles

There are many restrictions, which are vehicle dependent:

- the weight
- the dimensions (length, width, height)
- the pick-up points

During the planning process it has to be ensured that present and future vehicles can be assembled on the lines. For example, the conveyor system has to be compatible with the vehicle specific pick-up points and it must be able to handle the heaviest cars. Also the dimensions of the assembly stations have to be big enough. Based on these restrictions, technical standards can be defined.

2.2. Technical standards

The degree of automatization is the most important part of the technical standards for the assembly processes. Countries with a high wage level are called high-cost-countries. In these countries the degree of automatization is normally higher than in low-cost-countries. That is why two different standards are described, for the low- and the high-cost-countries. Automatization is to ensure the product/process quality and/or to improve the working conditions used in several locations.

The benefits of technical standards in automatization are:

- reduced construction costs and less planning time (reason: one-time planning)
- higher transparency and better effects of improvements, (reason: adoption of optimization results to each identical process)

A premise therefore is the consideration of weight and dimensions of the vehicles (chapter 2.1) and the same cycle time of the different assembly lines.

2.3. Assembly cycle time

Today, the cycle time distinguishes between the assembly lines, even if the same cars are assembled. Further on, the assembly cycle time is used to increase or reduce the output. Different cycle times lead to a different assembly content of the stations. It would be impossible to define technical standards like explained in chapter 2.2. Each assembly line