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Procedia CIRP 52 (2016) 80 – 83

www.elsevier.com/locate/procedia

Changeable, Agile, Reconfigurable & Virtual Production

Realising digital connectivity by using interdependencies within a production process.

Georg Kasakow[a,]*, Jan C. Aurich[a]

[a]*Institute for Manufacturing Technology and Production Systems (FBK), 67663 Kaiserslautern, Germany*

* Corresponding author. Tel.: +49-631-205-4210; fax: +49-631-205-3304. *E-mail address:* publications.fbk@mv.uni-kl.de

Abstract

An objective of companies is to create a digital connectivity within a production. To achieve a comprehensively connected production it is necessary to identify interdependencies between elements within a production process. Elements, in this context, are for example the inventory, the machine utilization or the bill of material. This paper shows a method to identify direct dependencies and influences of these elements between each other. An example therefore is the bill of material. The bill of material gives an overview of required parts. An inventory check shows if these parts are available. Missing parts are ordered, available parts are send into production. This shows exemplary an impact of the bill of material on remaining steps in a production process. First, it is necessary to collect these elements within a production process. Following by the identification of the element specification and interdependencies. The result is a concept map that allows an overview of these elements and their interdependencies. These identified interdependences support the realisation of a digital connectivity in a production.

Peer-review under responsibility of the scientific committee of the Changeable, Agile, Reconfigurable & Virtual Production Conference 2016

Keywords: Digital connectivity; Interdependencies; Production Process; Make-to-Order Production Process

1. Introduction

Digital connectivity leads to smarter value adding enterprises. The result is a seamless interaction between supplier and customer that enables new competitive advantages [1]. For this purpose, enterprises have to create a connectivity within the production via combination of tools as embedded systems, sensors and actors [2,3]. A good example for such a combination are cyber-physical products, which enables a connection between equipment and workpieces [4].

Current research focus on the necessity to develop new tools to achieve higher flexibility, autonomy and smart production systems [5,6]. The missing part within the research is an approach to combine these tools, to achieve a digital connectivity. These tools can store, handle, and communicate information, whereby each tool fulfils different requirements depending on its application [7]. However, it is not uniquely defined how to combine and equip these tools to achieve a digital connectivity.

Every production process is individual and has different requirements [8]. This means that there are consequently different ways to realize a digital connectivity by using various tools. It is not sufficient known how to implement and combine these tools in an appropriate way to achieve a digital connectivity in a consisting production. Therefore, an individual combination of the tools is required.

This paper shows a method to identify the requirements of a production process and find a suitable way to realise a digital connectivity for a consisting production. The presented method is described exemplarily on a make-to-order production with a lot size of 1.

Peer-review under responsibility of the scientific committee of the Changeable, Agile, Reconfigurable & Virtual Production Conference 2016
doi:10.1016/j.procir.2016.07.076

2. Procedure of the method

First step of this method is an analysis of the production process. It must be evident which elements are part of a production process. Elements, in this context, are for example inventory, machine utilization or bill of material. Direct dependencies and influences between the elements lead to interdependencies of the production process. Additionally the element specification is to identify. The specification describes the actions and information that elements have to handle. The interdependencies between the elements resulting from this analysis are collected as a concept map. This concept map gives a visual representation of the connections of the production process based on the interdependencies [9]. The visual representation enables an overview of the complete production process.

The next step is to identify the core elements that have the greatest influence on the production process. Requirements for necessary tools derive from these core elements and their specification. The tools must fulfil the element specification. How to connect these tools results from the interdependencies within the concept map. This method facilitates the realisation of a digital connectivity. Figure 1 represents the procedure of the method of realising a digital connectivity.

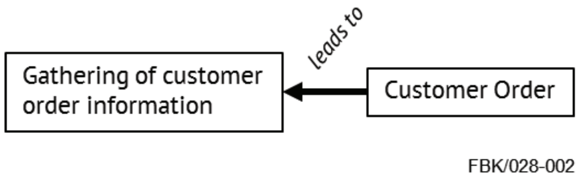

Fig. 2. Representative connection within the concept map

orders a car with a sport suspension and navigation system, it is different as an order for a car with comfort suspension an automated air-conditioning system. This individual bill of material leads to the next element, the "inventory check".

Now the concept map shows that the customer order has an indirect influence on the inventory check. At this point, the inventory check separates the process. If parts of the bill of material are not available, the element "purchasing of missing parts" starts. This element transfers the missing parts to the appropriate "Supplier". The "Supplier" is also an element of this make-to-order production process. It returns the confirmation of the "Delivery date".

If parts of the bill of material are available, the element "Creation of production order" starts. The bill of material has an arrangement as a multi-level bill. The element "Creation of production order" creates production orders based on this multi-level bill. After producing the subordinated part, this element creates the production order for the superordinate part. Created production orders move to the element "Comparison of machine loading".

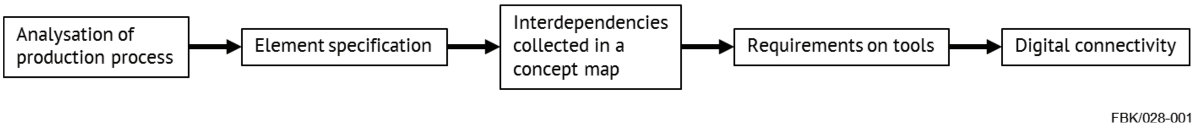

Fig. 1. Realisation of a Digital connectivity

3. Exemplary analysis of a production process

A digital connectivity must adjust to a production process. For the realisation of this digital connectivity, it is necessary to analyse the production process first. The analysis should be done as a concept map, which enables the visualisation of interdependences of elements within a process. The following description bases on a make-to-order production process.

The first element of the concept map is the starting point of the process. For this make-to-order production process, the starting point is a "customer order" [10]. The next step is to identify the following element, which is the "gathering of customer order information". This is for example the date of order and the content of the order. As these both elements build up on each other, they need a representative connection. An arrow that leads from the element "customer order" to the element "gathering of customer order information". See Fig. 2 for an example.

This arrow is the first connection of this make-to-order production process. The next element is the "bill of material" that derives from the customer order content. Each customer order has its own content and therefore an individual bill of material. A good example is the order of a car. If the customer

This element compares the appropriate machine utilization and creates a new element "Ranking". Each machine tool or assembly has its own ranking, which contains all production orders for this equipment. The element "Ranking" returns a feedback, the element "Ranking feedback". This feedback is the date of completion of a production order. The element "Schedule adjustment" compares the "Ranking feedback" and the "Delivery date" from the "Supplier". Based on this it is possible to create a detailed planning for the production.

The described connections are the main process of this make-to-order production process. See Figure 3.

Additionally to these elements of the main process, there are elements that have an influence on it. For example the element "Machine Information". It composes of different other elements like "Wear", "Energy consumption", "Set-up time"

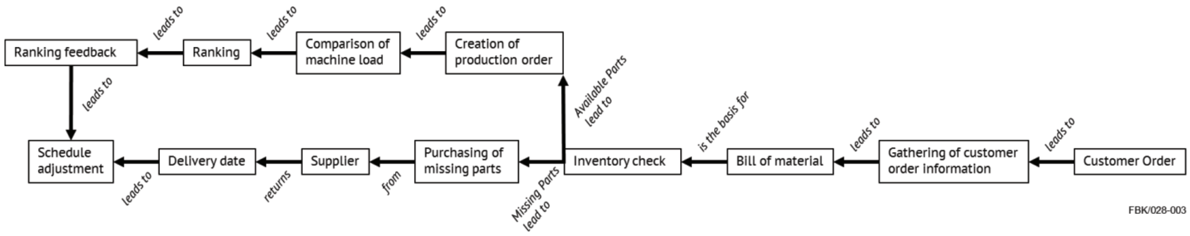

Fig. 3. Main Process

and “Scrap”. According to the composition of these four elements, the element “Machine Information” has an individual influence on the element “Comparison of machine loading” of the main process. Broken lines show the influence connection of these elements in the concept map.

Now all elements of the production process have to be identified and added into the concept map.

which has the ability to store and communicate information. Transport units will be equipped with these embedded systems. The transport unit respectively the embedded system receives the information from the extended bill of material for one production order. This creates a connection between transport unit and production order and stores all information for further actions, for example the order picking.

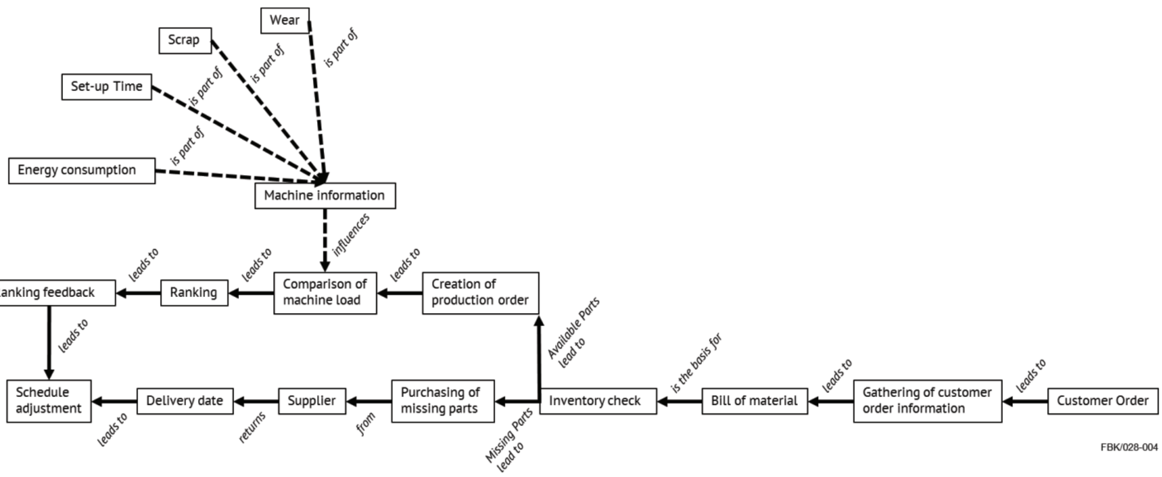

Fig. 4. Influence connection

4. Realisation of a digital connectivity

The concept map represents visually all connections within the production process. It shows an overview of the interdependencies of the production process. Depending on the production process, it is necessary to ascertain the core elements, which have the greatest influence on the process. For the presented make-to-order production process, the bill of material is the core element. According to the structure and the content of the bill of material, all further activities derive from it. Therefore, the bill of material is to extend with additional information, to realise a digital connection. For example, size and mass of a part that leads to the selection of the necessary transport unit. Another example is the name of equipment to determine the destination for each part. The tools, for the realisation of the digital connectivity of this process, is a combination of a trackable tool and an embedded system,

The result of using the presented method on a make-to-order production process is an event-driven production control, which is a reflection of the production process. The control algorithm bases on the extended bill of materials which results from an individual customer order.

5. Conclusion

The presented method enables the collection of elements of a production process and leads to a visual representation of their interdependencies. These interdependencies are a promising approach to realize a digital connection. First, it is necessary to create a concept map of the production process to understand the behavior of a production process. Only if this behavior is clear, a digital connectivity can be realised. To verify this approach it was applied on a make-to-order production process. The resulting concept map was used to realise a digital connectivity of the process and enabled the development of an event-driven production control system.

Acknowledgements

This research was funded by the German research foundation (DFG) within the IRTG 2057 “Physical Modeling for Virtual Manufacturing Systems and Processes”.

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