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Integrated control system simulation for supporting changes of routing strategy in an automated material flow system

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Abstract

Increased demand for customised products, sophisticated scheduling requirements caused by shorter product life cycle and hardly foreseeable disturbances have created a new challenge for the manufacturing industry. Planned production schedules often become ineffective in actual execution on the shop floor. If forecasts become less and less accurate, support for continuous changes is helpful. Given the high degree of automation in manufacturing systems, automatic control systems have become central to shop floors' responsiveness. However, their state-of-the-art architectures are unable to cope with the challenge successfully. Improvements in information and communication technology makes the integration of simulation and control system more promising. The paper proposes an approach for supporting changes of routing strategy in an automated material flow system by utilising the integration. The approach includes (re-)planning of the automated material flow system, commissioning its logic control and controlling the material flow.

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Keywords: Simulation; Control System; Changeability; Automated Material Flow System

1. Introduction

Impacts of globalisation have created a new challenge for manufacturing industry. The possibility for greater integration within the world economy through movements of goods and services, capital, technology and labour is leading to hardly predictable market situation. Customers are coming from all over the globe and demand for more customised products. Besides, global competitors keep competing for introducing new products which effects on shortening the product life cycle. The implications of this situation are the diversity of environments within which the production planning and control system must operate have increased and will continue to do so [1]. In other word the scheduling become more sophisticated and even worst the planned production schedules often become ineffective in actual execution on the shop floor due to barely foreseen disturbance.

As forecasting and planning become less and less reliable, the support for continuous changes is helpful. Short response times and high changeability in layout and in processes for the production and logistics structures are strongly required [2].

Changeability is used as a generic term for various abilities to carry out change within the manufacturing industry [3]. Changeability is defined as a characteristic of a production system that enables an economical, timely and proactive adaptation of all factory components, levels, and processes [4]. Nyhuis et al. differentiates changeability from flexibility by its ability and potential to realize fast adaptation within narrow range of change, both at the organization and the strategic levels, with low investment (Fig.1) [5].

In current practices, ad-hoc solutions have been developed in response to changes, which the implementation often took several months or years. Frequently, the expenses used to implement the solution did not produce the expected payback, since the next change wave often starts while earlier adjustments are still taking place [6]. It will not only deprive of time and cost, unexpected results also might appear during the implementation.

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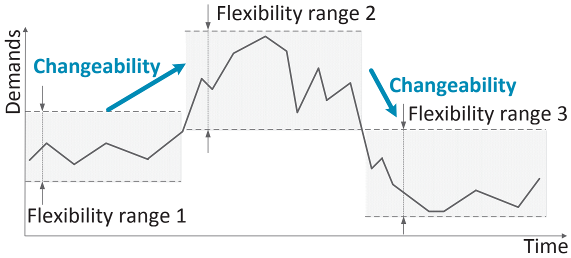

Fig. 1. Flexibility vs changeability [5]

In response to the individual customer's demands and inconsistence market trends has result in small batch sizes production, thereby increasing the number of transport requests together with their routing path. This substantially increases the costs for the entire material flow and their control [7]. Therefore in dynamic production scenarios manual material flow systems are mostly used, as present automated material flow systems are less flexible and changes of their control are difficult in case of complex systems.

However manual material flow systems such as forklift and stacker possess neither highest productivity nor quantifiable advantages like the zero error strategy or time optimised applications. Furthermore manual transportations cause not only high working costs, but also more expose to the surrounding and might reduce quality [7], [8].

Thus improvement in automated material flow systems is still required, which allow operating in cost-efficient and changeable in hardly predictable production environment. A solution lies in the design of autonomous, decentralised controlled material flow system with standardise interfaces on the physical and its control level [7].

Evolvement of ICT has encouraged development of simulation software and broadens their application in manufacturing industry. The latest state-of-the-art simulation software offers automation hardware integration and real time online functionality. The paper will present an approach which utilised simulation capabilities with real time Programmable Logic Controller (PLC) based control system for supporting changes in routing strategies of an automated material flow system. In presenting this approach systematically, the paper is structured as follows: Section 2 will present the state of the art in controlling and reconfiguring of automated material flow systems. Continue with the state of the art in simulation technology that supports automation integration in section 3. Architecture of the integrated control system simulation approach is going to be presented in section 4. In section 5 the approach application study will be described and its outcomes will be explained followed by future perspective and challenges in section 6.

2. Automated Material Flow System

Automation is the independent performance of processes by means of suitable technical means [9]. The main elements of an automated material flow system are the control, sensors and actuators that record and influence the material flow processes such as translocation, i.e. the transport of products (Fig. 2).

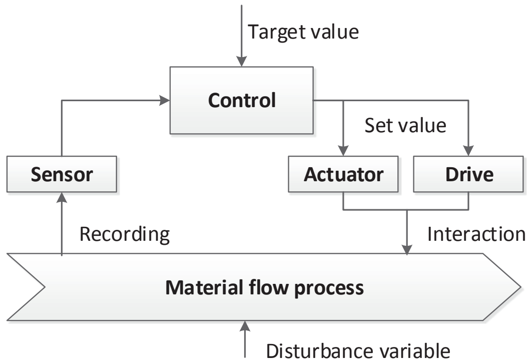

Fig. 2. Principle of automated material flow systems

The standard DIN 19233 defines control as the operation in a system, in which one or several input variables influence the output variables according to the system rules or laws [9]. The material flow control coordinates the flow of material through synchronizing information and material flow, in order to meet the goal, by providing the material on the right time and right place in the desired quantity and quality [10]. The technical structure of a material flow control is mainly determined by the type and number of the processes to be automated. It may either be centralized or decentralized.

2.1. Reconfigure of control system

Most of the automated material flow system particularly in automotive production lines or systems have generally been designed using PLC [11], which is the preferred choice for user-customised automation on the industrial shop floor [12]. An actual control of the system are normally configured once for a designated mechanical structure and routing strategy. If the mechanical structure or their routing strategy is changed, the control system has to be configured again.

Reconfiguration of control system implies a change to the control software or hardware that is initiated by the user and/or by some automatic process. Typically, a change would be required in the event of a system upgrade (software components or mechanical structure)