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Next generation logistics: Reinventing the warehouse by using autonomous vehicle storage and retrieval systems

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Abstract

The development trend of intralogistics, in a variety of industries, is based on the development of new technologies, the introduction of Information and Communications Technology (ICT), the concept of the "Internet of Things" (IoT) connected with the concept of Industry 4.0 and industrial robotization with autonomous vehicles.
By using an interdisciplinary scientific approach by implementing advanced and environmentally friendly technology, these elements together create the condition for new possibilities and dimensions in manufacturing systems of the future (Figure 1).
The modern development of intralogistics systems requires the simultaneous treatment of production and storage infrastructures, transport-warehouse techniques and technology and information support based on a company's material flow. Industry requirements guide scientists to integrate environmental protection standards, ergonomic principles, occupational health and safety standards as well as social and economic impacts within models. Due to contributions of organizing intralogistics in manufacturing enterprises to lower costs and improve customer satisfaction, the demand for transport-warehouse processes optimization by manufacturing companies is growing. In order to meet this demand, there exist many opportunities for research work, such as the application of the autonomous vehicles storage and retrieval systems in intralogistics.
Autonomous vehicles storage and retrieval systems (AVS/RSs) were introduced during the late 1990s to improve the flexibility and responsiveness in warehouses. The main components of an AVS/RS are autonomous vehicles, lifts, and a system of rails in the storage rack area. Autonomous vehicles storage and retrieval systems can be divided for unit-load (pallets) and for totes handling. The latter are also known as Shuttle-based storage and retrieval systems (Figure 2).
Shuttle-based storage and retrieval systems (Figure 2) consist of the elevator with a lifting table that is moving in the vertical direction and is feeding the storage rack. The elevator's lifting table has its own drive for vertical movement. The elevator's lifting table operates on single and double command sequence. The storage rack consist of columns in the horizontal direction and tiers in the vertical direction. At the beginning of each tier is a buffer location, where totes are delivered by the elevator's lifting table. Delivered totes wait for a shuttle carrier to be transferred in the storage rack. In each tier of the storage rack is a single tier-captive shuttle carrier that is traveling in the horizontal direction. The shuttle carrier is an autonomous vehicle with four wheels and has its own drive for horizontal movement. The shuttle carrier operates on single and double command sequence, as well.
In this paper, we will provide a basic description of the next generation logistics with the objective of reinventing the warehouse by using autonomous vehicle storage and retrieval systems. Different types of AVS/RS will be presented along with models for calculating the performance of AVS/RS.

Keywords: Next generation logistics, Internet of Things, Industry 4.0, Intralogistics, Autonomous vehicles storage and retrieval systems, Methods and models, Performance analysis.

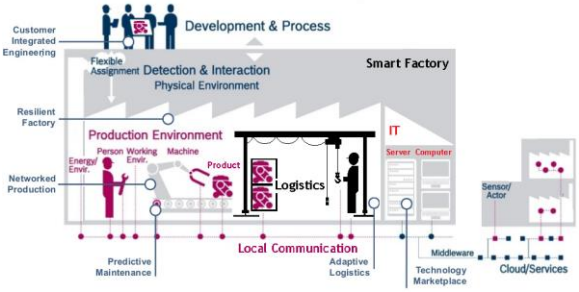

Fig. 1. Manufacturing system of the future

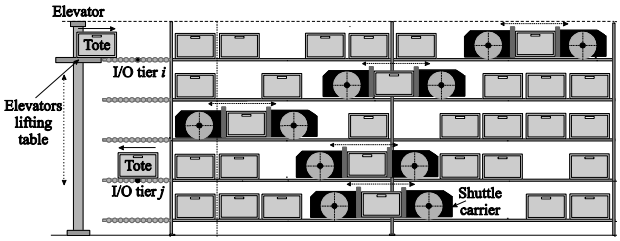

Fig. 2. Shuttle-based storage and retrieval system

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