Cost Efficiency and Profitability through Intelligent Warehouse: Case Study of Unmanned Warehouse "Asia One" in JD Logistics

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Abstract. With the general environment of consumer purchasing power and the popularity of flexible supply chains, many warehousing companies have been based on their own needs for intelligent warehouse transformation, some warehouses for a comprehensive unmanned transformation, while some through the human-machine collaboration to control storage costs. But most of these warehouses to achieve transformation are only used to store one or a class of goods, such as the medicine and equipment industry. Able to carry out a large number and multiple items stored at the same time, intelligent warehouse construction is not popular enough, this paper will be the existing large-scale intelligent warehouse working principle, efficiency results and profit costs, and other aspects of the analysis to explore the large-scale warehouse intelligent transformation can bring specific benefits to the enterprise. The representatives of large, intelligent warehouses Amazon and Jingdong's large and unmanned warehouses have a strong benchmark. In this paper, we select Jingdong's large, unmanned warehouse, "Asia No. 1" and explain the working process and the role of hardware and software systems to find out what advantages the operation of these machines can bring to enterprises, what the competitiveness of intelligent equipment compared with manual labor, and how to help enterprises increase benefits and reduce costs.

1 Introduction

Warehousing is an integral part of the supply chain, in which goods are stored for a certain period and through which consistent product scheduling and delivery can be achieved during export transportation. Now most of the warehousing is a completely manual or human-machine interaction form of operation[1, 2], such forms have been in the current era of the diversity of demand faced with high costs, low space utilization and other issues, the urgent need for the digital transformation of the warehouse operation mode, the direction of this paper is to Jingdong unmanned warehousing as an example, analysis in the process of intelligent warehousing transformation of the digital, intelligent upgrade of various parts of the enterprise cost and revenue The software part explores the operation of WMS, WCS and WES cooperative storage management system, while the hardware part studies the optimization of storage efficiency and cost by three types of AGV carts, visual sorting robot arm and Sirius sorting system.

With the gradual increase of large-scale flexible supply chains and multi-category, low-volume demand, many warehousing facilities to complete the transformation of human-machine collaboration or even fully automated unmanned warehouses, the core of its transformation is focused on the tagging and subsequent tracking of goods, various types of storage systems and automation of storage equipment [3-7]. In terms of commodity tagging identification, the implementation of the introduction of RFID forward and reverse tracking of the commodity transport process greatly enhances the efficiency of the processing of lost pieces when they occur, while more diverse information, many storage and other factors have made it the cornerstone of the intelligent transformation of warehousing [8]. In addition, to WCS, WMS, for example, the role of an intelligent storage management system is generally reflected in the coordination of commodity access, storage space allocation, control of storage equipment and other general direction regulation. The addition of such systems mainly enhances the synergy of the processes and overall efficiency of the storage facilities [9]. Most of the research and practice are only based on the service of a single business warehouse. For many categories, a very large number of intelligent storage construction is still to be researched, and this paper will analyze such intelligent storage facilities carrying diverse needs.

2 Hardware part case study

In the process of building an intelligent warehouse, the most immediate difference from the original form of warehouse operation is the unmanned construction of the grassroots level, the product from storage, sorting to loading the complete process from the former manual

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replacement of different intelligent machinery work, and these processes in intelligent warehousing are assigned to three major hardware systems, respectively, Sirius sorting system, visual sorting robot arm and AGV sorting system, as shown in Figure 1.

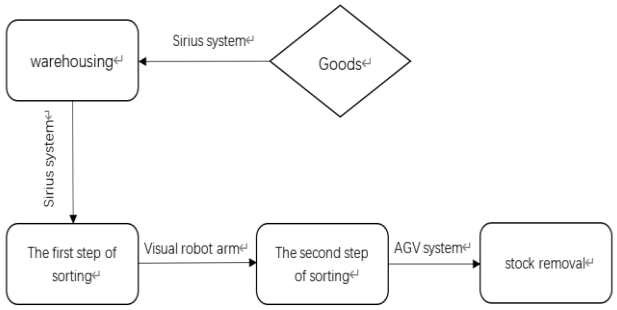

Figure 1. JD's intelligent storage operation process. (Photo/Picture credit :Original)

2.1 Sirius sorting system

Sirius sorting system is a fully automated shelving system, by the horizontal transport of goods in the warehouse shuttle, vertical transport of goods lifting machine, integrated picking, counting as one of the workstations, plus with this picking system connected to the conveyor system. Shuttle car has a compact structure that can be used freely to complete the entire process in a single storage level, so usually, only one shuttle is required for efficient operation. The lift is responsible for transporting goods between the different layers, and the shuttle can also enter the lift so that the two can work together to change layers. The workstations are the monitoring points for the incoming goods, with RFID technology tagging and identifying each piece of merchandise to understand the transport trajectory and other basic information. With the advent of the e-commerce era, the construction of traditional warehouses requires great land use. Tens of thousands of SKUs require manual work to complete picking and handling, which is not only low in actual efficiency, but the long hours of manual work will also lead to an increase in the error rate and even injuries caused by unexpected situations in the transportation process. The application of the Sirius sorting system directly solves the problem of manual work around the clock and the possibility of injury, and its high accuracy rate of 99.99% and RFID technology also greatly reduces the cost of transport errors and retrieval of goods [8]. The use of shuttles and lifts with the entry method also makes the warehouse area more densely discharged, increasing storage space while also greatly reducing inventory costs and helping companies to This helps companies to make more profit.

2.2 Visual sorting robot arm

After the goods have been discharged from the Sirius system, they are conveyed to the first picking step - the vision robot arm picking. The system comprises a six-axis robot system, a vision camera system and an end picker picking system. In the picking process, the robot arm is first given a position to mark a drop point and then rotates to this coordinate [10]. Finally, the captured goods will be placed on the AGV trolley for the next sorting step. In contrast to the usual setup, the robot arm in "Asia One" can position and pick the goods by itself by presenting the coordinates of the goods to the robot arm and by combining vision technology with infrared distance measurement. The advantage of this system is that it enables logistics and warehousing workstations to work 24 hours a day with less than 0.1% manual intervention and a peak efficiency of 600 items per hour, saving a lot of human resources while meeting the current demand for sorting a wide variety and quantity of goods.

2.3 AGV sorting system

A typical AGV system in an intelligent warehouse will be equipped with more than a hundred AGV trolleys operating simultaneously. The trolleys are composed of a power supply system, a control system, and an information system [11], they are also equipped with single or dual motors for basic movements and have steering capabilities. The sorting robot arm grabs the goods and places them on the trolley. The trolley identifies the destination of the goods. It starts to move in a straight line along the magnetic lines laid on the ground according to the navigation system, which can find the best path to the exit according to the algorithm [12]. The ultrasonic and infrared sensors at the front of the AGVs will identify the obstacles ahead and break the AGVs to avoid collision [13]. If the congestion is still detected after waiting some time, the carts will re-plan the road to the shipping point. The transport status and information of each AGV will be networked to the main controller to facilitate the manager's response to unexpected situations and daily inspections. Many trolleys are also equipped to prevent some equipment from running low on power. They are equipped with an intelligent charging strategy that allows them to automatically go to a fixed charging pile when there is no task, or the power level falls below a set threshold. The high current delivery ensures that the trolleys can achieve a charge of 10 minutes and work for an hour. The goods dumped by the trolleys into the warehouse entrance will go into a large woven bag, which will then be carried by the large AGVs to the conveyor for direct transport to the lorry, thus completing the final discharge of the goods from the warehouse. The application of hundreds of AGVs operating simultaneously in intelligent warehouses, through high-precision non-stop rotating operations, in the transport efficiency can even reach ten times the traditional warehouse. And the long service life of the cart, the warehouse to buy the cost of the cart compared to years of labor costs can be said to be a drop in the bucket. Secondly, the whole set of AGV sorting systems can also be increased, reducing the number of carts and workstations to achieve flexible facilities construction, which can better cope with the changing needs of the environment.

3 Software part case study

To achieve the automation of the warehousing process, the use of various types of warehouse management systems for control is essential. Companies available use warehouse management systems (WMS) combined with warehouse control systems (WCS) model to achieve intelligent warehouse from macro-control to the control and monitoring of each intelligent device, and "Asia One" based on the two also has independent research and development of warehouse execution system (WES), through more modular functions, stronger intelligent collaboration and data exchange platform to help enterprises achieve efficient and low-cost intelligent upgrade of the warehouse.

3.1 WMS system

In the traditional warehouse management process, the unreasonable layout of the warehouse, the low utilization of inventory and the lack of accurate data to record feedback and other factors lead to low productivity, inaccurate manual performance, and high costs of all kinds. The WMS is a series of efficiency and cost improvements in warehouse management through optimizing the entire process between inbound and outbound storage of goods. In this paper, the functions of the WMS are analyzed in three processes: inbound, storage and outbound [9]. As shown in Figure 2, after the goods are sent to the warehouse, first of all, the unqualified products will be removed, while the over-checked goods WMS through RFID and other identification techniques to determine their product type and quantity and then divided into the corresponding bin for storage, to be all the goods on the shelves and then the storage space for real-time updates, record the basic commodity information and storage time, to avoid the repeated allocation of bin space to lead to errors. The system will also monitor the storage situation in real time and optimize the storage solution for maximum space utilization according to the algorithm. During the warehousing process, the bill of lading will be downloaded to the Sirius sorting system to formulate the warehousing task, and the shuttle will scan the barcode of the goods when it arrives at the designated location to ensure the task is accurate. The system records the complete goods dispatch process and vehicle information for subsequent logistics tracking.

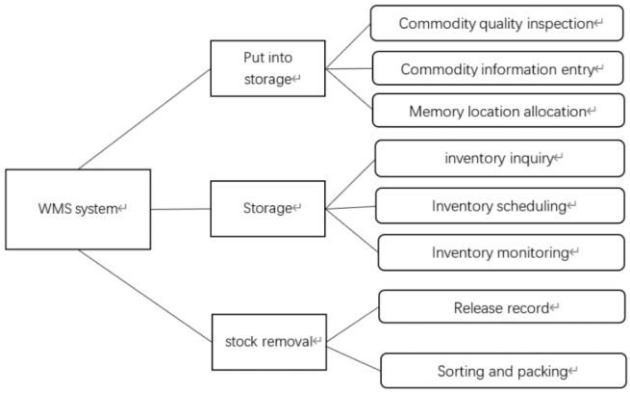

Figure 2. Analyzing the Flow of the WMS System. (Photo/Picture credit :Original)

In addition to conventional goods management, the WMS system contains relevant risk prevention functions, such as inventory warnings. Managers can set up inventory quantity over or under alerts according to the actual situation in the warehouse, and it is to timely production and sales, reduce the cost of additional inventory generated by the enterprise due to inventory backlog and prevent the loss of revenue from the scarcity of goods. RFID-based quality traceability can also be used to quickly provide information such as the date of shipment, batch, and other information to reverse track the transportation of goods in the event of a transportation error, facilitating the discovery of problematic links and timely correction. Overall, the use of WMS systems is the cornerstone of intelligent logistics software, able to replace the macro-control capabilities of several managers, faster and more perfect resource allocation, uninterrupted work and problem-solving, long-term application costs far less than the employment of manual labor and other obvious advantages have made it an inaccessible part of the digital transformation of warehousing.

3.2 WCS system

The function of the WCS system is mainly to assist the WMS system in deploying automation equipment and information feedback. In the management system of the warehouse, WMS is usually a standardized management system; sometimes, it can directly control the operation of automated equipment, but because different warehouses are equipped with different types and numbers of automated facilities. There are fixed settings of the WMS system in connecting these devices that are prone to deployment, maintenance, and other difficulties. Therefore, introducing the WCS system becomes a better choice for the intermediary connection automation system, as shown in Figure 3. The system's main function is to accept instructions from the WMS and, after sorting and combining, to allocate to each intelligent facility and to feed back the working condition of each facility to the WMS, such as the WCS controls the above three hardware systems. Its core function is to control the automation equipment instead of the WMS and to achieve a smooth interaction between the entire management system.

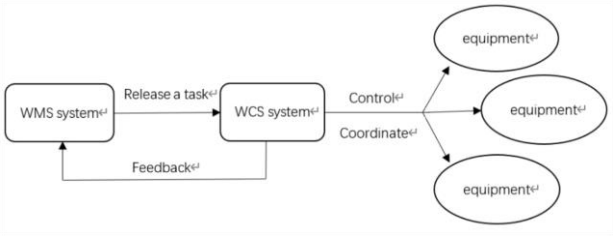

Figure 3. Collaboration between WMS and WCS. (Photo/Picture credit :Original)

3.3 WES system

As a derivative of the continuous progress of intelligent storage technology, WES integrates all the functions of WCS and some of the deployment functions of WMS. Compared with WMS, the WES system has better scheduling capability, which enables higher work efficiency of working equipment and achieves relative load balance of each device. The WES system, independently developed by Jingdong, also has a highly visual interface, which is easy for managers to operate and maintain, and more convenient data exchange for the WCS and robot control system (RCS) developed by Jingdong. Meanwhile, WES can also connect to multiple WCS systems, mainly those with many intelligent equipments. More than 1,000 square meters of super-large intelligent warehouse to achieve scientific and efficient unified management. With the expansion of the scale of storage facilities, intelligent management systems that tend to collaborate on automated, integrated management and control will be further developed and launched.

4 Conclusions

With the overall intelligent transformation of warehousing equipment like "Asia One", more third-party warehousing companies may respond to market demand, providing a greater tendency to multiple types and quantities of commodity storage to prevent individual products due to sudden increases or decreases in demand and other factors that lead to empty warehouses, burst warehouses, such as the risk of reduced profits, but also to increase The flexibility of storage helps companies to generate revenue. In addition, located on the assembly line, more automated equipment and warehouse management is more comprehensive and efficient intelligent storage systems in use. Many low-cost, low error rates, high efficiency, high tolerance rate of intelligent warehouses, or even unmanned warehouse will be presented to the public. In addition to providing people with better quality services, standing in the strategic level of the enterprise, located in the middle of the supply chain of warehousing links to help enterprises to cut costs and increase profit so that enterprises can put more human resources, financial resources, time in other links to enhance its overall advantage, in the increasingly competitive and relatively tight profits in the global market may become one of the keys to seize the first opportunity.

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