OPTIMIZING PICKING OPERATION IN AN OMNICHANNEL WAREHOUSE USING SIMULATION AND AUTOMATION TECHNIQUES

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ABSTRACT – Omnichannel retailing involves the integration of brick-and-mortar stores and online platforms, which can provide a seamless shopping experience to consumers. However, proper functions and features provided by retail alone may not suffice. Therefore, it is imperative to consider the role of the omnichannel warehouse, which offers significant features such as shorter lead time, lower cost, and larger product assortments. Our research focuses on picking operations as it is one of the primary operations in the omnichannel warehouse that consumes a high amount of time, labor, and cost. We aim to enhance the efficiency of picking operations in an omnichannel warehouse through the utilization of simulation and automation methodologies. Flexsim software was selected as the simulation tool after a thorough analysis of available methodologies. We use three modern automated technologies, conveyor belts, mobile robotic fulfillment systems, and automated guided vehicles, and identify the most appropriate picking technique for the omnichannel warehouse through a comparison of simulation models. Finally, we develop a basic framework utilizing operators for executing pickup operations and generating multiple models, incorporating automated techniques. Subsequently, a comparative analysis of all models is conducted based on each scenario's time, distance, and cost to identify the most optimal scenario. To implement the OC concept in future studies, it should include new picking methods, operations, and sectors.

Keywords: Warehouse Optimization; Omnichannel Retailing; Omnichannel Warehouse; Simulation; Automation

1. INTRODUCTION

The supply chain is a process and flows that combine the phase and manage all stages to fulfill the customer's requirement. The retail store represents the ultimate point of contact between the supply chain and its customers. The modern era is currently grappling with omnichannel retailing as a crucial aspect of the retail industry's revaluation. Omnichannel (OC) retail refers to the integration of brick-and-mortar stores and online platforms with the aim to provide a seamless shopping experience to consumers [1]. Mou [2] has defined the primary retail operations to include store layout and design, order fulfillment, sales and returns, inventory management, customer service, and accounting. The seamless shopping experience cannot be achieved without the support of the OC warehouse, as proper functions and features provided by retail alone may not suffice. The omnichannel concept offers significant features such as shorter lead time, lower cost in the supply chain, and larger product assortments through the implementation of omnichannel warehouses [2]. Our study focuses on the picking operation as one of the primary five operations in the OC warehouse [2]. This operation is of particular relevance because of its high time, labor, and cost consumption. Furthermore, modern technology must be considered in the OC warehouse, as the manual technique becomes difficult to adopt when demand increases by more than 30% owing to the installation of OC operations. [3]. This study seeks to discover the most efficient picking method for OC warehouses. Conveyor Belts, Mobile Robotic Fulfillment Systems (RMFS), and Automated Guided Vehicles (AGV) are the most commonly used automation approaches in research [4]. Therefore, we examine each of these techniques in order to improve the efficiency of warehouse-picking operations. Further, we attempt to identify an efficient picking system that utilizes automation and simulation methodologies to meet the demands of customers in the OC warehouse by

ISSN: 2513-2504

conducting a comparative analysis of the effectiveness of each model. The implementation of this efficient picking system facilitates effective order fulfillment and inventory management in OCR, ultimately enhancing the overall shopping experience for customers.

2. MATERIALS AND METHODS

2.1. Data Collection

We use quantitative and secondary data, which is obtained from a small-scale business entity. The dataset comprises 27,000 sales records and more than 4,000 purchase records, organized by date and time of pickup. We conducted data normalization and clearance in order to select Fast Moving Consumer Goods (FMCG), as we focus on this particular area. In addition, the study considers around 1500 Stock-Keeping Units (SKUs) for inventory. When building the warehouse for simulation, standard dimensions are used for equipment and tools.

2.2. Methodology

The result of the study is obtained via simulation software. Literature highlights Flexsim, Anylogic, Plant Simulation, Simulink, and Simcad as the top simulation tools in this domain [4]. The assessment encompassed an analysis of several factors, namely the proficiency of 3D graphic performance, the availability of object-oriented means libraries and functions in software, the utilization of high-level programming language, the implementation of intricate data structures, and the capability to import and export diverse types of data files [4], [5]. After a careful analysis, the Flexsim simulation software was selected due to its ability to effectively execute all required functionalities. To begin, we simulated the manual picking process using single and batch picking approaches in order to determine the best picking approach in OC. Among the several manual picking models, we chose the one that used minimum time, distance, and cost. Then, we implement conveyor belts, AGV, and RMFS for automation as recommended by the literature and compare them to the chosen base model. When comparing models, we gave time a high weight because it is a sensitive and crucial aspect of OCR [3]. The parameters are weighted 40% for time and 30% for distance and cost, respectively. Simulating to complete each order measures time and distance, and the cost to complete the order is determined using the operators' hourly wage and operating cost for each technique.

3. RESULTS AND DISCUSSION

Our study involves the development of a basic framework utilizing operators for the purpose of executing pickup operations (Figure 1). The outcomes of the non-automated model demonstrate that single picking is an s

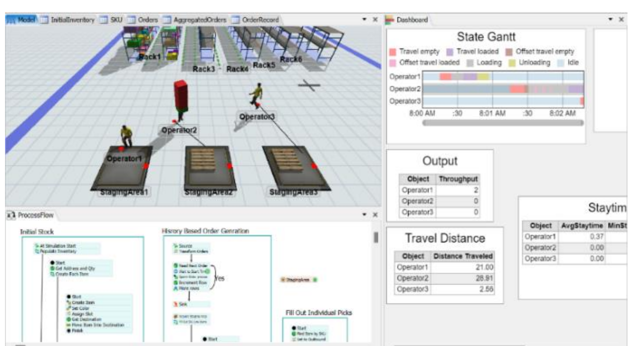

Figure 1. Basic Simulation Model

appropriate method for OC warehouses. We chose the reduced time, distance, and cost-consuming models as our benchmarks by multiplying recorded parameters with weighted factors. Then determine others' performance using this measurement. The single-picking models show higher performance than batch picking since it consumes lower lead time to order complete and low operation cost for orders. The model was established using fixed parameters, including warehouse, racking dimensions, storage systems, and quantities of sales and purchase demands collected from the small-scale enterprise. We adjust certain parameters, such as the loading and unloading time, travel speed of individual operators, and implementation of automation tools, to achieve the most optimal scenario. The automation techniques of conveyor belts, RMFS, and AGV were used to develop models for each technique, incorporating single-picking methods. Based on the non-automated best model, the simulation results compare each automated model with it. Table 2 summarizes the findings of the analysis. Except for conveyor belts, the findings demonstrate that using automated processes enhances performance by more than 80%. Given that the conveyor model employs human operators, it takes longer to complete orders and costs more to run; as a result, it performs worse than expected under the automated model. It has been demonstrated that RMFS exhibits a lower resource consumption in comparison to other models across all three parameters. Consequently, the study asserts that RMFS represents the most optimal automated model for the OC warehouse, with a notable performance increase of 97.5%.

Table 1. Model Output Result of Each Automation Technique

Model	*Average picking time per order (Sec.)*	*Average travel distance per order (m)*	*Cost for order complete (LKR)*	*Utilization*
SP Model 2	514.98	48.97	107.29	0.00%
RMFS Model 1	146.56	31.90	14.41	97.51%
RMFS Model 2	128.15	30.49	25.20	96.36%
AS/RS	160.77	62.45	50.24	81.36%
Conveyor	282.55	106.03	112.40	24.45%

4. CONCLUSION

The omnichannel warehouse PO was the primary focus of this research. Furthermore, the research investigates optimizing the effectiveness of picking procedures in a warehouse that operates in an OC by using automation techniques. Intergrading with all the channels leads to an increased number of orders with shorter lead times, and an effective picking system using automation and simulation techniques necessary to satisfy customer demands in the OC warehouse. The simulation findings demonstrate that the single-picking strategy is appropriate for the OC picking process. Furthermore, using automated procedures boosts the efficiency of the picking activity by more than 80%. We suggest RMFS with a single-picking method is the most optimal picking system that uses automated approaches to meet customers' demand in the omnichannel warehouse. This optimal solution decreases the lead time required to complete customer orders more cost-effectively. It also helps with order fulfillment and inventory management. As a result, our customers in OCR benefit from a seamless shopping experience due to effective and efficient picking operations in the OC warehouse.

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