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DESIGN AND SIMULATION OF A MULTI-SPECIFICATION AND SMALL FLOW FLEXIBLE STORAGE SYSTEMS

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Abstract
This paper conducts innovative research on the stand-alone equipment and warehousing mode in the automated warehousing system to address the automatic warehousing of various specifications of products in small and medium-sized enterprises in China. The research proposes a new type of robotic storage device and storage method. Furthermore, the proposed storage scheme is simulated, and the results show that the scheme is feasible. In addition, the system layout was optimized based on the simulation results. This research proposes a new solution for the automatic storage problem of multi-specification and low-traffic products and, at the same time, proposes new storage devices and models, which enrich the research in the field of automatic storage.
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Key Words: Flexible Storage, Multi-Variety, Multi-Specification, Small Flow, Multi-Specification Rack, Interchangeable Fork Stacker

1. INTRODUCTION

As the core and hub of a modern logistics system, the ASS (automated storage system) is vital for firms to optimize production efficiency and benefits. In the past, enterprises have tended to produce vast numbers of single-species products to enhance their response time. However, with the rapid change of the market and the needs of customers becoming more diversified, as a result, this makes more enterprises gradually move from the previous single variety of mass production to multi-variety, multi-specification, and small-batch production [1]. Depending on statistics, enterprises using this production method account for 70 percent to 90 percent of the proportion in various manufacturing industries [2]. Li [3] explores management decisions in a multi-variable small-batch product manufacturing process in a discrete manufacturing environment. Therefore, multi-variety and small-batch production has gradually become the mainstream product manufacturing to cope with this shift in market demand, improve customer satisfaction, and boost enterprise competitiveness [4]. However, it is harming the production efficiency and benefits of China's small and medium enterprises and is becoming the main obstacle to the high-quality development of the manufacturing industry [5]. For customized production, the limited resources of a single manufacturing company have been difficult to independently and quickly respond to the personalized needs of high-frequency changes [6]. For example, this production model has put forward higher requirements for warehouse management. The traditional single-item inventory management has been unable to meet the need of the current development of the logistics industry.

The production model of multi-variety and small-batch orders has become the focus of manufacturing enterprises [7]. This production model has a wide variety of materials, and demand and demand-time are uncertain, leading to the inapplicability of automated three-dimensional warehouses with large flows. The box-stacker can only carry out part of the hybrid storage of multiple specifications with the height limitation, and it cannot carry out high-shelf storage in a restricted area. In addition, the use of automation and manual mixing in storage or sorting can reduce overall productivity. The current storage system cannot solve these multi-variety, multi-specific, and small-flow cargo automation storage problems and will increase the cost of construction and management. However, some SMEs, such as large department stores, and household appliances, face this automated warehousing problem. So, to adapt to the current production model and market demand, how to improve the flexibility of ASSs to improve multi-variety, multi-specific, and small-flow cargo automation storage problems is a problem that urgently needs to be addressed.

Adaptive automation technology can automatically adjust its behaviour to improve work efficiency and respond to changes in a complex environment [8]. In other words, flexible automation technology is the means of accelerating product renewal to meet the dynamic needs of the market. Therefore, to help the storage industry adapt to the change in material storage characteristics, there has been considerable research to improve the flexibility of storage systems, such as multi-specification or combined shelves, stacker equipment composition optimization, and job scheduling optimization. However, after reading relevant literature at home and abroad and investigating the current state of the market storage system, discovered the ASS with many goods of species, many specifications, and small flow still has the following issues:

- The limitations of shelves on the specifications and storage tools of materials,
- The limitations of stackers on materials specifications and storage tools for materials,
- Building an automated warehousing system usually involves high construction costs,
- Energy-saving problems include heavy automatic storage equipment having enormous power and energy consumption.

Therefore, to adapt to the change in the production pattern and versatility of storage requirements, this paper designed a system based on interchangeable goods forks, stacker machines, and automatic flexible storage systems to solve the problem of automatic storage of products with multiple specifications and small flow. It also provides novel insights into ASS research.

2. LITERATURE REVIEW

2.1 Stacker

Stackers are a kind of automated warehouse handling equipment that consists of frames, operational mechanisms, lifting mechanisms, cargo platforms, pallet forks, electrical equipment, and safety protection devices [9]. Baryshnikova [10] gives the design ideas and vital points of these components. Among them, stacker scheduling and structure are vital factors to consider.

Firstly, frequently used research methods for scheduling the optimization of stackers to include establishing target models and simulation. For example, optimize scheduling targets [11, 12]. In terms of path optimization, optimization of stacker crane path based on the cost matrix and improved greedy algorithm [13] or by establishing a model for the problem of the stacker's path selection [14]. The above kind of optimization belongs to external optimization, which has a significant reference value for the operation of the stacker designed in this paper, such as the overall scheduling design of compound picking mode and shortest path.

Secondly, designing or transforming the equipment composition of the stacker. For instance, to increase the number of goods that the stacker can carry at one time, a stacker with a double extension cargo-fork can be installed in parallel [15] to improve the efficiency of the stacker. In addition, research on the cargo-fork includes the structure that makes it easy to replace the new cargo-fork [16] and the flexible and telescopic cargo-fork [17]. At the same time, the performance parameters of the stacker can be optimized [18]. Incorporate the benefits of the previous research throughout the operating system to design a new stacker. In addition, the stacker design also includes a control system. For example, the design and control scheme of an automatic logistics system based on PLC [19], Nagano et al. [20] proposed a simulation method for speed development and verification, and Siciliano et al. [21] proposed a control strategy for a new dynamic mixed pallet warehouse based on system control, the ability to alleviate their throughput bottlenecks.

By summarizing the literature reviewed above, aiming at the ASS problem characteristic defined in this paper, although some researchers are designing stackers for a multi-specification problem, the specification still has definite limits. So, this paper will provide a novel solution for stackers in such application scenarios.

2.2 Multi-specification shelves

The shelf is one of the indispensable pieces of equipment in an automatic, three-dimensional warehouse. However, research on multi-specification shelves started from the fact that the goods of many orders were of different sizes and scattered, which caused difficulties for the traditional sorting method. In this regard, Boysen et al. [22] proposed an automated three-dimensional warehouse system with numerous devices, such as mixed shelf storage, dynamic order processing and batch processing, and a partition and sorting system. This concept gives many thought directions for the research of multi-specification shelves.

In terms of multi-specification shelves, there are drawer-type shelves of various specifications [23] or rapid-assembly three-dimensional shelves of unit type [24]. Changing the shelf's width can be done by moving the load-bearing plate left and right [25]. At the height, an alteration device uses perforations at the four corners of the placing plate [26]. Similarly, the crossbeam shelves can be modified by changing the buckles connecting the beams and columns [27].

According to the above literature research, the width adjustment is generally for the load-bearing plate, and the height adjustment is for the beam-type rack. According to market research, snap-on beam shelves are the most commonly utilized. In addition, most of the goods stored on the shelves designed in the literature belong to the same carrying method. However, the research goal of this paper is to design a multi-specification rack so that the goods can be carried in various ways. Therefore, the design of the shelf will start with the structure of the buckle type beam shelf and combine the standard beam type shelf equipment into a multi-specification shelf.

2.3 Flexible storage systems

The global manufacturing trend is gradually changing from the erstwhile single-specification to multi-specification and multi-variety. The manufacturing industry introduced flexible manufacturing into the aforementioned automated manufacturing systems to meet production demand and improve manufacturing system flexibility [28]. Flexibility refers to a system's ability to cost-effectively respond to changes in quantity requirements, product mix requirements, machine status, and processing capacity. At the same time, flexible automation technologies allow companies to shorten product life cycles and increase product variety [29]. With the rise of multi-variety and multi-specification production models, warehousing, as a core component of the supply chain, is gradually transforming from the previous automated warehousing to flexible automated warehousing.

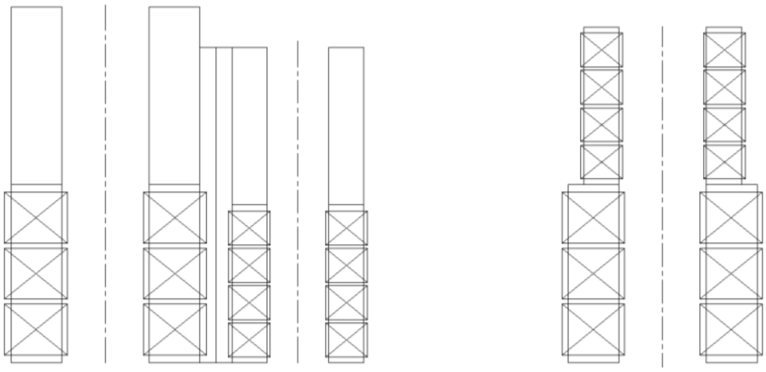
However, Custodio and Machado [29] pointed out that the lack of flexibility in automated warehouses has become a bottleneck, and the key to achieving flexibility lies in the combination of automation equipment, data acquisition techniques, and management solutions. Based on the change in production form, improving production flexibility can shorten the production process's waiting time [30]. Based on automation technology and equipment, it can also improve the way physical information is integrated to improve the warehousing process's operational efficiency [31]. Furthermore, optimizing racks and stackers can improve overall operational efficiency, lower logistics costs, and increase revenue [32]. The inspiration for the above research for this paper is that enterprises can reduce the costs of operations and improve work efficiency through the design of automation equipment and the rational use of resources.

3. RESEARCH METHOD OF FLEXIBLE STORAGE SYSTEM

3.1 Research on stand-alone equipment

1. Multi-specification shelf

Depending on the current state of multi-specification rack research, beam-type racks are primarily used for pallet storage, but multi-specification and multi-carrier means are restricted. This paper proposes a multi-specification shelf mode according to the composition of beam-type shelves. The shelf can store goods of diverse specifications simultaneously and can use pallets and cartons for hybrid storage at the same time. Fig. 1 shows the combination of multi-specification shelves. First, only one specification for the same direction of the material is suitable for batch storage and storage. The second is that there are multiple specifications in the same row. This storage method is suitable for items of various specifications that must be mixed in and out of storage.



a) Single row unified specification shelf b) Single row mixed specification rack

Figure 1: Two kinds of multi-specification shelves.

The composition form of multi-specification shelves is still the ordinary hanging buckle-type beam shelf on the market. Adjust the shelves' height and width by hanging buckles. In the vertical direction, the goods' specifications are consistent. This multi-species rack can also accommodate mixed storage of cartons, turnover boxes, and pallets–store cartons and turnover boxes by adding four support structures similar to a small upright on the beams. The purpose is to leave pickup space for the forks. This storage mode is an innovation of the aisle-type three-dimensional warehouse, which improves the adaptability of high-rise shelves to product changes.

2. Replaceable fork stackers

This paper studies the tunnel-type stacker to meet the requirements that the beam-type racks can transport various specifications. Given the operation requirements of multiple specifications and small-flow, this paper proposes a stacker that can exchange different forks for picking up different-sized materials. Furthermore, different material specifications will not limit high-rise shelves, and the material-carrying method can be expanded simultaneously. In this paper, a stacker is intended to serve the entire warehouse, reducing the number of stackers while still meeting the warehouse's storage needs. This stacker can help businesses save money on equipment by avoiding the purchase of multiple pieces of stand-alone equipment with unique specifications.

In addition to the standard components, the stacker includes fork storage, primarily used to store forks and facilitate fork replacement from the rack. Among them, the structure of the fork's base is the same, making it easier to replace. Different widths and lengths can be adjusted according to material specifications. Fig. 2 depicts the stacker's facade structure, including the stacker's rack, the storage platform, and the shelf's lowest position. The total height of the shelf is similar to the highest point of the goods. Forks need to be designed according to specific material specification requirements, as shown in the case section.

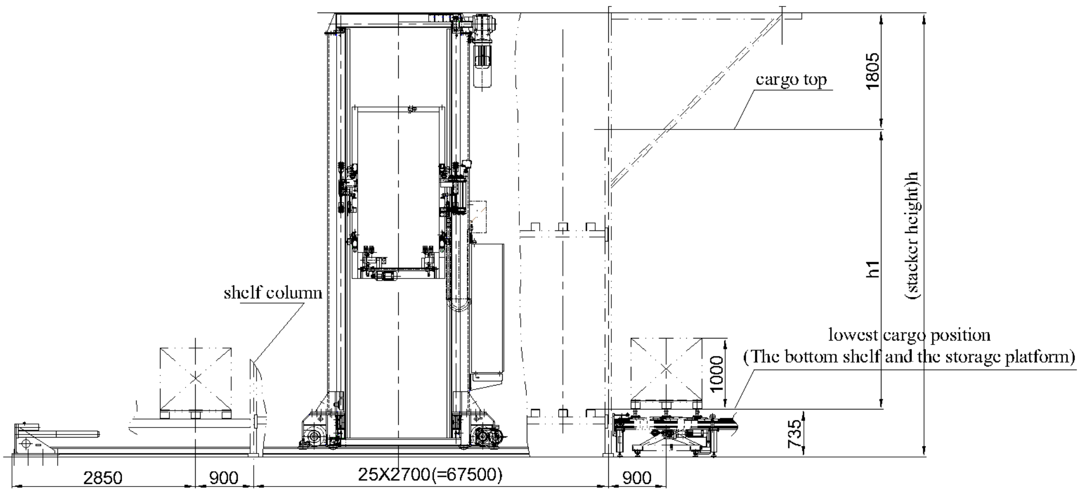


Figure 2: Frame diagram of the stacker.

3.2 Case scheme design of a flexible storage system

The case object of this article is the logistics distribution centre A of a supermarket that sells daily necessities. As we all know, department stores have a wide variety of goods in different sizes, which is entirely consistent with this paper's type of research object. The scheme design will be introduced from material specification design, cargo-fork design, and cargo-fork library design. Finally, the case's overall design plan for the flexible storage system will be given. In addition, the data in this section is based on assumptions made based on the dimensional requirements of the material combined with the data commonly used in the market.

1. Material specification design

Four sizes are designed for A. The size of the main A1 is 525×650×850 mm, and its packaging is the smallest among the four materials. Therefore, A1 can use two loading methods: turnover boxes or pallets for storage and the other is directly using standard cartons for single material transportation to reduce the cost of carrying equipment. Considering the expansion of hybrid storage, the A1 will utilize box loading to transport directly.

The second, third, and fourth materials are A2 (800×1000×1000 mm), A3 (900×1300×1800 mm), and A4 (900×900×1800 mm) (this data includes the pallet). These three materials are relatively large in volume and weight, so wooden pallets will be used to carry and transport such heavy packaging items to reduce the friction between the box and the conveyor belt caused by the weight of the items. At the same time, it ensures the items' safety and stability during transportation and avoids damaging the box's contents.

2. Fork and fork library design

According to the four material specifications designed above, there are four corresponding forks (Fig. 4). Among them, the structure principle of the fork equipment is the same, and the structure is similar, which is conducive to mass production. In the production process, it is only necessary to modify the size of the part according to the size required by the material. Except for A1, which uses a single fork, the other three materials use a double fork.

The position of the fork warehouse can generally be set above the in-out platform of each material or in the middle position above the in-out platform. The simulation results in Section 4 will give priority to these two positions. Locating above the inbound and outbound platforms saves floor space and enables the stacker to pick up and store goods from the nearest inbound and outbound platforms after exchanging forks, saving time. In addition, equipment for the forks is provided with an automatic transfer platform, which facilitates the automatic and rapid exchange of the forks and reduces the time required to exchange forks.

3. The overall scheme design of the case

The case's overall design scheme is based on primary data, and the shelves are composed of four goods in a 1:1:1:1 ratio, with the layout based on the fewest stackers possible. In addition, Table I shows the shelf data of the good, indicating the number of trays and explicitly giving the number of rows, columns, and layers of the shelf. This data will serve as the primary data used in the fourth part of the simulation.

Table I: Display of specific data shelves.

Material	**Length×width×height** (mm)	**Number of goods** (Column×Row×Layer×Number of Grids)
A1	525×650×850	11×2×15×4 = 1320
A2	800×1000×1000	10×2×15×3 = 900
A3	1050×1300×1800	12×2×9×2 = 432
A4	1050×900×1800	12×2×9×2 = 432
Total number of goods	-	3084

The design scheme includes warehouses, stacker cranes, and inbound and outbound platforms. Among them, the racks are connected to the racks through the replacement path of the stacker guide rails. By utilizing track change technology, the number of stackers can be less than the number of roadways to meet the needs of enterprises, reducing the purchase of stackers while meeting the inbound and outbound flow. At the same time, it also reduces the cost and idle resources of the enterprise and maximizes the judicious use of resources for the enterprise. The warehouse layout is shown in Fig. 3. The layout scheme of the storage system can improve the flexibility of the previous unified specification storage system and address the problem of enterprises with multiple varieties, specifications, and small flows.

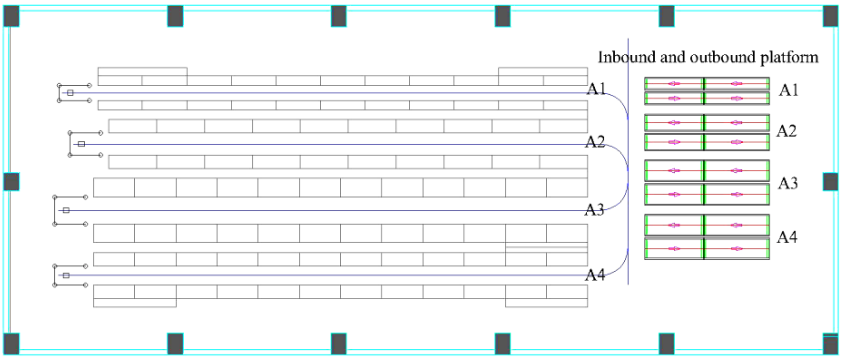


Figure 3: Case design diagram of a flexible storage system.

4. SIMULATION RESULTS

The simulation software used throughout this paper is AutoMod 12.6 because this software is suitable for logistics simulation. The main work of this section has three parts:

- To model the flexible warehouse system scheme in Section 4,
- Write code based on the current process,

- The parameter debugging and optimizing is carried out according to the enterprise's need to ensure the system's regular operation.

4.1 Modelling of flexible storage systems

First, modelling is carried out according to the overall design scheme in Fig. 3, but there are places in the modelling software that do not meet the requirements of the flexible storage system. For example, the stacker designed in this article needs to change rails, but in the ASRS system in AutoMod software, one stacker is used for each channel by default and cannot change track. In order to address this problem, this paper will use the PathMover system in the software instead and adjust the trolley parameters in PathMover to be consistent with the stacker parameters. Also, queues will be used instead of shelves, but the shape of the shelves will remain in the simulation model. The established simulation model is shown in Fig. 4, including the ASRS system, PathMover system, and conveyor system.

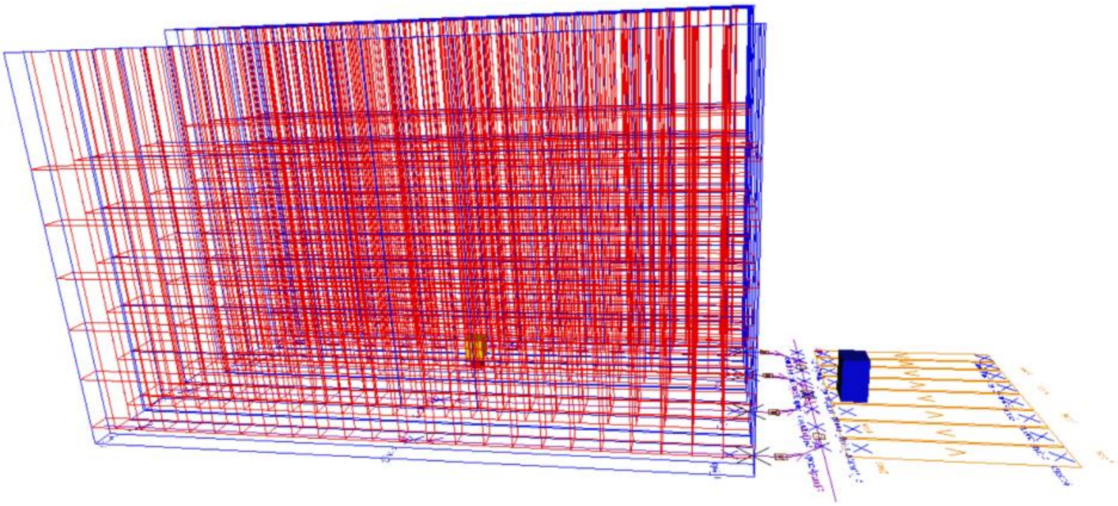


Figure 4: Modelling diagram of flexible storage system.

Among them, the equipment parameters of the stacker are set according to the commonly used parameters in the market: the running speed is 180 m/min, the horizontal acceleration is 0.5 m/s^2, the goods pick up time and set down time is 11 s, the fork changing is 10 s, and the running time is 8 hours. The supplementary material will present the complete code according to the pre-set storage process.

4.2 Analysis of simulation results

First of all, this paper simulates different positions of the cargo-fork storage under other equal conditions. One position is above the in-out platform of each material, and the other is in the middle of the total in-out platform. According to the simulation results, it is found that setting the fork library in the middle of the platform can reduce the equipment utilization by 2.2 % of the stacker, but the difference in transportation efficiency is not significant. It can be seen that it is better to put the cargo-fork storage in the middle.

The second is tantamount to analysing the equipment utilization rate of the fork and the working capacity and equipment utilization rate of the stacker. In this paper, the feeding speed of the four materials is randomly set as A1 is a constant at 10 minutes, A2 is normal at 9.3 minutes, A3 is uniform at 7.3 minutes, and A4 is uniform for 7.5 minutes. Four materials are randomly set to different delivery speeds according to the above arrival speed. For example, A1 waits 60 minutes, A2 waits 40 minutes, A3 waits 20 minutes, and A4 waits 30 minutes. The ultimate running result is shown in Fig. 5.

```
*** AutoMod 12.6 ***
Model min
Statistics at Absolute Clock = 8:00:00.00, Relative Clock = 8:00:00.00

Queue Statistics
Name          Total  Cur  Average Capacity  Max  Min  Util  Av_Time  Av_Wait
==============================================================================
Space          232    0    0.00 Infinite     1    0    --     0.00
Qin(1)          47    6    5.69 Infinite     7    0    --  3486.81
Qin(2)          54    4    4.48 Infinite     7    0    --  2387.33
Qin(3)          66    3    2.87 Infinite     5    0    --  1253.24
Qin(4)          63    3    4.03 Infinite     6    0    --  1842.33

Resource Statistics
Name          Total  Cur  Average Capacity  Max  Min  Util   Av_Time  Av_Wait  State
=====================================================================================
Rhuocha(1)     156    0    0.05    1    1    0  0.054    10.00    0.00    Up  ----
Rhuocha(2)     188    0    0.07    1    1    0  0.065    10.00    0.00    Up  ----
Rhuocha(3)     226    0    0.08    1    1    0  0.078    10.00    0.00    Up  ----
Rhuocha(4)     213    0    0.07    1    1    0  0.074    10.00    0.00    Up  ----

Vehicle Statistics
     Delivering            Retrieving           Going To Park       Parking
 Percent      Average  Percent      Average  Percent      Average  Percent
Of Total  Trips  Time/  Of Total  Trips  Time/  Of Total  Trips  Time/  Of Total
  Time    Made   Trip     Time    Made   Trip     Time    Made   Trip     Time
==============================================================================
DefVehicle:
  0.348   444   22.56   0.209   445   13.55   0.179   783   6.60   0.263
All DefVehicle:
  0.348   444   22.56   0.209   445   13.55   0.179   783   6.60   0.263

Station Statistics
Name          Total  Cur  Average Capacity  Max  Min  Util  Av_Time  Av_Wait
==============================================================================
staout1_1       41    0    0.01 Infinite     1    0    --     6.00
staout1_2       50    0    0.01 Infinite     1    0    --     6.00
staout1_3       63    0    0.01 Infinite     1    0    --     6.00
staout1_4       60    0    0.01 Infinite     1    0    --     6.00
```

Figure 5: Simulation results of flexible storage system.

Four Rhuocha in Fig. 5 represents the four forks with usage rates of 4 %, 4 %, 7 %, and 6 %, respectively. Four queues represent the shelves corresponding to the four materials, and the total quantity entering the queue represents the total storage quantity. According to the outbound points designed in the Conveyor system, the outbound quantity is Staout1_1, Staout1_2, Staout1_3, and Staout1_4. The total number of outbound points is the outbound quantity. According to the simulation results in Fig. 7, Eq. (1), the working capacity of the stacker (DefVehicle).

$$A_S = \frac{Q(1)+Q(2)+Q(3)+Q(4)+Staout1\_1+Staout1\_2+Staout1\_3+Staout1\_4}{8} = 55.5 \text{ PL/h} \quad (1)$$

From the above results, it can be seen that the in-out capacity of the stacker is 55.5 PL/h, and the utilization rate of the stacker is (1 – 0.263) % = 73.7 %.

According to the above simulation results, it is proved that the flexible storage system scheme designed in this paper is feasible. Secondly, the working efficiency of the stacker can typically meet the enterprise's inbound and outbound flow requirements.

5. DISCUSSION AND CONCLUSION

The production method of multiple specifications and small batches is already inevitable. This paper proposes a flexible storage system to solve its automatic storage problem. The system mainly consists of stackers with replaceable forks and multi-size racks. The system can change how goods are transported in a stereoscopic warehouse through mixed storage such as cartons, turnover boxes, and pallets. And stackers with no limitation on the size of the goods. In addition, the storage efficiency of a single specification stacker is usually 60 PL/h, while the storage efficiency of the multi-size stacker studied in this paper is 55.5 PL/h, which means that about 5 PL of time is lost to switching to other sizes. However, its efficiency can still meet enterprises' inbound and outbound traffic needs. This solution will effectively solve the automatic warehousing of multi-specification and low-flow products for small and medium-sized enterprises.

This paper discusses the theoretical significance of the paper from three distinct aspects. One is tantamount to overcoming the limitations of the roadway stacker on product size and carrier. The stacker studied in this paper can handle products of various specifications and store them in cartons, turnover boxes, or pallets, depending on their weight. On the other hand, this paper proposes a new combination method based on ordinary shelves, which breaks the restrictions on product size and the carrying form of vertical warehouses. Finally, based on the combination of the first two devices, a new automated storage mode is proposed, which proposes a new solution to the problem of multi-specification and low-flow. In addition, it enriches the theoretical research on automated warehousing systems.

The limitation of this paper is contained in the efficiency problem. For example, if a stacker serves the whole warehouse, the flow in and out of the warehouse is necessarily lower. If the outbound and inbound flows of the enterprise are significant, they still need to add to the number of stackers. The advantage of this study is that there is no need to have a stacker for each specification, lowering the enterprise's equipment costs. Compared with automated and manual hybrid storage, this study adopts a fully automated method with efficiency advantages. In general, the solution set out in the present study is more advantageous.

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SUPPLEMENTARY MATERIAL

```
begin Pfuzhi arriving
 set Vr(1) to 0
 set Vr(2) to 0
 set Vr(3) to 1
 set Vr(4) to 0
 send to die
end

begin Pstart arriving
  if load type = L1 then
   begin
   move into Conv.stain1
   travel to Conv.stain1_1
   end
  else if load type = L2 then
    begin
    move into Conv.stain2
    travel to Conv.stain1_2
    end
  else if load type = L3 then
    begin
    move into Conv.stain3
    travel to Conv.stain1_3
    end
  else if load type = L4 then
    begin
    move into Conv.stain4
    travel to Conv.stain1_4
    end
  send to Ph
end

begin Ph arriving
  wait until Vc=0 and Vh=0
   if load type = L1 then set AX to 1
   if load type = L2 then set AX to 2
   if load type = L3 then set AX to 3
   if load type = L4 then set AX to 4
  inc Vh by 1
  send to Pm
end

begin Pm arriving
  if Vr(AX)=1 then
    begin
    move into PM.cpin(AX)
    send to Pruku
    end
  else
    begin
    if Vr(1)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph1
      use Rhuocha(1)
      dec Vr(1) by 1
      end
    if Vr(2)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph2
      use Rhuocha(2)
      dec Vr(2) by 1
      end
    if Vr(3)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph3
      use Rhuocha(3)
      dec Vr(3) by 1
      end
    if Vr(4)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph4
      use Rhuocha(4)
      dec Vr(4) by 1
      end
    dispatch PM.DefVehicle(1) to PM.cph(AX)
    use Rhuocha(AX)
    inc Vr(AX) by 1
    travel to PM.cpin(AX)
    move into PM.cpin(AX)
    send to Pruku
    end
end

begin Pruku arriving
  set AL to oneof(1:1,1:2,1:3)
  if load type = L1 then
    begin
    travel to PM.cp1_(AL)
    move into Qin(1)
    dec Vh by 1
    wait for 60 min
    send to Ppuan
    end
  else if load type = L2 then
    begin
    travel to PM.cp2_(AL)
    move into Qin(2)
    dec Vh by 1
    wait for 40min
    send to Ppuan
    end
  else if load type = L3 then
    begin
    travel to PM.cp3_(AL)
    move into Qin(3)
    dec Vh by 1
    wait for 20min
    send to Ppuan
    end
  else if load type = L4 then
    begin
    travel to PM.cp4_(AL)
    move into Qin(4)
    dec Vh by 1
    wait for 30 min
    send to Ppuan
    end
end

begin Ppuan arriving
  wait until Vc=0 and Vh=0
  inc Vc by 1
  if Vr(AX)=1 then
  begin
    if load type = L1 then move into PM.cp1_(AL)
    if load type = L2 then move into PM.cp2_(AL)
    if load type = L3 then move into PM.cp3_(AL)
    if load type = L4 then move into PM.cp4_(AL)
    travel to PM.cpout(AX)
    move into Conv.staout1_(AX)
    dec Vc by 1
    travel to Conv.staout(AX)
    send to die
  end
  else
    begin
    if Vr(1)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph1
      use Rhuocha(1)
      dec Vr(1) by 1
      end
    else if Vr(2)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph2
      use Rhuocha(2)
      dec Vr(2) by 1
      end
    else if Vr(3)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph3
      use Rhuocha(3)
      dec Vr(3) by 1
      end
    else if Vr(4)=1 then
      begin
      dispatch PM.DefVehicle(1) to PM.cph4
      use Rhuocha(4)
      dec Vr(4) by 1
      end
    dispatch PM.DefVehicle(1) to PM.cph(AX)
    use Rhuocha(AX)
    inc Vr(AX) by 1
    send to Pchuku
    end
end

begin Pchuku arriving
  if load type = L1 then
    begin
    travel to PM.cp1_(AL)
    move into PM.cp1_(AL)
    end
  else if load type = L2 then
    begin
    travel to PM.cp2_(AL)
    move into PM.cp2_(AL)
    end
  else if load type = L3 then
    begin
    travel to PM.cp3_(AL)
    move into PM.cp3_(AL)
    end
  else if load type = L4 then
    begin
    travel to PM.cp4_(AL)
    move into PM.cp4_(AL)
    end
  travel to PM.cpout(AX)
  dec Vc by 1
  move into Conv.staout1_(AX)
  travel to Conv.staout(AX)
  send to die
end
```