

RESEARCH THE DIGITAL TRANSFORMATION MODEL OF MATERIALS MANAGEMENT IN VIETNAM GARMENT COMPANIES

LA THI NGOC ANH¹, NGUYEN THI HANH¹,
HOANG THANH THUY¹, NGUYEN KIEU OANH²

¹Hanoi University of Science and Technology,
1st Dai Co Viet, Hanoi, Viet Nam

²National University of Arts Education

DOI: 10.17973/MMSJ.2023_10_2023058

anh.lathingoc@hust.edu.vn

This article introduces a warehouse management model of raw materials in the factory thanks to MS Access that allows updating information about raw materials in stock, searching for materials, reporting - statistics, calculating inventory, locate storage and assign smart identifiers to materials. This solution completely transforms the content of the "job ticket system" in the warehouse management process into a visually electronic management system through the material inventory management software. The system allows access to information about materials such as production plans, suppliers, orders, order information, raw materials, shelf information, inspection criteria, etc. Through the software system, managers can easily oversee the materials and the quality of tasks executed within the warehouse. The application of the system in production in garment companies in Vietnam has increased labor productivity, production efficiency and product quality.

KEYWORDS

MS Access, digital transformation, material warehouse, smart garment factory.

1 INTRODUCTION

The warehouse is one of the most important parts of a company's logistics system [Maryam 2013]. "Any warehouse system needs to perform the following tasks: providing materials to the warehouse, loading and unloading goods, identifying, checking, classifying, and arranging them on shelves, determining goods delivery notes, issuing materials to departments, conducting inventory checks, and calculate the remaining materials for each production code [Maryam 2013] [Abba 2017]. Warehouse management work that was previously done manually is now automated in some stages, even progressing to fully automated warehouse design [Chen 2018]. Warehouse management practices show that digital technology is needed [Areti 2018] [Diego 2016] [Dang 2023] to eliminate manual processes, and instead streamline processes, saving time and providing a more accurate snapshot of what's going on without the need for constant inventory checks [Debraj 2022] [Kate 2021]. In fact, many tools have been born to support the warehouse management process such as Perfect Warehouse, BS silver, Adaline, [Woo 2020] [Paola 2018] allowing to check inventory status and search products by SKU code, barcode, IMEI code or by serial number; accurately grasp the location of goods at the warehouse, easily find goods without going to the place; conveniently track and check the process, track the import/export history immediately [Krishna 2016] [Chen 2018].

The effectiveness of digitizing warehouse management will be determined through warehouse performance evaluation indicators such as costs, throughput, use of space and information services, and connecting information between departments in the enterprise [Maryam 2013].

In Vietnam, garment companies are currently implementing warehouse management through Bravo software systems, BizforceOne 7, etc [Truong 2019]. Initially, there has been a connection and understanding of information between departments such as the planning department, and technical department. However, the warehouse management and inventory statistics process is still limited and not optimized, causing issues such as inefficient use of warehouse space and confusion in the process of importing and exporting materials and components. To facilitate digital transformation in production management [Anh 2023] and particularly in the management of material warehouses in Vietnamese garment companies, we conducted a study on the current state of raw material warehouse management in Vietnamese garment companies, as presented in Section 2. Section 3 is the study of MS Access software for application in serving the digital transformation of warehouse management process and evaluating the effectiveness of this application. Finally, in Section 4, we have made a conclusion about the contents that have been implemented.

2 THE CURRENT SITUATION OF MATERIALS MANAGEMENT IN VIETNAMESE GARMENT COMPANIES

Research on the current situation of warehouse management of Vietnamese garment companies in two aspects: Materials profile and warehouse layout

Regarding to space arrangement, the warehouse includes 2 separate areas: material warehouse and accessory warehouse. They are divided into 5 subdivisions: a working area, a waiting area for inspection, an area for checking input materials, an area for waiting for defective goods, a storage area for materials, and the area for the equipment to transport goods in the warehouse. In particular, the storage area for materials is usually divided by each customer and each order.

Besides, the arrangement of goods on the shelves in the warehouse usually follows the principle that the old orders are finished before entering new orders on the shelves. The size of the shelves in the warehouse is different depending on whether it is materials or accessories. In fact, shelves are often not completely filled. They are even left blank for the entire time the order is in production. Accordingly, the exploitation of the warehouse will be inefficient and may cause additional obstacles to the transportation of materials in the warehouse. Moreover, the response time and quality of tasks in the warehouse are often slower than planned.

Regarding warehouse records, they include the import - export ledgers or data of stored orders that are stored in Excel files. The warehouse operates according to two processes: import process and export process as shown in Fig. 1 and Fig. 2.

Moreover, the survey results on the current situation of warehouse management in some Vietnamese garment companies also showed that these companies only have a manual tracking system, also known as a "work order system".

IMPORT PROCESS

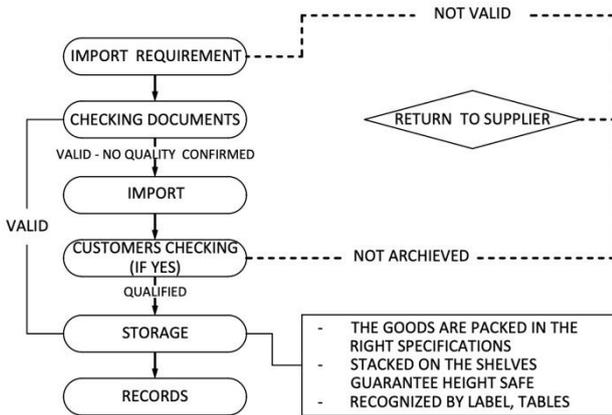


Figure 1. The import process at the garment company

EXPORT PROCESS

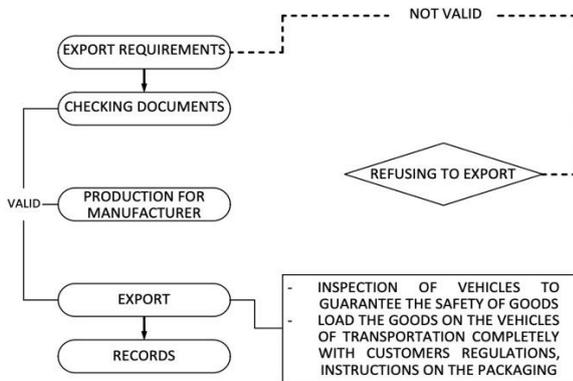


Figure 2. The export process at the garment company

The operators use paper forms to track each activity that has been performed, while the warehouse keeper checks the forms the next day to calculate the actual inventory of materials and accessories. Furthermore, each job is lacking real-time data, making it difficult for managers to monitor the production progress and detect operational issues in a timely manner.

Looking at the import and export processes of the operating companies, it can be seen that they do not fully reflect all the ongoing work steps. In particular, they have not considered how to maximize warehouse capacity and the necessary labor for each work step, as well as arranging the allocation of materials according to the production plan in the most reasonable way.

3 RESEARCH FOR THE APPLICATION

The garment industry has its own unique characteristics such as various types of materials and rapidly changing product codes. Warehouse management is truly more challenging than other industries. Up to now, there are still many shortcomings as analyzed in section 2. Therefore, in this study, we propose the warehouse importing and exporting process as shown in Fig. 3 and Fig. 4 with the aim of incorporating software support for management. This will enable managers to manage and retrieve data instantly.

MS Access is a relational database management software that provides users with a set of tools to quickly and easily build application programs [Phuong 2013] [The University of Nottingham 2017] [Anh 2023]. MS Access allows users to manage, manipulate, and store data in an organized manner on

a computer [The University of Nottingham 2017]. Based on the needs of the manufacturing unit and research conditions at the Hanoi University of Science and Technology, we have chosen MS Access software to be applied in the conversion of managing data for the garment industry warehouse. The warehouse import process, as shown in Fig. 3, illustrates that digitizing the warehouse management process requires solving various problems. First, it is necessary to build the information fields of the warehouse management database, including production plans, suppliers, orders, material information, warehouse space, inspection information, and allocation data. Then, depending on the requirements of the reports, the relationships between these information fields are designed and optimal solutions are calculated for warehouse management problems. Within the In the scope of this study, we present the results of the research completing the information of the required material input records into the warehouse, calculating the storage capacity, and determining the storage location of the warehouse material.

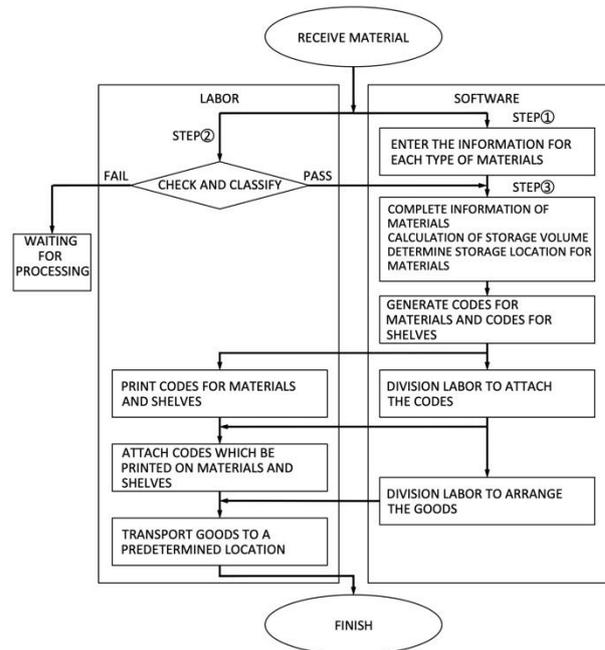


Figure 3. The proposal chart of import management

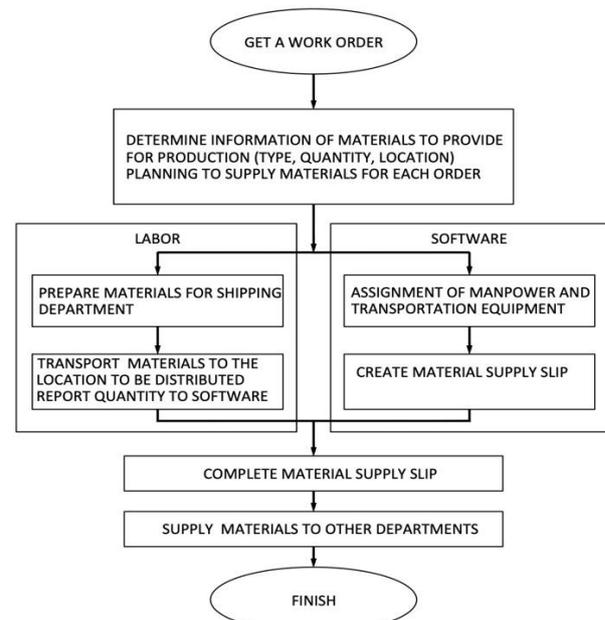


Figure 4. The proposal chart of export management

3.1 Design of warehouse management database

TT	Tools	Content	Purpose
1	Tables	Production plan	Record production plan information
2		Supplier	Record supplier's information
3		Order	Record information about processing orders
4		Order detail	Record specific types of materials in the order
5		Material	Record information about materials
6		Check Criteria	Record materials test results with criteria
7		Shelf information	Record shelf information and storage
8	Forms	Main interface	Categorize key information items Create an easy-to-use desktop
9		Material management interface	Classification of items of material management
10		Production plan	Enter the information about the production plan
11		Import information	Enter, view supplier information, order information, and details of import types of that order
12		Material information	Enter material information
13		Material list	View full information on materials
14		Check quality	Check the quality of materials
15		List of checked material	View the list of full material information
16		Storage location information	View storage information of warehouse locations
17		List of material SKU code	View list of material ID
18	Module	Placement	Automated stocking of materials

Table 1. Statistics of designed objects in MS Access

We have utilized 3 main objects: Table, form, and programming module for creating the management software. Tab. 1 presents the content and purpose of objects that have been designed to carry out this study.

The material management system is designed with a database consisting of tables: production plan, supplier, order, order details, materials, inspection criteria, and shelf information. Then, we need to determine the relationships between the data fields in order to manage the fluctuations that occur in the warehouse.

3.2 Application Design

A warehouse management system applying digital technology is designed through the overall relational data model presented in Fig. 5. It has shown the relationship between entities and their

attributes to facilitate updating information occurring in the warehouse. Based on the task contents shown in the warehouse import and export process (Fig. 3 and Fig. 4), the interface of the warehouse management system homepage has been designed as shown in Fig. 6.

This warehouse management system performs multiple tasks: "Production planning", "Import data", "Material management", and "Storage management". Among these tasks, the "Material management" task includes managing 4 categories directly related to each material: "Material information input", "Material list", "Quality checking", and "SKU code creation". The detailed content of each task is presented in Tab. 1.

Next, we will analyze the content of each task, especially the "Materials management" task (Fig. 7), to research completing the material import dossier information, calculating the storage capacity, and determining the storage location of the materials, corresponding to steps 1, 2, and 3 in the proposal chart of import management (Fig. 3).

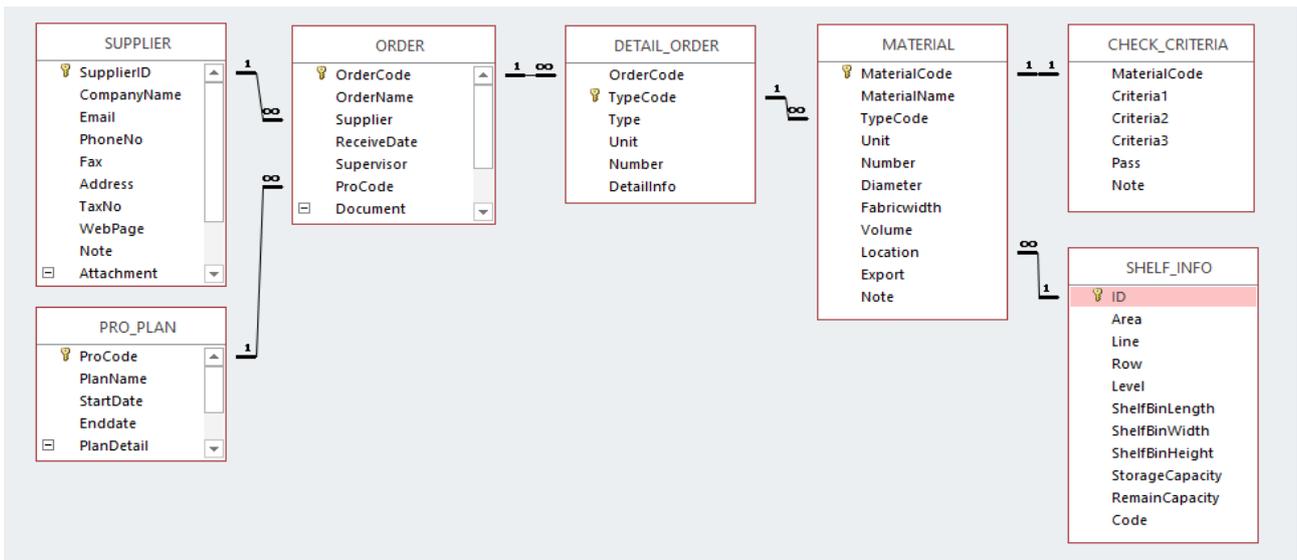


Figure 5. Material management overall relational data model

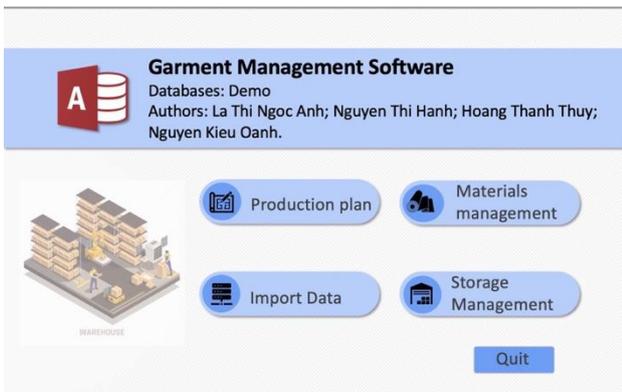


Figure 6. Home page interface of warehouse management software

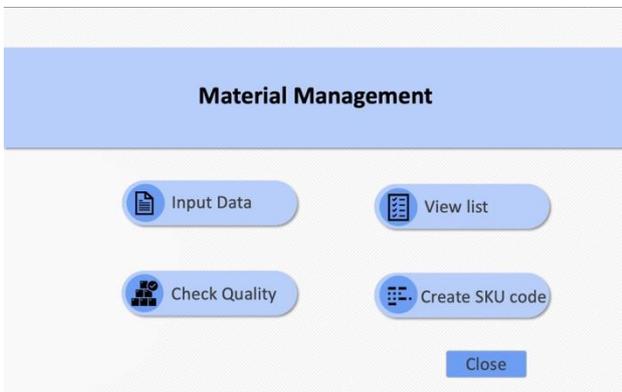


Figure 7. Material management interface

*** Complete the information for the material import profile**

This is achieved by creating forms to input information and evaluate the quality of materials according to testing criteria.

Firstly, input all the information of the product code based on the data provided by the customer. Then, it is necessary to inspect and classify the input materials. In terms of design, we need to establish the relationships among the following 6 data tables: Production plan, Supplier, Order, Order details, Material, and Check criteria table.

Enter the production plan information through the "Production Plan" form as shown in Fig. 8.

After entering production plan data, the system will automatically transfer the input results to the corresponding data table and store them (Fig. 9).

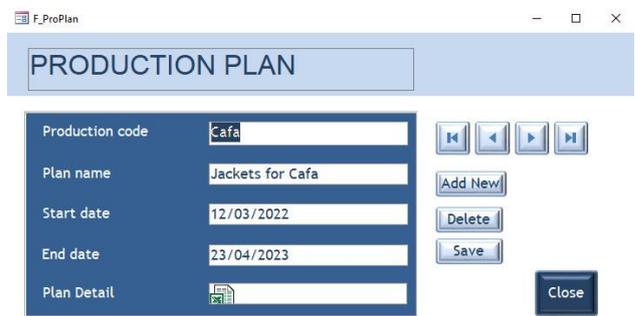


Figure 8. "Production plan" form

Production	Plan name	Start date	End date	Plan detail	Click to Add
Cafa	Jackets for Cafa	12/03/2022	23/04/2023	@(1)	
HSE		11/04/2022	23/03/2023	@(0)	
HSK		6/09/2022	23/10/2023	@(0)	
HSS		13/06/2022	23/05/2023	@(0)	
Tommy		11/01/2022	23/08/2022	@(0)	
TT		11/02/2022	16/06/2023	@(0)	

Figure 9. Production plan table

Based on the production plan data, the merchandisers search for suppliers to place orders according to the plan. The "Import information" form is established from the linkage of 3 data tables: "Supplier", "Order", and "Order details" as shown in Fig. 10.

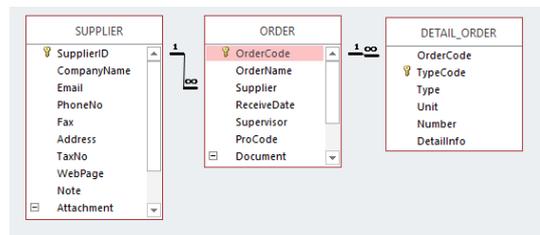


Figure 10. The relational data model for import data

Return to the home page of the software and select the 'Import data' button to open the 'Import Information' form. Users will enter the information of the order into the form, as shown in Fig. 11 and Fig. 12 below. The results will be stored in the corresponding data tables.

Import Information

Supplier ID: GiaBao Address: 95 Le Dinh Can, Ward 7, Tan Tao Ward,
 Company Name: GiaBao limited liability company Tax code: 0315961374
 Email: bachthanh.interlining@gmail.com Web Page: www.giabao.biz.vn
 Phone number: 0969.368.889 Note:
 Fax: Attachment:

Order: Order detail

Order code	Order name	Received date	Pro_code	Supervisor	Attachment
Cafa01	Order cotton for jacket	15/02/2023	Cafa	Sara Nguyen	(0)
HSE01	Order cotton for TS	1/04/2022	HSE	Lily	(0)

Figure 11. "Import information form" _ Supplier and Order

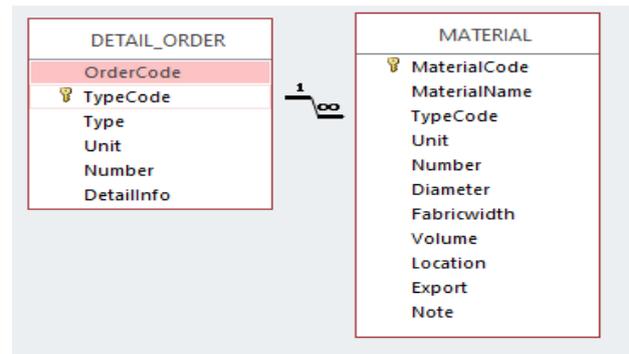


Figure 13. Relational data model between orders and materials

Import Information

Supplier ID: GiaBao Address: 95 Le Dinh Can, Ward 7, Tan Tao Ward,
 Company Name: GiaBao limited liability company Tax code: 0315961374
 Email: bachthanh.interlining@gmail.com Web Page: www.giabao.biz.vn
 Phone number: 0969.368.889 Note:
 Fax: Attachment:

Order: Order detail

Order code: Cafa01

Type code	Type	Unit	Number	Detail
C75/25	Cotton C75/25	Roll	3	
C60/40	Cotton 60/40	Roll	2	
			0	

Figure 12. "Order Information form" – Order details

Material Information

Order code: Cafa01 Type code: C60/40
 Type code: C60/40
 Type: Cotton 60/40
 Unit: Roll
 Number: 2
 Detail:

MATERIAL

Input Data

Material code	Material name	Type code	Unit	Number	Diameter	Fabricwidth
CafaC604001	Cotton blend	C60/40	Roll	1	0.3	1.6
CafaC604002	Cotton blend	C60/40	Roll	1	0.3	1.6
0		C60/40		1	0	0

Figure 14. "Material information" form

Next, when the materials are transported to the warehouse, the warehouse personnel proceed to enter detailed information for each type of material and inspect them according to the criteria provided by the customers. Based on the input of the order information, they proceed to enter the information for each unit of material.

Enter material information: The relationship between order information and material information is made through the relational data model in Fig. 13.

To open the input form, at the main screen, select "Materials Management" -> "Input data". The input form is displayed as shown in Fig. 14

After entering the information about the material, the system will automatically save the data. Users can view the "Material list" form by clicking the "View list" button. The text boxes are designed to search corresponding to the information fields: Material code; Material name; Type code; Order code (Fig. 15). So that, the manager can easily search for the entered material information.

MATERIAL LIST

Material code Material Type code Order code

Material code	Material	Type code	Order code	Diameter	Fabricwidth	Unit	Volume	Number	Export
CafaC752501	Cotton blend	C75/25	Cafa01	0.35	1.6	Roll	0.196	1	<input type="checkbox"/>
CafaC604001	Cotton blend	C60/40	Cafa01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
CafaC752503	Cotton blend	C75/25	Cafa01	0.35	1.6	Roll	0.196	1	<input type="checkbox"/>
CafaC604002	Cotton blend	C60/40	Cafa01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10001	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10002	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10003	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10004	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10005	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10006	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10007	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10008	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10009	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10010	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10011	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>
HSEC10012	Cotton 100%	C100	HSE01	0.3	1.6	Roll	0.144	1	<input type="checkbox"/>

Figure 15. "Material list" form

The materials must go through a quality control process according to the testing criteria before being stored in the warehouse, after the information is declared. The testing process is carried out sequentially for each material code, if the material meets the testing criteria, it will be marked as "Pass". The tested materials will be stored in the "Check Criteria" table. This data is linked through Fig. 16.

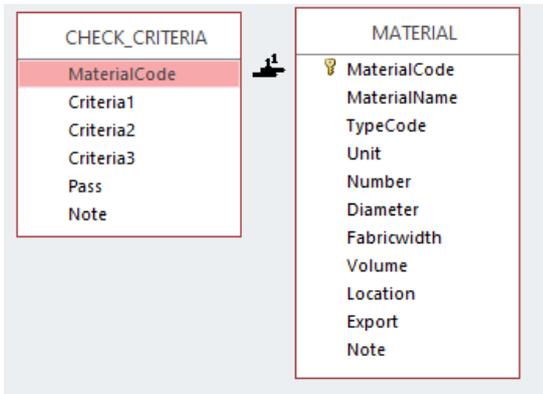


Figure 16. Relational data model between "Materials" and "Check criteria"

Quality control content is done by declaring in the "Quality Check" form as shown in Fig. 17. The overall result after checking all materials is managed through the "List of Checked Materials" form as shown in Fig. 18. Then, use the "Pass" field to filter and view the materials that meet the requirements.



Figure 17. "Check quality" form

List of checked materials

Material code	Type code	Pass	Note	Location
CafaC752503	C75/25	<input checked="" type="checkbox"/>		AA101
CafaC604002	C60/40	<input checked="" type="checkbox"/>		00000
HSEC10001	C100	<input checked="" type="checkbox"/>		00000
HSEC10002	C100	<input checked="" type="checkbox"/>		00000
HSEC10003	C100	<input checked="" type="checkbox"/>		00000
HSEC10004	C100	<input checked="" type="checkbox"/>		00000
HSEC10005	C100	<input checked="" type="checkbox"/>		00000
HSEC10006	C100	<input checked="" type="checkbox"/>		00000
HSEC10007	C100	<input checked="" type="checkbox"/>		00000

Figure 18. "The list of checked materials" form – filter pass materials

The management staff can access information about the status or results of quality control of input materials. From there, data on orders and suppliers can be queried.

At this point, the information on the materials that meet the requirements for entry into the warehouse is considered complete.

* Calculation of storage capacity

In reality, the main input material for industrial sewing production is fabric rolls. Each fabric roll has a cylindrical shape. The arrangement of fabric rolls in the warehouse will be calculated to be compatible in terms of the volume of the fabric roll and storage position. To do this, it is necessary to determine the fabric roll volume and storage capacity as follows:

Determine the volume of the roll of fabric

Each fabric roll has 2 characteristic dimensions: the roll diameter and the fabric width, also known as the length of the roll. These dimensions will generally differ among fabric rolls. When arranging the fabric rolls on a shelf bin, there will be gaps between the rolls in both cross-sectional and longitudinal directions. To simplify the calculation, we can convert the cross-section of the fabric roll from a circle to a square with a side length equal to the diameter of the circle, as shown in Fig. 19. The converted volume of the fabric roll can be calculated using the following formula (1):

$$V_{NL} = D^2 * K_v \tag{1}$$

In which

V_{NL} : Converted volume of the fabric roll

D : The diameter of the fabric roll

K_v : The fabric width

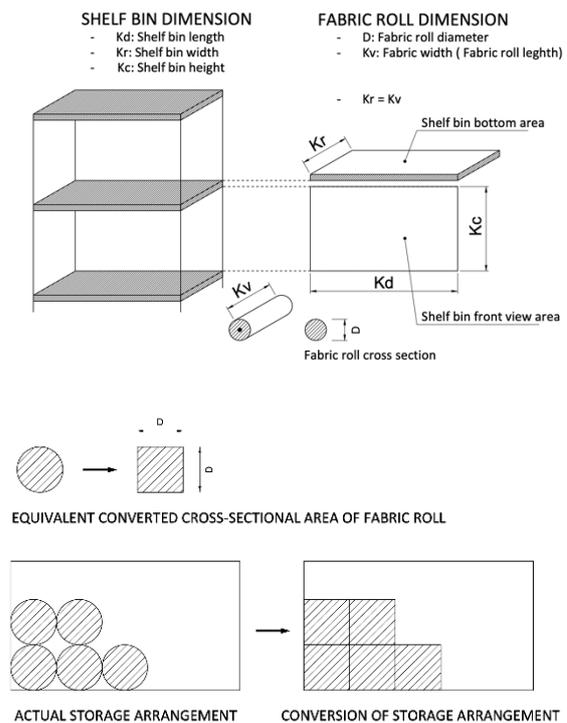


Figure 19. Cross-sectional conversion of the fabric roll

Determine the storage capacity of the shelf bins

In the warehouse, the shelves are rectangular prisms. Each shelf is divided into different shelf bins, determined by three dimensions: length, width, and height. However, in reality, it is not possible to fully utilize 100% of the capacity of the shelf. According to Frazelle, "when utilization exceeds 86 percent, productivity and safety decrease exponentially" [Gwynne 2014]. In other words, the remaining 14% of the volume is necessary for arranging and unloading the fabric rolls. Therefore, the research group chose a common storage factor of 0.85 for all shelf bins. The storage volume of a shelf bin is determined by the following formula (2):

$$V_{VT} = H_s * K_c * K_d * K_r \quad (2)$$

In which:

V_{VT} : Storage capacity of the position

H_s : Storage utilization factor, $H_s = 0.85$

K_c : Height of shelf bin

K_r : Width of shelf bin

K_d : Length of shelf bin

The remaining capacity of each shelf bin

(V_{CL}) is determined by the formula (3):

$$V_{CL} = V_{VT} - \sum V_{NL} \quad (3)$$

With $\sum V_{NL}$ is the total volume of the fabric rolls arranged on the shelf bin.

*** Determine the storage location of materials**

To arrange fabric rolls in suitable positions in the shelf bins, we can simplify the problem by assuming that the length of the fabric rolls and the width of the shelf bins are equal. Therefore, arranging fabric rolls in appropriate warehouse positions will be based on the compatibility of the cross-sectional area of the fabric rolls and the standing area of the shelf bins. The Greedy algorithm is applied here to select fabric rolls to fill 85% of the empty spaces to maximize the storage capacity.

The built-in "macro" and "query" tools of MS Access are not sufficient to solve this problem. Therefore, we used a "Module" to write additional code to perform the task of selecting and arranging fabric rolls in appropriate positions. The module is built on the databases of 3 tables: Check criteria, Material, and Shelf information (Fig.20).

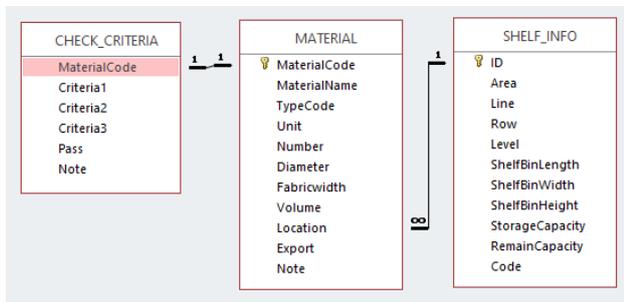


Figure 20. The relational data model determines the placement of materials

The code performs the following tasks:

Step 1: Filter through each material code that has been checked by iterating through records in the "CHECK_CRITERIA" table.

Step 2: Compare the record found with the material code in the "MaterialCode" table to find the corresponding record.

Step 3: Check both conditions simultaneously:

- Position condition: No position available (location status is "0") - in the "MATERIAL" table
- Quality condition: Passed (check status is "True") - in the "CHECK_CRITERIA"

If not satisfied, return to Step 1.

If satisfied, move on to the next step

Step 4: Search for a location for the material

Check the condition: Volume ("MATERIAL") <= RemainCapacity of the position (in "SHELF_INFO")

If not satisfied, go to the message "No more locations to place material" or "All materials have been arranged"

If satisfied, move on to the next step

Step 5: Updated "Location" for materials (in the "MATERIAL" table)

Step 6: Update "RemainCapacity" (in the table "SHELF_INFO")
RemainCapacity = RemainCapacity (before stacking) – Volume

Step 7: Display the message: "Material arrangement successful"

Below is the code that the team wrote in the "Module" of MS Access (Fig. 21).

```

Public Function ArrangeMaterial(inputMa As String)
Public Function ArrangeFullMaterial()

' Define the problem and inputs
Dim rsMaterials As DAO.Recordset
Dim rsLocations As DAO.Recordset
Dim rsCheck As DAO.Recordset
Dim strMaterialCode As String
Dim strLocationID As String
Dim foundLocation As Boolean
Dim checkRange As Boolean

' Determine the objective function
Set rsMaterials = CurrentDb.OpenRecordset("SELECT * FROM MATERIAL WHERE MaterialCode = '" & inputCode & "'")
Set rsLocations = CurrentDb.OpenRecordset("SELECT * FROM MATERIAL")
Set rsCheck = CurrentDb.OpenRecordset("SELECT * FROM SHELF_INFO")
foundLocation = False
checkRange = False

' Loop through each Material
rsCheck.MoveFirst
Do Until rsCheck.EOF
    rsMaterials.MoveFirst
    Do Until rsCheck.MaterialCode = rsMaterials.MaterialCode
        rsMaterials.MoveNext
    Loop
    If rsMaterials.Location = 0 Then
        If rsCheck.Pass = True Then
            rsLocations.MoveFirst
            Do Until rsLocations.EOF
                If rsLocations.RemainCapacity >= rsMaterials.Volume Then
                    strLocationID = rsLocations.ID
                    strLocationName = rsLocations.Code
                    rsMaterials.Edit
                    rsMaterials.Location = strLocationID 'Update the location of the material table
                    rsMaterials.Update

                    rsLocations.Edit
                    rsLocations.RemainCapacity = rsLocations.RemainCapacity - rsMaterials.Volume 'Update remain capacity
                    rsLocations.Update

                    foundLocation = True
                    checkRange = True
                    Exit Do
                End If
            Loop
            rsLocations.MoveNext
        End If
    End If
    rsMaterials.MoveNext
Loop
End If
End Function

```

Figure 21 Code to determine the storage location

After creating the material arrangement module, it will be installed on the command button "Intuitive automatic warehouse arrangement". The command button is located in the left corner of the screen at the "List of checked material" form (Fig.22).

List of checked materials

Material code	Type code	Pass	Note	Location
CafaC752503	C75/25	<input checked="" type="checkbox"/>		AA101
CafaC604002	C60/40	<input checked="" type="checkbox"/>		00000
HSEC10001	C100	<input checked="" type="checkbox"/>		00000
HSEC10002	C100	<input checked="" type="checkbox"/>		00000
HSEC10003	C100	<input checked="" type="checkbox"/>		00000
HSEC10004	C100	<input checked="" type="checkbox"/>		00000
HSEC10005	C100	<input checked="" type="checkbox"/>		00000
HSEC10006	C100	<input checked="" type="checkbox"/>		00000
HSEC10007	C100	<input checked="" type="checkbox"/>		00000



Figure 22. Determining the location of materials in the warehouse

Clicking on the "Intuitive automatic warehouse arrangement" button to automatically arrange the materials into suitable locations.

To check the storage arrangement results and visually view the storage location, on the main screen interface, select "Storage management", the "Storage location information" form as shown in Fig. 23.

Storage location information

Material code	Type code
CafaC604001	C60/40
CafaC604002	C60/40
CafaC752501	C75/25
CafaC752503	C75/25
HSEC10001	C100
HSEC10002	C100
HSEC10003	C100
HSEC10004	C100

Figure 23. "Storage location information" Form

After determining the position of materials on shelf bins, it is necessary to identify these materials for the purpose of easy checking and unloading materials from their positions and serving the task of providing materials to the cutting department.

* Material Identification

There are various methods for identifying materials, such as using barcodes, QR codes, SKU codes, IMEI codes, or serial numbers. However, to meet the security requirements of each business, the choice of material identification is based on SKU codes. In this material management software, the convention for SKU codes is as follows:

The SKU code of each material consists of 4 parts arranged in the following order:

Production code: taken from the production plan source

Type code: taken from the source of order information

Sequential number: a natural number that is not duplicated

Warehouse location: taken from the shelf information table. The warehouse location is determined by 4 factors: Area + Line + Row + 0 + Sheft level

"Area", and "Line": marked with capital letters in the alphabet table

"Row", and "Shelf Level": marked with natural numbers

Character "0": distinguishes information between "Line" and "Shelf level".

Then we design the SKU code field through 3 data fields are "MaterialCode" "Location" and "Code" belonging to the relational data model "MATERIAL" and "SHELF_INFO" as shown in Fig. 24.

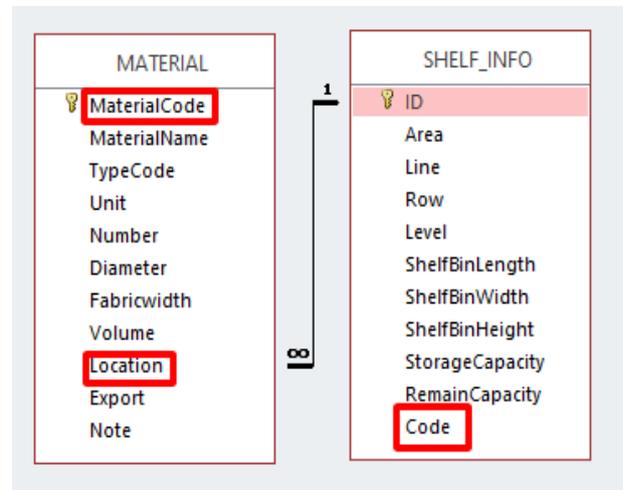


Figure 24. The relational model for generating SKU

List of material SKU code

Material code	Material name	Order code	Type code	Location	SKU
CafaC752501	Cotton blend	Cafa01	C75/25	AA101	CafaC752501AA101
CafaC604001	Cotton blend	Cafa01	C60/40	AA101	CafaC604001AA101
CafaC752503	Cotton blend	Cafa01	C75/25	AA101	CafaC752503AA101
CafaC604002	Cotton blend	Cafa01	C60/40	AA101	CafaC604002AA101
HSEC10001	Cotton 100%	HSE01	C100	AA101	HSEC10001AA101
HSEC10002	Cotton 100%	HSE01	C100	AA101	HSEC10002AA101
HSEC10003	Cotton 100%	HSE01	C100	AA101	HSEC10003AA101
HSEC10004	Cotton 100%	HSE01	C100	AA101	HSEC10004AA101
HSEC10005	Cotton 100%	HSE01	C100	AA101	HSEC10005AA101
HSEC10006	Cotton 100%	HSE01	C100	AA101	HSEC10006AA101
HSEC10007	Cotton 100%	HSE01	C100	AA101	HSEC10007AA101
HSEC10008	Cotton 100%	HSE01	C100	AA101	HSEC10008AA101
HSEC10009	Cotton 100%	HSE01	C100	AA101	HSEC10009AA101
HSEC10010	Cotton 100%	HSE01	C100	AA101	HSEC10010AA101
HSEC10011	Cotton 100%	HSE01	C100	AA101	HSEC10011AA101
HSEC10012	Cotton 100%	HSE01	C100	AA101	HSEC10012AA101
HSEC10013	Cotton 100%	HSE01	C100	AA101	HSEC10013AA101

Figure 25. The form shows the location and SKU of some materials

Therefore, the issues of completing material profiles, optimizing warehouse capacity calculations, and intelligently identifying the location of materials have been researched and solved using digital technology for management.

This solution has completely transformed the content of the "work order system" in the warehouse management process into visual management on an electronic screen through the materials management software system. This system is considered an initial experiment in the process of digitizing warehouse management data through application software to prepare for the design of a smart garment factory. Due to security requirements, the system is currently in the internal testing phase. Research results show that the system has helped simplify the warehouse import process, and the materials in the warehouse are arranged clearly and scientifically. The transportation process for arranging materials on shelves as well as unloading them for distribution is now more convenient. The materials management system in the warehouse has increased labor productivity, production efficiency, and product quality.

4 CONCLUSION

By using a combination of theoretical research and experimentation, we have developed a solution that applies MS Access software to design a material inventory management model in a garment factory. This solution allows for updating information about materials in the warehouse, searching for materials, generating reports and statistics, optimizing storage capacity, determining storage locations, and assigning intelligent identification codes to the materials. The material records include information such as production plans, suppliers, orders, order details, materials, shelf information, and inspection criteria. This solution completely transforms the content of the "job ticket system" in the warehouse management process into a visually intuitive electronic management system through the material inventory management software. Through the software system, managers can easily oversee the materials and the quality of tasks executed within the warehouse. More importantly, it enables efficient calculation of warehouse space utilization. Specifically, it calculates the capacity utilization of shelves, avoids prolonged vacancies in the shelves, and allows for adjustments to expand or contract warehouse space to align with the current capacity of the business. For small and medium-sized enterprises with limited financial resources, this system can be considered as a potential solution. It simplifies the inventory receiving process, streamlines paperwork, organizes materials in the warehouse clearly and systematically, and facilitates transportation for arranging materials on shelves and retrieving them for distribution. The inventory management system has increased labor productivity, production efficiency, and product quality.

ACKNOWLEDGMENTS

This research is funded by Hanoi University of Science and Technology (HUST) under project number T2021-PC-043.

REFERENCES

[Abba 2017] Abba, S.G. and Andhika, P. et al. Controlling System for Stock Raw Material for Production Planning and Inventory Control in a Pharmacy Company. *International Review of Mechanical Engineering (I.R.E.M.E.)* [online]. November 2017, volume 11, No 11. Available from:

<https://doi.org/10.15866/ireme.v11i11.12330>

[Anh 2023] La Thi Ngoc Anh et al., Research MS Access Software for Application in Smart Garment Factory Machine Management, *MM Science Journal*, 2023/ June, pp 6561-6567, https://doi.org/10.17973/MMSJ.2023_06_2023042

[Areti 2018] Areti, K. Digitalization in the apparel manufacturing process. Master's Thesis. Netherlands: Utrecht University, Institute for Innovation Sciences, 2018.

[Chen 2018] Chen, C.; Jian, M. and Xingwen, G. et al. Design of Automated Warehouse Management System. *MATEC Web of Conferences* [online]. November 2018, volume 232, No 03039. Available from: <https://core.ac.uk/download/pdf/187726101.pdf>

[Dang 2023] Dang, T. V., and Bui, N. T. 2023. " Obstacle Avoidance Strategy for Mobile Robot based on Monocular Camera." *Electronics* 12(8): 1932. <https://doi.org/10.3390/electronics12081932>

[Diego 2016] Diego, G.P.; Pasquale, D. and Uday, K. et al. *Handbook of Industry 4.0 and Smart Systems*. Milton: Taylor & Francis Group, 2019. ISBN: 9780429849688, 9781138316294

[Debraj 2022] Debraj, S. and Md Bakash, A. et al. Latest Technology Solutions Trends in Apparel Industry and Tools used for Production Management. *Journal of Emerging Technologies and Innovative Research (JETIR)* [online]. March 2022, volume 9, issue 3. Available from: <https://www.jetir.org/papers/JETIR2203392.pdf>. ISSN-2349-5162

[Gwynne 2014] Gwynne Richards. *Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse*. Kogan Page, 2014. ISBN 074946934X, 9780749469344

[Kate 2021] Kate, D.; Logan, F. and Rajeev, K. et al. Creating an Affordable, User-Friendly Electronic Inventory System for Lab Samples [online]. June 2021, volume 26, issue 3, pages 300-310. Available from: <https://www.sciencedirect.com/science/article/pii/S2472630322011098>

[Krishna 2016] Krishna, A.R.; Raed, A. and Thang, K. F et al. Smart Stock Management Control. *International Journal of Applied Engineering Research* [online]. February 2016, volume 11, No 1, pages 492-500. Available from: https://www.researchgate.net/publication/298710967_Smart_stock_management_control

[Maryam 2013] Maryam, D. *Warehouse Redesign Process: A Case Study at Enics Sweden AB*. URN: urn:nbn:se:mdh:diva-19508. Eskilstuna: Mälardalen University, School of Innovation, Design and Engineering, 2013.

[Paola 2018] Paola, B. and José, T. et al. Fashion 4.0. Innovating fashionindustry through digital transformation. *Research Journal of Textile and Apparel* [online], 2018, volume 22, issue 4, pages 352-369. Available from: https://www.researchgate.net/publication/327894020_Fashion_40_Innovating_fashion_industry_through_digital_transformation

[Phuong 2013] Phuong, N.T. *Microsoft Access - 2012 Curriculum*. Hoa Binh Technical and Economic College website, 2013, Hoa Binh [online]. Available from <https://kinhtekythuathoabinh.edu.vn/SiteFolders/c>

aodangtkkt/2369/Gi%C3%A1o%20Tr%C3%ACnh/GI
AO-TRINH-ACCESS-2010.pdf (In Vietnamese)

[The University of Nottingham 2017] The University of Nottingham, Microsoft Access 2016- An Introduction. Melbourne: Watsonia Publishing, 2017.

[Truong 2019] Truong, L.T. Research and evaluate the impact of the 4th industrial revolution on Vietnam's textile and garment industry in order to propose strategic orientations, policies and development solutions in the period of 2019-2030. Report DTDLXH.13/18.

Summary report of scientific research project, 2019. (In Vietnamese)

[Woo 2020] Woo, K.J.; Dong, R.K.; Hyunsu, L.; TaeHun, L.; Insoon, Y.; Byeng, J.; Daniel, Z.; Matthias, B.; Christian, B. and Sung, H.A. et al. Appropriate Smart Factory for SMEs: Concept, Application and Perspective [online]. December 2020, volume 22, pages 201-215. Available from: <https://link.springer.com/article/10.1007/s12541-020-00445-2>

CONTACTS:

La Thi Ngoc Anh, Associate Professor, Ph.D. in Garment Technology
Hanoi University of Science and Technology, Departement of Mechatronics
No 1 DaiCoViet Road, Hanoi,10000, Vietnam
anh.lathingoc@hust.edu.vn

Nguyen Thi Hanh, Post-graduate student in Garment Technology
Hanoi University of Science and Technology, School of Textile - Leather and Fashion
No 1 DaiCoViet Road, Hanoi,10000, Vietnam
Hanh.NT212444M@sis.hust.edu.vn

Ma. Arch Hoang Thanh Thuy
Hanoi University of Science and Technology, Departement of Mechatronics
No 1 DaiCoViet Road, Hanoi,10000, Vietnam
Thuy.hoangthanh@hust.edu.vn

Nguyen Kieu Oanh, Master in Garment Technology
National University of Arts Education, Fashion design department & faculty of garment technology
No 55, TranPhu Road, Hanoi,10000, Vietnam
Oanh.cmt@gmail.com