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REVIEW

Applying value stream management to improve warehouse operation processes – A case study

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The warehouse under study is an important link in the supply chain of a multinational company. At the moment, wastes still exist in warehouse operation processes, which lead to a low rate of order fulfilment and a low customer's service level and negatively affect the company's competitive advantages. This research shows how warehouse operations can be improved by using value stream management as a platform with the objective to reduce the non-value-added time and decrease the lead time and hence reduce the late order rate and increase the customer's service level. The current state map has been drawn. Non-value-added activities in the current state map are analyzed to define causes and solutions to the problems; then the future state map is drawn. The result shows that the non-value-added time reduces by 50.69%, from 143 (mins) to 70.5 (mins), and the lead time decreases by 19.07%, from 464 (mins) to 375.5 (mins).

Keywords: warehouse operations, receiving, put away, picking, packaging, shipping, value stream management

Introduction

A warehouse is a point in the supply chain, where the products are stored and processed and continue to move on the supply chain. Warehouses play an important role in supply chains (1). Warehouses need both storage space and time of labor operating inside; these are the costs that need to be taken into account when it comes to warehouse management. Warehouse management includes warehouse planning and operations. Warehouse planning includes layout planning, materials handling equipment (MHE) planning, and inventory planning. Warehouse operations include receiving, putting away, picking, packing, and shipping.

The distribution center under study is one of the largest and most modern distribution centers in Vietnam, also a critical link in the company's supply chain. Products at the distribution center include homecare, personal care, foods, and promotion products. The distribution center has just started an operating warehouse, storing finish goods (FGs), which account for 60% in stock.

The company is concerned that the late order rate in the warehouse (up to 20%) will negatively affect the customer's service level. Analysis shows that there is plenty of waste in logistics management in the warehouse. Wastes in warehouse operations can be movement waste caused by unreasonable space allocation and waste of resources or time caused by uncareful resource planning. Causes of these wastes lie in the warehouse layout, storage and MHE planning, and operations.

Failure mode and effect analysis (FMEA) indicates that the main reason is warehouse operations. This research uses value stream management (VSM) as the platform to improve warehouse operations with the objectives to reduce the non-value-added time and reduce the lead time and hence reduce the late order rate and increase the customer's service level. The scope of research is limited to the FG warehouse.

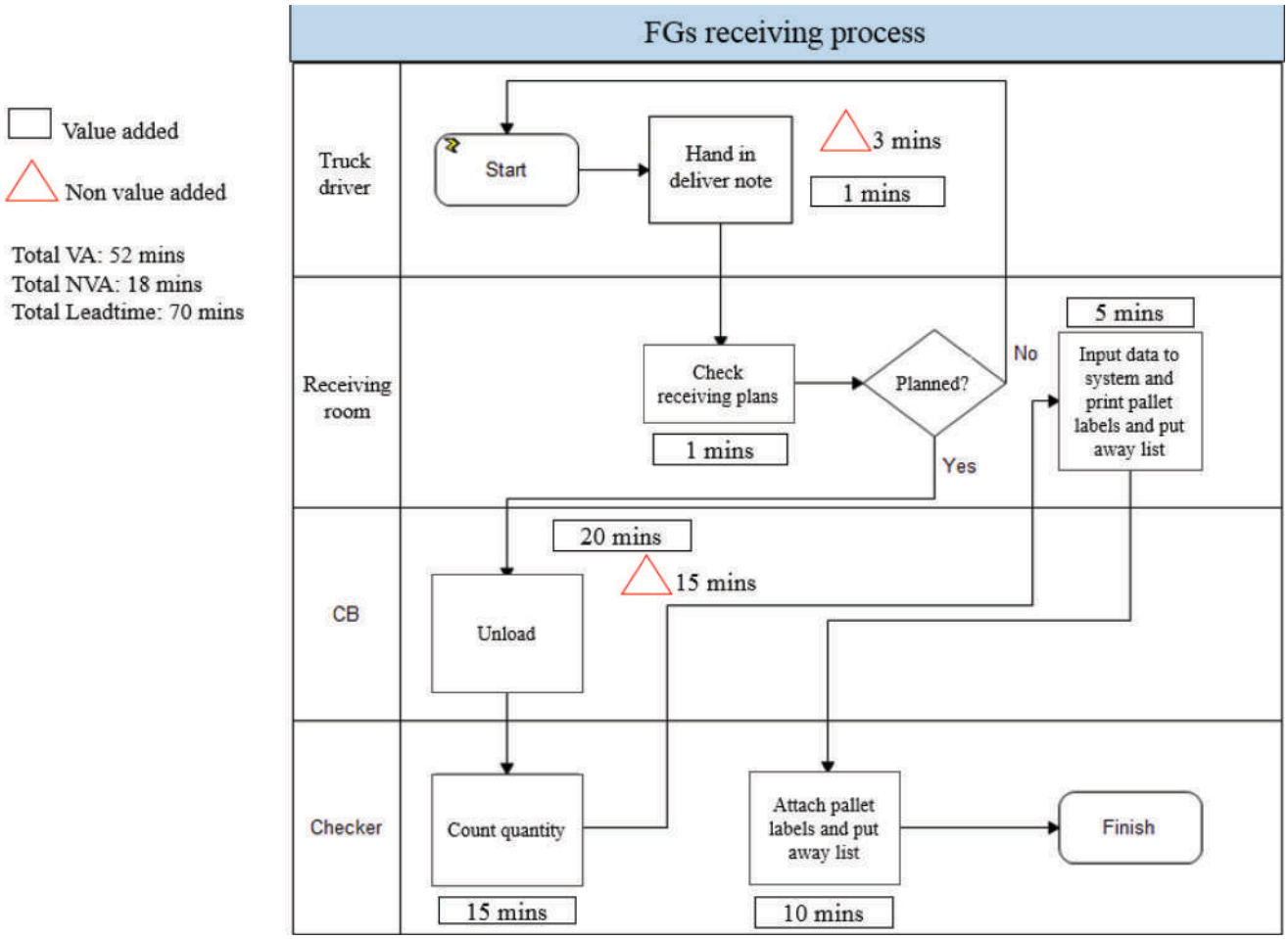

FIGURE 1 | Finish good (FG) receiving process.

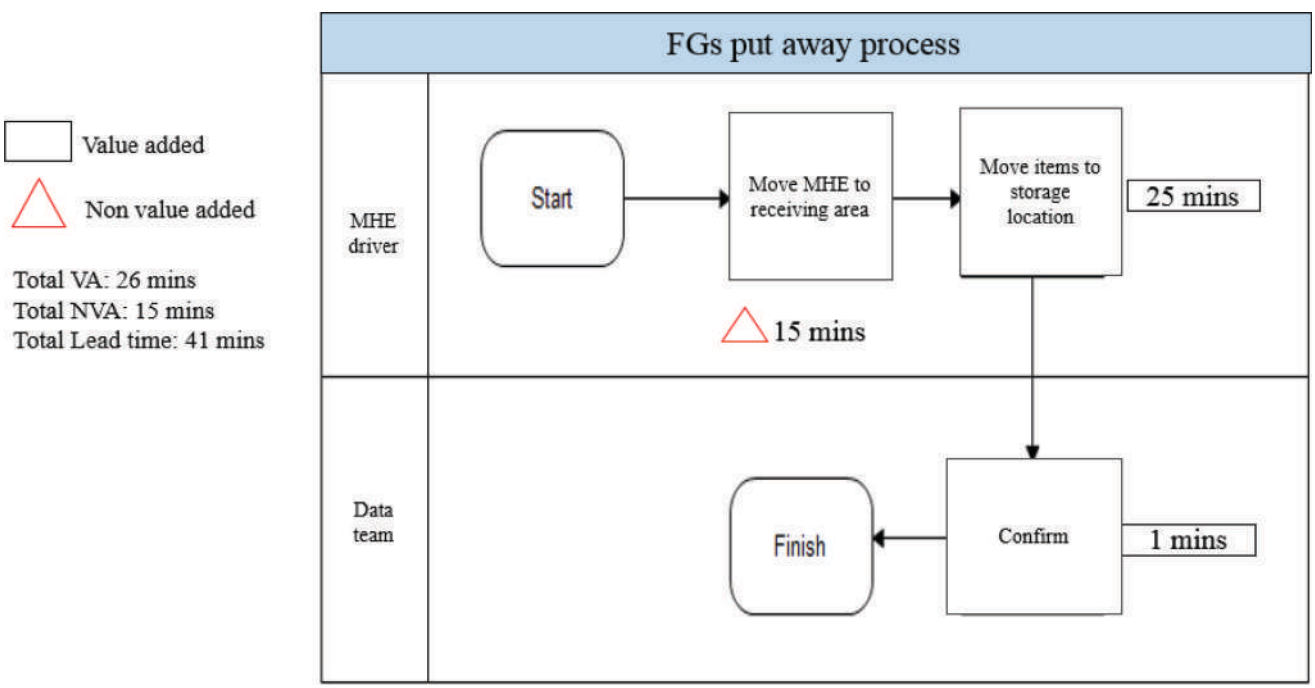

FIGURE 2 | Finish good (FG) put-away process.

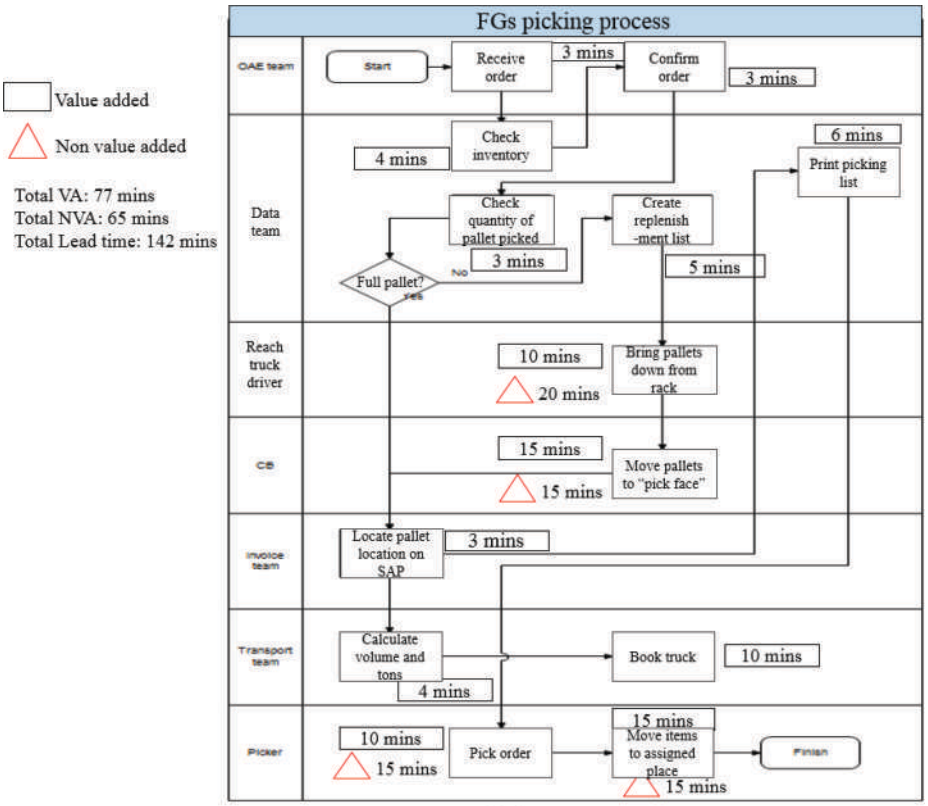

FIGURE 3 | Finish good (FG) picking process.

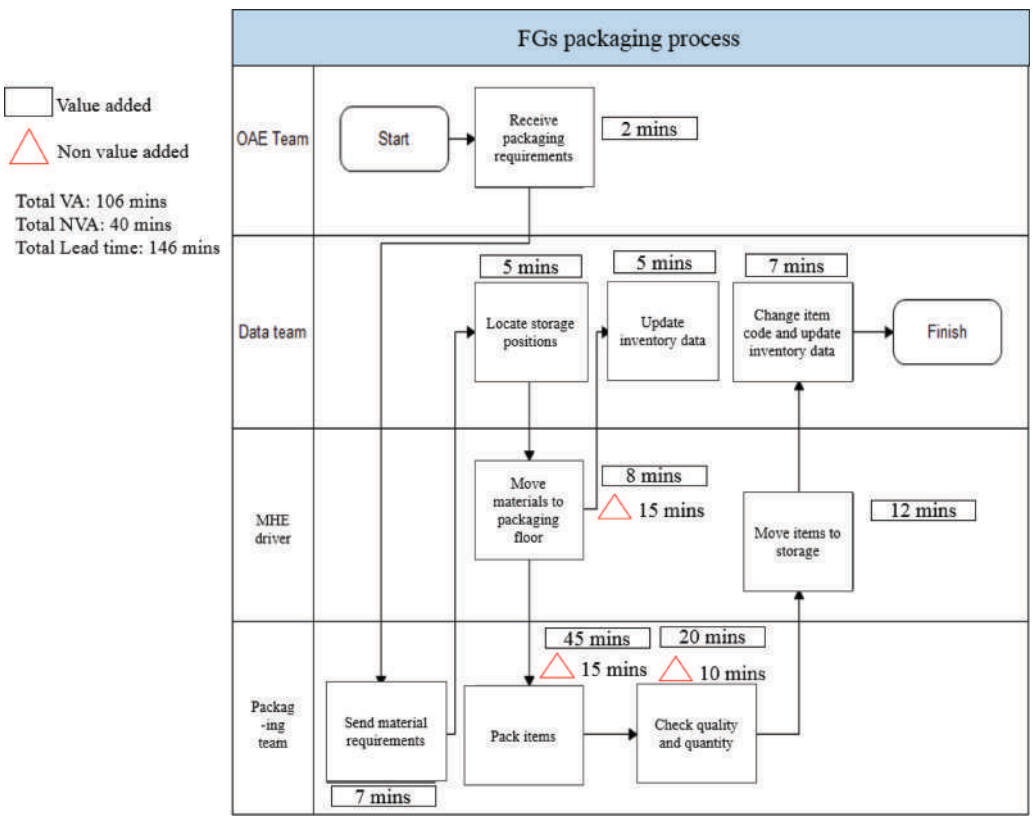

FIGURE 4 | Finish good (FG) packaging process.

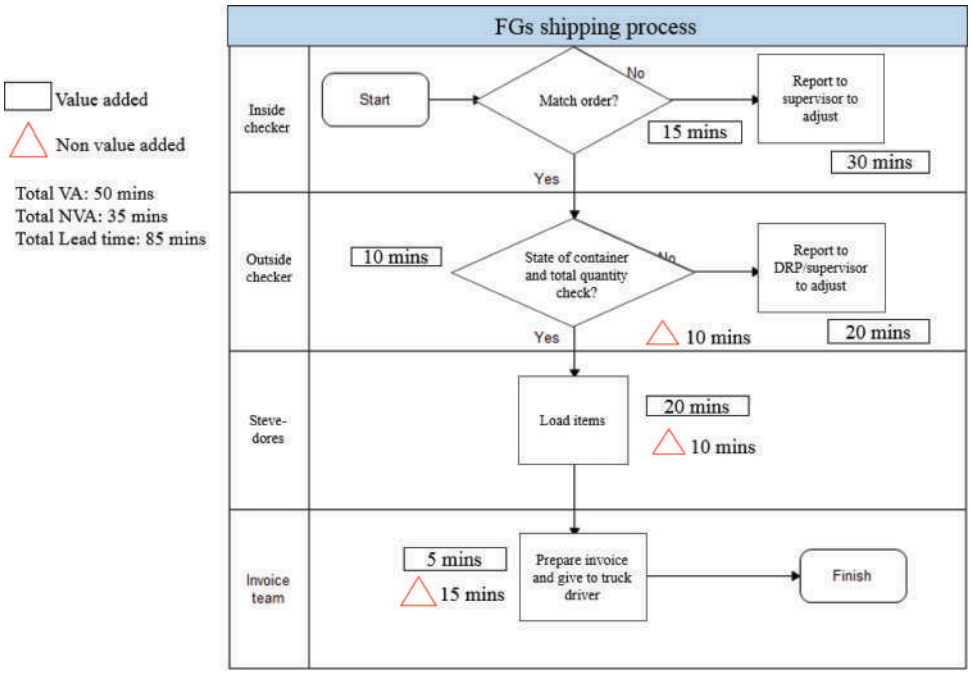

FIGURE 5 | Finish good (FG) shipping process.

Literature review

Warehouse operations and lean thinking

Warehouse operations play a very important role in warehouse management. Lean tools are widely used to improve warehouse operations (2). Lean seeks to improve the performance of operations by eliminating waste (1, Detty and Yingling, 2000; Hofer et al., 2012; Liker and Convis, 2011; Pavnaskar et al., 2003; Womack and Jones, 2003). Warehouse improvement requires optimizing material flow (3). Picking orders, packing them, and shipping them to the customer should be done with minimum wastage (Garza et al., 2011; 4).

In order to improve warehouse operations, lean tools are used to remove the non-value-added time in warehouse operations and then reduce the warehouse lead time.

Value stream management

Value stream management is an effective methodology in order to apply lean thinking to improve warehouse operations. VSM is the process of planning and implementing activities to eliminate wastes in supply chain processes.

Value stream management is useful in visualizing warehouse operations and identifying non-value-added activities in warehouse operations. VSM helps identify solutions to reduce the non-value-added time, thereby achieving the goal of reducing the warehouse lead time. Applying VSM to improve warehouse operations includes the following steps:

TABLE 1 | Time distributions in the current processes.

Number	Process	LT	VAT (mins)	NVAT (mins)
1	Receiving	70	52	18
2	Put away	41	26	15
3	Picking	122	87	35
4	Packaging	146	106	40
5	Shipping	85	50	35
Total		464	321	143

1. Draw the current state map.
2. Analyze the current state map to identify solutions.
3. Draw the future state map after applying solutions.

Draw the current state map

The warehouse under study stores FGs and gifts. The FG storage area is categorized as a pallet layout, using a double deep racking system. FGs are stored with dedicated storage policy and are always picked in full pallet with single cycle operation.

Warehouse operation processes consist of receiving, putting away, picking, packaging, and shipping activities. Besides the storage time and delivery time, other operation times can be reduced by eliminating non-value-added activities. Value-added activities are activities that are essential for warehouse operations and to customers. Non-value-added activities are wait and movements.

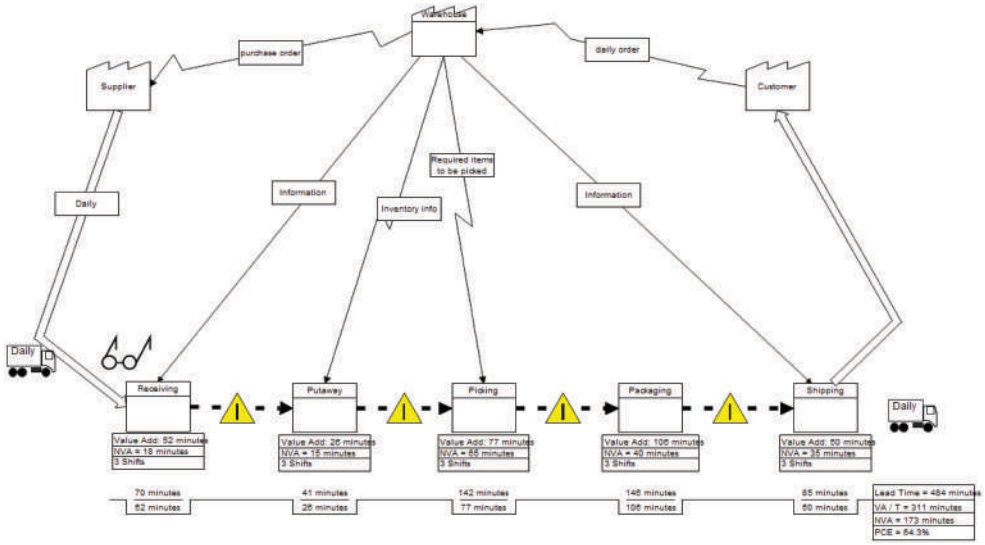

FIGURE 6 | Current state map.

TABLE 2 | Current performance indexes.

Index	Value
LT (mins)	464
VAT (mins)	321
NVAT (mins)	143
PCE (%)	69.18

In order to assess the current warehouse operations, the current value stream mapping for FGs is developed. For FGs, processes for receiving, putting away, picking, packaging, and shipping with time distributions are shown in these following figures.

The current FG receiving process is shown in **Figure 1**.

The current FG put-away process is shown in **Figure 2**.

The current FG picking process is shown in **Figure 3**.

The current FG packaging process is shown in **Figure 4**.

The current FG shipping process is shown in **Figure 5**.

Time distributions in the current processes are shown in **Table 1**.

From **Table 1**, the current state map is drawn as in **Figure 6**.

TABLE 3 | Current state analysis.

Processes	NVA activities	Causes	Solutions
Receiving	Movement of handing in good delivery note	Long distance	Relocated functional areas
	MHE preparation	Unpreparation of MHEs	Resource allocation (labor, MHEs) for each functional area
Put away	MHE preparation	Unpreparation of MHEs	Resource allocation (labor, MHEs) for each functional area
Picking	Movement of MHEs to required locations	Unreasonableness of functional areas, locations, and product placement	Layout planning
Packaging	MHE preparation	Unpreparation of MHEs	Resource allocation (labor, MHEs) for each functional area
	Wait for materials replenishment	Unpreparation of materials	Setting up of a material storing area to store materials in advance for the work day
	Wait for quality check	Congestion at quality stage	Train workers to check quality at each station
Shipping	Wait for truck status check	Uncheck truck status before hand	Re-engineering of the shipping process
	MHE and labor preparation	Unpreparation of MHEs and labor for shipping	Preparation of resources (labor, MHEs) in advance
	Wait for invoice	Redundant procedure through many departments	Re-engineering of the shipping process

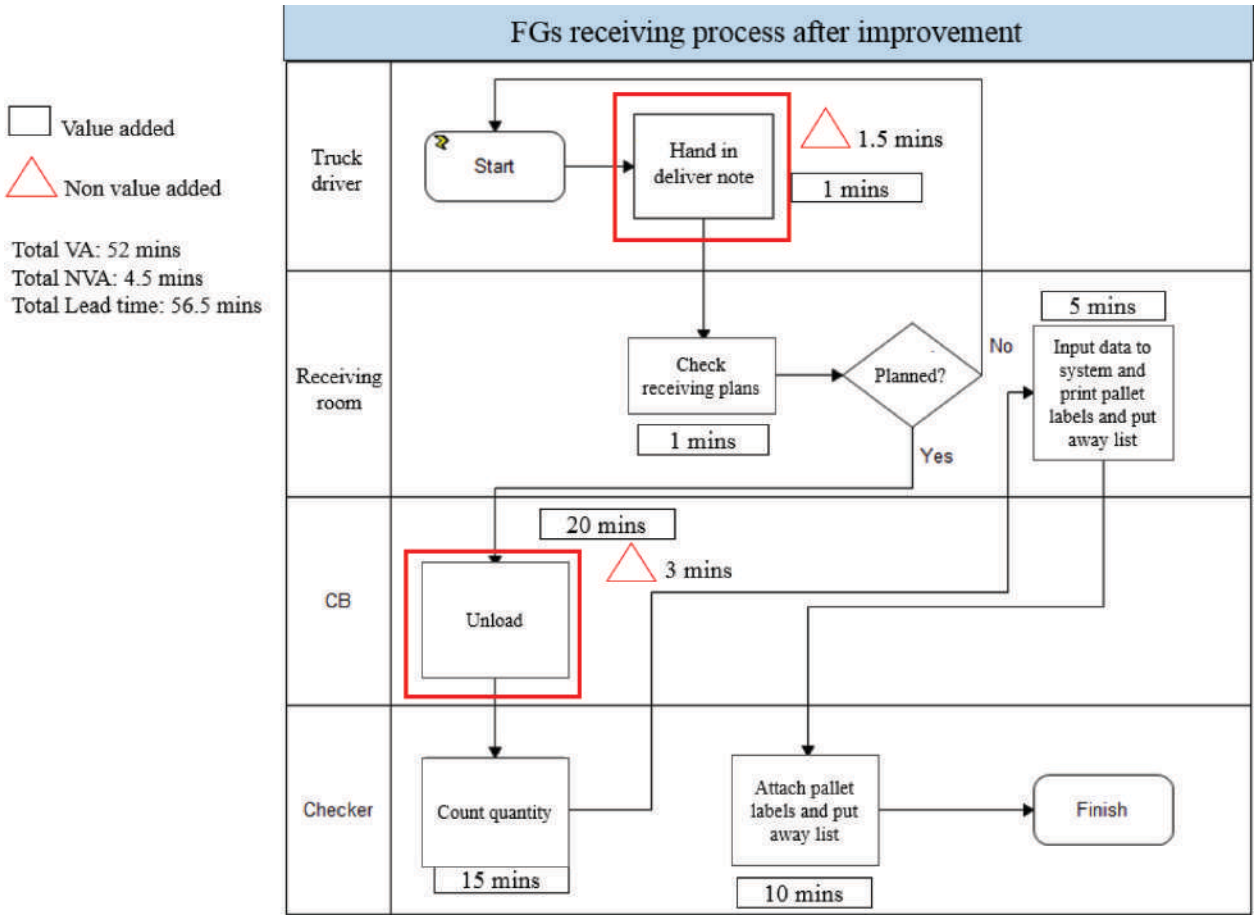

FIGURE 7 | Finish good (FG) receiving process after improvement.

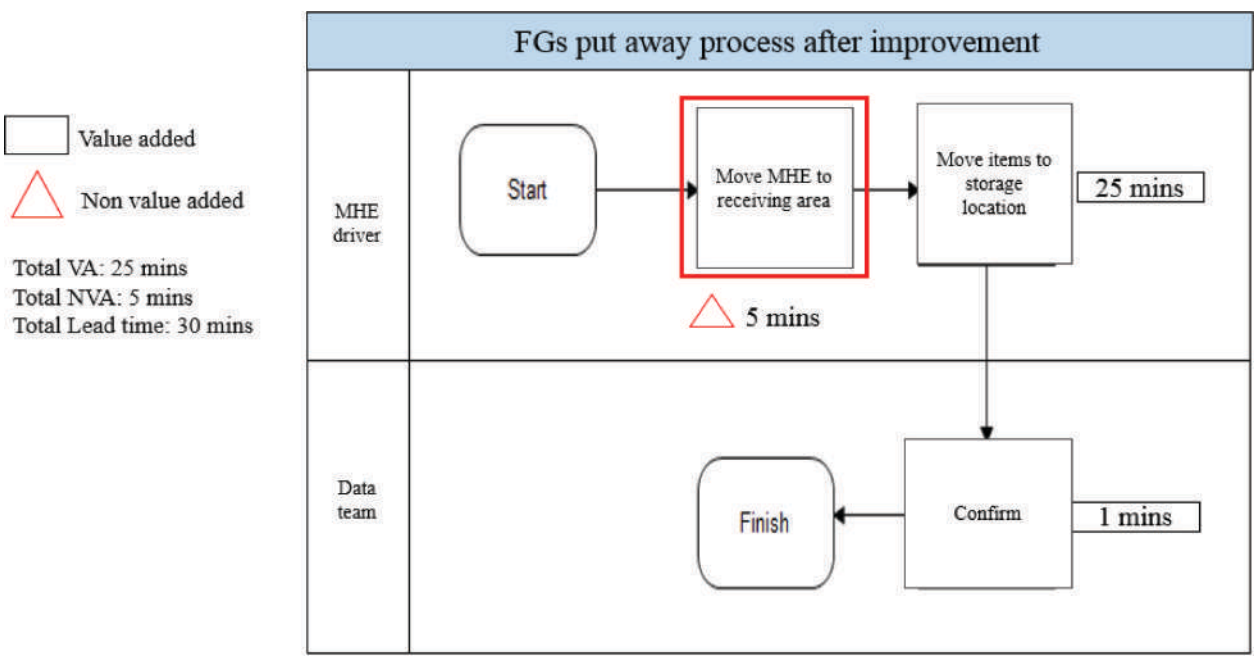

FIGURE 8 | Finish good (FG) put-away process after improvement.

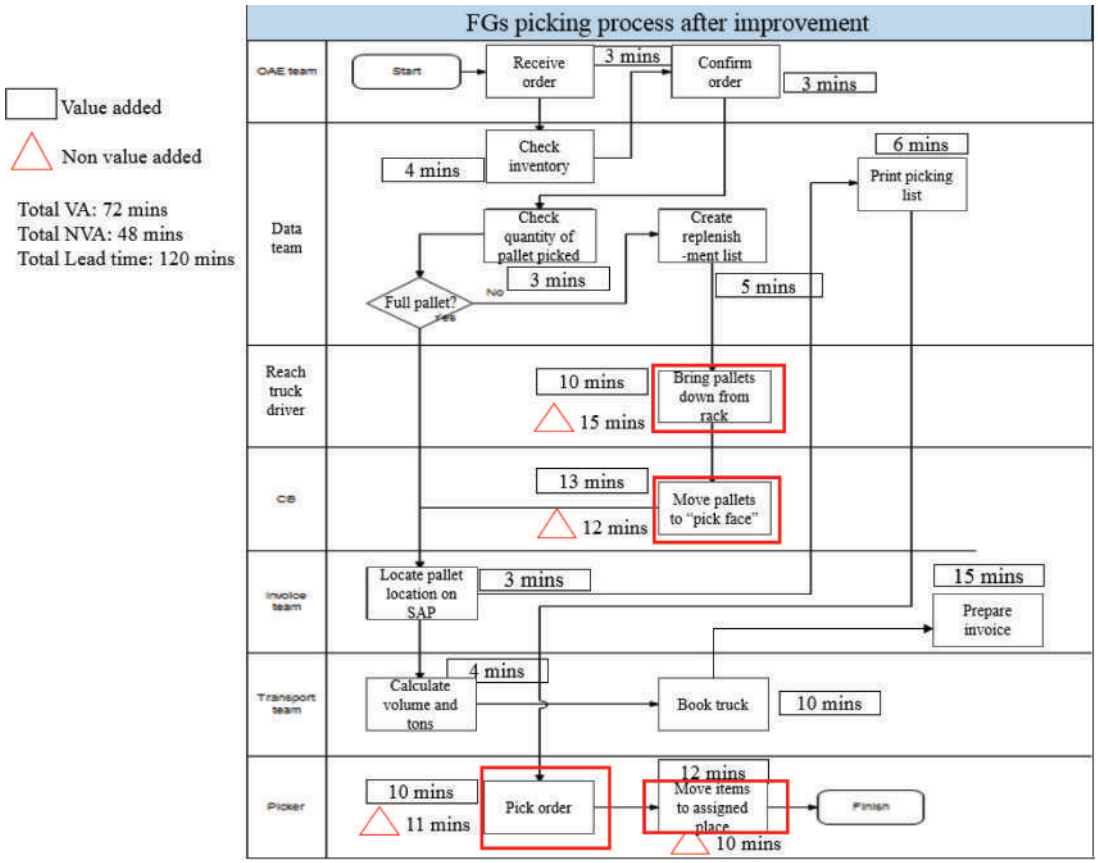

FIGURE 9 | Finish good (FG) picking process after improvement.

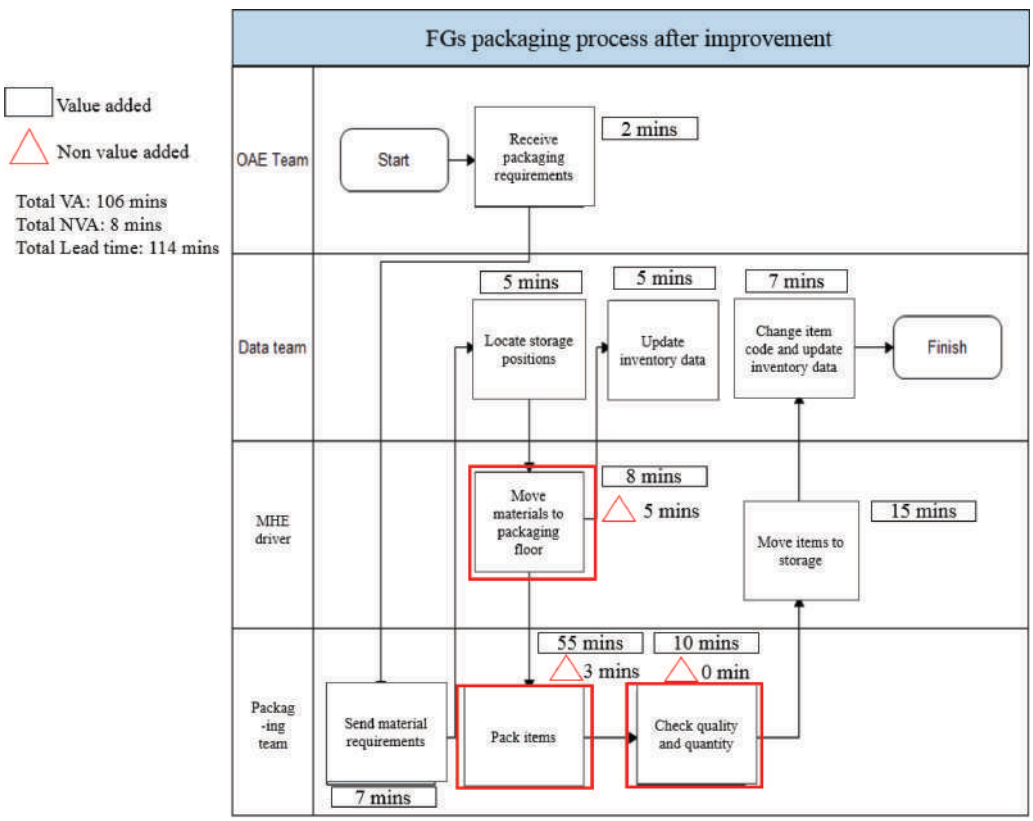

FIGURE 10 | Finish good (FG) packaging process after improvement.

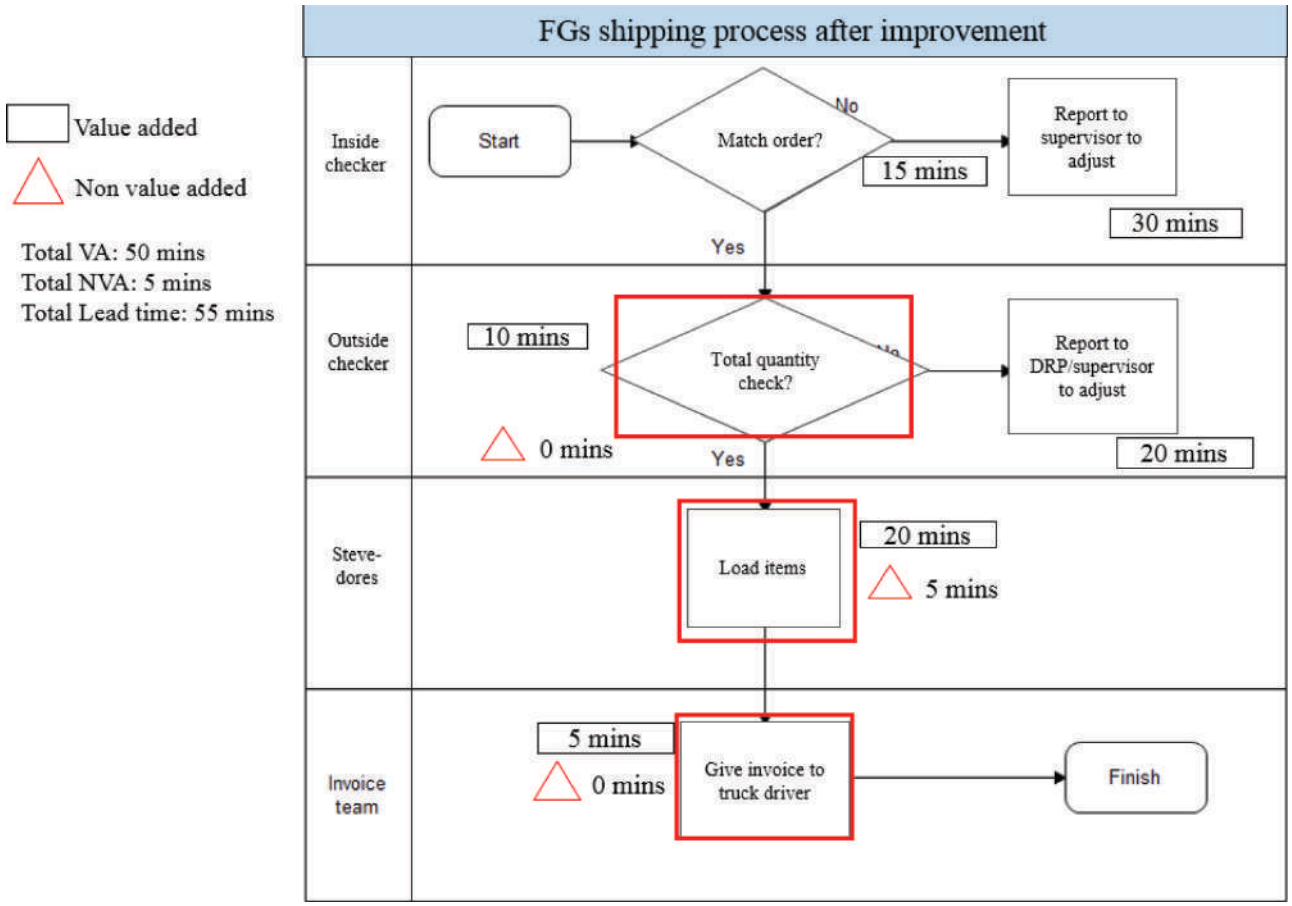

FIGURE 11 | Finish good (FG) shipping process after improvement.

From **Figure 6**, the current performance indexes are shown in **Table 2**.

From **Table 2**, it can be seen that the Personal Consumption Expenditures (PCE) is quite low due to high NVAT. There is still room for improvement in operation processes. The NVAT needs to be reduced to reduce lead time LT.

Analyze the current state map

The current state map is analyzed and improved in order to achieve the above objectives. Non-value-added activities in the current processes are analyzed to define causes and solutions to the problems. They are all shown in **Table 3**.

Draw the future state map

After applying the solutions, the future processes are re-engineered as in these following figures.

The future FG receiving process is shown in **Figure 7**.

The future FG put-away process is shown in **Figure 8**.

The future FG picking process is shown in **Figure 9**.

The future FG packaging process is shown in **Figure 10**.

TABLE 4 | Time distributions in future processes.

Number	Station	LT (mins)	VAT (mins)	NVAT (mins)
1	Receiving	56.5	52	4.5
2	Put away	30	25	5
3	Picking	120	72	48
4	Packaging	114	106	8
5	Shipping	55	50	5
Total		**375.5**	**305**	**70.5**

The future FG shipping process is shown in **Figure 11**.

The time distributions in future processes are shown in **Table 4**.

The future state map is drawn as in **Figure 12**.

From **Figure 12** the future state indexes are summarized in **Table 5**.

The current and future state indexes are summarized in **Table 6**.

From **Table 6**, it can be seen that NVAT decreases by 50.69%, from 143 (mins) to 70.5 (mins), PCE increases by 17.74%, from 69.18 (%) to 81.22 (%), and LT decreases by 19.07%, from 464 (mins) to 375.5 (mins).

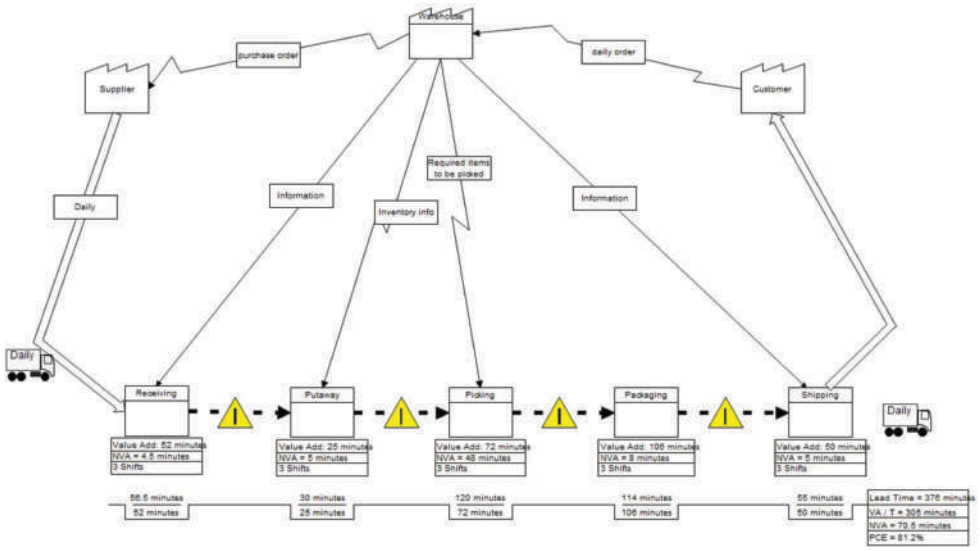

FIGURE 12 | Future state map.

TABLE 5 | Future state indexes.

Index	Value
LT (mins)	375.5
VAT (mins)	305
NVAT (mins)	70.5
PCE (%)	81.22

TABLE 6 | Current and future state indexes.

Index	Current	Future	Improvement (%)
LT (mins)	464	375.5	19.07
VAT (mins)	321	305	4.98
NVAT (mins)	143	70.5	50.69
PCE (%)	69.18	81.22	17.4

Conclusion

Value stream management has been applied as the platform in order to improve the operation processes of the warehouse under research with the objective to reduce the wasted time and to decrease the lead time. Data have been collected to draw the current state map. Non-value-added activities in the current state map are analyzed to define causes and solutions to the problems. The future state map has been drawn after applying the solutions. The result shows that the non-value-added time decreases by 50.69%, from 143 (mins) to 70.5 (mins), and the lead time decreases by 19.07%, from 464 (mins) to 375.5 (mins).

The research has advantages of using scientific methods to solve problems. However, the research still has the disadvantage that the solutions are not implemented to assess their effectiveness, and the future performance indexes are only estimated with the assumption that the solutions are effective. The weakness guides us to future studies.

Author contributions

PN was the thesis advisor of PH, PhatT, and PhuongT. PN has developed the models for the thesis. PH, PhatT, and PhuongT have collected and analyzed the data and run the models. PN has composed the article based on the thesis. All authors contributed to the article and approved the submitted version.

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