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LEAN INVENTORY MANAGEMENT OF AN INDUSTRIAL TOOL DISTRIBUTOR IN THAILAND USING A DATA VISUALIZATION TOOL

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Inventory management continues to play a critical role in the success of an organization. It is the collection of all the materials and goods stored, whether for use to complete the production process or for sale to the customer. The efficiency of inventory management is a challenge for all companies that have a warehouse or distribution center. Therefore, all firms need to adapt their business strategies to survive in a highly competitive market by applying tools or systems to support inventory control and management. This research was conducted to increase the efficiency of inventory management of an industrial tool distributor in Thailand by using the data visualization tool. It focused on the inventory planning process. Lean manufacturing was implemented to identify, improve and eliminate unnecessary activities in operations. Microsoft Power BI is a data visualization tool that was used in this study to support officers in operational decision-making and planning. It facilitated the monitoring of inventory levels, evaluating the value of inventory, and analyzing the key vendors on an almost real-time basis. The results showed that unnecessary activities were improved and simplified by integrating the data visualization tool. The lead time of the inventory planning process was decreased by 76.19% from 10.5 days to 2.5 days per time. It can increase the efficiency of inventory management.

Keywords: inventory management, lean manufacturing, data visualization tool, inventory planning

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1. INTRODUCTION

During the COVID-19 pandemic, all companies are facing many business problems and challenges at the same time. Many companies are forced to lay off employees or terminate their business. The remaining companies have to struggle to survive and preserve their business. The automotive industry in Thailand is a key industry for the Thai economy with strong infrastructures and a vast network of small and large, local and foreign companies all along the car-production supply chain. It has been significantly developed for over 50 years. Recently, the automotive sector was stalled by the COVID-19 pandemic. All companies in the automotive sector have to have a business strategy to pass through a crisis. Industrial tool distributors are important companies in the automotive supply chain that support the success of the automotive industry. One of the leading distributors of industrial tools and machines participates in this research. This company assists the automotive manufacturing company in productivity improvements, promotes quality systems, and takes part in driving the Thailand Industry to 4.0 through automation and smart technology. Inventory represents one of the most important assets for this company because its turnover represents revenue for the company. Inventory management is one of the major activities of a company that refers to the process of ordering, storing, and selling the inventory of both raw materials (components) and finished goods (products). Inventory management enables the company to succeed in having the right stock, at the right levels, in the right place, at the right time, and at the right cost as well as price. The aim of inventory management is to minimize holding costs while optimizing inventory. The most important part of efficient inventory management is accurate forecasting that can make informed predictions and ordering decisions. The inventory planning process is an important process that is the practice of using past data, trends and known upcoming events to predict needed inventory levels for a future period. Accurate forecasting ensures businesses have enough product to fulfill customer orders. Moreover, this company is facing the challenge of massive disruption and change. The rise of information technology has paved a new way for providing services to meet customers' needs or expectations. To increase the efficiency of inventory management and meet customers' needs or expectations, the company needs to adapt its business strategy to survive in a highly competitive market by applying a tool or system to support inventory management, thereby acquiring a competitive advantage. A data visualization tool was used to support officers in operational decision-making and planning. It allowed the company to monitor the inventory levels, evaluate the value of inventory, and analyze the key vendors on an almost real-time basis.

2. LITERATURE REVIEW

2.1. Lean manufacturing

Lean manufacturing is a philosophy that aims to minimize waste while productivity remains constant. It began and was applied by Toyota during the 1950s and is famously known as the Toyota Production System (TPS). The goals of TPS are to eliminate waste, streamline processes, increase efficiency, improve productivity, respect people, and please the customers. TPS directly influenced the creation of lean manufacturing. At first, Lean manufacturing was presented as the generic version of TPS that focused on cost reduction and productivity improvement for businesses to learn and implement into their own facilities (Womack et al., 1990). Over time, Lean manufacturing is interpreted as distinct from TPS and more its own unique thing. Today, Lean manufacturing is not suited only for manufacturing. It can apply to every business and every process. It is the strategy that seeks to deliver more value to customers as efficiently as possible (Womack, Jones, 2003).

Lean manufacturing focuses on the customer, workflow, accuracy, and relationships first while TPS focuses on respect for employees and continuous improvement first. However, waste elimination and continuous improvement are present in both strategies. The 5 Lean manufacturing principles are still at the core and a guide to implement Lean manufacturing starting with 1) specifying the value, 2) identifying the value stream, 3) making the value flow, 4) configuring the pull system by the customer, and 5) pursuing perfection (Rohania, Zahraeea, 2015). Based on the Toyota Production System, Lean manufacturing consists of a set of powerful "tools" and "techniques" that assist in the identification and steady elimination of waste (Muda) such as 5S, just-in-time (JIT), Jidoka, PDCA, Kanban (Pull system), Andon, Gemba, Hejunka (Level production), Kaizen (Continuous improvement), total productive maintenance (TPM), ECRS, single-minute exchange of dies (SMED), value stream mapping (VSM) and standardized work (Liker, Hoseus, 2008; Yadav et al., 2012). These tools and techniques serve as the basis of TPS and Lean manufacturing that stabilizes processes, makes production flow smoothly based on customer demand, identifies defects to improve quality, and ultimately delivers what the customer needs.

Many studies have applied lean manufacturing to inventory management. Hemalatha et al. (2021) applied lean manufacturing in boiler component fabrication work, where the aim was to determine the factors affecting the Work-In-Process (WIP) inventory levels to meet the required demand for each product. Tasdemir and Hiziroglu (2019) studied the impact of increased inventory leanness on financial performance of a value-added wood products manufacturer, which was expected to contribute to the intersection zone of three research streams, namely lean inventory management, procurement lot-sizing and demand forecasting. Berger et al. (2018)

analyzed different strategies of inventory management for finished products in a supplier-customer relationship in a logistics supply chain management environment by using computational simulation.

2.2. Data visualization

Data visualization is the process of translating large data sets and metrics into charts, graphs and other visuals. The resulting visual representation of data makes it easier to identify and share real-time trends, outliers, and new insights about the information represented in the data. A dashboard is an information visualization tool which monitors the events or activities at a glance by providing insights on one or more pages or screens. Unlike an infographic, which presents a static graphical representation, a dashboard conveys real-time information by pulling complex data points directly from large data sets. As the amount of big data increases, more people are using data visualization tools to access insights on their computer and on mobile devices. Dashboards are used by business people, data analysts, and data scientists to make data-driven business decisions (IBM, 2021).

Business Intelligence (BI) is a technology-driven process for analyzing data and presenting actionable information which helps executives, managers and other corporate end users make informed business decisions. BI encompasses a wide variety of tools, applications and methodologies that enable organizations to collect data from internal systems and external sources, prepare it for analysis, develop and run queries against that data and create reports, dashboards and data visualizations to make the analytical results available to corporate decision-makers, as well as operational workers. BI is both a process and a product. The process is composed of methods that organizations use to develop useful information, or intelligence, that can help organizations survive and thrive. The product is information that will allow organizations to predict the behavior of their "competitors, suppliers, customers, technologies, acquisitions, markets, products and services, and the general business environment" with a degree of certainty (Caseiro, Coelho, 2019). Within the architecture of the BI, it is important that a correct interaction between its components is given. Brannon (2010) describes the importance of four components for this platform, which are systems source, acquisition of data, data warehouse, and reporting and analysis tools.

Recently, business intelligence has been successfully applied to various sectors and services such as university management (Niño et al., 2020), agricultural biodiversity (Bimonte et al., 2021), restaurant marketing strategy (Halim et al., 2019), hospital services (Lopesa et al., 2021), education-employment (Conejero et al., 2021), cargo control (Václav et al., 2021), and traffic safety management (Veeramisti, Paz, Baker, 2020, p. 100-110).

3. METHODOLOGY

This research was conducted to increase the efficiency of inventory management of an industrial tool distributor in Thailand by using the data visualization tool. It focused on the inventory planning process. Lean manufacturing was implemented to identify, improve and eliminate unnecessary activities in operations. Microsoft Power BI is a data visualization tool that was used in this study to support the inventory planning officers in operational decision-making and planning. It enabled the company to monitor the inventory levels, evaluate the value of inventory, and analyze the key vendors on an almost real-time basis. This study was conducted in 4 phases. First, it was to study the current inventory planning process. Second, it was to identify, improve and eliminate unnecessary activities in operations. Third, it was to develop a new inventory requirement planning process. Fourth, it was to evaluate the efficiency of inventory management.

3.1. First phase: study the inventory planning process

This phase was to study the inventory planning process. The inventory planning process has 5 steps: 1) retrieve the inventory data, 2) prepare the inventory data, 3) calculate the minimum inventory level, 4) determine the minimum inventory level, and 5) modify the inventory data as shown in figure 1.

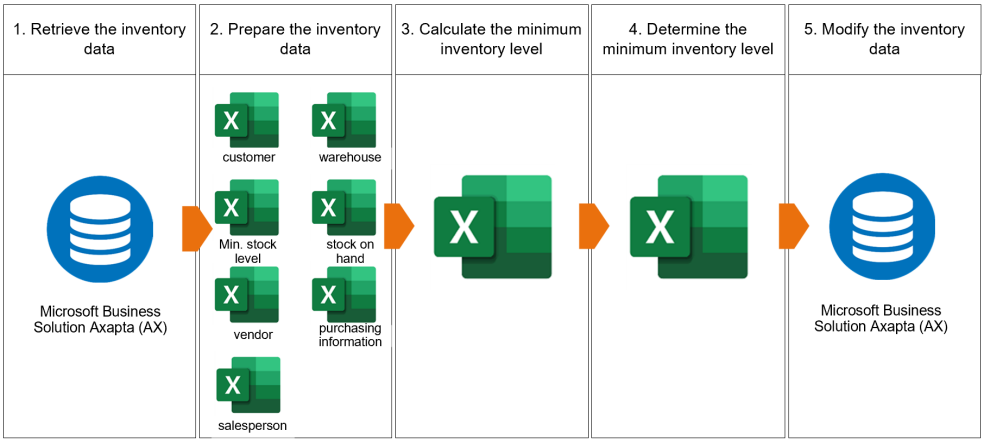


Fig. 1. The current inventory planning process

Step 1: Retrieve the inventory data – this step is to retrieve the inventory data from Enterprise Resource Planning (ERP) database. Microsoft Business Solution

Axapta is an ERP system that is used in the company. The inventory data is retrieved and exported monthly in an Excel file by the inventory planning officer. The inventory consists of customer data, the warehouse data, the minimum stock level data, the inventory stock on hand data, the vendor data, the purchasing information data, and the salesperson data.

Step 2: Prepare the inventory data – this step is to prepare the inventory data before it is used to calculate the minimum inventory level. It has 3 activities. The customer data and the warehouse data are matched to determine the relationship between the customer and the warehouse office. This company has three warehouse offices to distribute the products to customers. The eight vendors' data are matched with the customer data to determine the relationship between the warehouse office and the product item which is used to purchase by the customer. The product items, which are determined to zero stock value are removed from the minimum stock level data. The inventory stock on hand data and the stock on backorder data are classified in each warehouse office.

Step 3: Calculate the minimum inventory level – this step is to calculate the minimum stock level of each product item. It has 7 activities. The purchasing information data for the last 12 months are summarized and classified into 2 groups: the first 9 months and the last 3 months. The summarized data are integrated with the inventory stock on hand and stock backorder data to calculate the minimum stock and the maximum stock of each product item.

Step 4: Determine the minimum inventory level – this step is to determine the minimum stock level of each product item. Many product items have been assigned a salesperson who is the person responsible for following and determining the minimum stock level. In case of a product item without a responsible person, the inventory planning officer makes a decision to determine the minimum stock level with the following conditions: continuous use, regular use, and inconsistent use.

Step 5: Modify the inventory data – after determining the minimum stock level of each product item, the inventory planning officer inputs/modifies this information to the Microsoft Business Solution Axapta.

3.2. Second phase: identify, improve and eliminate unnecessary activities

This phase was to identify, improve and eliminate unnecessary activities. The study of the current inventory planning process found that the process of preparing the inventory data and the process of calculating the minimum inventory level takes a long time as shown in table 1.

Table 1. The number of working days and the number of activities for each process

Process	No. Working Days	No. Activities
Retrieve the inventory data	0.2	1
Prepare the inventory data	3.0	3
Calculate the minimum inventory level	7.0	7
Determine the minimum inventory level	0.1	1
Modify the inventory data	0.2	1
Total	10.5	13

The inventory planning officer needs to spend 3 working days to prepare the inventory and spend 7 working days to calculate the inventory level. These activities are complicated and iterative operations. Errors can occur and decrease the efficiency of inventory management. Therefore, it is important to improve and eliminate unnecessary activities.

3.3. Third phase: develop the new inventory planning process

This phase was to develop the new inventory planning process. Microsoft Power BI is a data visualization tool that was used in this study to improve and eliminate unnecessary activities in the inventory planning process. It was applied in the inventory planning process to support the inventory planning officers in operational decision-making and planning. The new inventory planning process still has 5 steps: 1) retrieve the inventory data, 2) prepare the inventory data, 3) calculate the minimum inventory level, 4) determine the minimum inventory level, and 5) modify the inventory data as shown in figure 2.

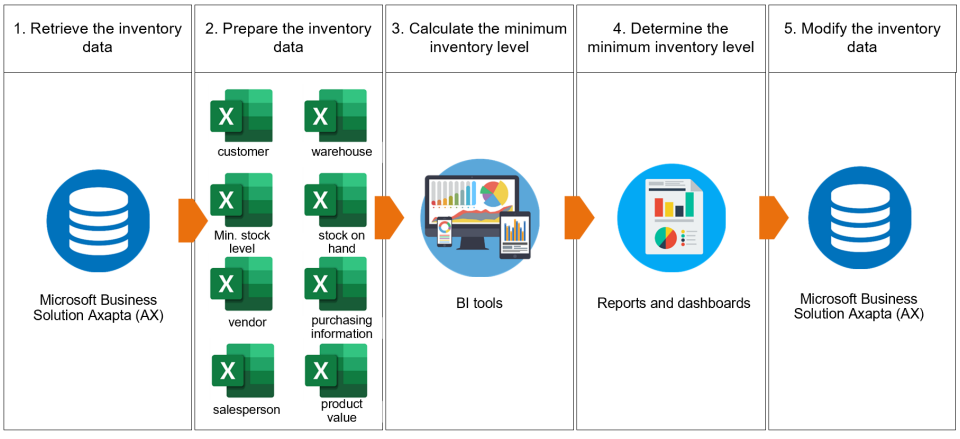


Fig. 2. The inventory data dashboard of each vendor

Step 1: Retrieve the inventory data – the operation is still the same as the previous inventory planning process. Microsoft Power BI cannot directly connect with the Microsoft Business Solution Axapta. The inventory data is retrieved and exported monthly in an Excel file by the inventory planning officer. The product value data is new data that is retrieved and exported.

Step 2: Prepare the inventory data – the process of preparing the inventory data has been changed to remain a single activity. The inventory data in the Excel file from the previous step is directly connected with the Microsoft Power BI desktop.

Step 3: Calculate the minimum inventory level – after developing the new inventory planning process by integrating the Microsoft Power BI Desktop, the process of calculating the minimum inventory level has been changed from 7 to 2 activities: 1) open the Microsoft Power BI Desktop, and 2) refresh the minimum inventory level.

Step 4: Determine the minimum inventory level – the result from the previous inventory planning process is illustrated in the Excel file but the new inventory planning process is shown in terms of the reports and dashboards. The reports and dashboards are shown in the results and discussion section.

Step 5: Modify the inventory data – this step is still the same as the previous inventory planning process, the inventory planning officer has to input/modify the inventory data to the Microsoft Business Solution Axapta.

3.4. Fourth phase: evaluate the efficiency of inventory management

This phase was to evaluate the efficiency of inventory management between the previous inventory planning process and the new inventory planning process. Two criteria were used to compare the efficiency of inventory planning process. They are the working days and working steps. The results are shown and discussed in the next section.

4. RESULTS AND DISCUSSION

This section was to illustrate the results from integrating the Microsoft Power BI to enable the company to monitor the inventory levels, evaluate the value of inventory, and analyze the key vendors on an almost real-time basis.

4.1. Reports and dashboards

Three dashboards were developed to monitor the inventory levels, the product value of each warehouse, and to analyze the key vendors. They are the inventory data dashboard, the inventory data dashboard of each vendor, and the minimum stock level dashboard of each vendor.

The first dashboard is the inventory data dashboard shown in figure 3. It shows the total of the products (blue area), the total number of products and the number of products in each warehouse (white area). The number of products on hand are compared with the minimum stock level. The total product value and the total product value of each warehouse are shown in the grey area.

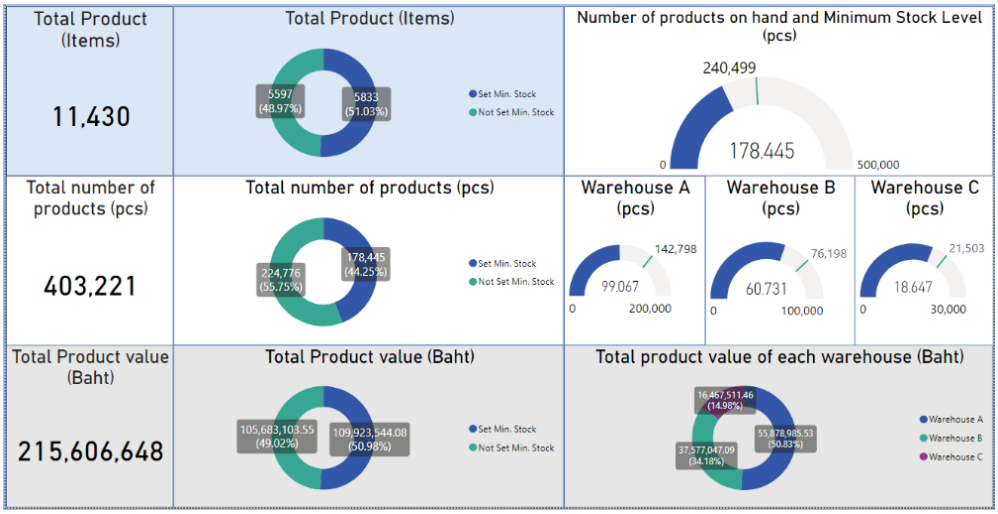


Fig. 3. The inventory data dashboard

The second dashboard is the inventory data dashboard of each vendor, shown in figure 4. The top blue area illustrates the number of products on hand and the minimum stock level of the vendor, the stock on hand of each warehouse, and the minimum stock level of each warehouse. The white area shows the purchasing information data of the vendor in the past 12 months. The grey area shows the product with minimum stock level, the total product value of the vendor, and the product value of each warehouse. The bottom blue area illustrates the number of products with a minimum stock level for each warehouse that have to be reviewed and determined, and the button for reviewing and determining the minimum stock level. The new dashboard for setting the minimum stock level will pop-up.

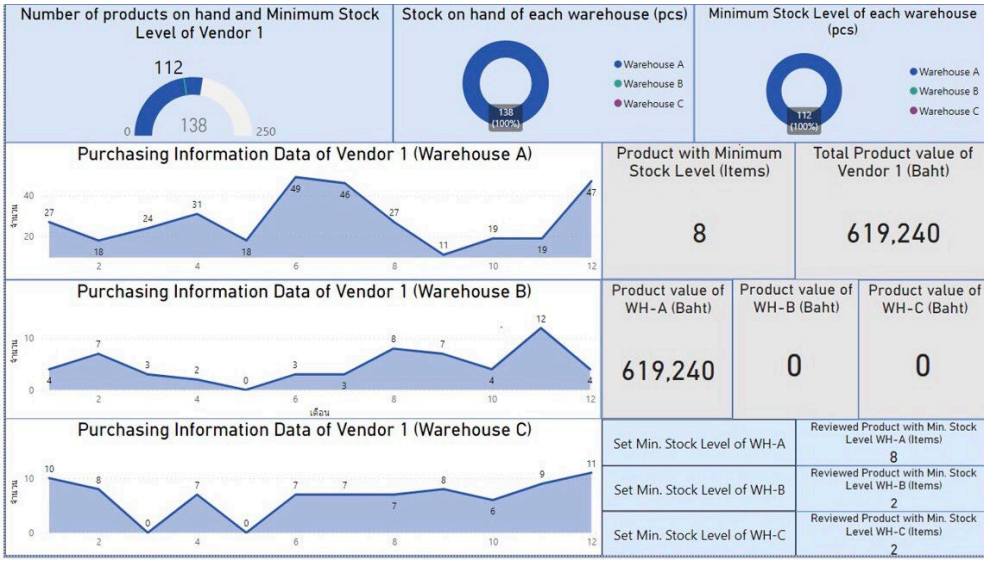
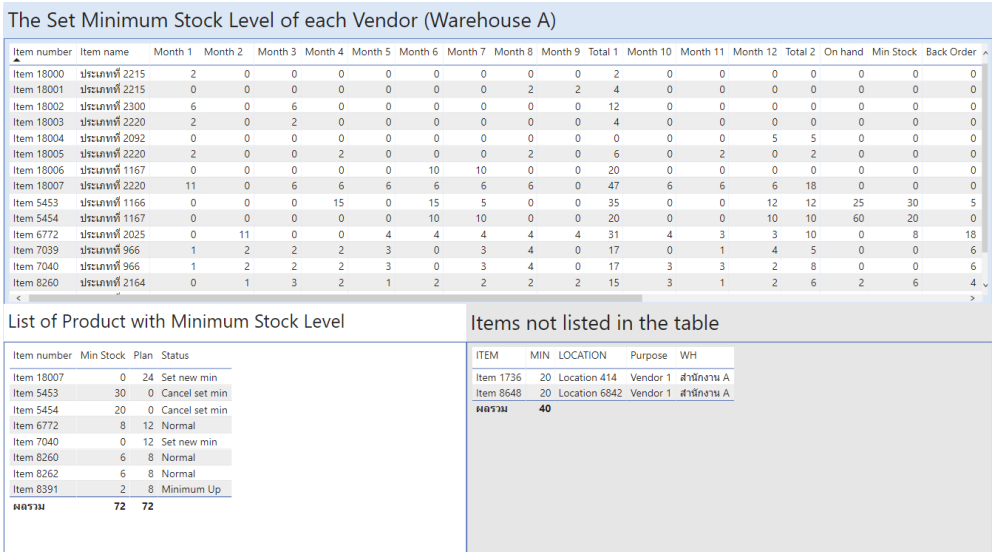


Fig. 4. The inventory data dashboard of each vendor

The third dashboard is the minimum stock level dashboard of each vendor shown in figure 5. It shows the purchasing product data for the past 12 months (blue area). The white area illustrates the list of products with a minimum stock level that have to be reviewed and the minimum stock level determined. The grey area shows the product items that are not listed in the table.



The Set Minimum Stock Level of each Vendor (Warehouse A)

Item number	Item name	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Total 1	Month 10	Month 11	Month 12	Total 2	On hand	Min Stock	Back Order
Item 18000	ประเภทที่ 2215	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Item 18001	ประเภทที่ 2215	0	0	0	0	0	0	0	2	2	4	0	0	0	0	0	0	0
Item 18002	ประเภทที่ 2300	6	0	6	0	0	0	0	0	0	12	0	0	0	0	0	0	0
Item 18003	ประเภทที่ 2220	2	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Item 18004	ประเภทที่ 2092	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0
Item 18005	ประเภทที่ 2220	2	0	0	2	0	0	0	2	0	6	0	2	0	2	0	0	0
Item 18006	ประเภทที่ 1167	0	0	0	0	0	10	10	0	0	20	0	0	0	0	0	0	0
Item 18007	ประเภทที่ 2220	11	0	6	6	6	6	6	6	0	47	6	6	6	18	0	0	0
Item 5453	ประเภทที่ 1166	0	0	0	15	0	15	5	0	0	35	0	0	12	12	25	30	5
Item 5454	ประเภทที่ 1167	0	0	0	0	0	10	10	0	0	20	0	0	10	10	60	20	0
Item 6772	ประเภทที่ 2025	0	11	0	0	4	4	4	4	4	31	4	3	3	10	0	8	18
Item 7039	ประเภทที่ 966	1	2	2	2	3	0	3	4	0	17	0	1	4	5	0	0	6
Item 7040	ประเภทที่ 966	1	2	2	2	3	0	3	4	0	17	3	3	2	8	0	0	6
Item 8260	ประเภทที่ 2164	0	1	3	2	1	2	2	2	2	15	3	1	2	6	2	6	4

List of Product with Minimum Stock Level

Item number	Min Stock	Plan	Status
Item 18007	0	24	Set new min
Item 5453	30	0	Cancel set min
Item 5454	20	0	Cancel set min
Item 6772	8	12	Normal
Item 7040	0	12	Set new min
Item 8260	6	8	Normal
Item 8262	6	8	Normal
Item 8391	2	8	Minimum Up
ผลรวม	**72**	**72**	

Items not listed in the table

ITEM	MIN	LOCATION	Purpose	WH
Item 1736	20	Location 414	Vendor 1	สำนักงาน A
Item 8648	20	Location 6842	Vendor 1	สำนักงาน A
ผลรวม	**40**			

Fig. 5. The minimum stock level dashboard of each vendor

4.2. Results

The differences in the efficiency of inventory management between the previous inventory planning process and the new inventory planning process were evaluated by the number of working days and the number of activities, as shown in table 2.

Table 2. The efficiency of new inventory management

Process	Previous		New	
	No. Working Days	No. Activities	No. Working Days	No. Activities
Retrieve the inventory data	0.2	1	0.2	1
Prepare the inventory data	3.0	3	1.0	1
Calculate the minimum inventory level	7.0	7	1.0	2
Determine the minimum inventory level	0.1	1	0.1	1
Modify the inventory data	0.2	1	0.2	1
Total	**10.5**	**13**	**2.5**	**6**

The result showed that unnecessary activities were improved and simplified by integrating the Microsoft Power BI. The lead time of the inventory planning process was decreased by 76.19% from 10.5 days to 2.5 days per time. The activities of the inventory planning process were decreased by 53.84% from 13 activities to 6 activities per time. The results illustrate that a data visualization tool can increase the efficiency of inventory management. It can reduce the working time and support the inventory planning officers in operational decision-making and planning.

5. CONCLUSION

This study was conducted to increase the efficiency of inventory management of an industrial tool distributor in Thailand by using the data visualization tool. Microsoft Power BI is a data visualization tool that was used in this study to improve and eliminate unnecessary activities in the inventory planning process. It was applied in the inventory planning process to support the inventory planning officers in operational decision-making and planning. The inventory data were retrieved from an ERP system and exported monthly in an Excel file. They directly connected with the Microsoft Power BI desktop to calculate and determine the minimum stock level of each product item. The number of working days and the number of activities were used to compare the efficiency of inventory management between the pre-

vious inventory planning process and the new inventory planning process. The results showed that unnecessary activities were improved and simplified. The lead time of the inventory planning process was decreased by 76.19% from 10.5 days to 2.5 days per time. The activities of the inventory planning process were decreased by 53.84% from 13 activities to 6 activities per time. It can be summarized that the data visualization tool can increase the efficiency of inventory management. It can reduce working time and support the inventory planning officers in operational decision-making and planning.

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SZCZUPŁE ZARZĄDZANIE ZAPASAMI – PRZYKŁAD ZASTOSOWANIA NARZĘDZIA DO WIZUALIZACJI DANYCH DLA DYSTRYBUTORA NARZĘDZI PRZEMYSŁOWYCH W TAJLANDII

Streszczenie

Zarządzanie zapasami nadal odgrywa kluczową rolę w sukcesie organizacji. Zapasem określa się wszystkie materiały i towary przechowywane w celu wykorzystania ich do procesu produkcyjnego czy też sprzedaży klientowi. Efektywność zarządzania zapasami jest wyzwaniem dla wszystkich firm, które mają magazyn lub centrum dystrybucyjne. Wszystkie firmy muszą dostosować strategie biznesowe, aby przetrwać na wysoce konkurencyjnym rynku. W tym celu stosuje się narzędzia lub systemy wspomagające kontrolę i zarządzanie zapasami. Przeprowadzone badanie miało zwiększyć efektywność zarządzania zapasami dystrybutora narzędzi przemysłowych w Tajlandii za pomocą narzędzia do wizualizacji danych. Skupiono się na procesie planowania zapasów. Wdrożono koncepcję zarządzania szczupłego w celu identyfikacji, poprawy i eliminacji zbędnych działań w operacjach. Do wizualizacji danych zastosowano Microsoft Power, które zostało wykorzystane w tym badaniu do wspierania pracowników w podejmowaniu decyzji operacyjnych i planowaniu. Umożliwiło ono monitorowanie poziomów zapasów, ocenę ich wartości oraz analizę kluczowych dostawców w czasie niemal rzeczywistym. Wynik pokazał, że zbędne czynności zostały usprawnione i uproszczone dzięki integracji narzędzia do wizualizacji danych. Czas realizacji procesu planowania zapasów został skrócony o 76,19% z 10,5 dnia do 2,5 dnia. Przeprowadzone badania stanowią przykład, jak można zwiększyć efektywność zarządzania zapasami.

Słowa kluczowe: zarządzanie zapasami, lean manufacturing, szczupłe wytwarzanie, narzędzie do wizualizacji danych, planowanie zapasów