

Application of Waterfall-System Development Life Cycle Methodology for Designing Purchase Order Material Control System

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Abstract— In this fast-paced demand consumer chain, the manufacturer has to go even faster to follow the stream. A strong purchasing monitoring system is required to ensure material delivery time accuracy and provide material adjustment for production continuity. This study discussed the information flow of material purchasing to understand the important role of Purchase Order (PO) Material Control in managing the production material. This research was conducted a plastic packaging manufacturing. PO Material Control is used to carry out material purchasing management activities from the PO release stage, PO processing, and material receiving. The current system does not run well due to deficiencies of unclear instructions, unclear purpose, disorganized structure, and lack of supervision. It harms the management of material purchases. This research employs a Waterfall-System Development Life Cycle (SDLC) for identifying and improving the PO material control system. The improved system provides an organized visualization of inputs, displaying clear objectives as information outputs and refining the flowchart to utilize the system for better supervision. By implementing the proposed system, users become more understanding of running the system. The system that has been suggested can be utilized following its goal, where the monitoring of material procurement can also be carried out. The system also provides an output such as reports that can be used for operations and planning for future material purchases.

Keywords— Material purchasing, Purchase Order, Flow of information, Information system, Macro-VBA, SDLC.

I. INTRODUCTION

Material management is one of the most crucial processes in supporting production processes' continuity. Material management includes planning, purchasing, receipting material, supplier evaluation, inventory control, and warehousing [1]. In implementing material management, it is beneficial to establish a communication network and control the flow of material. In addition, it needs to be well managed because it can affect several activities in the factory, such as scheduling, production process, and production quality.

Many studies have been conducted on material management [2], stating that the traceability system is important for material requisition. The traceability system in material requisition is needed to prevent the unpreparedness or unavailability of material when the project is run because it directly affects work. In line with that, the incoming material, material withdrawal, and material utilization are recorded in the system to control the material circulation [3] and reduce the cost of production because of material loss [4].

Many studies discussed technology's use for production tracking, inventory control, and monitoring. The previous research was conducted to control and monitor the inventory stock using web-based. The web-based online inventory system has numerous advantages, including making it simpler for businesses to monitor their current stock situations, produce reports or gather information about the product, and makes it simple for companies to produce additional products to be stocked [5].

Other studies related to production tracking and monitoring using technology were conducted. Tracking technology is used to concurrently verify and take required actions to promptly ensure the product's completeness [6]-[8]. In addition, technology Android platform was offered to provide a dashboard for finding the current job [9].

This study aims to improve the material management system, especially the material purchase order control system, using technology to track the material purchasing starting from a supplier and the material delivery to the factory. Material purchasing includes ordering, expediting, maintaining inventory, receiving goods, storing supplies, and payment arrangements [10][11]. Material purchasing activities start from selecting suppliers, making contracts with suppliers, ordering goods, and ensuring goods are sent to the factory. Ensuring the delivery of these goods is related to the guarantee of production supply [12]. Even though purchasing is mainly about transactional and commercial activities, two factors must be considered. Those two factors are the physical flow of material and information. Of these two things, the object of research is the flow of information. Because it affects the factory's workflow, the information flow must be controlled most efficiently.

This research took place in a plastic packaging company and was carried out from July 2021 to October 2021. This company manages material purchase orders in a PO Material Control system. Ideally, the system works by inputting all the material purchase information. The information includes the Purchase Order (PO) details from release until material

handling. After observation, it is found that the system is not used properly. The information is only distributed orally and not well recorded in the system. Uncontrolled systems caused adverse effects on the other processes involved, including inbound activity, material inspection, document preparation for imported material, scheduling, and supplier evaluation. It also impacts the company's expenses for raw material purchasing. Moreover, due to the unrecorded information, it is difficult to evaluate both internal and external parties. This study focused on improving the PO Material Control system by identifying the weaknesses of the existing system and developing the proposed system by applying the System Development Life Cycle (SDLC). System Development Life Cycle (SDLC) is a staged method of analysis and design that asserts that systems are best built by following a set of analyst

and user tasks [13]-[15]. The tool used in this research is Microsoft Excel, where the system will be built. This research is expected to contribute to the development of a material management system, especially in the process of purchasing materials controls.

II. RESEARCH METHODOLOGY

The software development methodology plans, manages, and controls information system creation [16]. The methodology used for this study is the system development life cycle (SDLC) because it clearly describes the development of a good system in the right order [15]-[17]. The research methodology using Waterfall SDLC is presented in Figure 1.

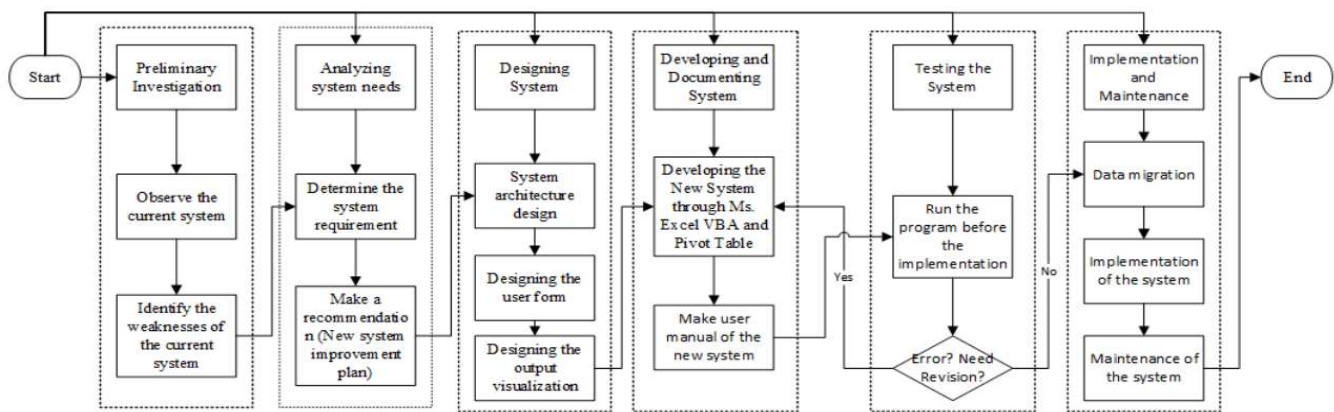


Figure 1. Research Framework of Waterfall-SDLC

A. Preliminary Investigation

The first phase of this research is conducting a preliminary investigation. The purchase order (PO) material control system is observed and compared to the standard. Ideally, all information about the material purchase process is recorded in the system following existing progress so that the material PO can be controlled properly.

Once the observation is completed, the weaknesses of the current system must be identified. Based on problem mapping, the system needs to be fixed so that an overhaul of the old system must be done.

B. Analysing System Needs

At this stage, system development begins with the analysis of the needs of the system. Analyzing the system's requirements is important because it defines how it works. There are two main parts to this phase. The first part is determining the system requirements of the users to eliminate the root causes. In this case, a discussion with all users is conducted. The users are purchasing administrators, supervisor purchasing, and manager purchasing. After the users determine their needs, the next stage is to develop an improvement plan by determining the tools used for improvement. In this case, Microsoft Excel is specified as a

tool. The discussion results at this stage are used to make system improvement recommendations.

C. Designing System

The third phase is design. In this phase. The rough model of the new system will be translated into the proper system. Several aspects are the focus of this phase:

- Design of the user form.
- Design of the output visualization
- System architecture design

D. Developing and Documenting System

The next step is developing and documenting the system. In the developing phase, the code of the system will be made. Thus, the system can work to its function. Besides that, in documenting phase, a user manual will be written to guide the user to the new system.

E. Testing the System

Testing is the phase where the system is tried before the real implementation. It will be conducted using the black box testing method. Each function of the system will be tried. Thus, if there is an error, it can be fixed immediately. However, it is not only focused on errors but also on how the system works.

F. Implementing and Maintenance

After the testing phase is completed, the next step is implementing the system. The old data will be transferred into the new database during implementation. Then, the system will be installed to be used.

In addition, maintenance is conducted to ensure the system is run correctly. The new system requires maintenance once the user requests a new feature, and the system needs to be adjusted.

III. RESULT AND DISCUSSION

The system is based on the previous section's research framework. It discussed the detailed implementation of SDLC.

A. Preliminary Investigation

In this study, the first stage is the observation and analysis of the current system. The source of the problem and the room for improvement is obtained through these observations and analysis. The current system is shown in Figure 2, Figure 3, and Figure 4.

Figure 2. Current System – 1

Figure 3. Current System – 2

Figure 4. Current System – 3

This system is created in Microsoft Excel and uploaded to the purchasing team's share folder. In the current system, all the information that has to be completed is made into one worksheet. Thus, it must be filled horizontally. The information includes general information, material purchase developments, and material retrieval from ports.

This system involves three parties as users in its operation, including purchasing administrator, the productive item (PI) purchasing supervisor, and purchasing manager. The flowchart of the current system is depicted in Figure 5.

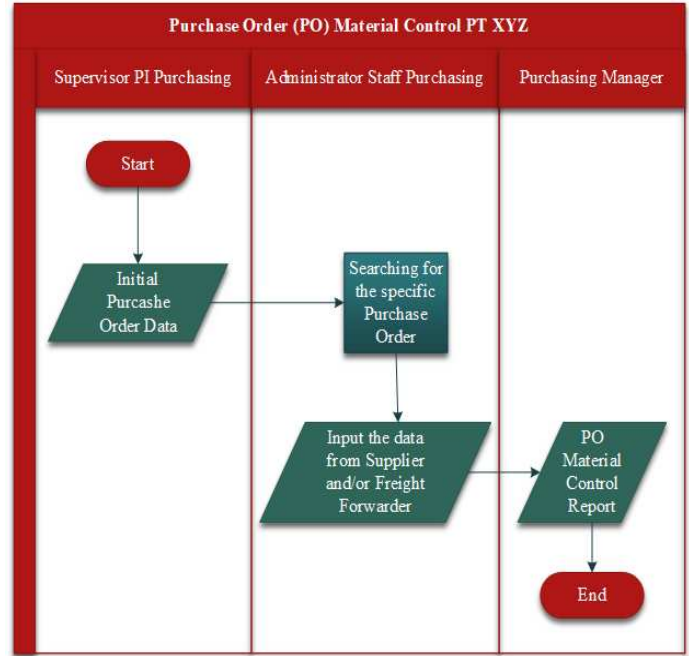


Figure 5. Current Flowchart

In the current system, the supervisor PI is assigned to input the initial data of PO material. The data contains details of the materials purchased and the supplier. Furthermore, the purchasing administrator is tasked with completing the data obtained from a third party, a supplier. In addition to suppliers, there is a freight forwarder if the material is imported. Meanwhile, the manager will generate reports from the system for monitoring and planning material purchases in the next period. The system's weaknesses were obtained based on observations and user interview results, as shown in Table I.

TABLE I
WEAKNESSES OF THE CURRENT SYSTEM

Weakness	Explanation
Unclear instruction	It does not have clear and straightforward instructions about how to use the system. Thus, it leads to confusion when the users run it.
Unclear purpose	The purpose of the system is not revealed. Users have not explained the purposes of the current system. Thus, it is considered useless.
Disorganized structure	Input data of the system is mixed up and not structured according to the correct section.

Weakness	Explanation
Lack of supervision	Lack of supervision in running this system. Thus, the system is uncontrolled when the supervisor PI purchasing or administrator staff purchasing are not updating the information.

Through this identification, the new system is expected to provide organized visualizations following the correct section. Then, the output presents the function of the system. Guidance is provided to users, so they can correctly fill in the information on the system. In addition, there will be refinement in the process flow to ensure supervision in running the system.

B. Analysing System Needs

The needs of the system are collected from the three users who will use the system. Then the set of needs of the system will be made into a new system improvement plan. The user requirement is shown in Table II.

TABLE II
USER REQUIREMENTS

User	Requirements
Supervisor PI Purchasing	1. The system authorizes the user to add the new initial data. 2. The system authorizes the user to edit the initial data. 3. The system authorizes the user to search the existing data. 4. The system authorizes the user to delete the data.
Administrator Staff Purchasing	1. The system authorizes users to search the data based on the PO Number. 2. The system authorizes users to update information on the existing data. 3. The system authorizes the user to search for the Arrival Date of the PO. 4. Agreed sections group the visualization of the system. 5. The system authorizes the user to read the output.
Purchasing Manager	1. The system authorizes users to search the data based on PO Number, Order Status, and Arrival Date. 2. The system authorizes the user to read the output. 3. The system summarises material purchasing based on the agreed criteria.

In this case, the system requirements identified by the users are adjusted to the responsibilities given. Defining the system's needs can contribute to constructing a new system that follows the desired objectives and functions. The sequence shown in the summary table does not define the priorities.

After determining the system requirements is implementing an improvement plan. The improvement plan includes refining the flowchart, software development, user form design for the proper data entering, output visualization, and preparing the user manual for system guidelines.

Figure 6 shows the improvement of the previous flowchart. The improved flow chart is modified in the checking process.

The purchasing manager will be responsible for supervising the system. Thus, the system will be updated.

The software used to build the PO material control system is Microsoft Excel. Microsoft Excel is selected because of its capability to develop a system that can be easily used and simple. The users of the system are also familiar with the software.

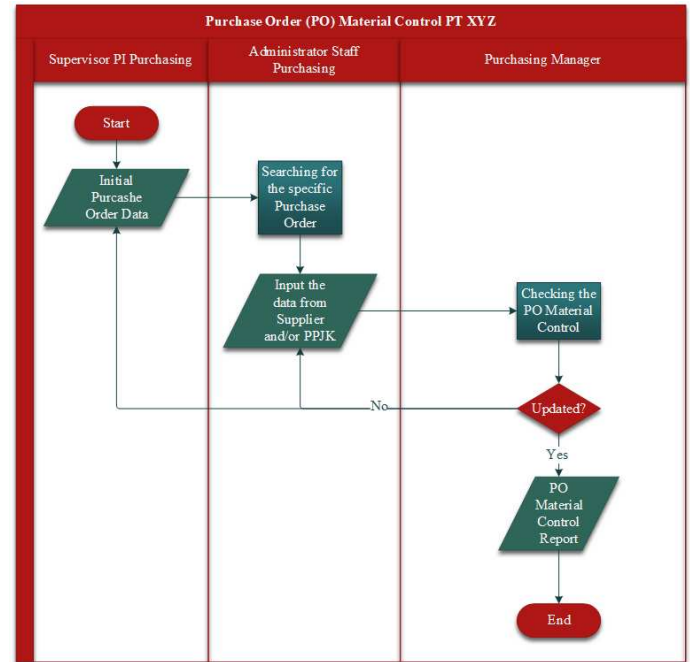


Figure 6. Improved Flowchart

As for the user form, it is used to design the proper data entry. It is equipped with visual basic for Application (VBA) in Microsoft Excel. Some functions can be performed in the user input form, including searching for information, saving the data, reading the PO material data, adding information to the PO material, updating the PO material, and deleting the data.

Besides the data input designed in the user form, there is data visualization for the output. The visualized output is provided to show the function of the system. Thus, it can be employed to control material purchasing. The output is designed using a pivot table in Microsoft Excel. It includes information about the Letter of Credit (LC) application, shipping schedule information, material arrived at the port, and a report of material purchasing.

In addition, the system guidance and user manual are prepared to explain the whole system. Thus, the users can operate the proposed system.

C. Designing System

The next step is to design the new system based on the system requirements and the improvement plan. The system architecture of the system will be shown. Then the system will be designed using tools in Microsoft Excel such as Visual Basic Application (VBA), Pivot Table, and shapes. The

design will be divided into two parts: design of user form input data and output visualization. Figure 7 is the architecture of the new system.

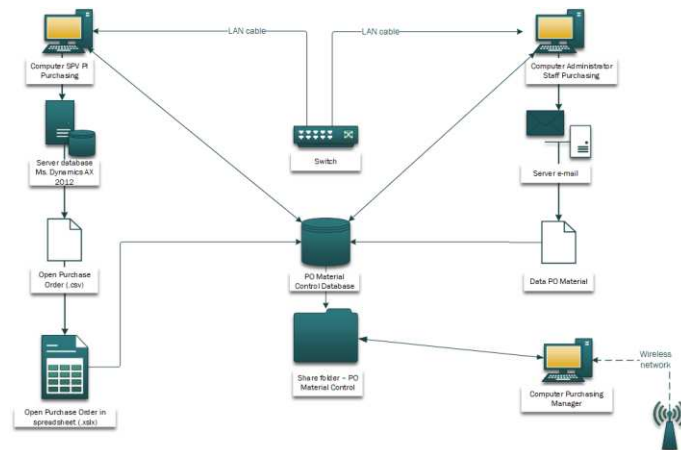


Figure 7. System Architecture

At this stage, the user form is also designed. In the design of the user form, several things are considered, including the database, data input, and system output.

The database is created in one of the worksheets of the workbook of PO material control. The database will be used to store all the information on the system. General information about material purchases will be taken from Microsoft Dynamics AX. Thus, in its implementation, the approved purchase plan will be extracted in Microsoft Excel output format. Data extraction on the system is shown in Figure 8.

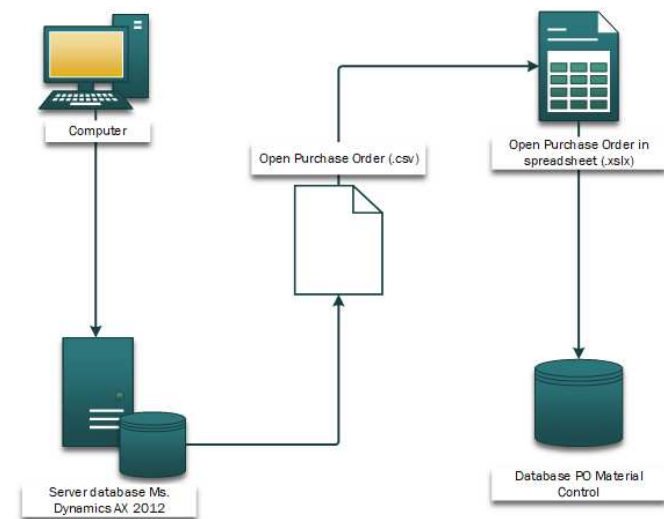


Figure 8. Data Extraction

In the input data, the information will be grouped into predefined sections. Then, some information remarks are adjusted to the agreed options. Data inputs are shown in several images according to the design phase, including the initial data input design and data input display. Figure 9 shows a user form model designed using visual basic. In the initial data input design, several items are used, including frames,

textbox, combo box, command button, page, label, and list box. In this data input, any information is classified according to the section separated by the page.

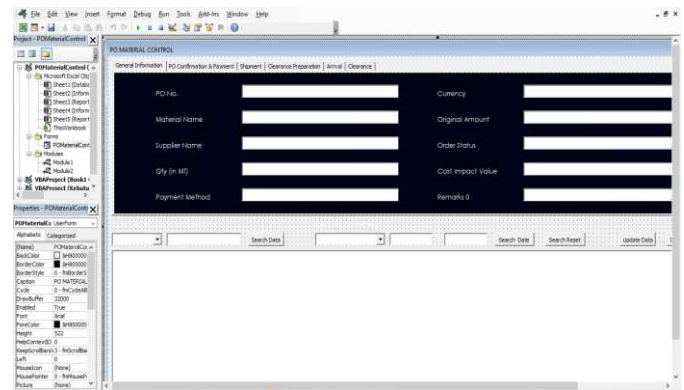


Figure 9. User Form Design of Improved PO Material Control System

Figure 10 shows the initial data input display when the system is running. The top part is to enter information and offer detailed information from the selected PO material. Meanwhile, the bottom part shows the data stored in the system. This system's output will be shown in the user form and the output for the daily report and overall material purchasing report.

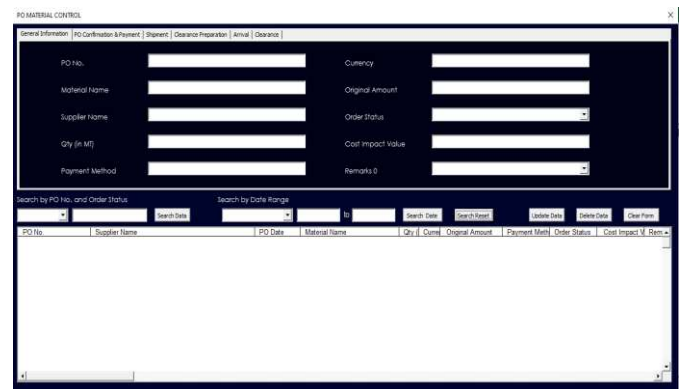


Figure 10. User Form of Improved Material Control

Figure 11 shows a daily report used to track material purchases. Meanwhile, Figure 12 depicts a design of the entire material purchase and the deviations of the purchasing.

Kapal yang akan sampai Hari Ini - 7 Hari ke depan		Informasi PO yang tertahan di Port	
Setting: SOON TO BE ARRIVED		Setting: Have Not Released, TRUE	
ETA PORT FIN ARRIVED SOON TO BE ARRIVED ☐		Status SPBB (2)	Have Not Released ☐
		E to P (2) Lebih dari 7 Hari?	TRUE ☐
PO No.	ETA Port Date Final	PO No.	ETA Port Date Final
Data PO No.	Date of arrival	Data PO No.	SPPB Released Date

Figure 11. Daily Report Improved PO Material Control

Material purchasing reports can be filtered according to the supplier, material name, and purchase time. It provides information that can be used to evaluate and plan future material purchases.

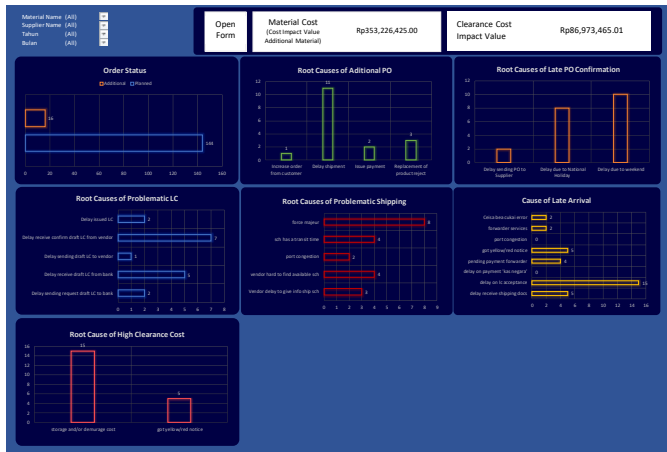


Figure 12. Material Purchasing Report Design of Improved PO Material Control

D. Developing and Documenting System

Once the system's design is created, the next stage is to develop the system and prepare documents to support the use of the system. System development is done to activate the functions in the system. In this case, the system will be developed by assigning code to the VBA. The function includes calling, searching, updating, and deleting data.

Meanwhile, the system will have a user manual as a guide during the documenting stage. System guidelines must be prepared to give information regarding the utilization of the new system. Thus, in operating the new system, users do not experience confusion. In the system guidelines, the contents written are as follows.

- General information for PO Material Control
- Duties of PO Material Control users
- Guide to using PO Material Control

E. Testing the System

In this stage, the system was tested using the black box testing method. The test was performed to find out whether the system that has been made can run properly. This test was performed for editing, deleting, and generating the report. The test is conducted in the correct sequence of using the system. The summary of the system test is shown in Table III. It is concluded that all functions can run well.

TABLE III
TESTING RESULT SUMMARY

Case	Step	Desired Result	Testing Result
Calling data	Double-click on the desired data in the list box.	Data appears on the text box of the system.	Complete
Searching data	Choose a search category and fill in the data name based on the category. Then run the search command button.	A message box appears if valid (Data found successfully) or invalid (The data you are looking for was not found).	Complete

Case	Step	Desired Result	Testing Result
Updating data	Run (click) the update command button on the user form.	A message box pops up (Data successfully updated).	Complete
Deleting data	Call the desired data. Then run (click) the delete command button on the user form.	A message box pops up asking for confirmation to Delete the data selected.	Complete
Report visualization	Set the desired report parameter.	The chart and information are shown based on the parameter set.	Complete

F. Implementation and Maintenance of the System

In this stage, the implementation of the new system begins to be used. This stage shows the use of the new system. These things include data migration, the implementation of the new system, and data updating. In addition, some reports contain useful information from material purchasing.

The first step of implementing the system is migrating the data. Figure 13 shows the data that has been migrated to the new database. The data migrated is material purchase data from January 2021. The purpose of migrating this data is to find out the history of the purchase of materials and continue controlling the maintenance of unfinished materials. Meanwhile, the latest material purchase data is taken from the extracted Dynamics AX. Meanwhile, Figure 13 is the notification of the successful use of the system. The picture shows the data from the system that has been successfully updated.

Figure 13. Data Migration

Figure 14, Figure 15, and Figure 16 are output visualization data from information that has been entered into the system. The report can be used to control the purchase of materials. The data contained in Figure 15, Figure 16, and Figure 17 is an overview of the implementation of daily reports and overall reports from the system. Figure 15 and Figure 16 provide information on the progress of material purchases. Meanwhile, Figure 17 includes comprehensive information on the purchase of completed materials

Figure 14. Data Updating

Figure 15. Daily Report of Improved PO Material Control – 1

Figure 16. Daily Report of Improved Material Control – 2



Figure 17 Material Purchasing Report of Improved PO Material Control

This system is developed based on predetermined requirements by the user. Thus, the requirements are used to evaluate whether the system has satisfied the user's needs. Table IV presents the summary of the evaluation of implementation. It is concluded that all the requirements are successfully implemented.

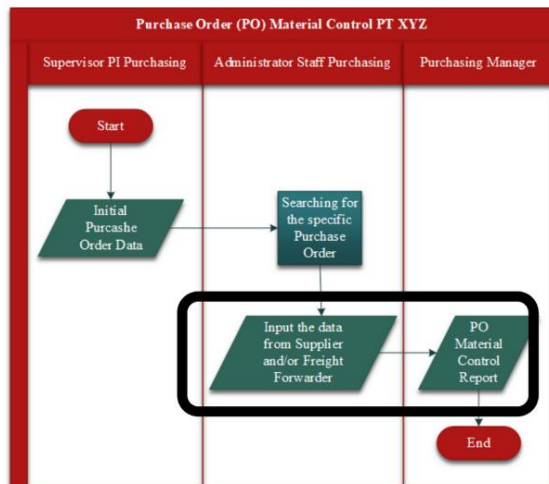
TABLE IV
STATUS IMPLEMENTATION OF SYSTEM REQUIREMENTS

User	Requirements	Implementation
Supervisor PI Purchasing	1. The system authorizes the user to add the new initial data.	Successfully implemented
	2. The system authorizes the user to edit the initial data.	Successfully implemented
	3. The system authorizes the user to search the existing data.	Successfully implemented
	4. The system authorizes the user to delete the data.	Successfully implemented
Administrator Staff Purchasing	1. The system authorizes users to search the data based on the PO Number.	Successfully implemented
	2. The system authorizes users to update information on the existing data.	Successfully implemented
	3. The system authorizes the user to search for the Arrival Date of the PO.	Successfully implemented
	4. Agreed sections group the visualization of the system.	Successfully implemented
	5. The system authorizes the user to read the output.	Successfully implemented
Purchasing Manager	1. The system authorizes users to search the data based on PO Number, Order Status, and Arrival Date.	Successfully implemented
	2. The system authorizes the user to read the output.	Successfully implemented
	3. The system summarises material purchasing based on the agreed criteria.	Successfully implemented

The last stage of development of this system is maintenance. This stage is a part of maintaining the system running smoothly. In this study, maintenance was performed to repair system errors and add features. System error is fixed by revising the VBA coding editor on macro. In this case, the additional features are the addition of the output report, namely the Letter of Credit (LC) daily report and PO information held at the port (port). Meanwhile, some maintenance parts are also explained in the system's guidance.

The improvement plan can identify the difference between the current and new systems. Both systems differ in the flow process, data input display, and output. Figure 18 depicts the comparison of the flowchart between the current and proposed system.

Current Flowchart



Improved Flowchart

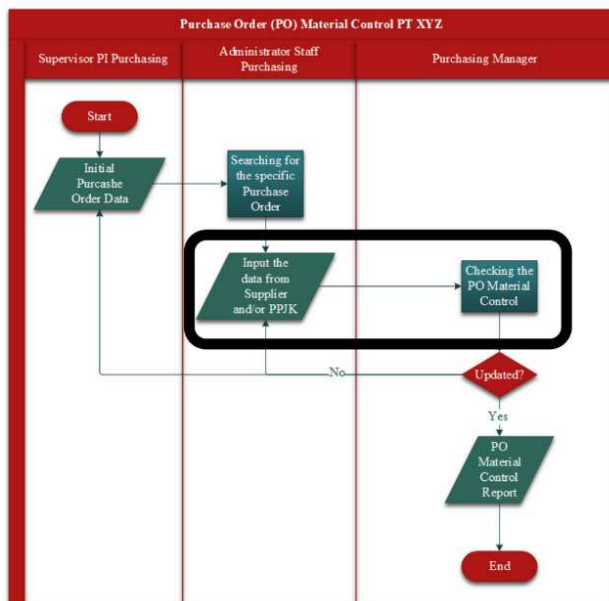


Figure 18 Comparison between Current and Improved Flowchart

The current flowchart does not have the supervision step. In the proposed system, supervision is added due to real-time information updating. In addition, the comparison between the two systems is made to know the improvement has been made to the system. The differences are identified by three categories: flowchart, input, and output of the current and proposed system. The comparison is summarized in Table V.

TABLE V
COMPARISON BETWEEN CURRENT AND IMPROVED SYSTEM

Comparison	Current System	Improved System
Flowchart	There is no checking process by the manager. Thus, the system lacks supervision.	The checking process is added. Thus, the manager can check the progress of the material purchasing.

Comparison	Current System	Improved System
Input	Disorganized data entry visualization and unclear instruction lead to confusion.	Structured data entry is categorized into several sections based on process and given guidance.
Output	No specific output leads to an unclear purpose in running the system.	Provide daily operation and material purchasing reports that can be used to monitor material purchasing and planning.

IV. CONCLUSION

Purchase Order (PO) Material Control is a system owned by PT X as a plastic packaging company to monitor the purchase of materials from suppliers and the receiving material at the factory. In its implementation, the current system has several weaknesses. These weaknesses include unclear instruction, purpose, disorganized structure, and lack of supervision. Thus, the system cannot run optimally.

The proposed improvement was successfully implemented. The system was developed using the System Development Life Cycle (SDLC) methodology utilizing macro-VBA and Pivot Table. In the improved system, several features are added, including a user form for input data and system output in the form of daily reports and material purchasing reports. In addition, the current flowchart is refined to add supervision in running the system, and system guidance is made to give clear instructions and explanations about the whole system.

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