SITEKIN: Jurnal Sains, Teknologi dan Industri, Vol. 22, No. 2, June 2025, pp.355 - 364
ISSN 2407-0939 print/ISSN 2721-2041 online

Optimization Of Integrated Material Procurement Processes in The Vendor Managed Inventory (VMI) System

Fadhil Adita Ramadhan[1], Agus Mansur[2]
[1,2] Magister of Industrial Engineering, Faculty of Industrial Technology, Universitas Islam Indonesia
Jl. Kaliurang KM 14,5 Sleman, Yogyakarta, Indonesia 55584
Email: 23916008@students.uii.ac.id, agusmansur@uii.ac.id

ABSTRACT

This study aims to address challenges in the material procurement process within the steel fabrication industry, which currently relies on a manual, Excel-based system. Such a system is prone to data errors, delivery delays, and ineffective interdepartmental communication. The research employs a case study approach, incorporating direct observations, historical data analysis, and interviews with relevant stakeholders. The proposed solution is an integrated Vendor Managed Inventory (VMI) system, developed using the Waterfall model through stages ranging from requirements definition to system testing. Findings reveal that implementing the VMI system significantly enhances efficiency, transparency, and the speed of material procurement while improving collaboration between the company and its suppliers. Additionally, the system optimizes inventory management, reduces operational risks, and offers a scalable solution for various manufacturing sectors. In conclusion, the integrated VMI system contributes substantially to improving overall supply chain performance.

Keywords: *Efficiency, Integration, Inventory Management, Procurement, VMI System*

Introduction

The material procurement process is a critical component of the supply chain in manufacturing industries, particularly within the steel fabrication sector, where the timely acquisition of materials is essential to sustain production flow [1]. The material procurement process is essential for meeting both immediate production demands and ensuring the long-term sustainability of manufacturing operations by guaranteeing the timely availability of materials and preventing production delays that could disrupt the supply chain [2]. Furthermore, it has a direct impact on cost control by optimizing inventory management and minimizing the risks of both overstocking and stockouts [3]. A well-organized procurement process also contributes to customer satisfaction by guaranteeing on-time delivery, high product quality, and competitive pricing [4].

Despite advancements in technology, many organizations still rely on manual systems to manage material procurement. The use of Excel-based tools to monitor stock levels, material requirements, and orders, without the benefit of automation, presents several challenges [5]. A primary concern is the high risk of data entry errors, which can lead to inaccurate inventory records, material shortages or surpluses, and delivery delays due to the reliance on manual updates and reviews in the procurement process [6]. The absence of automated monitoring and reordering further exacerbates this issue, as companies struggle to maintain optimal inventory levels [7].

A lack of interdepartmental integration presents a substantial challenge in the current material procurement system, where communication between production planning (PPIC), warehouse, purchasing, and supplier departments is often ineffective [8]. This breakdown in communication leads to slow and inaccurate decision-making processes, while the reliance on manual calculations further delays the procurement cycle [9]. The underutilization of historical data and market trends hinders informed decision-making, resulting in an inefficient procurement system, wasted time and labor, and delays in material acquisition that disrupt production schedules [10]. These inefficiencies not only lower productivity but may also result in financial losses, as poor communication with suppliers frequently leads to incorrect material deliveries, further deteriorating overall operational performance [11].

To mitigate inventory management challenges, the implementation of Vendor Managed Inventory (VMI) has proven to be highly effective. VMI allows suppliers to take responsibility for managing a company's inventory, adjusting it according to actual material demand and current stock levels [12]. This approach fosters enhanced collaboration and integration between the company and its suppliers, offering benefits such as reduced excess inventory, faster delivery times, and increased transparency [13]. Accordingly, this research aims to develop an integrated VMI-based material procurement system that involves key departments within the organization. The expected outcome is a system that minimizes operational risks, enhances the efficiency and accuracy of the procurement process, and provides a scalable VMI model that can be implemented across various manufacturing sectors to improve overall supply chain performance.

Research Methods

This study employs a case study methodology to examine the material procurement process within the steel fabrication industry, with the objective of identifying challenges in the current system and developing a more efficient, integrated Vendor Managed Inventory (VMI) system. Data is gathered through direct observation, analysis of historical data, and interviews with key stakeholders, including the PPIC team, purchasing department, warehouse personnel, and suppliers, to gain a comprehensive understanding of the existing system's limitations. To design the VMI system, the research adopts the Waterfall model, a structured, sequential approach to information system development [14]. The Waterfall model encompasses six primary stages: Requirements Definition, which focuses on identifying the system's needs; System and Software Design, in which the necessary data processes are specified using tools such as UML; Implementation and Unit Testing; Integration and System Testing; and, finally, Operation and Maintenance, ensuring the system remains effective and up-to-date through ongoing updates and enhancements [15]. To provide a clearer understanding of the research process, the research flow is outlined in Figure 1.

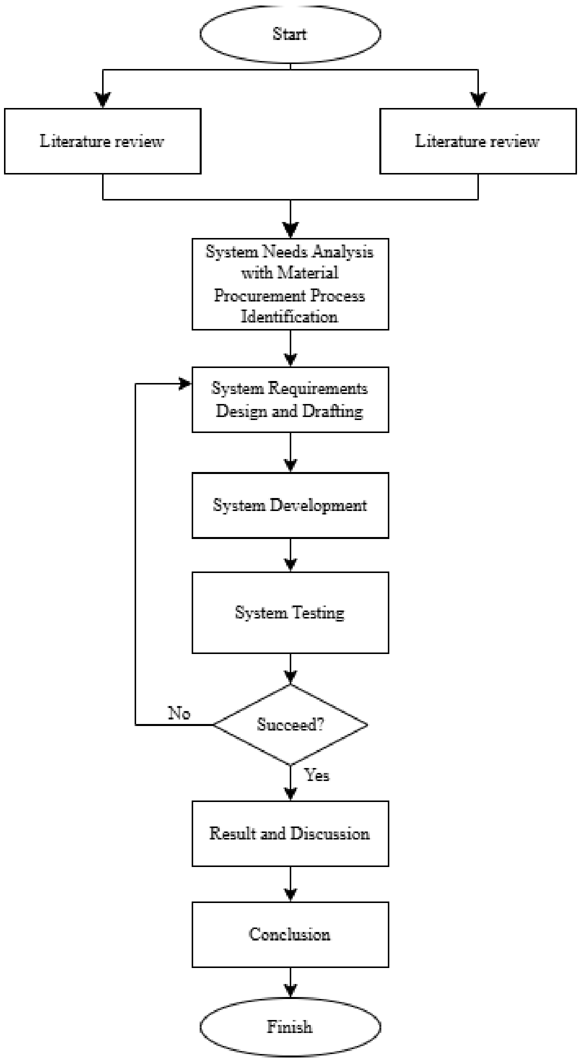

Figure 1. Research Flow

Results and Discussion

Identification of Material Procurement Process

The material procurement process begins with the engineering division designing engineering drawings and generating a material requirement list, which is verified by the PPIC division for consistency. If discrepancies arise, the engineering division revises the design; otherwise, the warehouse checks stock availability. Material procurement system currently uses Excel to record stock, needs, and purchases, which rely on manual input. This increases the risk of errors, delays, and material overloads or shortages due to the absence of an automated system to monitor stock or reordering. A flow chart depicting the current material procurement process is presented in Figure 2.

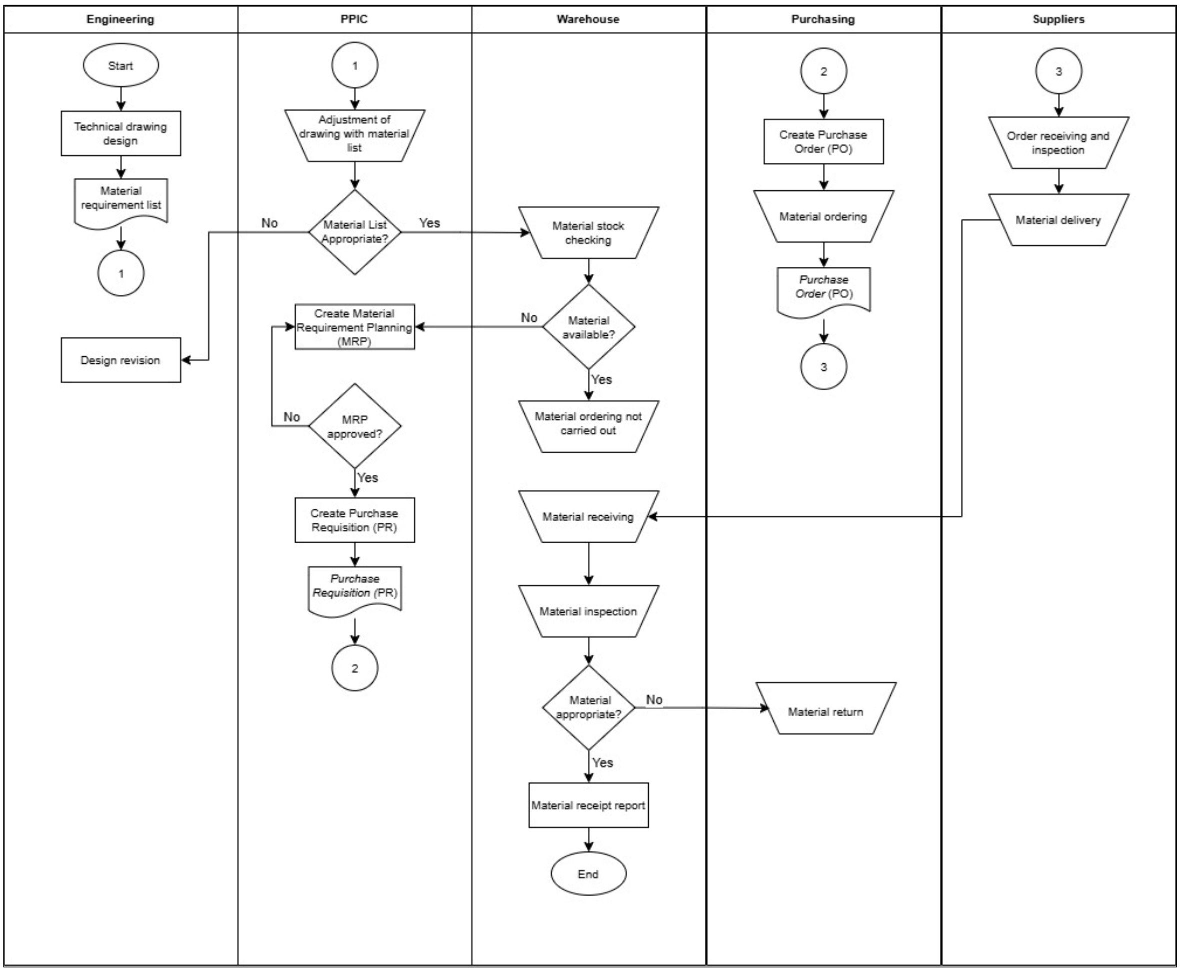

Figure 2. Current material procurement process

System Requirements Design and Drafting

A use case diagram is a visual modeling tool commonly used in software engineering to represent the interactions between users (referred to as actors) and the system; each aimed at achieving specific functional goals [16]. Prior to constructing the use case diagram, it is essential to identify all actors and define their roles and responsibilities within the information system. Results of actor identification and manufacturing use case diagram listed in Table 1 and Figure 3.

Table 1. Identification of actors

Actor	Role
User	Integrate system access for admin, PPIC, purchasing, warehouse, and supplier actors.
System Admin	Maintain the system, create accounts, update data, and manage access according to the hierarchy.
PPIC	Planning material needs, identifying, and providing information to the purchasing team.
Purchasing	Order materials, ensure availability on production schedules, and handle returns in case of non-conformities.
Warehouse	Receiving, storing, and managing material stocks to meet production needs.
Supplier	Manage material stock based on production schedules, ensure quality, quantity, and delivery time.

SITEKIN: Jurnal Sains, Teknologi dan Industri, Vol. 22, No. 2, June 2025, pp.355 - 364
ISSN 2407-0939 print/ISSN 2721-2041 online

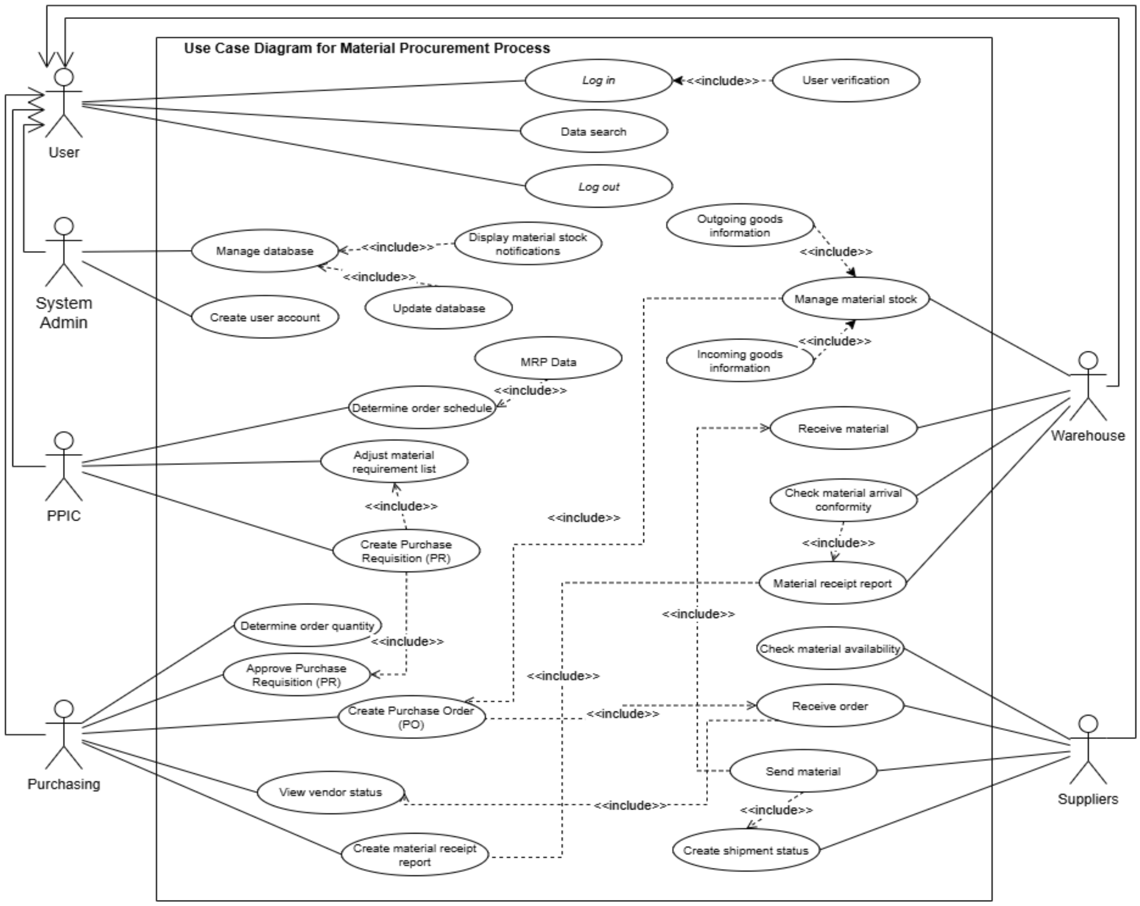

Figure 3. Use case diagram

After developing the use case diagram that illustrates user interactions within the system such as logging in, managing stock, ordering materials, and processing receipts, the next step is to design the Data Flow Diagram (DFD). A DFD visualizes how data moves and is processed within the system. It consists of four key elements: external entities (sources or destinations of data), processes (activities that transform data), data stores (where data is held), and data flows (arrows showing movement between components) [17]. Level 0 DFD (context diagram) provides an overview of the system's core process and its interactions with external actors, while Level 1 DFD breaks it down into detailed subprocesses like material checking, ordering, and reporting. These diagrams help clarify the internal data logic of the Vendor Managed Inventory (VMI) system and support the system’s integration goals across departments [18]. The DFD results are illustrated in Figure 4 and Figure 5.

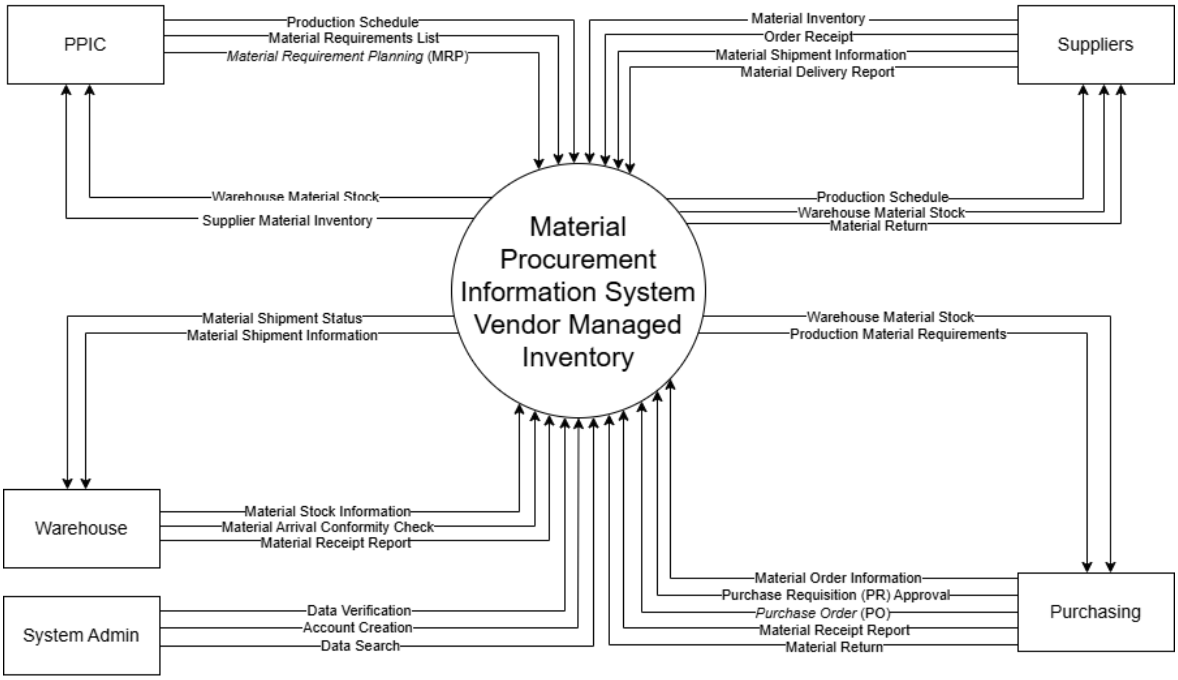

Figure 4. DFD Level 0

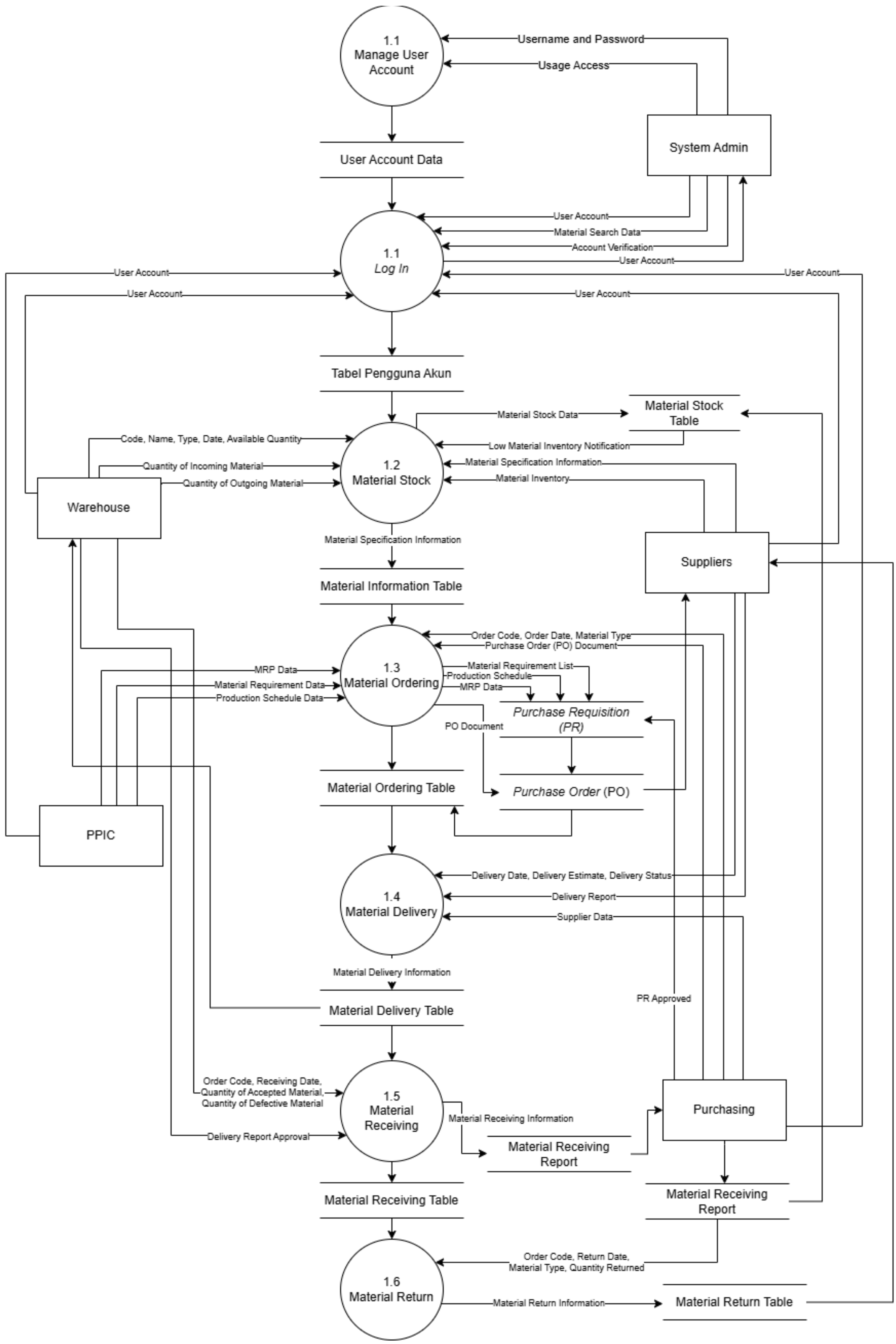

Figure 5. DFD Level 1

After defining the interaction of actors with the system using use case diagrams and the flow of system information using Data Flow Diagrams, the next step is to create a system view consisting of several views, including:

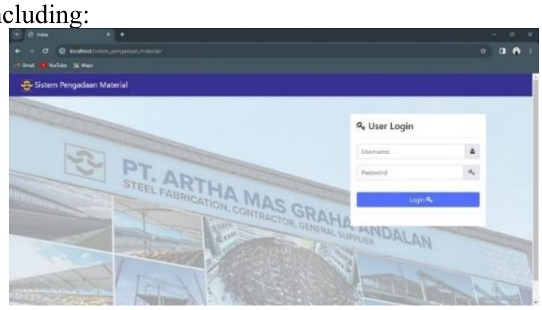

Figure 6. Login display

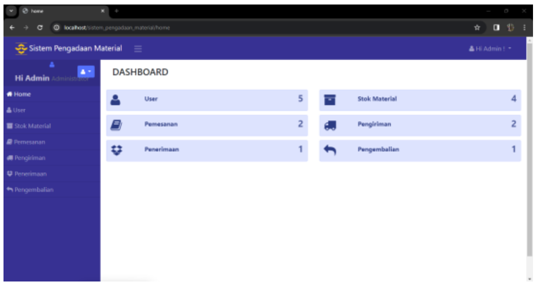

Figure 7. Dashboard display

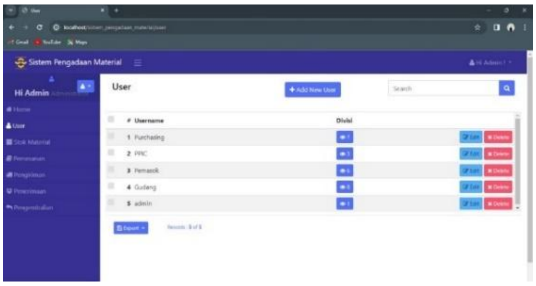

Figure 8. User view

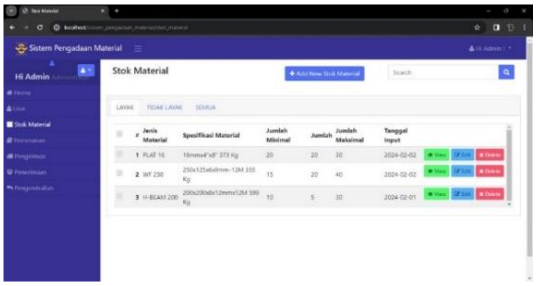

Figure 9. Material stock display

The login page serves as the primary access for users to the material procurement system, where the admin is responsible for creating user accounts by assigning usernames and passwords, as well as managing user access. The home or dashboard menu displays the progress of the currently accessed menus, allowing users to track progress. The user menu shows the number of users with access rights, with each user given an account by the admin and assigned access restrictions based on their role and responsibilities. The material stock menu displays the inventory, divided into usable and unusable materials. Usable materials meet specifications and are ready for production, while unusable materials are returned due to defects and failure to meet specifications. All users can view the material stock menu to monitor inventory, but only the warehouse division can add stock. Suppliers also monitor the material stock, including available, minimum, and maximum stock levels, and provide offers to deliver material accordingly.

System Testing

The system that has been created will be tested using black box testing. Black box testing is a test to verify the usability of a system without understanding the code that makes up the system being developed [19]. The results of the system test are presented in **Kesalahan! Sumber referensi tidak ditemukan.**.

Table 2. System testing

Testing Activities	Test Scenarios	Expected results	Conclusion
System Login	Log in to the system according to the username and password that has been given by the system admin	Successfully log in to the system according to the username and password provided by the system admin	Succeed
	Log in to the system not according to the username and password provided by the system admin	Pop up with username and password errors	Succeed
Click Add New stock material	Adding material stock by users who are given access by the system admin	Material stock is successfully added based on the source that inputs the material stock	Succeed
	Adding material stock by users who are not given access by the system admin	Users can only see the display of material stock and cannot access the addition of material stock	Succeed

Testing Activities	Test Scenarios	Expected results	Conclusion
Click Add New Booking	Place an order by a user who is granted access by the system admin	Material order can be added	Succeed
	Placing an order by a user who has not been granted access by the system admin	Users can only view the order view and cannot access order additions	Succeed
Click Add New submission	Adding a shipment by a user who is granted access by the system admin	Shipments can be added	Succeed
	Adding a shipment by a user who is granted access by the system admin	Users can only view the delivery view and cannot access additional shipments	Succeed
Click Add New Receipt	Adding receipts by users who are granted access by system admins	Admissions can be added	Succeed
	Adding receipts by users who are granted access by system admins	Users can only see the receipt view and cannot access the receipt addition	Succeed
Click Add New Return	Adding returns by users who are granted access by the system admin	Returns can be added	Succeed
	Adding returns by users who are granted access by the system admin	Users can only view the return view and cannot access return additions	Succeed

Material Comparison Proposal

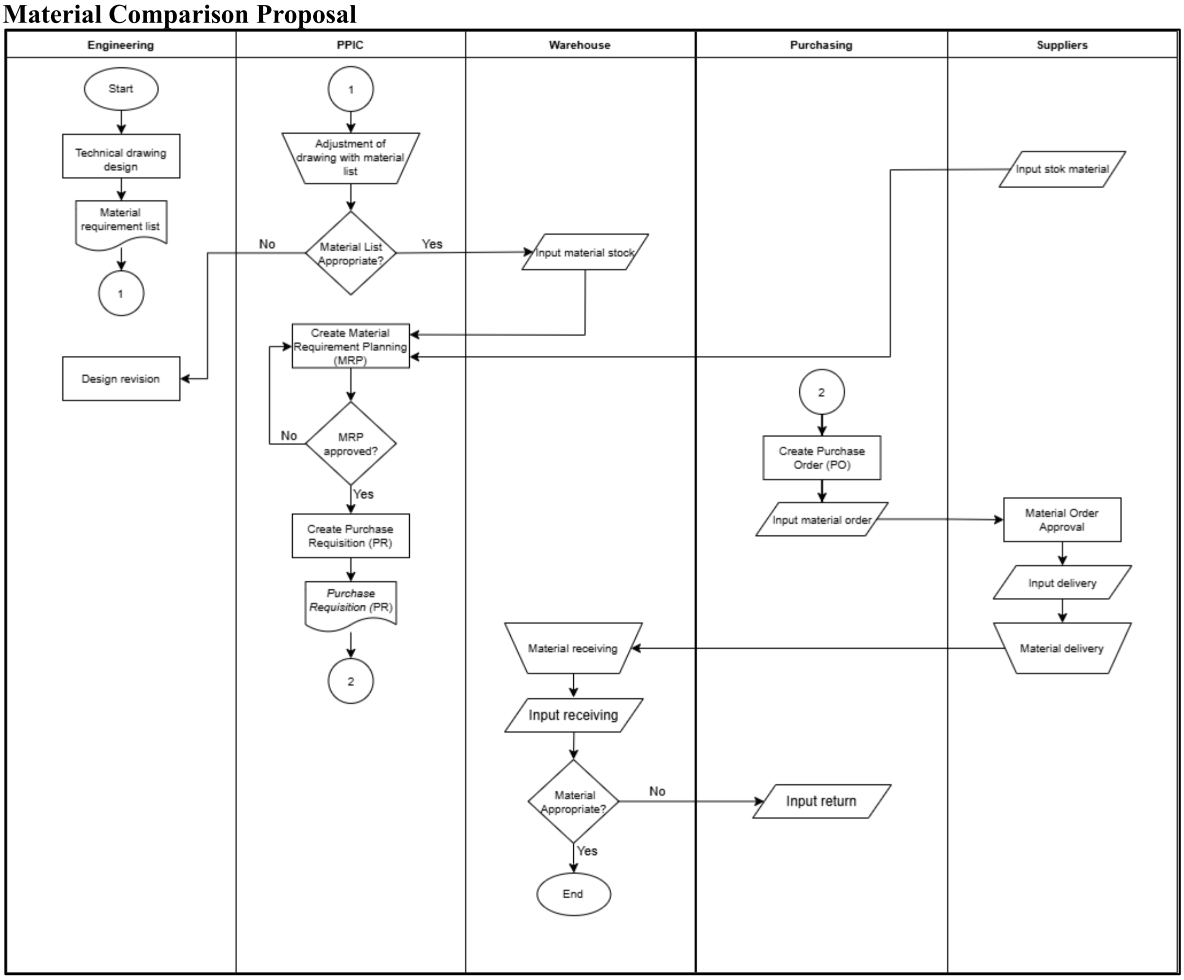

Figure 10. Material procurement process proposal

According to the results of the implementation of the VMI system, the material procurement process that is currently implemented with the proposals given will be compared at the operational stage. The results of the comparison of the material procurement process are presented in Table 1.

Table 1. Comparison of material procurement process

Aspects	Material Procurement Process	
	Now	**Suggestions given**
Material Requirements	Conducted by the PPIC division based on the estimated production process	It is carried out using an integrated system on each user to analyze historical production data, market trends, and customer demand
Material Supplies	Estimates made by warehouse divisions	Regular monitoring using the system
Stock Management	No supplier involved	Engaging Suppliers
Material Ordering	Carried out manually by the purchasing division according to the ordering cluster	Conducted based on the minimum capacity of the set material stock
Information	The information provided was incomplete and other divisions did not know about the material procurement process	Companies and suppliers exchange information related to material inventory
Material Delivery	Shipments are made based on the estimated and availability of materials owned by the supplier	Delivery is carried out faster because the stock owned by the supplier can be known by the company.

To evaluate the effectiveness of the material procurement process after the implementation of the proposed changes involving analysis of current challenges and identifying any improvements or ongoing issues that may emerge after the implementation of the proposal.

Conclusion

The findings of this study indicate that the material procurement process in the steel fabrication industry faces significant challenges due to reliance on manual systems, such as Excel. This dependence leads to risks of data errors, delivery delays, and inefficiencies in interdepartmental communication. The study highlights the critical need for integration among departments including PPIC, warehouse, purchasing, and suppliers, while emphasizing the importance of utilizing historical data and market trends to enhance decision-making processes. To address these challenges, the study proposes the implementation of an integrated Vendor Managed Inventory (VMI) system, which allows suppliers to actively manage inventory based on actual demand and current stock levels.

Using a case study approach, the research developed a VMI-based system following the Waterfall model, encompassing stages from requirement definition to system testing and maintenance. The testing outcomes indicate that the implemented system significantly enhances operational efficiency, transparency, and responsiveness in material procurement processes, while simultaneously strengthening collaboration between the company and its suppliers.

References

[1] A. K. Sahu, R. K. Padhy, D. Das, and A. Gautam, “Improving financial and environmental performance through MFCA: A SME case study,” *J Clean Prod*, vol. 279, p. 123751, Jan. 2021, doi: 10.1016/j.jclepro.2020.123751.

[2] O. Karabağ and B. Gökgür, “Integrated optimisation of pricing, manufacturing, and procurement decisions of a make-to-stock system operating in a fluctuating environment,” *Int J Prod Res*, vol. 61, no. 24, pp. 8423–8450, Dec. 2023, doi: 10.1080/00207543.2022.2152127.

[3] E. Chinello, Z. N. Lee Herbert-Hansen, and W. Khalid, “Assessment of the impact of inventory optimization drivers in a multi-echelon supply chain: Case of a toy manufacturer,” *Comput Ind Eng*, vol. 141, p. 106232, Mar. 2020, doi: 10.1016/j.cie.2019.106232.

[4] W. Sun, Q. Wang, Y. Zhou, and J. Wu, “Material and energy flows of the iron and steel industry: Status quo, challenges and perspectives,” *Appl Energy*, vol. 268, p. 114946, Jun. 2020, doi: 10.1016/j.apenergy.2020.114946.

[5] S. Tripathi and M. Gupta, "A framework for procurement process re-engineering in Industry 4.0," *Business Process Management Journal*, vol. 27, no. 2, pp. 439–458, Dec. 2020, doi: 10.1108/BPMJ-07-2020-0321.

[6] Z. Cui, D. Z. Long, J. Qi, and L. Zhang, "The Inventory Routing Problem Under Uncertainty," *Oper Res*, vol. 71, no. 1, pp. 378–395, Jan. 2023, doi: 10.1287/opre.2022.2407.

[7] E. Piva, L. Tebaldi, G. Vignali, and E. Bottani, "Simulation of different reordering policies for optimizing the inventory of perishable food: an Italian case study," *International Journal of Food Engineering*, vol. 18, no. 3, pp. 201–238, Mar. 2022, doi: 10.1515/ijfe-2021-0047.

[8] A. T. W. Yu, S. K. Yevu, and G. Nani, "Towards an integration framework for promoting electronic procurement and sustainable procurement in the construction industry: A systematic literature review," *J Clean Prod*, vol. 250, p. 119493, Mar. 2020, doi: 10.1016/j.jclepro.2019.119493.

[9] C. Alejandrino, I. Mercante, and M. D. Bovea, "Life cycle sustainability assessment: Lessons learned from case studies," *Environ Impact Assess Rev*, vol. 87, p. 106517, Mar. 2021, doi: 10.1016/j.eiar.2020.106517.

[10] H. Kaur, S. P. Singh, J. A. Garza-Reyes, and N. Mishra, "Sustainable stochastic production and procurement problem for resilient supply chain," *Comput Ind Eng*, vol. 139, p. 105560, Jan. 2020, doi: 10.1016/j.cie.2018.12.007.

[11] U. Schmelzle and P. S. Mukandwal, "The impact of supply chain relationship configurations on supplier performance: investigating buyer–supplier relations in the aerospace industry," *The International Journal of Logistics Management*, vol. 34, no. 5, pp. 1301–1321, Aug. 2023, doi: 10.1108/IJLM-12-2020-0465.

[12] A. A. Taleizadeh, I. Shokr, I. Konstantaras, and M. VafaeiNejad, "Stock replenishment policies for a vendor-managed inventory in a retailing system," *Journal of Retailing and Consumer Services*, vol. 55, p. 102137, Jul. 2020, doi: 10.1016/j.jretconser.2020.102137.

[13] T. Song, Q. Zhang, J. Ran, and W. Ran, "Research on Supplier Collaboration of Daily Consumer Goods under Uncertainty of Supply and Demand," *Sustainability*, vol. 13, no. 10, p. 5683, May 2021, doi: 10.3390/su13105683.

[14] A. Saravanos and M. X. Curinga, "Simulating the Software Development Lifecycle: The Waterfall Model," Aug. 2023, doi: 10.3390/asi6060108.

[15] D. Lantara, A. Pawennari, A. Padhil, R. Malik, I. N. Afiah, and A. Cahya, "DESIGN INFORMATION SYSTEMS OF PRODUCTION RESULTS IN THE RAJAWALI BROMO CONVECTION INDUSTRY, MAKASSAR," *Journal of Industrial Engineering Management*, vol. 6, no. 1, pp. 57–62, May 2021, doi: 10.33536/jiem.v6i1.885.

[16] S. Iqbal, I. Al-Azzoni, G. Allen, and H. Ullah Khan, "Extending UML Use Case Diagrams to Represent Non-Interactive Functional Requirements," *e-Informatica Software Engineering Journal*, vol. 14, no. 1, 2020, doi: 10.37190/e-Inf200104.

[17] K. Hapsari and Y. Priyadi, "Perancangan Model Data Flow Diagram Untuk Mengukur Kualitas Website Menggunakan Webqual 4.0," *JURNAL SISTEM INFORMASI BISNIS*, vol. 7, no. 1, p. 66, May 2017, doi: 10.21456/vol7iss1pp66-72.

[18] H. Alshareef, K. Tuma, S. Stucki, G. Schneider, and R. Scandariato, "Precise Analysis of Purpose Limitation in Data Flow Diagrams," in *Proceedings of the 17th International Conference on Availability, Reliability and Security*, New York, NY, USA: ACM, Aug. 2022, pp. 1–11. doi: 10.1145/3538969.3539010.

[19] G. S. Mahendra and I. K. A. Asmarajaya, "Evaluation Using Black Box Testing and System Usability Scale in the Kidung Sekar Madya Application," *Sinkron*, vol. 7, no. 4, pp. 2292–2302, Oct. 2022, doi: 10.33395/sinkron.v7i4.11755.