Jurnal TA

by Naila Hida Kholik

Submission date: 03-Jan-2023 11:34AM (UTC+0700)
Submission ID: 1988113362
File name: Jurnal_Budidarma_Naila_Hida_Kholik_1.docx (678.3K)
Word count: 4851
Character count: 25714

JURNAL MEDIA INFORMATIKA BUDIDARMA
Volume 7, Nomor X, Bulan 2023, Page 999-999
ISSN 2614-5278 (media cetak), ISSN 2548-8368 (media online)
Available Online at https://ejurnal.stmik-budidarma.ac.id/index.php/mib
DOI 10.30865/mib.v5i1.2293

Reduce Inventory Cost By Implementation of Just In Time Method In Raw Materials Inventory Control Website Application

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Abstrak−Proses produksi merupakan kegiatan utama dalam sebuah perusahaan manufaktur, dan salah satu faktor keberhasilan produksi adalah pengelolaan persediaan bahan baku yang baik. Salah satu permasalahannya adalah ketidakefisienan penggunaan bahan baku yang berdampak pada meningkatnya biaya persediaan akibat banyaknya bahan baku yang tersisa di gudang. Penelitian ini bertujuan untuk menekan biaya persediaan dengan menggunakan metode Just in Time (JIT) pada aplikasi persediaan untuk menghitung persediaan bahan baku. Aplikasi persediaan bahan baku dibangun dengan menggunakan metode Waterfall dan diuji dengan metode Black Box. Analisis menggunakan data tahun 2019-2021, JIT membuktikan dapat mengurangi total biaya persediaan sebesar 92%. Pada tahun 2019 total biaya persediaan mengalami penurunan dari Rp. 6.773.533 menjadi Rp. 829.976. JIT mampu menurunkan total biaya persediaan pada tahun 2020 dan 2021 sebesar 93% dan 96%. Hasil pengujian aplikasi menggunakan Black Box menunjukkan bahwa semua fitur aplikasi dapat digunakan dengan baik dan sesuai. Hal ini didukung dengan persentase nilai trial pass yang mencapai 100%. Berdasarkan hasil tersebut, dapat disimpulkan bahwa aplikasi persediaan bahan baku yang dibangun sudah tepat digunakan, sesuai, dan efektif untuk menekan biaya persediaan.

Kata Kunci: Aplikasi Website; Black Box Testing; Just In Time; Pengendaliaan Persediaan Bahan Baku; SDLC Waterfall

Abstract−The production process is the main activity of a manufacturing company, and one of the success factors of production is good raw material inventory management. One of the problems is the inefficiency of using raw materials that impacted raising inventory costs caused by the large number of raw materials left in the warehouse. This study aims to reduce inventory costs by embedding the Just in Time (JIT) method in the inventory application to calculate the raw material inventory. The inventory application is built using the Waterfall method and tested by the Black Box method. The analysis used data from 2019-2021, proving the JIT could reduce the total inventory cost by 92%. In 2019 the total inventory cost decreased from Rp. 6.773.533 to Rp. 829.976. JIT is able to lower the total inventory cost in 2020 and 2021 by 93% and 96%. The application testing results using Black Box shows that all application features can be used properly and accordingly. It's supported by the percentage of the trial pass value reaching 100%. Based on those results, it can be concluded that the established built inventory application was appropriately used, accordingly, and effectively to reduce the inventory cost.

Keywords: Black Box Testing; Just In Time; Raw Material Inventory Control; SDLC Waterfall; Website Application

1. INTRODUCTION

The production process is a major factor in manufacturing companies that must be supported by good raw material control[1]. Inventory of raw materials is an activity to determine the level and composition of the raw materials and goods produced so that the company can protect the smooth production effectively and efficiently[2]. The purpose of controlling raw material inventory is that there are no obstacles in carrying out the production process such as delays in purchasing raw materials.

The problem that often occurs in raw material inventories is the large number of raw materials remaining, which impacts increasing inventory costs and the need for more efficiency in using raw materials. Just in Time (JIT) is one of the methods used to manage raw material inventory. JIT is a production system designed to obtain quality, reduce costs, and eliminate all types of waste in the production process, one of which is managing raw materials[3]. In controlling the raw materials inventory, raw materials are purchased according to production needs and eliminate wasteful use in the production process. At the time of production, there is a stock of raw materials that can be used immediately provided that all raw materials are used for one period so that no raw materials are wasted or accumulated in the warehouse. The weakness of JIT itself is that there is no tolerance for errors in the production process and dependency on suppliers in terms of the quality of raw materials and delivery terms[4].

To help manage raw materials inventory, a website application needs to be developed. In the website application, which is a ready-to-use program, companies can quickly determine how much and when raw materials must be purchased with accurate results according to the purpose of making the application[5]. The website is a collection of related web pages containing pages and a group of pages called the homepage[6]. The application website contains features that the company needs to manage raw material inventory.

Submitted: **dd/mm/yyyy**; Accepted: **dd/mm/yyyy**; Published: **dd/mm/yyyy**

JURNAL MEDIA INFORMATIKA BUDIDARMA
Volume 7, Nomor X, Bulan 2023, Page 999-999
ISSN 2614-5278 (media cetak), ISSN 2548-8368 (media online)
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Research on the topic of raw material inventory control by Putri Lestari, Dedi Darwis, and Damayanti[7] conducted a comparison of the EOQ and JIT methods to increase inventory cost efficiency in oil raw materials by making a comparison application that led to JIT waiting more in saving raw material inventory costs. In increasing efficiency, companies use JIT by making purchases in a small scale and delivering them regularly. Another research by Rudi Kurniawan and Auzar Ali[8] intend to determine the application of JIT in controlling raw material inventory when compared to company data, EOQ, and JIT. The object of the research is palm oil. The result is that the JIT method produces a total cost of Rp. 71,167,800, EOQ generates a cost of Rp. 170,802,719, and the company's policy resulted in a fee of Rp. 253,297,450. The JIT method is more efficient in saving inventory costs.

A research by Chairul Anwar and Asep Endih Nurhidayat[9] intend to make warehouse cost efficiencies and not much left over steel wire raw materials for coil spring products in warehouses. Using data from 2016-2018, JIT method proves to be maximal in saving inventory costs. In the research of Siti Atikah Oktaviani, Sofah Listianti, Ramadhani Irma Tripalupi[10] disclose methods for saving raw material inventory costs by means during the Covid-19 pandemic. Covid-19 has had a big impact, especially on the economy sector, decreased production and large accumulation of raw materials in warehouses resulting high inventory costs. By implementing JIT measures, companies can reducing costs, increasing efficiency and profits from production. Research by Sri Dwiningsih and Andhika Ari Pratama[11] aims to compare company and JIT data on yarn raw materials. Using data from 2020 with using quantitative descriptive data collection techniques, thus JIT is proving 85% superior in inventory cost efficiency, although the delivery costs are increasing.

The purpose of this research is to create a website-based raw material inventory management application using the JIT method, where JIT is proven more capable of minimizing the accumulation of raw materials in warehouse and inventory costs. All website application features can be useful and run well. This can be proven using black box testing by the percentage of the trial pass value reaching 100%. Testing was done by trying to enter data in each form, this is necessary to find out that the program is running according to what is needed by the company[12].

2. RESEARCH METHODOLOGY

2.1 Research Stages

This research uses research stages consisting of the initial stage, the development stage, and the final stage. In developing or changing a software system using models and methodologies that people used to develop previous software systems (based on best practices or ways that have been tested well)[13]. The steps for developing a system using SDLC waterfall are communication, planning, construction, modeling, and deployment[14]. Figure 1 shows the plots for building website applications.

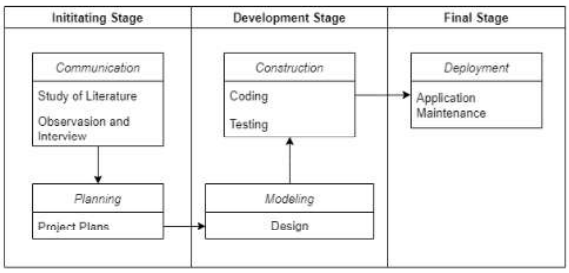

Figure 1. SDLC Waterfall System Process Flow

This research uses a study case on CV Mitra Bangunan Surabaya. The company's business overflow when about to carry out production is the marketing division will notify the number of orders to the production division which will be forwarded to the warehouse division. After that, the warehouse division will check the number of raw materials needed, if available it will be sent directly to the production division, and if it is lacking stock they will make a purchase. In making purchases, the warehouse division will make a list of raw material requirements to be purchased and propose disbursement of funds to the manager, if approved, a purchase transaction is made, and the warehouse division will make a purchase report. With the company's current flow, it will make production waiting time due to having to purchase raw materials first. Thus, it can affect the production process. Raw material stock is used only for emergencies such as errors in the production process.

2.2 Research Data

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The objects used in this study are raw materials such as plywood 9 mm, 12 mm, 18 mm, fiber sheet, melamine, black sheet, orange sheet, and wood fiber sheet. These raw materials are used to produce a 3-meter box display. Total production in 2019, 2020, and 2021 are 24, 51, and 79. Table 1 shows three years of company data, such as the frequency of purchases, inventories, purchases, usage, and remaining raw material.

Table 1. The Company Data

Data	2019	2020	2021
Purchase Frequency	131	271	411
Stock	170	315	301
Purchase	791	1292	1931
Usage	640	1299	1910
Leftover	315	301	322

Table 2 shows the raw material requirements list to build one 3-meter box display product.

Table 2. List Raw Material Requirements

Raw Material	Requirements
Plywood 9 mm	4
Plywood 12 mm	3
Plywood 18 mm	2
Fiber Sheet	2
Raw Material	Requirements
Melamine	4
Black Sheet	3
Orange Sheet	3
Wood Fiber Sheet	2

Table 3 shows the price of raw materials for each period. Prices of raw materials can change at any time, therefore companies must be good at making purchases.

Table 3. Raw Material Price

Raw Material	Year	Price
Plywood 9 MM	2019	Rp. 97.000
	2020	Rp. 97.000
	2021	Rp. 100.000
Plywood 12 MM	2019	Rp. 138.000
	2020	Rp. 140.000
	2021	Rp. 142.000
Plywood 18 MM	2019	Rp. 200.000
	2020	Rp. 200.000
	2021	Rp. 203.000
Fiber Sheet	2019	Rp. 45.000
	2020	Rp. 45.000
	2021	Rp. 45.000
Melamine	2019	Rp. 110.000
	2020	Rp. 112.000
	2021	Rp. 115.000
Black Sheet	2019	Rp. 35.000
	2020	Rp. 33.000
	2021	Rp. 35.000
Orange Sheet	2019	Rp. 40.000
	2020	Rp. 40.000
	2021	Rp. 42.000
Wood Fiber Sheet	2019	Rp. 45.000
	2020	Rp. 45.000
	2021	Rp. 47.000

Table 4 shows total inventory costs obtained from 3% of raw material price, and ordering cost for each period.

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Table 4. Total Inventory Cost and Ordering Cost

Cost Type	2019	2020	2021
Ordering	Rp. 442.888	Rp. 426.481	Rp. 367.201
Inventory	Rp. 21.300	Rp. 21.360	Rp. 21.750

2.3 Just In Time

Just in time is an activity to produce the required output at the time needed by the customer in the amount according to customer needs in each process in the production system most economically or efficiently[15]. JIT ensures that all production processes are in accordance with sales accuracy, such as reducing inspection time, moving time, and waiting time[9]. JIT also ensures that there is a stock of raw materials which can be used directly at the time of production with the result that all raw materials are used for one period so that no raw materials are wasted.

In implementing JIT, in addition to paying attention to relationships with consumers, companies must also establish harmonious relationships with suppliers. A good cooperative relationship can be fostered if the company trusts the supplier to provide the best raw materials for the company[16].

In the implementation of JIT there are steps needed as follows[16]:
Formula 1 calculates the minimum purchase quantity.

$$Q^* = \sqrt{\frac{2 \times O \times D}{C}} \quad (1)$$

Q^* is the purchased quantity at minimum cost in units with EOQ. O is the purchase cost for each time order, D is the total material requirement in one year, and C is the storage cost per unit.
Formula 2 calculates the total minimum annual cost.

$$T^* = \frac{CQ^*}{2} + \frac{OD}{Q^*} \quad (2)$$

T^* is the minimum total annual cost.
Formula 3, calculates the optimal number of delivery each time ordering.

$$na = \left(\frac{Q^*}{2a}\right)^2 \quad (3)$$

na is the number of deliveries each time ordering, and a is the average inventory of raw materials.
Formula 4, calculates the order quantity for each order.

$$Qn = \sqrt{na \times Q^*} \quad (4)$$

Where Qn is JIT order quantity in units.
Formula 5, calculates the optimal delivery quantity for each delivery.

$$q = \frac{Qn}{na} \quad (5)$$

q is the optimum delivery quantity.
Formula 6, calculates the frequency of purchasing raw materials.

$$n = \frac{D}{Qn} \quad (6)$$

Where n is the optimal number of delivery for one year.
Formula 7, calculation of total inventory cost with the JIT system.

$$Tjit = \frac{1}{\sqrt{n}}\ (T^*) \quad (7)$$

$Tjit$ is the Total annual inventory cost for the system.

3. RESULT AND DISCUSSION

3.1 Modeling

At this stage the modeling process is carried out for application development. In this process there are several stages such as problem identification, identification of business requirements, identification of user requirements, identification of functional requirements, identification of non-functional requirements, and identification of data requirements.

3.3.1 Identification of Business Requirements

Based on the results of the existing problems, a list of business requirements in application design can be made such as Table 5.

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Table 5. Identification of Business Requirements

Item	Minimum Specification
Hardware	1. Processor core 2 duo 2. RAM 2 GB 3. Monitor with resolution 1024 x 768 4. Mouse and keyboard
Software	1. Operation system windows 7 or Linux 2. XAMPP 3. Visual Studio Code 1.47

3.3.2 Identification of User Requirements

User identification is created to determine the access rights of each user. Identification of these users can be seen in Table 6.

Table 6. Identification of User Requirements

No.	User	Description
1.	Admin	Users have access rights to all application features.
2.	Warehouse Division	Users who have access rights to manage raw material master data, supplier master data, products, inventory, order cost data, storage percentage data, and raw material purchase data.
3.	Production Division	Users who have access rights to manage master data of raw materials, products, inventory, and production data.
4.	Manager	Users have the right to receive reports on purchases, production, and the results of JIT calculations.

3.3.3 Identification of Functional Requirements

Functional requirements are used to perform an analysis of the functional system to be developed. The following is the result of functional requirements such as:

1. Login function
2. Dashboard viewing function
3. Master user data management function
4. Raw material master data management function
5. Master supplier data management function
6. Product master data management function
7. Purchasing data management function
8. Inventory data management function
9. Production data management function
10. Management function of inventory calculation using the JIT method
11. Order cost management function
12. Storage percentage management function
13. The function of managing reports on purchases, production, and JIT calculations

3.3.4 Identification of Non-Functional Requirements

The results of the non-functional needs analysis such as:

1. Operational
   The system has a database as a container for storing data and information and can be run with a minimum error percentage.
2. Security
   The system will provide security to users with usage management in the form of usernames and passwords that need to be entered at the beginning of using the system (login feature) as in Table 7.

Table 7. Username and Password User

No.	Actor	Username	Password
1.	Admin	admin	xxxxxx
2.	Warehouse Division	Warehouse	xxxxxx
3.	Production Division	production	xxxxxx
4.	Manager	manager	xxxxxx

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3.3.5 Identification of Data Requirements

The data requirements are made based on the analysis that has been done. The data requirements can be defined as:

1. Raw material data
2. Product data
3. Supplier data
4. User data
5. Number of production requests data
6. Raw materials requirements data
7. Storage percentage data
8. Order cost data
9. Average raw material inventory data

3.2 Design

In the previous stage, data analysis and business processes have been carried out, the next stage is the design system. System design is carried out with the aim of helping to identify and provide an overview of the software system to be built. The system design using Unified Modeling Language (UML) defines the requirements and describes the architecture in object-oriented programming[17]. The results of system design are a use case system and class diagram. The use case system is used to describe the interaction between the user and the system through the story of how the system is used[8].

Figure 2 is the result of the use case system design using the administrator as a user. In Figure 2, there are 15 main activities in the application, such as login application, viewing dashboard, managing data master user, raw material, supplier, product, ordering cost, and inventory cost. Following transaction activities such as managing purchasing data, production data, inventory data, and calculating inventory management with the JIT method as the main activity.

The next one is a class diagram to describe the system's structure in terms of defining the classes that will be made to build the system[18]. In the class diagram, there is 19 entity table database which contains 6 master table database and 13 transaction table databases. The database system is created using an SQL server.

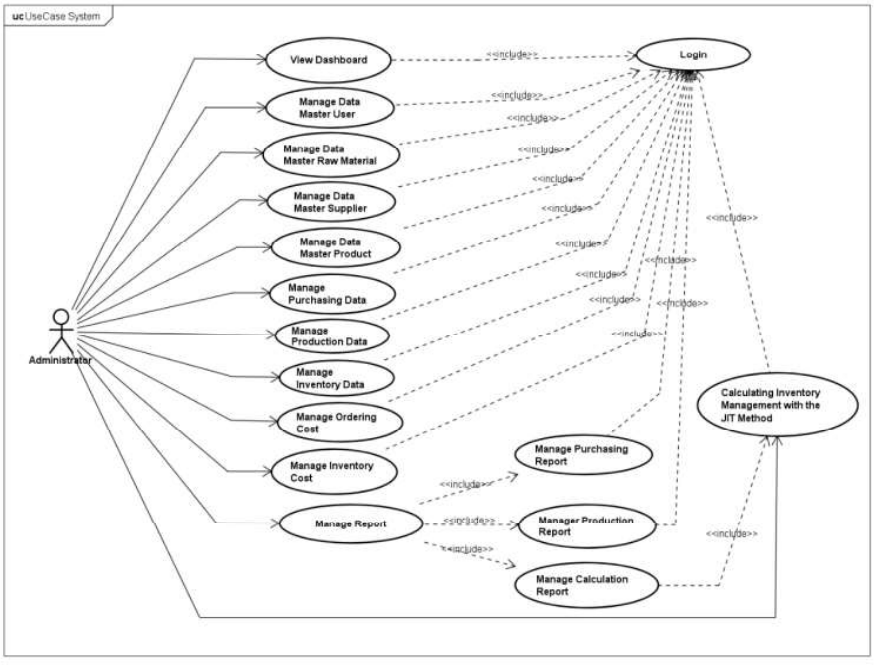

Figure 2. Use Case System

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3.3 Coding

After the stages of system analysis and design have been carried out, the next stage is implementing the design results into an application form. An application display shows the process of interaction between the program and the user[19]. Figure 3 is a dashboard to present information displays from business intelligence (BI) processes by providing interfaces such as diagrams, reports, etc[20]. In this application, dashboard displaying purchasing and production graphs as information on company development and as statistical data for predictions for the next period.

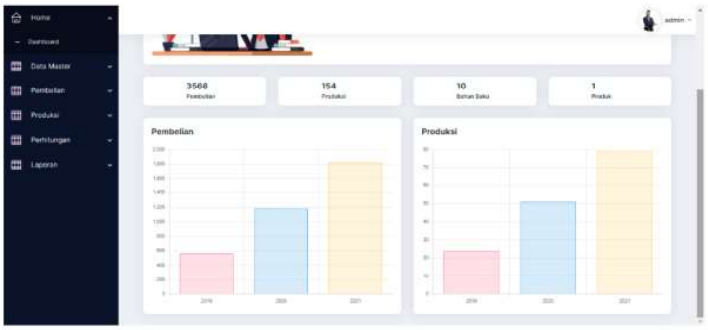

Figure 3. Dashboard

In Figure 4, the user can input raw material name and after that user can see the display of the raw material name and details of the raw material which includes the price of the raw material each period which can be obtained from entering price from purchasing menu.

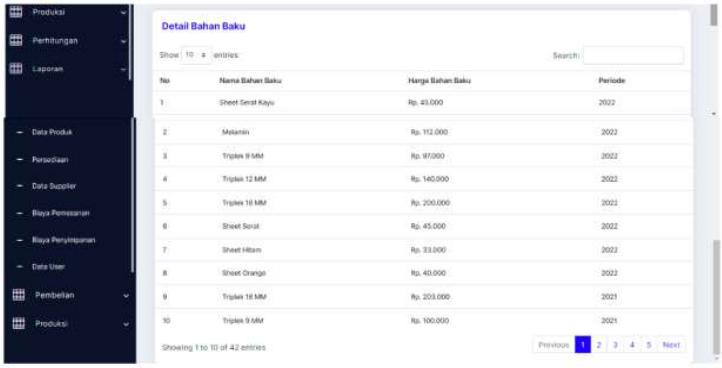

Figure 4. Raw Material Data Master

In Figure 5, the user can enter production quantities to carry out calculations for raw material inventory management using the JIT method. User should select the optimal order quantity calculation menu, then input production quantity data. In the calculation system, the system will automatically total raw materials requirements then mitigate the amount of inventory stock first and then generate the results of calculations so there is no raw material wasted.

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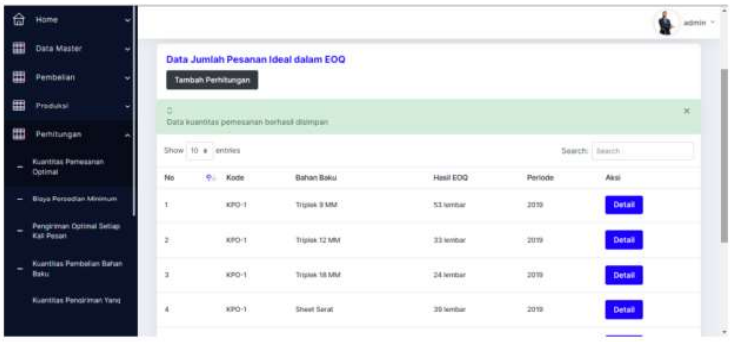

Figure 5. Add Calculation with JIT Method

In Figure 6 user can view the result of calculating the total inventory cost with the JIT system application. The triggers for JIT calculation is from Figure 5, which is where the system will be automatically performs calculations starting from calculating the optimal order quantity, minimum annual cost, optimal number of delivery per order, order quantity per order, optimal delivery per delivery, purchase frequency, and JIT inventory costs.

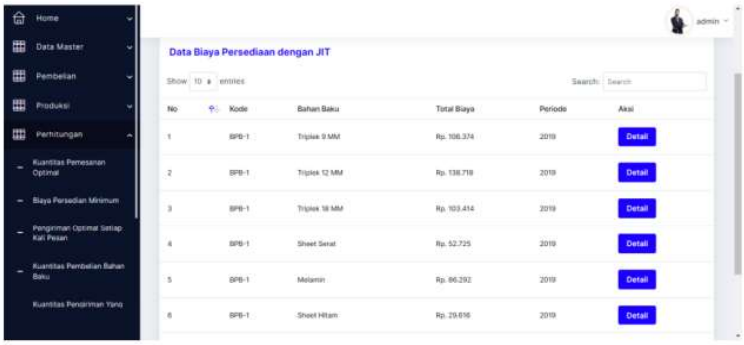

Figure 6. Page of Calculation of The Total Inventory Cost with JIT

In Figure 7 user can view the report page of the calculation result with JIT. Reports are used to make it easier for users to get the results of the information needed and printable. There is a filter to choose from based on raw material and period then click submit button. Users can download the file via pdf by clicking cetak button.

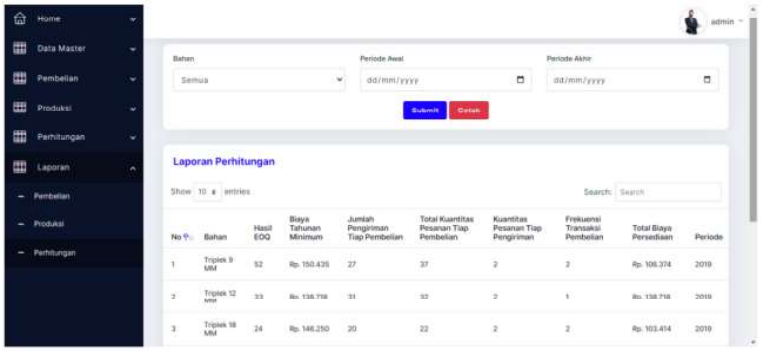

Figure 7. JIT Calculation Report Page

After the analysis, Table 8 shows the JIT calculation result such as total period from 2019-2021 of minimum purchase quantity, total minimum annual cost, optimal delivery, order quantity, delivery quantity frequency of purchasing, and total inventory cost using JIT.

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Table 8. JIT Calculation Result

Total	2019	2020	2021
Minimum Purchase Quantity	362	500	651
Total Minimum Annual Cost	Rp. 927.414	Rp. 1.337.240	Rp. 1.682.469
Optimal Delivery	279	122	68
Order Quantity	312	239	204
Delivery Quantity	13	21	31
Frequency of Purchasing	10	34	62
Total Inventory Cost	Rp. 829.976	Rp. 721.327	Rp. 603.120

In the application, the minimum purchase quantity data is obtained from system summing the total raw material requirements for one product multiplied by the production amount before mitigating by the inventory data.

Table 9. Comparison Result

Year	The Company Data	JIT Calculation Result
2019	Rp. 6.773.533	Rp. 829.976
2020	Rp. 11.683.232	Rp. 721.327
2021	Rp. 18.587.099	Rp. 603.120

Table 9 shows the JIT calculation result can reduce the inventory cost. In 2019 the total inventory cost for the raw material company data is Rp. 6.773.533 while for the JIT method Rp. 829.976, the difference obtained is Rp. 5.943.557. In 2020 the total inventory cost for the raw material company data is Rp. 11.683.232 while for the JIT method Rp. 721.327, the difference obtained is Rp. 10.961.905. in 2021 the total inventory cost for the raw material company data is Rp. 18.587.099 while for the JIT method Rp. 603.120, the difference obtained is Rp. 17.983.979.

3.4 Testing

Table 10 shows the result of testing the application features using black box testing.

Table 10. Black Box Testing

Testing Activity	Detail Testing Activity	Expected Result	Conclusion
Login Testing	The user enters the correct username and password	Login access successfully and the dashboard page appears	Pass
Login Error	The user enters the wrong username and password	A warning label appears 'incorrect username or password	Pass
View Dashboard	Viewing Dashboard	Display dashboard page	Pass
Raw Materials Master Menu	Add data and edit raw material master data	Data is saved and appears in the table	Pass
Product Master Menu	Add data and edit product master data	Data is saved and appears in the table	Pass
Inventory Menu	Viewing inventory data	Managed to see the data	Pass
Supplier Master Menu	Add data and edit supplier master data	Data is saved and appears in the table	Pass
Ordering Cost Menu	Add data and edit ordering cost data	Data is saved and appears in the table	Pass
Inventory Cost Menu	Add data and edit inventory cost data	Data is saved and appears in the table	Pass
User Master Menu	Add data and edit user master data	Data is saved and appears in the table	Pass
Purchasing Menu	Add new purchasing data	Data is saved and appears in the table	Pass
Production Menu	Add new production data	Data is saved and appears in the table	Pass
Add Calculation Data	Adding Calculation Data	Calculation data appears	Pass

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DOI 10.30865/mib.v5i1.2293

View calculation of the optimal number of deliveries each time ordering data	Viewing the calculation of the optimal number of deliveries each time ordering data	Can view the result data	Pass
View the result of the calculation of the order quantity for each order data	viewing the result of the calculation of the order quantity for each order data	Can view the result data	Pass
View the result of the calculation of the optimal delivery quantity for each delivery	Viewing the result of the calculation of the optimal delivery quantity for each delivery	Can view the result data	Pass
View the result of the calculation of the frequency of purchasing raw materials	Viewing the result of the calculation of the frequency of purchasing raw materials	Can view the result data	Pass
View the result of calculating the total inventory cost with the JIT system data	Viewing the result of calculating the total inventory cost with the JIT system data	Can view the result data	Pass
Creating purchasing report	Viewing purchasing data and downloading data	Download the data file via pdf	Pass
Create production report	Viewing purchasing data and downloading data	Download the data file via pdf	Pass
Create a JIT calculation report	Viewing purchasing data and downloading data	Download the data file via pdf	Pass
Pass Rate Percentage			100%

From the test results of Table 10, all testing activities got a pass value, pass indicates that the user can easily carry out testing activities and all features can be used properly, which means the trial results are 100% successful.

4. CONCLUSION

The conclusion based on the result of the application to calculating management inventory cost using JIT is that companies be able to get production efficiency by using raw materials in conforming with the raw material list, so there are no wasted raw materials. This can be seen from the results of application development and implementation indicating that there is a difference between company policies and JIT methods, in 2019 the total inventory cost for the raw material company policy is Rp. 6.773.533 while for the JIT method Rp. 829.976, the difference obtained is Rp. 5.943.557. In 2020 the total inventory cost for the raw material company policy is Rp. 11.683.232 while for the JIT method Rp. 721.327, the difference obtained is Rp. 10.961.905. in 2021 the total inventory cost for the raw material company policy is Rp. 18.587.099 while for the JIT method Rp. 603.120, the difference obtained is Rp. 17.983.979.

The analysis proves JIT can reduce the cost inventory by 87% in 2019, 93% in 2020, and 96% in 2021. The results of the black box testing trial show that all application features can be used properly and accordingly. Its evidence can be proved by the percentage of the trial pass value reaching 100%.

ACKNOWLEDGMENT

Thanks to the CV Mitra Bangunan Surabaya for allowing to analyze their data company as the study object.

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Submitted: **dd/mm/yyyy**; Accepted: **dd/mm/yyyy**; Published: **dd/mm/yyyy**

JURNAL MEDIA INFORMATIKA BUDIDARMA
Volume 7, Nomor X, Bulan 2023, Page 999-999
ISSN 2614-5278 (media cetak), ISSN 2548-8368 (media online)
Available Online at https://ejurnal.stmik-budidarma.ac.id/index.php/mib
DOI 10.30865/mib.v5i1.2293

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