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Decision Support System for Inventory Control of Raw Material

(Case Study : PT Suwarni Agro Mandiri Plant Pariaman, Indonesia)

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***Abstract*—PT Suwarni Agro Mandiri Plant Pariaman is a company which produces fertilizer. This company has a problem related to raw material inventory. The inventory can be overstock or stock out. It is due to their working which is not guided by an information system. Therefore, this research proposes a decision support system for controlling the inventory of the raw material. The system uses Material Requirement Planning (MRP) approach and is designed in three sub-systems. They are OLTP database for managing the daily activities, MRP for determining the lot size and the raw material ordering time, and OLAP with data warehouse for analyzing the raw material data.**

Keywords-inventory; inventory control; online analytical processing; online transaction processing

I. INTRODUCTION

In enhancing effectiveness and efficiency in handling inventory, companies must have inventory control system of firms (5). This system can avoid the financial burden caused by the overload inventory or the production disturbant caused by the run out of stock (5). Furthermore, practicing and embracing the effectiveness of management will improve the competitiveness among the companies (8).

To reach this achievement, the company named PT Suwarni Agro Mandiri Plant which is located in Pariaman must overcome their problems such as the overstock of urea (raw material) and the shortage of Rock Phospate Egypt (RPE). The overstock happens since the urea is ordered in massive amounts in the beginning but are used in some small amounts in the production process, while the RPE shortages happens when there was a stop production due to the small amount of order, but high amount in using the material. This happend around March 2017.

The problems occur because the numbers of raw materials ordered are not determined and the optimal time of ordering is not decided. Facilities for getting information quickly and for giving summary of information relating to the current status of raw material are also not provided. This condition becomes worse since the management of the company is still using manual way like using worksheet to other divisions of raw material inventory. More time is needed to process the data into a decision maker. In addition, the long duration of the time is also the caused of mis-schedule in ordering the raw material and the delay of delivering raw material to the company. Therefore, a decision support system for inventory control of raw material is developed.

II. METHODOLOGY

This research starts with the process to determine the Material Requirement Planning (MRP) for all raw material. MRP is a method to schedule the purchased planned orders and manufactured planned orders [3],[11]. It is based on custumers' orders, sales forecasts, and manufacturing policy [2].

The company has a production target for each product which the target is for one-year period. This production target is derived as the Master Production Scheduled (MPS) for each product by using disagregate method. After MPS is known, the need for each raw material can be determined by using this MPS. MRP system uses MPS which explodes into a bill of material (BOM) [4]. Generally, MRP uses the following notations, which may vary in some application. They are [9] :

GRi : gross requirements during time period i,
SRi : scheduled receipts during time period i,
OHi : on hand inventory during time period i,
NRi : net requirements during time period i,
POi : planned orders during time period i.

Based on the MPS, the amount of raw material and the time to order is determined by using MRP approach. The steps are as followed. Firstly, the netting process is conducted in order to determine the net requirement for each material. Secondly, the lotting process is conducted in order

to determine the optimal lot size for each raw material. In this research, Algorithma Wagner Within (AWW) is used as the lot sizing technique. The last, the offsetting process is conducted to determine the time to release the order plan. The results of those processes are arranged and become a MRP report.

While, the Decision Support System (DSS) is designed with three sub-systems using Waterfall Method. Decision Support System (DSS) is a system to support non-routine decision making for middle management [6]. The steps of designing the DSS are: the first sub-system is determining the Online Transaction Processing (OLTP). This sub-system is designed to help users in managing the daily data using database. It uses PHP as the framework and XAMPP as local server. The second sub-system is MRP application. This sub-system is designed to help users to determine the lot size and time to order, and it also uses PHP as the framework as the first one. The last sub-system is Online Analytical Processing (OLAP). OLAP is the used of graphical tools that allow users to use multidimensional data and allow users to analyze data with a simple graphical interface. [1], [7]. This sub-system is designed to analyze all data of raw material. It helps users to make a decision for inventory control of raw material. This sub-system uses Pentaho Data Integration (PDI) to build a data warehouse. This data warehouse is the source for OLAP to analyze data in multidimensional. Data warehouses are subject-oriented, integrated, time-dimensional data, and the collections are used to support decision-making processes by managers at every level [12].

III. FINDING AND RESULT

A. *Determining MPS and MRP*

There are two types of fertilizer produced by the company. They are NPK and POG. NPK consists of NPK15-15-15, NPK 13-6-27 and NPK 12-12-12. The production fractions are 0,998; 0,001; and 0,001. The company states that the production target for NPK, is 10.000 ton/year or 833,333 kg/month and for POG is 8.000 ton/year or 666,667 kg/month. Based on the production target, the MPS is derived as the Table I. The horizon of planning is for April 2017.

TABLE I. MPS FOR APRIL 2017

Production Target (kg/ day)			
NPK 15-15-15	***NPK 12-12-12***	***NPK 13-6-27***	***POG***
36.154	39	39	28.986

The company has eight types of raw materials. By using the composition for each product, the Gross Requirement (GR) can be determined. The GR which is determined from multiplying the composition of raw material with the amount of product production is needed to calculate the Net Requirement (NR). The NR is the difference between GR and inventory on hand (POH) and Scheduled Receipts (SR). The example of determining the urea, one of the raw materials, NR and POH for day 1 is as followed:

$$NR = \text{Max}(0, GR_t - POH_{t-1} - SR_t)$$
$$= \text{Max}(0, 11.810 - 22.990 - 20.000)$$
$$= 0$$

$$POH = \text{Max}(0, GR_t - POH_{t-1} + SR_t)$$
$$= \text{Max}(0, 11.810 - 22.990 + 20.000)$$
$$= 31.180 \text{ Kg}$$

This net requirement is needed for determining the lot size using AWW. AWW is chosen since it gives the optimal solution for lot sizing. The steps for calculating the lot size using AWW are as followed:

Step 1. Calculate the cummulative demand (Q_{ce}) for each raw material for each day using the following equation

$$Q_{ce} = \sum_{i=c}^{e} Qi \quad (1)$$

The Q_{ce} for urea for day 4 is :

$$Q_{14} = Q_1 + Q_2 + Q_3 + Q_4$$
$$= 0 + 0 + 0 + 4.252$$
$$= 4.252 \text{ Kg}$$

Step 2. Calculate the total inventory cost (O_{en}) using the following equation

$$O_{en=A+h} \sum_{t=e}^{n} (q_{en} - q_{et}) \quad (2)$$

Note that A is the ordering cost and h is the holding cost. The O_{en} for urea for day 4 is :

$$O_{14} = A + h \times (Q_{14}-Q_{11}+Q_{14}-Q_{12}+Q_{14}-Q_{13}+ Q_{14}-Q_{14})$$
$$= \text{Rp}10.850 + \text{Rp}0{,}2014 \times (4.252 - 0 + 4.252 - 0 + 4.252 - 0 + 4.252 - 4.252)$$
$$= \text{Rp}13.419$$

Step 3. Calculate the minimum total inventory cost (F_{en})

F_n is an optimal cost for alternative of ordering policy until the n period. The F_{en} for urea for 4 days ordering are :

$$F_4 = \min(F_{14}, F_{24}, F_{34}, F_{44})$$
$$= \min(\text{Rp}13.419, \text{Rp}23.413, \text{Rp}22.556, \text{Rp}21.700)$$
$$= \text{Rp}13.419$$

F_{14} is the cost for ordering raw material from day 1 until day 4 which is calculated as follows :

$$F_{14} = O_{14} + F_0$$
$$= \text{Rp}13.419 + \text{Rp}0$$
$$= \text{Rp}13.419$$

Step 4. Transform the F_n as the lot size

Finally, the planned order release is determined by offsetting process using lead time for each raw material. The lot size is the result of AWW method that has been calculated. The lot size and planned order release for each raw material are as shown in Table II.

All of the results from the processing of determining the MRP is summarized in the form of MRP report. MRP report for urea is shown in Table III.

MRP approach gives information not only about the lot size and time to order raw material, but also the information about the total inventory cost. The total inventory cost is as followed

B. *System Design*

By analyzing the system, the functional and non-functional needs can be identified. The functional needs are: :

TABLE II. PLANNED ORDER RELEASE

Date	*Planned Order*							
	Urea	RP	KC	Kaptan	Pewarna Merah	Kompos Ayam	Tanah Hitam	Tanah Gambut
24/03/1						45.59		
25/03/1								
27/03/1						46.37		
28/03/1								
29/03/1	4.25	5.05	5.65		16	46.37		
30/03/1								
31/03/1				7.49		46.37	48	2.59
01/04/1		40.22						
03/04/1	35.43		27.19			46.37		
04/04/1		40.22						
05/04/1						46.37		
06/04/1	35.43	40.22	27.19	21.41				
07/04/1						46.37		
08/04/1		40.22						
10/04/1	35.43		27.19			46.37		10.14
11/04/1		40.22						
12/04/1						46.37		
13/04/1	35.43	40.22	27.19	21.41				
15/04/1						46.37		
17/04/1		40.22					18.86	
18/04/1	35.43		27.19			69.56		
19/04/1		40.22						
20/04/1								10.14
21/04/1	47.24	40.22	36.25	21.41				
22/04/1							18.86	
25/04/1		40.22						
26/04/1								
27/04/1								
28/04/1								
29/04/1								

TABLE III. MRP REPORT OF UREA FOR APRIL 2017

Date	29/03/17	30/03/17	31/03/17	01/04/17	03/04/17	04/04/17
Gross Requirement				11.810	11.810	11.810
Schedule Receipts				20.000	0	0
Project on Hand			22.990	35.431	23.621	11.810
Net Requirement				0	0	0
Planned Order Receipt				4.252		
Planned Order Release	4.252				35.431	

TABLE IV. TOTAL INVENTORY COST

Raw Material	Ordering Cost	Holding Cost	Total Cost
Urea	Rp 75.950	Rp 52.519	Rp 128.469
RPE	Rp 119.350	Rp 42.541	Rp 161.891
KCL	Rp 75.950	Rp 41.751	Rp 117.701
Kaptan	Rp 43.400	Rp 36.839	Rp 80.239
Pewarna Merah	Rp 10.850	Rp 452	Rp 11.302
Kompos Ayam	Rp 119.350	Rp 55.561	Rp 174.911
Tanah Hitam	Rp 32.550	Rp 17.099	Rp 49.649
Tanah Gunung	Rp 32.550	Rp 16.225	Rp 48.775
Total	Rp 509.950	Rp 262.987	Rp 772.937

1. There is an application for calculating the amount of raw material needed based on production rate. Furthermore the Production Planning and Inventory Control (PPIC) division can also control the inventory of raw material.. PPIC which is an integrated application is required to create a raw material inventory report.
2. In the production division, an integrated application is required to record data production.
3. In the logistic division, there is an application that can record the amount of raw material that comes in and out from the warehouse.
4. In the marketing division, an application is required to manage ordering data of raw material and product demand
5. For the head of the factory, OLAP application which contains analytical data is required. The data are the amount of raw material usage and raw material entered per period

Meanwhile, the non-functional needs of the system are :

1. Applications can be used by multiple users at the same time and using different computers.
2. The interface of the application is easy to be understood and operated.
3. The application uses a username and password for users' authentication.

After analysing the need of system, the system concepts is built. Unified Modelling Language (UML) is used as the language for system concept using visual paradigm software. UML consists of business process diagram, use case diagram, class diagram, and entity relationship diagram. This system concept is executed by programming the program using PHP. The result of programming is the users interface for OLTP sub-system as shown in Fig. 1. This OLTP sub-system is connected to *bahan baku* database.

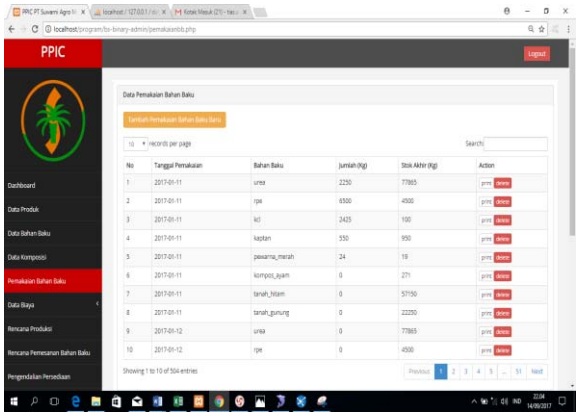

Figure 1. OLTP user interface.

The MRP application is designed after running the OLTP. The MRP application is the model management sub-system which is the design of mathematical models used in the program. This study applies MRP by using WWA method for determining the optimal lot size. The user interface for MRP application is shown in Fig. 2.

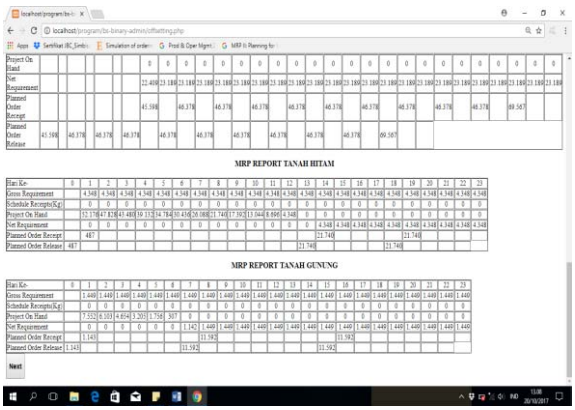

Figure 2. MRP application user interface.

The last sub-system is OLAP application. It is designed using data warehouse. Data warehouse is obtained from *bahan baku* database, after going through the Extract, Transform, and Load (ETL) process. This ETL process is conducted using Pentaho Data Integration (PDI) to get the uniform data from *bahan baku* database. The data from ETL process is loaded to a new database named data warehouse. This data warehouse is non-volatile, and will be used further using OLAP tools named SAP lumira. The OLAP user interface using SAP lumira is shown as Fig. 3.

To make sure this system is running well, a testing is conducted to this system. The testing is to verify that this system is no error and gives the same value for MRP calculation. The testing which validates the system is fit with the user needs of the system. This system is verified and validated.

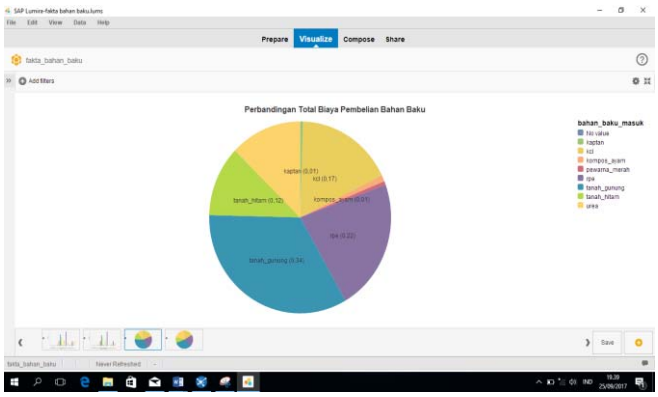

Figure 3. OLAP application user interface.

IV. Discussion and Analysis

A. Actual System and Propose System Analysis

The decision support system is designed to help users in PT Suwarni Agro Mandiri such as the head of factory, PPIC division, production division, logistic division, and also marketing division to manage their data of daily activities. By using this system, the data is easier to be collected, processed, and transformed into information. As a decision maker, the PPIC division can calculate the amount of raw material easily and the time to order the raw material from supplier using the MRP application.By using MRP approach, the company will save Rp348.901 in April 2017 if they order the raw material based on planned order release from MRP. Table V shows the different cost between actual system and the proposed system.

TABLE V. Total Inventory Cost

Raw Material	Ordering Cost		Holding Cost		Total Cost	
	Actual	Propose	Actual	Propose	Actual	Propose
Urea	Rp 119.350	Rp 75.950	Rp 127.909	Rp 52.519	Rp 247.259	Rp 128.469
RPE	Rp 173.600	Rp 119.350	Rp 85.555	Rp 42.541	Rp 259.155	Rp 161.891
KCL	Rp 141.050	Rp 86.800	Rp 91.082	Rp 30.901	Rp 232.132	Rp 117.701
Kaptan	Rp 54.250	Rp 43.400	Rp 44.465	Rp 36.839	Rp 98.715	Rp 80.239
Pewarna Merah	Rp 10.850	Rp 10.850	Rp 608	Rp 452	Rp 11.458	Rp 11.302
Total Inventory Cost					Rp 848.719	Rp 499.602

B. The Advantage and Disadvantage of The System

There are some advantages of the decision support system, such as :

1. The flow of information is clear

The forms contained in the application is based on the activities performed by each user. As in the design of business process diagrams and use case diagrams, information flowing from one user to another user occurs according to the information needs of the user and the information can be known by looking at the usefulness of the information.

2. Friendly user interface

The appearance of the designed application has been adjusted to the needs of users of the system. In addition, the display is designed to be attractive and to be understood and utilized easily by the user.

3. Data Security

The system is designed to have different access rights, based on the needs of users and the role of users in the system. The head of the factory can only see the data of raw material usage, while the PPIC division can input data and see the data of raw material usage.

4. Able to perform the calculation of inventory control

The ability of inventory control calculation feature facilitates the division of PPIC in determining raw material inventory policy that must be done. PPIC division can know the quantity and time of ordering of raw materials.

Beside, there are some disadvantages of this decision support system, such as :

1. The proposed system has not been able to display the user interface for OLAP.

The proposed system only at the stage of building a data warehouse for OLAP. As for displaying the output of OLAP, additional software such as SAP Lumira to display analytical data in the form of graph is still needed

2. There is still a process of inputting manually in determining the inventory control of raw material.

In the process of calculating raw material inventory control, the application still needs the user translating the tables of the calculation of costs into the lot size of ordering at the lotting stage. This is because at this stage, there are two variables that must be determined simultaneously, namely the amount of order and order time. To determine the amount and the time of ordering can be done through trial and error stage by following algorithm rule wagner within in determining lot size. With such limitations, the system is designed only to the limit of displaying the calculation results, while the process of translation of raw material size and ordering time is done using the user knowledment.

V. Conclusion

The conclusions obtained from the results of this study are as follows:

1. The proposed system for inventory control of raw material in PT Suwarni Agro Mandiri Plant Pariaman is conducted by using Material Requirement Planning (MRP) approach. Based on the results of lotting using AWW method, it is

known that the total cost of inventory for one planning period is Rp772.937. The output obtained from this method is the optimal order quantity and ordering time for each raw material.

2. The proposed decision support system for inventory control of raw material in PT Suwarni Agro Mandri Plant Pariaman with MRP method has performed inventory control, input data that related with raw material, and reported inventory which is integrated to each other. In addition, this system has a data warehouse that can be used to perform the process of inventory data analysis.

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