Analysis of Material Requirement Planning (MRP) Implementation on The Company

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Abstract: Inventory management has a strategic position in the company. As the one of the most expensive assets of many companies, inventory representing almost 50% of total invested capital. Therefore, this study aimed to analyse inventory management, especially Material Requirement Planning (MRP) implementation on the company. MRP system with lot sizing techniques such as Lot for Lot (LFL), Economic Order Quantity (EOQ), and Periodic Order Quantity (POQ) are implemented to decide when and how many materials are needed based on the cost that company will pay. The research use descriptive comparative methods. Most of the data analysed are about; product's specification, number of orders in one year period, lead time, setup cost, holding cost, and so on. The overall result shows that MRP analysis with POQ technique is the best method's with minimum cost of all materials.

1 INTRODUCTION

Fuel oil is one of the vital needs of our society. Unfortunately, the oil production in our country cannot meet domestic demand. For this purpose, oil production capacity should be optimized by increasing the capacity of the offshore pipeline as a means of transportation. One of the executors who are trying to fulfill the demand for upgrading the offshore pipeline capacity is XYZ Company through its project. The project is an offshore transmission pipeline replacement from one of the offshore platforms to the mainland oil refinery. The pipe to be replaced is a two-lane pipe along ± 15 km. Project implementation takes place approximately 16 months. Pipe coatings work are expected to last for ± 311 working days since the bare pipe received. It is included with the inspection, setup time, and the things required satisfying the client's needs. (Engineering center, 2015, Project Procurement Plan, 2016).

In previous projects, the company used three different types of coatings with different lead times. The ordering of all raw materials is done in the first week while the production process starts at the 10th week. This causes the length of material storage time; such conditions may increase the cost of storage. Limited project time and material endurance is a major consideration of why the ordering of raw materials must be timely (Project Execution Report, 2017).

The importance of inventory control planning and capacity becomes one of the major factors in minimizing storage costs and helping companies achieve production targets. Inventory management has a strategic position in the company. As the one of the most expensive assets of many companies, inventory representing almost 50% of total invested capital. One of the inventory management methods is Material Requirement Planning (MRP) (Heizer, 2014).

MRP systems became a prominent approach to managing the raw material flow and components on the factory in the late 20th century (Mabert, 2007). By using this method, the company is expected to get the minimum inventory cost by comparing three lot sizing techniques in MRP, namely Lot for Lot, Economic Order Quantity, and Periodic Order Quantity. Some previous research showed that the MRP implementation shall prevent the company from wasting materials, more effective production, and lead a more profitable business (Iasya, 2015). However, not all MRP users attained the same degree of MRP benefits (Salaheldin, 1998). This is what lies behind the research on analysis of MRP implementation on the company.

The purpose of this research is to analyze efficiency level of inventory control by comparing MRP methods with inventory cost incurred.

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2 LITERATURE REVIEW

The stock of material on inventory management is used to facilitate production or meet customer demand. The main reason companies should have inventory are; protecting from uncertainty, enabling economical purchase and production, masking changes in anticipated demand and supply, providing transit (Schroeder, 2011). The external customer demand also has to be an orientation for organization to keep a stock of items (Russell, 2006). The purpose of inventory management in general is to determine the amount of inventory to be stored, how much and when to order, and to get a balance between inventory investment and service to consumers. Inventory management has two main approaches, base on the customer demand which consists of dependent and independent. On independent demand, the method used is Economic Order Quantity, and others. As for the dependent demand techniques used are Material Requirement Planning (Heizer, 2014).

2.1 Material Requirement Planning

The main purpose of the MRP is to keep inventory levels as low as possible. The MRP achieves it by determining when a component is needed and scheduling it to be available on time. To minimize inventory cost, the company also can use JIT system, but it is more suitable for small lot size and large variety production, while MRP for large lot size and small variety production (Hui Wang, 2017).

To use the MRP method effectively, the required inputs are: Master Production Schedule (MPS), Bill of Materials (BOM), inventory records, purchase orders, and Lead Time are known. The MRP system parameter is one of the most important activities for the perfect system functioning. They should take into consideration some reality and circumstances of companies environment. For instance, supplier deliveries are not always on time (fuzzy lead time), so the safety stock option can be adopted as the included parameter (Santin, 2015). In the case of MRP problem with fuzzy lead times, analysis can use a fuzzy multi-objective integer linear programing (Madronero, 2015). The accuracy of the MRP input is the main factors of MRP system success. Once all inputs are available, the next step is to determine gross demand and net requirement of material. The difference of them lies in the calculation of inventory stocks of the company.

Most of MRP outputs needed by the company are; a) MRP report per period, b) MRP report per day, c) Report of the plan of reservation, this report contains Planned Order Releases and Planned Order Receipt, d) Purchase Recommendation, e) Exception report, is an additional report for raw materials that have special treatment in the ordering process (Heizer, 2014, Russell, 2006).

The MRP process consists of several steps; netting, lot measurement, and offsetting as a determination of order quantity and time by considering process time. To achieve cycle time reduction, it can use a smaller lot size, a reduction in lot size transferred directly into lower raw process times (Ying-MeiTu, 2017). MRP methods produce schedule of production and the need for material which required Lot Sizing technique. Determining lot sizes in production areas is an essential task of production planning and control (Schmidt, 2015). There are various kinds of lot sizing techniques, including: Lot for Lot (LFL), Economic Order Quantity (EOQ), and Periodic Order Quantity (POQ).

2.1.1 Lot for Lot (LFL)

Lot for Lot (LFL) is a technique that produces the right amount of raw materials to meet the plans that have been made. The LFL technique is in line with the objectives of the MRP to meet the needs of dependent demand. Therefore, the MRP system must produce goods as required (Heizer, 2014).

2.1.2 Economic Order Quantity (EOQ)

The objective of EOQ is to minimize the amount of ordering and storage costs. This technique is one of the most commonly used and easy-to-use based on the following assumptions: a) demand is known, constant, and independent, b) lead time is known and constant, c) receipt of inventory is instantaneous and complete, d) quantity discounts are not possible, e) only variable costs are setup and holding, f) stock outs can be completely avoided (Heizer, 2014). Although EOQ is more suitable for use when demand is relatively constant and independent, it can be used in known queries by finding the average requests that appear within a year. The formula used is:

$$Q^* = \sqrt{\frac{2DS}{H}} \quad (1)$$

Q* = Optimal number of pieces per order (EOQ)
D = Annual demand in units for the inventory item
S = Setup or ordering cost for each order
H = Holding or carrying cost per unit per year

2.1.3 Periodic Order Quantity (POQ)

POQ is a booking technique that issues orders within specified time intervals between orders with the number of items ordered must cover the number of items required during the interval, e.g. once every week. POQ is defined as the time interval when the number of economic orders is derived from the division of demand per period (Heizer, 2014). The formula used is:

$$POQ = \frac{EOQ}{\text{Avg. Period usage}} \quad (2)$$

2.2 Inventory cost

The costs that appear in inventory management are: a) Holding Cost, b) Ordering Cost, and c) Setup Cost (Heizer, 2014). Holding costs covers: building costs, material handling costs, labor costs, investment costs, loans to purchase inventory (Russell, 2006). Ordering costs are the costs incurred during the booking process. The cost of ordering includes several things: purchase cost of goods, consist of unit price of material ordered, supply fee that is cost incurred for delivery of goods, inspection, administration cost, consist of document issuance cost, certificate, letter examination, etc. Setup cost is the cost incurred when a company prepares a machine or an order manufacturing process. These costs include labor costs incurred and time. A high regulatory time will affect the labor costs incurred so that the company needs appropriate planning (Heizer, 2014).

3 METHODS

The research was carried out in 2016 to 2017. The data used in this study consisted of primary data and secondary data, include: number of pipeline orders, number of coats required for a pipe, number of coatings required for all pipes, lead time (raw material ordering time), ordering cost and storage cost incurred for the project, organizations and projects structure, data and events from the internet and journals.

This research uses quantitative approach with descriptive research type. Especially descriptive comparative analysis is used to compare three lot sizing techniques in MRP; Lot for Lot, EOQ, and POQ. The analysis start with MRP step which include: 1) creating a Master Production Schedule, 2) creating a product structure or Bills of Materials, 3) collecting lead time data of raw material ordering, 4) preparing a Gross Requirements Plan, 5) Make a Net Requirements Plan, 6) determine the ordering time of goods (Planned Order Release) with lot sizing method, 7) determine the right lot sizing method (Heizer, 2014).

Determining the right lot sizing method will result in a minimum total inventory cost. Determination of this method is done by comparing total inventory cost based on company calculation with total cost obtained through calculation by lot sizing method. Lot sizing methods used in this research are Lot for Lot, Economic Order Quantity (EOQ), and Periodic Order Quantity. The software for data analysis use Production and Operation (POM) for Windows ver. 3 (build 18).

4 RESULTS AND DISCUSSION

The Inventory analysis starts with the calculation of raw material using Product Structure or Bill of Material (BOM), and Records Inventory. Costs will be calculated using the Lot for Lot method, EOQ, and POQ.

The pipe to be produced by the company is pipes coated by 3LPP, MLPP and CWC coatings. 3LPP Coating consists of FBE, adhesive polypropylene, and polypropylene. While the MLPP coating consists of a pipe that has been coated 3LPP added solid polypropylene and polypropylene foam. Coating CWC is a concrete made from a mixture of cement, water, and ore which will be applied to a pipe that has been coated MLPP and has been installed with a reinforcing frame. Below is Product Structure or Bill of Materials (Figure 1).

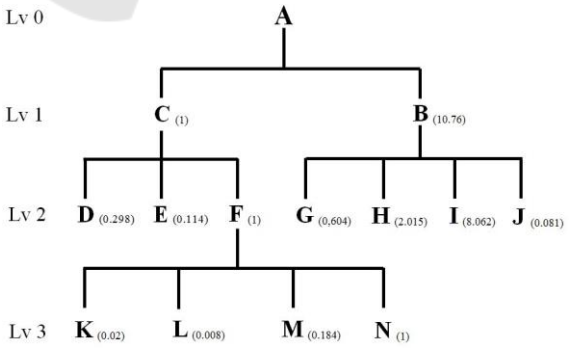

Figure 1: Bill of Materials of the Product.

Meanwhile the raw materials detail of the product can be shown in the Table 1.

Table 1: Raw Materials Detail of Product.

Level	Code	Component/ Material Name	Amount	Lead Time
0	A	CWC 100mm Coated Pipe	1 unit	3,5 weeks
1	B	Concrete Weight Coating	10,76 ton	4 weeks
1	C	MLPP coated pipe	1 unit	5,17 weeks
2	D	Polypropylene Foam	0,298 ton	12 weeks
2	E	Solid Polypropylene	0,114 ton	12 weeks
2	F	3LPP Coated Pipe	1 unit	2,7 weeks
2	G	Water	0,604 ton	1 weeks
2	H	Cement	2,015 ton	2 weeks
2	I	Iron Ore	8,062 ton	8 weeks
3	J	Reinforcement Frame	0,081 ton	4 weeks
3	K	FBE	0,02 ton	12 weeks
3	L	Adhesive polypropylene	0,008	12 weeks
3	M	Polypropylene	0,184 ton	12 weeks
3	N	Bare Pipe	1 unit	12 weeks

4.1.1 Lot for Lot (LFL) Analysis

The Lot for Lot (LFL) technique determines the amount of raw material purchased in accordance with the net amount of raw materials required in the production process. The cost of inventory should be reduced to 0 by this technique. Ordering of 100mm CWC pipe raw materials begins by ordering a bare pipe (N) 1230 units at first. In the same week, polypropylene (M), adhesive polypropylene (L), and Fusion Bonded Epoxy (K) ordered. Item M ordered as much as 52.44 tons, 87.4 tons, and 86.48 tons. For item L will be ordered a number of 2.28 tons, 3.8 tons, and 3.76 tons. At the same time item M also ordered a number of 5.7 tons, 9.5 tons and 9.4 tons. Production of 3LPP coated pipe (F) items will be made at the later week.

The production of concrete weight coating (B) requires water (G), cement (H), iron ore (I), and reinforcement frame (J). Any material needed in the production of concrete weight coating has a different lead time. The total requirement of 2478.45 ton H items is required to produce B item. All of H items needs will be met in five orders made for Meet the needs in next week after. The last material to produce B item is J item.

Although item F is completed in full at certain weeks, item C will be produced three days after item F. The total item C required is 1230 units Item C consisting of items D, E, and F will be completed whole at certain week. Item B has the same case as item C, it takes 13,234.8 ton items B to produce item A. Item A will be dried for 3.5 weeks.

The next step is to calculate the costs that appear based on the data that has been calculated by lot for lot technique. The calculation of costs by Lot for Lot techniques is shown in the following Table 2.

Table 2: Total Inventory Cost of Product Raw Material with Lot for Lot Technique.

No	Code	Amount (Ton)	Holding Cost	Ordering Cost	Total
1	N	3690	$308.03	$13,457.80	$13,665.83
2	M	226.32	$0.00	$449,239.67	$449,239.67
3	L	9.84	$0.00	$35,558.65	$35,558.65
4	K	24.6	$0.00	$82,549.32	$82,549.32
5	J	99.63	$0.00	$61,139.80	$61,139.80
6	I	9916.26	$0.00	$730,535.06	$730,535.06
7	H	2478.45	$0.00	$257,316.99	$257,316.99
8	G	743.73	-	$699.11	$699.11
9	E	140.22	$0.00	$278,747.40	$278,747.40
10	D	362.17	$0.00	$686,423.22	$686,423.22
Total					$2,595,975.04

4.1.2 Economic Order Quantity (EOQ) Analysis

The analysis of EOQ uses average demand per year. The amount of raw material demand in the project has been determined for several weeks so it is necessary to estimate the total annual demand for the raw materials. Estimated annual raw material demand is done by multiplying the average weekly requirement for a total of weeks in a year as described earlier. After the average annual use of raw materials is obtained, the number of economical orders can be calculated.

$$Q^* = \sqrt{\frac{2(4248.83)(\$100)}{\$3,10}} = 524 \text{ ton/order}$$

The EOQ calculation process generates an economic order of all raw materials that can be seen in the following Table 3:

Table 3: EOQ of Product Raw Material Technique

No	Code	Raw Materials Type	EOQ
1	M	Polypropylene	456 tons
2	L	Adhesive Polypropylene	95 tons
3	K	FBE	38 tons
4	J	Reinforcement Frame	93 tons
5	I	Iron Ore	8157 tons
6	H	Cement	2216 tons
7	E	Solid Polypropylene	278 tons
8	D	Polypropylene Foam	447 tons

Pipes and water are excluded from EOQ calculations because pipes can only be ordered once during the project, and water due to no storage and ordering costs. The number of items M ordered by EOQ technique is 456 tons, while the required number of M items is 226.32 tons so that there are 229.68 tons of raw materials remaining. The same is true for items D, E, K, and L, ordered L items totaling 95 tons with a requirement of 9.84 tons and leaving 85.16 tons. 38 tons of K items ordered with

the needs of 24.6 tons and remaining 13.4 tons. Similar to the remaining E item 137.78 tons, the ordered quantity is 278 tons with a requirement of 140.22 tons. The number of items D ordered was 447 tons with 80.46 tons remaining, and so forth.

After the amount of material ordered, the order amount, and the ordering time is determined by EOQ technique, the next step is to calculate the inventory cost shown in the following table 4.

Table 4: Total Inventory Cost of Product Raw Material with EOQ Technique.

No	Code	Amount (Ton)	Holding Cost	Ordering Cost	Total
1	N	3690	$308.03	$13,457.80	$13,665.83
2	M	456	$168.74	$904,644.40	$904,813.14
3	L	95	$56.39	$336,284.28	$336,340.67
4	K	38	$167.94	$126,886.23	$127,054.17
5	J	99.63	$83.41	$60,839.80	$60,923.21
6	I	9916.26	$89.65	$730,235.06	$730,324.71
7	H	2478.45	$82.70	$257,016.99	$257,099.69
8	G	743.73	-	$699.11	$699.11
9	E	278	$104.92	$551,554.70	$551,659.62
10	D	447	$112.04	$846,561.55	$846,673.59
Total					$3,829,253.75

4.1.3 Periodic Order Quantity (POQ) Analysis

POQ analysis uses a lot determination technique that orders the amount of raw material in accordance with the required within the specified time interval. The time span is determined by dividing the number of economic orders by the average requirement per period, in this study per week. The following Table shows the order interval for each raw material.

Table 5: EOQ of Product Raw Material Technique

No	Code	Raw Materials Type	Interval
1	M	Polypropylene	6 weeks
2	L	Adhesive Polypropylene	30 weeks
3	K	FBE	5 weeks
4	J	Reinforcement Frame	5 weeks
5	I	Iron Ore	4 weeks
6	H	Cement	4 weeks
7	E	Solid Polypropylene	11 weeks
8	D	Polypropylene Foam	7 weeks

The pre-defined reservation time interval will be used in the determination of the order amount. The number of units of raw materials ordered will be affected by the number of intervals and lead time of each raw material. Water does not have an interval because it is channeled directly when production is being pipe has no interval because pipeline ordering can only be done once during the project.

POQ technique determines the interval between materials ordering. Item M which has six-week intervals, ordered once 226.32 tons. The same conditions for items L, K, J, I, E, and D. Item L has an interval time ordered 9.84 tons at certain week, and K items ordered 24.6 tons on the same week. Item J also has a 5 week interval booked at certain week because it has 4 week lead time. Item I have a 4 week interval booked 9916.26 tons at certain week. All of these items are only ordered once with the POQ technique as there is no more requests for those items when the order is made after the interval of each item.

Different things happen to item H that has a 4 week interval. Item H is ordered twice with first order 1836,276 ton and second order 362,835 ton. The second order was made to increase the number of items H in inventory to meet demand at certain week.

After the ordering amount with POQ technique is determined, the cost of 100mm CWC pipe with POQ technique can be calculated as follows:

Table 6: Total Inventory Cost of Product Raw Material with POQ Technique.

No	Code	Amount (Ton)	Holding Cost	Ordering Cost	Total
1	N	3690	$308.03	$13,457.80	$13,665.83
2	M	226.32	$18.88	$449,039.67	$449,058.54
3	L	9.84	$0.82	$35,358.65	$35,359.47
4	K	24.6	$31.92	$82,349.32	$82,381.24
5	J	99.64	$97.56	$60,745.89	$60,843.44
6	I	9916.26	$121.12	$730,135.06	$730,256.18
7	H	2478.45	$57.65	$257,016.99	$257,074.63
8	G	743.73	-	$699.11	$699.11
9	E	140.22	$25.01	$278,247.40	$278,272.41
10	D	362.17	$65.38	$685,923.22	$685,988.60
Total					$2,593,599.45

4.1.4 Discussion of Research Results

Material requirement planning as a system of raw materials planning and control used to take decisions on the amount of raw materials to be ordered at a certain period. The use of lot sizing technique is expected to provide the minimum inventory cost. However, not all lot sizing techniques resulting minimum inventory cost. The analysis shows that the total inventory cost of all techniques as follows.

Table 7: Cost Comparison of Lot Sizing Technique

No	Technique	Total Inventory Cost
1	LFL	$2.595.975,04
2	EOQ	$3.829.253,75
3	POQ	$2.593.599.45

The inventory cost of the company's raw material control system is $2,605,654.34. The company ordering all raw materials in the first week and stored it until the production process begins to run. This leads to high storage costs.

Economic order quantity technique generates a total cost of $3,829,253.75. It is greater than the company cost calculation, due to the remaining raw materials.

The Lot for Lot technique adjusts the amount of raw materials ordered by the amount of raw material demand in order to reach 0 storage cost. However, the cost of ordering raw materials will soar due to the ordering process done repeatedly to meet the amount of raw material needs each week. Total inventory cost of Lot for Lot technique is $2,595,975.04.

The total inventory cost generated by the POQ is $2,593,599.45. This technique calculates the interval between ordering and buying raw materials in accordance with the required amount in a given period. With this technique, the cost of ordering and storage costs can be minimized optimally so that the total cost of raw material inventory of pipe with POQ technique is the minimum inventory cost compared to other lot sizing techniques, it can save inventory costs of $11,253.85.

5 CONCLUSIONS

Analysis of Material Requirement Planning (MRP) with lot sizing technique used in this research are: Lot for Lot (LFL), Economic Order Quantity (EOQ), and Periodic Order Quantity (POQ). The lot sizing technique that provides the minimum cost for all raw materials is POQ. Ordering raw materials using the POQ method is highly recommended to minimize the cost of inventory because it scheduling the ordering of raw materials in certain intervals with the amount of raw materials ordered in accordance with the demand of such raw materials in a certain period. The company can save a significant inventory cost by using appropriate technique in inventory management.

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