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Inventory Planning and Control on Packaging Raw Materials in the Bottled Drinking Water Business (AMDK) PT XYZ Samarinda City

Muhammad Wahyudi*, Wahyuda, Farida Djumiati Sitania
Industrial Engineering, Mulawarman University, Jalan Sambaliung No.9, Samarinda City 75119 Indonesia

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A B S T R A C T

The production of bottled drinking water (AMDK) has growth of 10.4% from 2010 to 2019. One of the AMDK companies located in Samarinda City is PT XYZ. The produced product is water packaged in 220 ml glass containers. The raw materials for the 220 ml water packaging product include cups, cup lids, straws, cardboard boxes, and cardboard dividers. The AMDK business operated by PT XYZ has only been in operation since 2021, and there is currently no inventory planning and control for the raw materials used in the packaging of the 220 ml AMDK product. This has resulted in a lack of packaging raw material inventory, thus hindering the AMDK production process in the company. Based on this issue, this research is conducted to plan and control the inventory of 220 ml water packaging raw materials at PT XYZ, in order to optimize inventory costs and meet consumer demand for AMDK. Inventory planning and control are carried out using the Material Requirement Planning (MRP) method, and the method used to determine the lot size is the Economic Order Quantity (EOQ) method with shipping capacity constraints. Based on the data processing conducted, the optimal order quantities using the EOQ method with shipping capacity constraints for each packaging raw material are 15.000 pieces for cardboard and cardboard dividers with an inventory cost of IDR 267.112.900. 1.500.000 pieces for straws with an inventory cost of IDR 46.831.630. 540.000 pieces for cups with an inventory cost of IDR 232.026.718. 150 rolls for cup lids with an inventory cost of IDR 87.125.910. The total inventory cost for packaging raw materials for 220 ml AMDK cups is IDR 633.097.158.

***Corresponding Author**
Muhammad Wahyudi
E-mail: mw.yudi264@gmail.com

1. INTRODUCTION

Water is the most important natural resource for living things after oxygen. The human body requires a daily water consumption of 1 to 2.5 liters, and this requirement varies depending on physical activity, body weight, age, climate, and diet (Ministry of Health, 2023). The AMDK or bottled drinking water is water that is packaged and processed without food ingredients or food additives, making it safe to drink (Ministry of

Industry, 2011). The rapid population growth is directly proportional to the demand for bottled water. AMDK is chosen because it is not only practical and hygienic but also can be consumed anytime and anywhere (Refangga et al., 2018). The AMDK industry has a market share of 85% compared to other beverage industry groups, where there are more than 2000 AMDK brands and 900 AMDK industry companies in Indonesia (Ministry of Industry, 2019). AMDK production volume increased at an average growth rate of 10.4% annually from 2010 to 2019 with an AMDK production volume in 2019 of 29.6 billion liters (Aspadin, 2021). PT XYZ is one of the companies engaged in the AMDK business. The results of AMDK production at PT XYZ are in the form of gallon bottled water and 220 ml glass packaging. Packaging raw materials used in the production of 220 ml glass bottled water at PT XYZ are cardboard boxes, cardboard dividers, straws, cups and lid cups. One box of 220 ml bottled water consists of one cardboard box, one cardboard divider, 48 220 ml glass bottled water and 48 straws. Bottled water raw materials must be stored properly so that the quality of production is in accordance with the established quality standards. AMDK packaging raw materials must be stored in a clean place with a cool room temperature and avoid direct sunlight exposure and kept away from sharp smelling objects.

PT XYZ is a new company in the bottled drinking water (AMDK) industry. The planning and control of AMDK packaging raw materials at PT XYZ follow the minimum order quantities set by the supplier. The phenomena at PT XYZ are often results in shortages of raw materials. As a result, in the days leading up to the arrival of ordered AMDK packaging raw materials, PT XYZ must reduce its daily production to ensure the continuous production process. These inventory shortages of AMDK packaging raw materials can lead to delays in the production process, impacting the ability to meet consumer demand. Therefore, the availability of packaging raw material supplies at PT XYZ significantly affects the smooth production process. One method that can be used to perform inventory planning is the Material Requirement Planning (MRP) method. According to Utama et al. (2019), MRP is a method used to solve problems related to determining the number of parts, components and materials needed to produce the final product. The MRP system also provides detailed scheduling of when each component, material and part should be ordered or produced. The MRP process starts from the netting stage, which is the process of calculating net requirements, then the lotting stage, which is the process of determining the amount of packaging raw material orders, then the offsetting stage, which is the process of determining the right time to order packaging raw materials and finally the explosion stage, which is the stage of calculating the gross needs of items that are at the lower level.

2. LITERATURE REVIEW

Inventory is an asset that comprises goods owned by the company intended for sale, goods in various stages of the production process, and raw materials awaiting processing in the production pipeline (Vikaliana et al., 2020). According to Sipper and Bulfin (1995) in Eunike et al. (2017), one of the variability test techniques that can analyze demand data patterns is to use the Peterson-Silver Rule technique. According to Aritantia et al. (2018), the nature of demand consists of static and dynamic which is measured by looking at the demand variability coefficient. Demand will be said to be static if the variability value $V < 0.25$ and is said to be dynamic if the variability value $V \geq 0.25$. Silver and Peterson suggested that when the variability value $V < 0.25$, lot sizing calculations can use the Economic Order Quantity (EOQ) method, while if the variability value $V \geq 0.25$, lot sizing calculations can use dynamic lot sizing.

MRP or Material Requirements Planning is an information system that utilizes interrelationships to plan and control manufacturing operations. It involves the calculations necessary to determine the components required for the final product and is a technique for establishing the quantity and timing of dependent demand items to fulfill the master production schedule requirements (Kadim, 2017). According to Eunike et al. (2018), the four basic steps in MRP processing are as follows: (1) Netting (calculation of net requirements). Net requirements (NR) are

calculated as the value of gross requirements (GR) minus scheduled receipts (SR) minus inventory on hand (OHI). Net requirements are considered zero when NR is less than or equal to zero, (2) Lotting (lot size determination). This step aims to determine the optimal individual order size based on the results of the net requirements calculation. This step is determined based on appropriate lotting or lot sizing techniques. The parameters used are usually storage costs and ordering costs, (3) Offsetting (determination of order size). This step aims to ensure that the item needs can be available exactly when needed by calculating the lead time for procuring the component, (4) Explosion This step is the process of calculating gross requirements for the item (component) level at a lower level than the available product structure.

MRP requires three essential information inputs, which are as follows: (1) Master Production Schedules (MPS): MPS is a planning phase that determines the quantity and timing for producing each end product. It divides the overall production plan into various end products based on forecast results. MPS is an allocation process that considers the company's capacity to produce the desired products, (2) Product Structure (Bill of Materials - BOM): A BOM is a list of items required to assemble a unit of the finished product. It includes a comprehensive description of the product, not only listing raw materials and components but also outlining the production sequences. The BOM is sometimes referred to as a product structure tree because it illustrates how a product is constructed from its components. This structure specifies the quantities of each item and the order of assembly. When entered into the master BOM, it details all component names, identification numbers, drawing numbers, and material sources, whether produced in-house or purchased externally. The list of components will be assembled, making the master BOM a form of processing, (3) Inventory Records File: This file maintains a record of items in the warehouse and items that have been ordered but not yet received. It is used when needed in production. The contents of this record include identification numbers, available quantities, safety stock levels, planned production quantities, and procurement lead times for each item. Keeping this record up to date is essential by recording transactions such as receipts, expenditures, defective products, and orders to prevent planning errors (Eunike et al., 2018).

One method commonly used in inventory management is the Economic Order Quantity (EOQ) method. The EOQ method is an approach that seeks to optimize inventory levels by considering factors such as ordering costs and storage costs (Aprilia et al., 2018). The research using the Material Requirements Planning (MRP) method to solve inventory problems has been conducted previously, as seen in studies by Assifa and Pujiyanto (2022), Silfiani et al. (2021), and Setiawan et al. (2020). However, in the current research, there is also a difference in the lotting calculation compared to previous studies. The present study employs the Economic Order Quantity (EOQ) method with shipping capacity constraints, similar to the approach taken in the research by Mubin et al. (2021).

3. RESEARCH METHOD

This research was conducted at PT XYZ, a company specializing in the bottled water industry. The research process began with a preliminary study, followed by data collection through observations and interviews to gather the necessary information. Subsequently, data processing was performed for the purpose of planning and inventory control of raw materials used in the production of 220 ml bottled water. The data collection phase aligned with research requirements, encompassing primary data such as dimensions for each raw material of the 220 ml bottled water, and secondary data consisting of demand patterns for 220 ml bottled water products over the last 12 months, product component data, pricing information for each raw material, ordering costs, storage costs, inventory lists, lead times for each raw material, and storage warehouse dimensions for packaging materials.

Data processing included demand forecasting for the 220 ml bottled water products, involving the creation of demand data plots, identification of demand patterns, and utilization of forecasting methods matching these patterns with minimal error values. Following this, the

Master Production Schedule (MPS) was determined based on the forecasted demand for the 220 ml bottled water products, and a Bill of Materials (BOM) was established using the component data for these products. Subsequently, the Material Requirements Planning (MRP) process commenced with the netting stage, followed by lotting, offsetting, and explosion processes. During the lotting stage, the EOQ method was applied, considering capacity constraints for determining the lot sizes of individual 220 ml bottled water raw materials. Finally, the total inventory costs were calculated, and the results of the data processing conducted earlier were analyzed.

4. RESULT AND DISCUSSION

Data Collection

PT XYZ is one of the companies engaged in the bottled water industry with production results in the form of 220 ml glass packaging and gallon packaging. AMDK gallon packaging has been produced since 2021 while AMDK 220 ml packaging has been produced since 2022. The following is the demand data for 220 ml bottled AMDK products for one year, namely July 2022 to June 2023.

Table 1. Product demand (box)

No	Month	Demand
1	July 2022	10.123
2	August 2022	5.798
3	September 2022	6.914
4	October 2022	7.604
5	November 2022	5.371
6	December 2022	6.227
7	January 2023	6.069
8	February 2023	3.988
9	March 2023	6.518
10	April 2023	3.799
11	May 2023	6.230
12	June 2023	4.066
	Total	72.707
	Average	6.059

Based on Table 1. Above, it is known that the total demand for 220 ml bottled water products for 1 year is 72,707 boxes with an average monthly demand of 6,059 boxes. Furthermore, data on the dimensions of the storage warehouse and the dimensions of the packaging raw materials from observations and interviews are obtained which will be used to determine the storage cost of each 220 ml bottled bottled raw material.

Table 2. Dimension of strogae warehouse and packaging raw materials

No	Description	Amount	Size(m)	Volume(m^3)	Volume (m^3)/unit
1	Storage warehouse	1	17x10x3	510	
2	Cardboard	1	0,571x0,421x0,007	0,001683	0,001683
3	Cardboard divider	1	0,338x0,219x0,003	0,00022	0,00022
4	Cup	3.600 pcs	0,35x0,25x0,33	0,02475	0,000006875
5	Lid cup	1 roll	0,23x0,23x0,40	0,02116	0,02116
6	Straw	96.000 pcs	0,5x0,5x1	0,25	0,0000026042

Inventory Record Data

Inventory records are one of the inputs to the MRP process and consist of both owned inventory and inventory on order. The following is the inventory data for raw materials for 220 ml bottled water products.

Table 3. Inventory in storage warehouse

Description	Inventory	Lead Time
220 ml AMDK product	18 box	0 week
Cardboard	4.680 pcs	2 week
Cardboard divider	4.680 pcs	2 week
220 ml bottled water	25 pcs	0 week
Straw	366.000 pcs	2 week
Cup	126.000 pcs	2 week
Lid Cup	32 roll	2 week

In addition to data on the inventory of packaging raw materials in the storage warehouse, there are packaging raw materials that are being ordered. The following is the order data for packaging raw materials for 220 ml bottled water products.

Table 4. Purchase order

Detail	Date of Order	Order Quantity
Cup	30 June 2023	540.000 pcs

Table 4 it is noted that on June 30, 2023, PT XYZ placed an order for 540,000 pieces of cup packaging materials, which are expected to arrive two weeks after the order placement.

The Bill of Materials (BOM) is a list of raw material items required to produce a single unit of a finished product. The bottled water product structure includes finished products, packaging raw materials, and the main raw material, which is water. Here is the product structure for 220 ml bottled water.

Table 5. Product structure

Part Number	Component Number	Component Level Number	Description	Component Usage
	WTR-001	0	220 ml AMDK product	1 box
WTR -001	WTR -111	1	Cardboard	1 pcs
WTR -001	WTR -112	1	Cardboard divider	1 pcs
WTR -001	WTR -113	1	220 ml bottled water	48 pcs
WTR -001	WTR -114	1	Straw	48 pcs
WTR -113	WTR -211	2	Cup	1 pcs
WTR -113	WTR -212	2	Water	220 ml
WTR -113	WTR -213	2	Lid Cup	1 pcs

Based on Table 5. above, it is evident that to produce a single item at level 0, which is the 220 ml bottled water product, the following components are required at level 1 is 1 piece of cardboard, 1 piece of cardboard divider, 48 pieces of 220 ml bottled water, and 48 pieces of straws. Moving to level 2, the components for items at level 1 consist of 1 cups and 1 lid cup to create the 220 ml bottled water.

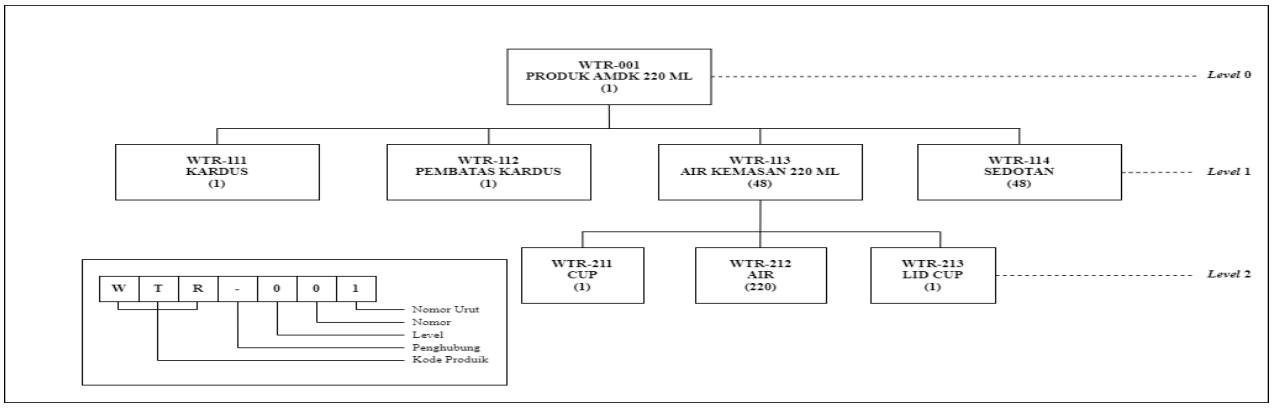

Figure 1. Bill of material-BOM

Ordering Cost

Ordering costs are costs that must be incurred by the Company every time it orders packaging raw materials. Ordering costs are obtained from the total cost of the message plus the shipping costs for each delivery capacity limit. The following is a breakdown of the cost of ordering 220 ml bottled raw materials.

Table 6. Order cost

No	Description	Amount	Cost	Unit	Cost/order
1	Telephone cost				
	a. Telephone to supplier	5 minutes	IDR 699	/30second	IDR 6.990
	b. Telephone to expedition	5 minutes	IDR 699	/30second	IDR 6.990
2	Administrative cost (making purchase order)				
	a. A4 Paper (Sinar dunia 70 Gr)	1 sheet	IDR 57.140	1 rim	IDR 114,28
	b. Printer ink (Epson E664)	1 sheet	IDR 109.000	1 bottle	IDR 36,33
Total					**IDR 14.130,61**

In addition to the cost of the message, there is the cost of shipping packaging raw materials. The following is a breakdown of the cost of shipping raw materials for 220 ml bottled water.

Table 7. Shipping cost of packaging raw materials

No	Description	Cost
1	Cardboard and cardboard divider	
	a. 12.000 pcs capacity	IDR 8.500.000
	b. 15.000 pcs capacity	IDR 10.000.000
	c. 18.000 pcs capacity	IDR 11.500.000
2	Cup	-
3	Lid Cup	
	a. 50 roll capacity	IDR 2.000.000
	b. 100 roll capacity	IDR 3.500.000
	c. 150 roll capacity	IDR 5.000.000
4	Straw	
	a. 600.000 pcs capacity	IDR 2.500.000
	b. 1.000.000 pcs capacity	IDR 4.000.000
	c. 1.500.000 pcs capacity	IDR 5.500.000

From the data on order costs and shipping costs, the cost of ordering packaging raw materials is then obtained from the summation of order costs and shipping costs.

Table 8. Ordering cost

No	Description	Order cost	Shipping cost	Ordering cost
1	Cardboard and cardboard divider			
	a. 12.000 pcs capacity	IDR 14.130,61	IDR 8.500.000	IDR 8.514.130,61
	b. 15.000 pcs capacity	IDR 14.130,61	IDR 10.000.000	IDR 10.014.130,61
	c. 18.000 pcs capacity	IDR 14.130,61	IDR 11.500.000	IDR 11.514.130,61
2	Cup	IDR 7.140,61	-	IDR 7.140,61
3	Lid Cup			
	a. 50 roll capacity	IDR 14.130,61	IDR 2.000.000	IDR 2.014.130,61
	b. 100 roll capacity	IDR 14.130,61	IDR 3.500.000	IDR 3.514.130,61
	c. 150 roll capacity	IDR 14.130,61	IDR 5.000.000	IDR 5.014.130,61
4	Straw			
	a. 600.000 pcs capacity	IDR 14.130,61	IDR 2.500.000	IDR 2.514.130,61
	b. 1.000.000 pcs capacity	IDR 14.130,61	IDR 4.000.000	IDR 4.014.130,61
	c. 1.500.000 pcs capacity	IDR 14.130,61	IDR 5.500.000	IDR 5.514.130,61

Holding Cost

Holding costs are costs incurred by the Company related to the storage of packaging raw materials. The following is a breakdown of the holding cost 220 ml bottled raw materials.

Table 9. Holding cost

No	Description	Amount	Unit	Cost per unit	Cost per day	Cost per year
1	Electricity cost					
	a. 6 Fluorescent lamp (24 hour per day @32 watt)	4,608	kWh	IDR 1.444,70	IDR 6.657,18	IDR 2.429.869,82
	b. 2 Exhaust Fan (24 hour per day @36 watt)	1,728	kWh	IDR 1.444,70	IDR 2.496,44	IDR 911.201,18
	c. 1 CCTV (24 hour per day @12 watt)	0,288	kWh	IDR 1.444,70	IDR 416,07	IDR 151,866,86
2	Warehouse maintenance cost					
	a. Pest control	1	/month	IDR 50.000	IDR 1.643,84	IDR 600.000
3	Labor cost					
	a. warehouse manager employee salary	1	/month	IDR 3.200.000	IDR 105.205,48	IDR 38.400.000
4	Depreciation cost					
	a. Warehouse depreciation cost	1	/year	IDR 68.000.000	IDR 186.301,37	IDR 68.000.000
			Total			**IDR 110.492.938**

After obtaining the holding cost per year, holding cost each raw material for 220 ml bottled water is calculated.

Table 10. Holding cost of packaging material

Description	Volume (m^3)/unit	Holding cost/ year
Cardboard	0,001683	IDR 607,62
Cardboard divider	0,00022	IDR 80,19
Cup	0,000006875	IDR 2,89
Lid cup	0,02116	IDR 7.640,62
Straw	0,0000026042	IDR 0,94

Forecasting

Before doing forecasting. Determination of demand data patterns is carried out which is useful for knowing the forecasting method to be used. The following is a plot of 220 ml bottled water product demand data.

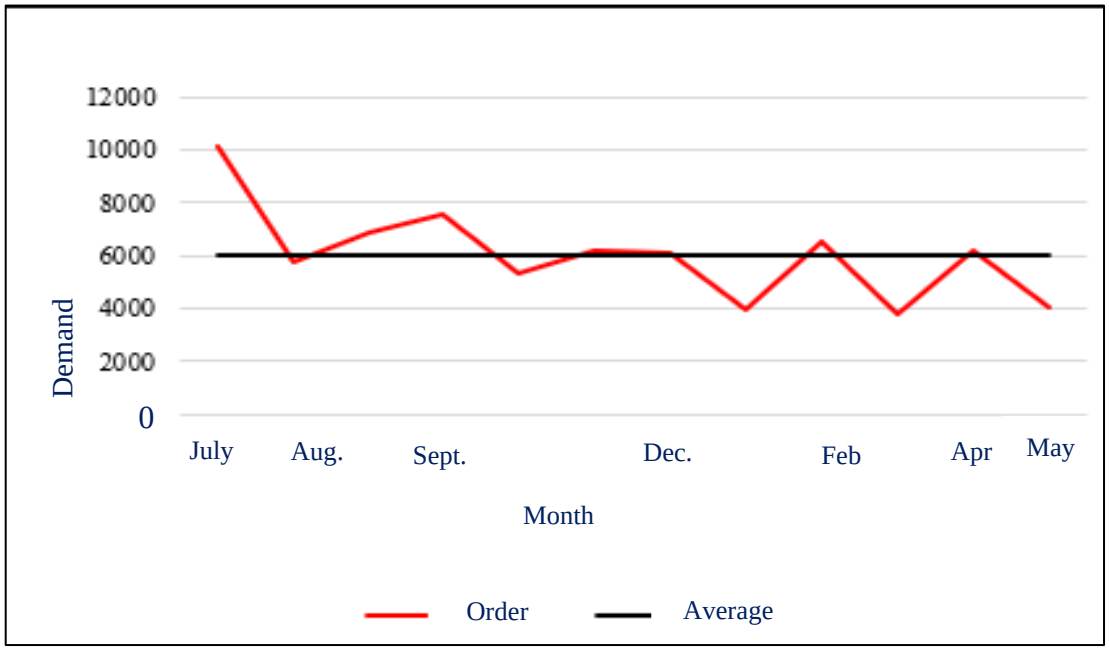

Figure 2. Data plot of demand product

Figure 2. Above is a plot of 220 ml bottled water demand data, it can be seen that the data moves up and down around the average value. According to Joven et al. (2022), data patterns that experience an increase or decrease but are around the average value are horizontal or stationary patterns. Therefore, it can be concluded that the data pattern of 220 ml bottled water demand is a horizontal or stationary pattern. Furthermore, the autocorrelation test is carried out with MiniTab software to see if there is an element of trend in the data pattern.

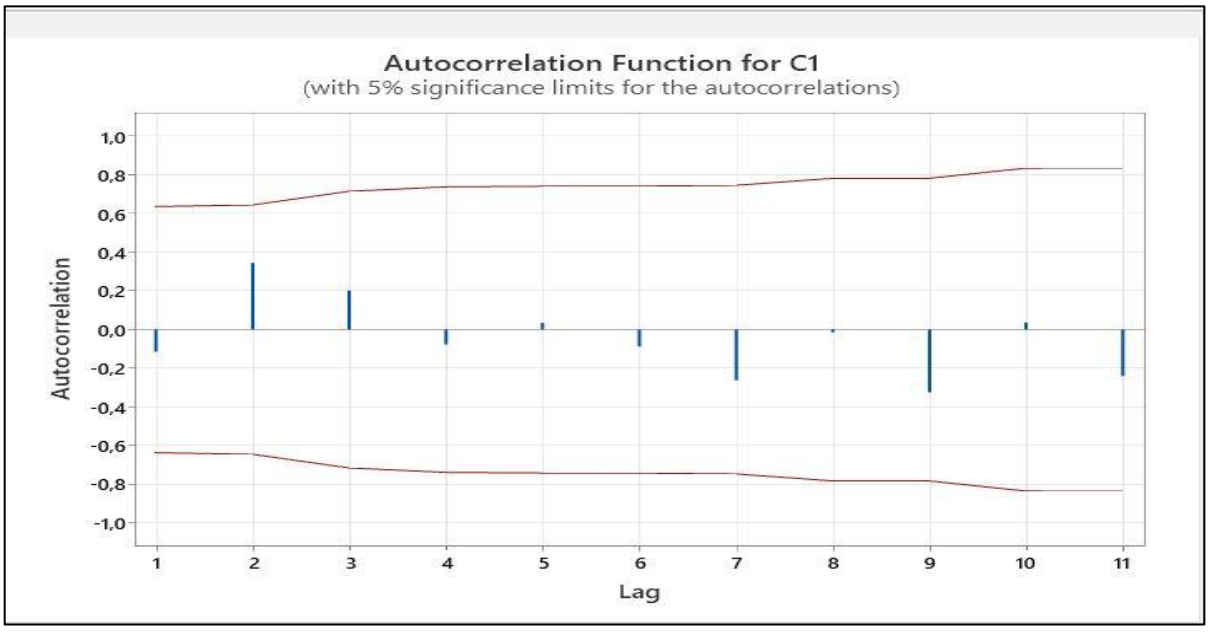

Figure 3. Autocorrelation graph

Based on Figure 3, it can be seen that the lag value does not cross the significance limit which indicates the absence of correlation between lags. The graph also shows that the lag value moves quickly to a value of 0, so it is concluded that there is no trend element in the data pattern and it is confirmed that the data pattern is stationary.

According to Lusiana and Yuniarty (2020), several forecasting methods that can be used for stationary data patterns are moving average, single exponential smoothing and weight moving average. The following are the results of forecasting with these three methods.

Table 11. Forecasting data

No.	Method		MAD	MSE	MAPE
1	Single Exponential Smoothing	α = 0,6	1510,023	3637163,0	29,73%
2	Moving Average	10 month	898,45	1594602,43	22,04%
3	Weight Moving Average	10 month	1080,99	1374121,15	23,91%

Based on Table 11. above, it is observed that in the single exponential smoothing method, the smallest error is obtained with a value of α equal to 0.6. Furthermore, in the moving average method, the smallest error is obtained with a 10-month moving average. Similarly, in the weight moving average method, the smallest error is obtained with a 10-month moving average. Subsequently, the errors of the three methods are compared, and it is found that the moving average method with a 10-month moving average produces smaller errors in two indicators, namely MAD at 898.45 and MSE at 22.05%. Therefore, the moving average method with a 10-month moving average is selected to forecast the demand for 220 ml AMDK products for the next year. Before conducting the forecast, a verification tracking signal is performed to assess the accuracy of the forecast.

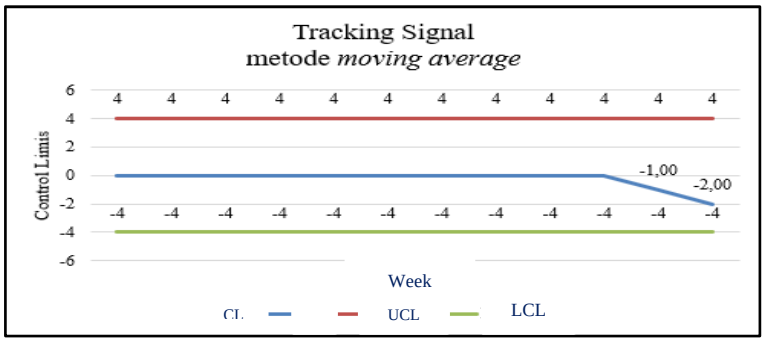

Fig 4. Tracking signal

Based on Figure 4. Above, it can be seen that there is no data that is outside the control limits so that the use of the moving average method in forecasting 220 ml bottled water products is appropriate.

Table 12. Forecasting results

No	Month	Demand	≈
1	July 2023	5.678,6	5.679
2	August 2023	5.555,1	5.555
3	September 2023	5.350,2	5.350
4	October 2023	5.348,1	5.348
5	November 2023	5.260,2	5.260
6	December 2023	5.179,3	5.179
7	January 2024	5.298,4	5.298
8	February 2024	5.176,5	5.176
9	March 2024	5.314,2	5.314
10	April 2024	5.222,7	5.223
11	May 2024	5.338,3	5.338
12	June 2024	5.304,3	5.304
	Total		**64.026**
	Average		**5.335**

Variability Test

Determining the type of demand is done so that the inventory method chosen is in accordance with the type of demand.

$$V = \frac{n \sum_{t=1}^{n} D_t^2}{(\sum_{t=1}^{n} D_t)^2} - 1$$

$$V = \frac{12\ (39.528.183)}{5.286.307.849} - 1$$

$$= 0{,}076755001$$

Based on the results of the calculation of demand variance, it is found that the variance value of 220 ml bottled water product demand is 0.076755001. The Peterson Silver rule explains that if the value of V < 0.25 then the demand is static, while if the value of V ≥ 0.25 then the demand is dynamic. Based on the results of the variance measurement, the variance value V < 0.25 so that the type of demand for 220 ml bottled water products is static. This determination can facilitate the selection of inventory methods later in order to plan the right inventory. One of the inventory methods that can be used for static demand is the Economic Order Quantity (EOQ) method.

Master Production Schedule (MPS)

After obtaining the 220 ml AMDK product forecasting results for the next 12 months, an MPS is then made by converting the forecasting results into units of weeks. The following is the MPS for AMDK 220 products.

Table 13. Master production schedule

No	Month	Demand /month	Week	Demand /week	No	Month	Demand /month	Week	Demand /week
1	July 2023	5.679	1	1420	7	January 2024	5.298	25	1325
			2	1420				26	1325
			3	1420				27	1324
			4	1419				28	1324
2	August 2023	5.555	5	1389	8	February 2024	5.176	29	1294
			6	1389				30	1294
			7	1389				31	1294
			8	1388				32	1294
3	September 2023	5.350	9	1338	9	March 2024	5.314	33	1329
			10	1338				34	1329
			11	1337				35	1328
			12	1337				36	1328
4	October 2023	5.348	13	1337	10	April 2024	5.223	37	1306
			14	1337				38	1306
			15	1337				39	1306
			16	1337				40	1305
5	November 2023	5.260	17	1315	11	May 2024	5.338	41	1335
			18	1315				42	1335
			19	1315				43	1334
			20	1315				44	1334
6	December 2023	5.179	21	1295	12	June 2024	5.304	45	1326
			22	1295				46	1326
			23	1295				47	1326
			24	1294				48	1326

Material Requirement Planning (MRP)

Netting

Netting is the process of calculating net requirements which are calculated from gross requirements (GR) minus scheduled receipts (SR) and inventory (OHI). The following is the calculation of net requirements for each item.

1. 220 ml AMDK product
   The following is the net demand for 220 ml AMDK product.

Table 14. Netting of 220 ml AMDK product

Component Number : WTR-001
Part Name : 220 ml AMDK product
Level : 0
Qty : 1
Lead Time : -

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	1420	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337
SR												
OHI	118											
NR	1302	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337

Component Number : WTR-001
Part Name : 220 ml AMDK product
Level : 0
Qty : 1
Lead Time : -

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294
SR												
OHI												
NR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294

Component Number	: WTR-001
Part Name	: 220 ml AMDK product
Level	: 0
Qty	: 1
Lead Time	: -

Week	January 2024				February 2024				March 2024			
	25	26	33	33	33	33	31	32	33	34	35	36
GR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328
SR												
OHI												
NR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328

Component Number	: WTR-001
Part Name	: 220 ml AMDK product
Level	: 0
Qty	: 1
Lead Time	: -

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	64.024
SR													
OHI													118
NR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	63.906

2. Cardboard
   The following is the net demand for cardboard.

Table 15. Netting of cardboard

Component Number	: WTR-111
Part Name	: Cardboard
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	1302	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337
SR												
OHI	4680	3378	1958	538								
NR				881	1389	1389	1389	1388	1338	1338	1337	1337

Component Number	: WTR-111
Part Name	: Cardboard
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	October 2023				November 2023				December 2023			
	13	14	15		13	14	15		13	14	15	
GR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294
SR												
OHI												
NR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294

Component Number	: WTR-111
Part Name	: Cardboard
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	January 2024				February 2024				March 2024			
	25	26	33	33	33	33	31	32	33	34	35	36
GR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328
SR												
OHI												
NR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328

Component Number	: WTR-111
Part Name	: Cardboard
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	63.906
SR													
OHI													10.554
NR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	59.226

3. Cardboard divider
   The following is the net demand for cardboard divider.

Table 16. Netting of Cardboard divider

Component Number	: WTR-112
Part Name	: Cardboard divider
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	1302	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337
SR												
OHI	4680	3378	1958	538								
NR				881	1389	1389	1389	1388	1338	1338	1337	1337

Component Number	: WTR-112
Part Name	: Cardboard divider
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	October 2023				November 2023				December 2023			
	13	14	15		13	14	15		13	14	15	
GR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294
SR												
OHI												
NR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294

Component Number	: WTR-112
Part Name	: Cardboard divider
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	January 2024				February 2024				March 2024			
	25	26	33	33	33	33	31	32	33	34	35	36
GR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328
SR												
OHI												
NR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328

Component Number	: WTR-112
Part Name	: Cardboard divider
Level	: 1
Qty	: 1
Lead Time	: 2 Week

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	63.906
SR													
OHI													10.554
NR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	59.226

4. 220 ml bottled water
   The following is the net demand for 220 ml bottled water.

Table 17. Netting of 220 ml bottled water

Component Number	: WTR-113
Part Name	: 220 ml bottled water
Level	: 1
Qty	: 48
Lead Time	: -

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	63681	69452	69452	69403	67936	67936	67936	67887	65442	65442	65393	65393
SR												
OHI	25											
NR	63656	69452	69452	69403	67936	67936	67936	67887	65442	65442	65393	65393

Component Number	: WTR-113
Part Name	: 220 ml bottled water
Level	: 1
Qty	: 48
Lead Time	: -

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290
SR												
OHI												
NR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290

Component Number	: WTR-113
Part Name	: 220 ml bottled water
Level	: 1
Qty	: 48
Lead Time	: -

Week	January 2024				February 2024				March 2024			
	25	26	27	28	29	30	31	32	33	34	35	36
GR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953
SR												
OHI												
NR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953

Component Number	: WTR-113
Part Name	: 220 ml bottled water
Level	: 1
Qty	: 48
Lead Time	: -

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	3.125.657
SR													
OHI													25
NR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632

5. Straw
   The following is the net demand for straw.

Table 18. Netting of straw

Component Number	: WTR-114
Part Name	: Straw
Level	: 1
Qty	: 48
Lead Time	: 2 Week

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	62496	68160	68160	68112	66672	66672	66672	66624	64224	64224	64176	64176
SR												
OHI	366000	303504	235344	167184	99072	32400						
NR						34272	66672	66624	64224	64224	64176	64176

Component Number	: WTR-114
Part Name	: Straw
Level	: 1
Qty	: 48
Lead Time	: 2 Week

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	64176	64176	64176	64176	63120	63120	63120	63120	62160	62160	62160	62112
SR												
OHI												
NR	64176	64176	64176	64176	63120	63120	63120	63120	62160	62160	62160	62112

Component Number	: WTR-114
Part Name	: Straw
Level	: 1
Qty	: 48
Lead Time	: 2 Week

Week	January 2024				February 2024				March 2024			
	25	26	27	28	29	30	31	32	33	34	35	36
GR	63600	63600	63552	63552	62112	62112	62112	62112	63792	63792	63744	63744
SR												
OHI												
NR	63600	63600	63552	63552	62112	62112	62112	62112	63792	63792	63744	63744

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	62688	62688	62688	62640	64080	64080	64032	64032	63648	63648	63648	63648	3.067.488
SR													
OHI													1.203.504
NR	62688	62688	62688	62640	64080	64080	64032	64032	63648	63648	63648	63648	2.701.488

6. Cup
   The following is the net demand for cup.

Table 19. Netting of cup

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	63656	69452	69452	69403	67936	67936	67936	67887	65442	65442	65393	65393
SR		540000										
OHI	126000	62344	532892	463440	394037	326101	258165	190229	122342	56900		
NR										8542	65393	65393

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290
SR												
OHI												
NR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	January 2024				February 2024				March 2024			
	25	26	27	28	29	30	31	32	33	34	35	36
GR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953
SR												
OHI												
NR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR													540.000
OHI													2.532.450
NR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	2.459.632

7. Lid cup
   The following is the net demand for lid cup.

Table 20. Netting of Lid cup

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	63656	69452	69452	69403	67936	67936	67936	67887	65442	65442	65393	65393
SR												
OHI	691200	627544	558092	488640	419237	351301	283365	215429	147542	82100	16658	
NR											48735	65393

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290
SR												
OHI												
NR	65393	65393	65393	65393	64317	64317	64317	64317	63339	63339	63339	63290

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	January 2024				February 2024				March 2024			
	25	26	27	28	29	30	31	32	33	34	35	36
GR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953
SR												
OHI												
NR	64806	64806	64757	64757	63290	63290	63290	63290	65002	65002	64953	64953

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR													
OHI													3.881.108
NR	63877	63877	63877	63828	65295	65295	65246	65246	64855	64855	64855	64855	2.434.432

Lotting

There is a difference in the lotting calculation in the MRP process, where there is a constraint in the shipping capacity of packaging raw materials at PT XYZ. The lotting stage aims to determine the optimal order size based on net requirements, ordering costs, and storage costs.

However, due to restrictions in shipping capacity, the determination of the optimal quantity is carried out using the EOQ developed by Zhao et al. (2004) as described in Mubin et al. (2021). This involves the following steps:
Optimal Q = EOQ if $Q_{min} < EOQ \leq Q_{max}$ or
Optimal Q = Q_{min} if $TIC(Q_{min}) \leq TIC(Q_{max})$ or
Optimal Q = Q_{max} if $TIC(Q_{min}) > TIC(Q_{max})$

Furthermore, lot sizing calculations for each packaging raw material are carried out as follows:

1. Cardboard and Cardboard Dividers
   Cardboard and cardboard dividers are ordered from the same supplier and considered as one unit. Therefore, the lot sizing calculation for cardboard and cardboard dividers shares the same value. The following are the lot sizing calculations using EOQ with delivery capacity constraints for these items.

Table 21. Optimal order quantity calculation result for cardboard and cardboard divider

Range	Min	Max	EOQ	Min < EOQ ≤ Max	TIC EOQ	TIC Min	TIC Max
1	10.000	12.000	40.892	False	-	IDR276.493.303	IDR 277.066.471
2	12.001	15.000	44.348	False	-	IDR 276.053.702	IDR **267.112.890**
3	15.001	18.000	47.552	False	-	IDR 273.113.602	IDR 274.187.590

2. Straw
   The following is a lot sizing calculation using EOQ delivery capacity constraints for straw items.

Table 22. Optimal order quantity calculation result for staw

Range	Min	Max	EOQ	Min < EOQ ≤ Max	TIC EOQ	TIC Min	TIC Max
1	550.000	600.000	3.632.793	False	-	IDR47.946.954	IDR 47.974.380
2	1.000.001	1.000.000	4.798.503	False	-	IDR 55.474.383	IDR 47.630.268
3	1.500.001	1.500.000	5.731.848	False	-	IDR 52.130.269	IDR **46.831.630**

3. Cup
   The following is the EOQ calculation for cup item.

$$EOQ = \sqrt{\frac{2DS}{h}}$$
$$= \sqrt{\frac{2(2.459.632)(7.140,61)}{(2,89)}}$$
$$= 110.128,93$$
$$\approx 110.129 \text{ pcs}$$

It was found that the EOQ value for cup items did not meet the minimum purchase requirement set by the supplier, which is 540,000 pcs. Therefore, the optimal order quantity for cup items follows the supplier's minimum order of 540,000 pcs.

4. Lid cup
   The following is a lot sizing calculation using EOQ delivery capacity constraints for lid cup items.

Table 23. Optimal order quantity calculation result for lid cup

Range	Min	Max	EOQ	Min < EOQ ≤ Max	TIC EOQ	TIC Min	TIC Max
1	44	50	261	False	-	IDR87.747.149	IDR 87.764.340
2	51	100	345	False	-	IDR92.257.973	IDR 88.909.389
3	101	150	412	False	-	IDR 91.889.838	IDR 87.125.910

Offsetting

Offsetting is one of the stages in the MRP (Material Requirements Planning) process used to determine the optimal time for placing orders, ensuring that the net requirements are met according to a predetermined schedule. The ordering time is adjusted by considering the waiting time or lead time of the raw materials being ordered. The following details the offsetting for each packaging raw material.

1. Cardboard and cardboard divider
   The following are the offsetting results for cardboard items and cardboard dividers.

Table 24. Lotting of cardboard and cardboard divider

Component Number	: WTR-111 & WTR-112											
Part Name	: Cardboard and Cardboard divider											
Level	: 1											
Qty	: 1											
Lead Time	: 2 Week											
Lot Sizing	: EOQ											
Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	1302	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337
SR												
OHI	4680	3378	1958	538	14119	12730	11341	9952	8564	7226	5888	4551
NR				881								
PORec				15000								
PORel		15000										

Component Number	: WTR-111 & WTR-112											
Part Name	: Cardboard and Cardboard divider											
Level	: 1											
Qty	: 1											
Lead Time	: 2 Week											
Lot Sizing	: EOQ											
Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294
SR												
OHI	3214	1877	540	14203	12866	11551	10236	8921	7606	6311	5016	3721
NR			797									
PORec			15000									
PORel	15000											15000

Component Number	: WTR-111 & WTR-112											
Part Name	: Cardboard and Cardboard divider											
Level	: 1											
Qty	: 1											
Lead Time	: 2 Week											
Lot Sizing	: EOQ											
Week	January 2024				February 2024				March 2024			
	25	26	33	33	33	33	31	32	33	34	35	36
GR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328
SR												
OHI	2427	1102	14777	13453	12129	10835	9541	8247	6953	5624	4295	2967
NR		223										
PORec		15000										
PORel												15000

Component Number	: WTR-111 & WTR-112												
Part Name	: Cardboard and Cardboard divider												
Level	: 1												
Qty	: 1												
Lead Time	: 2 Week												
Lot Sizing	: EOQ												
Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	63.906
SR													
OHI	1639	333	14027	12721	11416	10081	8746	7412	6078	4752	3426	2100	346068
NR		973											
PORec		15000											60000
PORel													60000

2. Straw
   The following are the offsetting results for Straw.

Table 25. Lotting of straw

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	62496	68160	68160	68112	66672	66672	66672	66624
SR								
OHI	366000	303504	235344	167184	99072	32400	1465728	1399056
NR						34272		
PORec						1500000		
PORel				1500000				

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	64224	64224	64176	64176	64176	64176	64176	64176
SR								
OHI	1332432	1268208	1203984	1139808	1075632	1011456	947280	883104
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	63120	63120	63120	63120	62160	62160	62160	62112
SR								
OHI	818928	755808	692688	629568	566448	504288	442128	379968
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	63600	63600	63552	63552	62112	62112	62112	62112
SR								
OHI	317856	254256	190656	127104	63552	1440	1439328	1377216
NR						60672		
PORec						1500000		
PORel				150000				

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	63792	63792	63744	63744	62688	62688	62688	62640
SR								
OHI	1315104	1251312	1187520	1123776	1060032	997344	934656	871968
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	64080	64080	64032	64032	63648	63648	63648	63648	3067488
SR									
OHI	809328	745248	681168	617136	553104	489456	425808	326160	34916544
NR									
PORec									3000000
PORel									3000000

3. Cup
The following are the offsetting results for Cup.

Table 26. Lotting of cup

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	63656	69452	69452	69403	67936	67936	67936	67887
SR		540000						
OHI	126000	62344	532892	463440	394037	326101	258165	190229
NR								
PORec								
PORel								540000

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	65442	65442	65393	65393	65393	65393	65393	65393
SR								
OHI	122342	56900	531458	466065	400672	335279	269886	204493
NR		8542						
PORec		540000						
PORel								

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	64317	64317	64317	64317	63339	63339	63339	63290
SR								
OHI	139100	74783	10466	486149	421832	358493	295154	231815
NR			53581					
PORec			540000					
PORel	540000							

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	64806	64806	64757	64757	63290	63290	63290	63290
SR								
OHI	168525	103719	38913	514156	449399	386109	322819	259529
NR			25844					
PORec			540000					
PORel	540000							

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	65002	65002	64953	64953	63877	63877	63877	63828
SR								
OHI	196239	131237	66235	1282	476329	412452	348575	284698
NR				63671				
PORec				540000				
PORel		540000						

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR									
OHI	220870	155575	90280	25034	499788	434933	370078	305223	13.020.092
NR				40212					
PORec				540000					2.700.000
PORel		540000							2.700.000

4. Lid cup
The following are the offsetting results for Lid cup.

Table 27. Lotting of lid cup

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	63656	69452	69452	69403	67936	67936	67936	67887
SR								
OHI	691200	627544	558092	488640	419237	351301	283365	215429
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	65442	65442	65393	65393	65393	65393	65393	65393
SR								
OHI	147542	82100	16658	3191265	3125872	3060479	2995086	2929693
NR			48735					
PORec			3240000					
PORel	3240000							

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	64317	64317	64317	64317	63339	63339	63339	63290
SR								
OHI	2864300	2799983	2735666	2671349	2607032	254693	2480354	2417015
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	64806	64806	64757	64757	63290	63290	63290	63290
SR								
OHI	2353725	2288919	2224113	2159356	2094599	2031309	1968019	1904729
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	65002	65002	64953	64953	63877	63877	63877	63828
SR								
OHI	1841439	1776437	1711435	1646482	1581529	1517652	1453775	1389898
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR									
OHI	1326070	1260775	1195480	1130234	1064988	1000133	935278	870423	79029692
NR									
PORec									3240000
PORel									3240000

Explosion

Explosion is the process of calculating MRP for items that are one level below, by calculating the gross needs based on the order plan prepared during the offsetting process at the top level, and then multiplying it by the number of item requirements. The following results are from the explosion process for items at levels 1 and 2.

1. Cardboard and cardboard divider
   Here are the results of MRP on cardboard and cardboard divider.

Table 28. Result of MRP on cardboard and cardboard divider

Component Number : WTR-111 & WTR-112
Part Name : Cardboard and Cardboard divider
Level : 1
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023				September 2023			
	1	2	3	4	5	6	7	8	9	10	11	12
GR	1302	1420	1420	1419	1389	1389	1389	1388	1338	1338	1337	1337
SR												
OHI	4680	3378	1958	538	14119	12730	11341	9952	8564	7226	5888	4551
NR				881								
PORec				15000								
PORel		15000										

Component Number : WTR-111 & WTR-112
Part Name : Cardboard and Cardboard divider
Level : 1
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	October 2023				November 2023				December 2023			
	13	14	15	16	17	18	19	20	21	22	23	24
GR	1337	1337	1337	1337	1315	1315	1315	1315	1295	1295	1295	1294
SR												
OHI	3214	1877	540	14203	12866	11551	10236	8921	7606	6311	5016	3721
NR			797									
PORec			15000									
PORel	15000											15000

Component Number : WTR-111 & WTR-112
Part Name : Cardboard and Cardboard divider
Level : 1
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024				March 2024			
	25	26	33	33	33	33	31	32	33	34	35	36
GR	1325	1325	1329	1329	1329	1329	1294	1294	1329	1329	1328	1328
SR												
OHI	2427	1102	14777	13453	12129	10835	9541	8247	6953	5624	4295	2967
NR		223										
PORec		15000										
PORel												15000

Component Number : WTR-111 & WTR-112
Part Name : Cardboard and Cardboard divider
Level : 1
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	April 2024				May 2024				June 2024				Total
	37	38	39	40	41	42	43	44	45	46	47	48	
GR	1306	1306	1306	1305	1335	1335	1334	1334	1326	1326	1326	1326	63.906
SR													
OHI	1639	333	14027	12721	11416	10081	8746	7412	6078	4752	3426	2100	346068
NR		973											
PORec		15000											60000
PORel													60000

2. 220 ml Bottled Water
   Here are the results of MRP on 220 ml Bottled Water.

Table 29. Result of MRP on 220 ml bottled water

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	63681	69452	69452	69403	67936	67936	67936	67887
SR								
OHI	25							
NR	63656	69452	69452	69403	67936	67936	67936	67887
PORec	63656	69452	69452	69403	67936	67936	67936	67887
PORel	63656	69452	69452	69403	67936	67936	67936	67887

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	65442	65442	65393	65393	65393	65393	65393	65393
SR								
OHI								
NR	65442	65442	65393	65393	65393	65393	65393	65393
PORec	65442	65442	65393	65393	65393	65393	65393	65393
PORel	65442	65442	65393	65393	65393	65393	65393	65393

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	64317	64317	64317	64317	63339	63339	63339	63290
SR								
OHI								
NR	64317	64317	64317	64317	63339	63339	63339	63290
PORec	64317	64317	64317	64317	63339	63339	63339	63290
PORel	64317	64317	64317	64317	63339	63339	63339	63290

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	64806	64806	64757	64757	63290	63290	63290	63290
SR								
OHI								
NR	64806	64806	64757	64757	63290	63290	63290	63290
PORec	64806	64806	64757	64757	63290	63290	63290	63290
PORel	64806	64806	64757	64757	63290	63290	63290	63290

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	65002	65002	64953	64953	63877	63877	63877	63828
SR								
OHI								
NR	65002	65002	64953	64953	63877	63877	63877	63828
PORec	65002	65002	64953	64953	63877	63877	63877	63828
PORel	65002	65002	64953	64953	63877	63877	63877	63828

Component Number : WTR-113
Part Name : 220 ml Bottled Water
Level : 1
Qty : 48
Lead Time : -
Lot Sizing : -

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.657
SR									
OHI									25
NR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
PORec	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
PORel	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632

3. Straw

Here are the results of MRP on Straw.

Table 30. Result of MRP on straw

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	62496	68160	68160	68112	66672	66672	66672	66624
SR								
OHI	366000	303504	235344	167184	99072	32400	1465728	1399056
NR						34272		
PORec						1500000		
PORel				1500000				

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	64224	64224	64176	64176	64176	64176	64176	64176
SR								
OHI	1332432	1268208	1203984	1139808	1075632	1011456	947280	883104
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	63120	63120	63120	63120	62160	62160	62160	62112
SR								
OHI	818928	755808	692688	629568	566448	504288	442128	379968
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	63600	63600	63552	63552	62112	62112	62112	62112
SR								
OHI	317856	254256	190656	127104	63552	1440	1439328	1377216
NR						60672		
PORec						1500000		
PORel				150000				

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	63792	63792	63744	63744	62688	62688	62688	62640
SR								
OHI	1315104	1251312	1187520	1123776	1060032	997344	934656	871968
NR								
PORec								
PORel								

Component Number : WTR-114
Part Name : Straw
Level : 1
Qty : 48
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	64080	64080	64032	64032	63648	63648	63648	63648	3067488
SR									
OHI	809328	745248	681168	617136	553104	489456	425808	326160	34916544
NR									
PORec									3000000
PORel									3000000

4. Cup

Here are the results of MRP on Cup.

Table 31. Result of MRP on cup

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	63656	69452	69452	69403	67936	67936	67936	67887
SR		540000						
OHI	126000	62344	532892	463440	394037	326101	258165	190229
NR								
PORec								
PORel								540000

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	65442	65442	65393	65393	65393	65393	65393	65393
SR								
OHI	122342	56900	531458	466065	400672	335279	269886	204493
NR		8542						
PORec		540000						
PORel								

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	64317	64317	64317	64317	63339	63339	63339	63290
SR								
OHI	139100	74783	10466	486149	421832	358493	295154	231815
NR			53581					
PORec			540000					
PORel	540000							

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	64806	64806	64757	64757	63290	63290	63290	63290
SR								
OHI	168525	103719	38913	514156	449399	386109	322819	259529
NR			25844					
PORec			540000					
PORel	540000							

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	65002	65002	64953	64953	63877	63877	63877	63828
SR								
OHI	196239	131237	66235	1282	476329	412452	348575	284698
NR				63671				
PORec				540000				
PORel		540000						

Component Number : WTR-211
Part Name : Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR									
OHI	220870	155575	90280	25034	499788	434933	370078	305223	13.020.092
NR				40212					
PORec				540000					2.700.000
PORel		540000							2.700.000

5. Lid Cup
   Here are the results of MRP on Lid cup.

Table 32. Result of MRP on lid cup

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	July 2023				August 2023			
	1	2	3	4	5	6	7	8
GR	63656	69452	69452	69403	67936	67936	67936	67887
SR								
OHI	691200	627544	558092	488640	419237	351301	283365	215429
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	September 2023				October 2023			
	9	10	11	12	13	14	15	16
GR	65442	65442	65393	65393	65393	65393	65393	65393
SR								
OHI	147542	82100	16658	3191265	3125872	3060479	2995086	2929693
NR			48735					
PORec			3240000					
PORel	3240000							

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	November 2023				December 2023			
	17	18	19	20	21	22	23	24
GR	64317	64317	64317	64317	63339	63339	63339	63290
SR								
OHI	2864300	2799983	2735666	2671349	2607032	254693	2480354	2417015
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	January 2024				February 2024			
	25	26	27	28	29	30	31	32
GR	64806	64806	64757	64757	63290	63290	63290	63290
SR								
OHI	2353725	2288919	2224113	2159356	2094599	2031309	1968019	1904729
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	March 2024				April 2024			
	33	34	35	36	37	38	39	40
GR	65002	65002	64953	64953	63877	63877	63877	63828
SR								
OHI	1841439	1776437	1711435	1646482	1581529	1517652	1453775	1389898
NR								
PORec								
PORel								

Component Number : WTR-213
Part Name : Lid Cup
Level : 2
Qty : 1
Lead Time : 2 Week
Lot Sizing : EOQ

Week	May 2024				June 2024				Total
	41	42	43	44	45	46	47	48	
GR	65295	65295	65246	65246	64855	64855	64855	64855	3.125.632
SR									
OHI	1326070	1260775	1195480	1130234	1064988	1000133	935278	870423	79029692
NR									
PORec									3240000
PORel									3240000

Total Cost of Inventory

After the MRP process, the total inventory cost is calculated using the EOQ method, taking into account shipping capacity constraints and company policies. The following represents the total inventory cost calculated with the EOQ method, considering shipping capacity constraints.

Table 33. Total cost of inventory with EOQ method shipping capacity constrains

Description	Purchase cost	Ordering cost	Holding cost	Total
Cardboard and Cardboard divider	IDR222.097.500	IDR 40.056.522	IDR 4.958.877	IDR 267.112.900
Straw	IDR 35.119.344	IDR 11.028.261	IDR 684.025	IDR 46.831.630
Cup	IDR 231.205.408	IDR 35.703	IDR 785.608	IDR 232.026.718
Lid Cup	IDR 81.529.500	IDR 5.014.131	IDR 582.279	IDR 87.125.910
Total				**IDR 633.097.158**

Then, calculate total cost of inventory with company's policy

Table 33. Total cost of inventory with company's policy

Description	Purchase cost	Ordering cost	Holding cost	Total
Cardboard and Cardboard divider	IDR222.097.500	IDR 51.084.784	IDR 3.311.020	IDR 276.493.303
Straw	IDR35.119.344	IDR 12.570.653	IDR 256.957	IDR 47.946.954
Cup	IDR 231.205.408	IDR 35.703	IDR 785.607	IDR 232.026.718
Lid Cup	IDR 81.529.500	IDR 6.042.392	IDR 175.257	IDR 87.747.149
Total				**IDR644.214.124**

The research conducted will be beneficial for the bottled drinking water industry, particularly at PT XYZ, in making purchasing decisions for packaging raw materials. This will lead to

obtaining optimal inventory calculations for the 220 ml bottled drinking water packaging materials at PT XYZ.

5. CONCLUSION

After processing the data, it can be concluded that the optimal order quantity, as determined by the EOQ method with constraints on the shipping capacity for each packaging raw material. Specifically, 15.000 pcs for cardboard and cardboard dividers, resulting in an inventory cost of IDR 267.112.900, 1.500.000 pcs for straws, with an inventory cost of IDR46.831.630, 540.000 pcs for cups, incurring an inventory cost of IDR232.026.718, and 150 rolls for cup lids, with an inventory cost of IDR87.125.910. The total inventory cost for the raw materials used for 220 ml bottled dringking water (AMDK) is Rp633.097.158. Then, the EOQ method with constain on the shipping capacity results in the following ordering frequencies for each packaging raw material is four orders for cardboard and cardboard dividers, scheduled for weeks 2, 13, 24, and 36. Two orders for straws, to be placed in weeks 4 and 28. Five orders for cups, with orders scheduled for weeks 8, 17, 25, 34, and 42 and One order for cup lids, only in week 9.

Based on calculations performed using the EOQ method with constraints on the shipping capacity, accounting for shipping capacity constraints and company policies, it has been determined that the EOQ method with constraints on the shipping capacity leads to a lower total inventory cost compared to the company's policy, resulting in cost savings of IDR11.116.966. The EOQ method with shipping capacity constraints results in a lower total inventory cost, mainly because it involves a reduced order frequency compared to the company's policy. For cardboard items, the EOQ method necessitates ordering four times, whereas the company's policy requires six orders. Meanwhile, for cup items, both the EOQ method and the company policy have a similar order frequency of four times, each with an order quantity of 540.000 cups. This similarity arises from the fact that shipping costs are not incurred by the company, allowing the optimal order quantity to be based on the supplier's minimum purchase requirement. In the case of straw items, the EOQ method leads to two orders, while the company policy requires five. For cup lids, the EOQ method results in a single order, while the company policy calls for three. The next research is expected to utilize lot sizing methods in the lotting calculation process within MRP.

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