Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.4, October 2024, pp. 0240407-01 ~ 0240407-09
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i4.909

Control of ABC Pen Production Raw Materials Using the Material Requirement Planning to Minimize Inventory

Melly Herliyati Utami[1], Qurtubi[1*], Danang Setiawan[1], Meilinda F. N. Maghfiroh[2]

[1]Faculty of Industrial Technology, Universitas Islam Indonesia, Yogyakarta, Indonesia
[2]Faculty of Transport and Logistics, Muscat University, Muscat, Oman.

*qurtubi@uii.ac.id

Abstract. This study addresses the issue of controlling the inventory of raw materials for pen production at PT. XYZ uses Material Requirement Planning (MRP) to minimize excess inventory. The MRP calculates net requirements, planned receipts, planned order releases, and projected on-hand inventory based on estimated demand, product structure, lot size, lead time, and safety stock. The results categorize 20 raw material components for ballpoint pen products into five levels, determining the optimal quantity and timing for ordering and receiving each component to meet production plans while avoiding excess stock or shortages. This study concludes that the MRP method can significantly optimize inventory management, reducing the risks of overstock and stockouts in the pen production process at PT. XYZ. Consistent application of the MRP method and regular evaluation of supplier capabilities are recommended to ensure efficient and effective raw material inventory planning and control.

Keywords: manufacturing, pen production, MRP method, inventory control.

(Received 2024-07-31, Accepted 2024-08-08, Available Online by 2024-08-16)

1. Introduction

Effective and efficient inventory management is crucial in manufacturing industries to maintain a smooth production flow and minimize costs [1]. Managing inventory poses significant challenges due to demand fluctuations and the complexity of supply chains [2]. Companies face two major issues in inventory control: overstocking, which impacts cash flow, and understocking, which disrupts manufacturing operations [3]. Therefore, efficient inventory management is essential to avoid unnecessary costs and prevent production delays.

Key considerations in inventory control include estimating the required quantity of raw materials, understanding their costs, and managing inventory-related expenses such as storage and ordering costs. Therefore, companies must implement efficient supply chain strategies, including careful monitoring of raw material supplies and accurate demand forecasting. Modern technologies, such as integrated software for material requirements and production capacity, can aid in real-time inventory monitoring and early detection of potential overstock issues. Pradata & Ernawati [4] states that modern systems, such as Enterprise Resource Planning (ERP), positively influence inventory management performance.

Material Requirement Planning (MRP) is an effective tool for managing inventory. It ensures the timely availability of materials while minimizing costs and waste due to overstock and understock situations. Studies have shown that MRP can effectively plan raw materials needed for specific products, reducing inventory costs [5]. However, understanding demand behavior is critical to utilizing MRP

effectively, as it projects demand into specific material requirements.

This paper presents a case study on determining the optimal quantity of raw materials for a company producing office supplies such as pens, markers, and highlighters. The digitalization trend has introduced significant challenges due to market demand fluctuations; therefore, Gusti & Yuliarto [6] emphasize the need for innovation to survive and achieve customer growth. The observed company is committed to offering quality and innovative products tailored to market trends, producing millions of products monthly for markets in Indonesia, China, Japan, Malaysia, Kuwait, and Hungary. Given the importance of meticulous material planning to ensure customer satisfaction, this article demonstrates the practical application and benefits of the MRP method for raw materials inventory management. By using MRP, the company can detail raw material inventory needs, avoid overstocking, plan production and purchasing more accurately, optimize resource use, and reduce unnecessary inventory costs [7].

2. Literature review

The methodologies reviewed in the referenced articles focus on optimizing inventory management across various industries, using approaches such as Material Requirement Planning (MRP) and Economic Order Quantity (EOQ). Apriliza et al. [8] utilized MRP for the shoe factory, specifically for planning the required raw materials for upper shoes to optimize inventory levels and reduce holding costs. The practicality of the MRP approach, especially in apparel industries, is apparent. Sudarwati & Panudju [9] analyzed fabric raw material inventory control in backpack products, while Yolanda and & Kurniawan [10] analyzed inventory control of raw materials for making the men's formal trousers. Other study on apparel industry is conducted by Badruzzaman & Harahap [11]. They used EOQ to optimize order quantities for hijab raw materials, demonstrating cost savings through efficient order management.

MRP has also been utilized in the pharmacy industry, as presented in study of Chandradevi & Puspitasari [12] the authors incorporated lot-sizing techniques to manage raw material procurement effectively. Sri [13] employed MRP in the healthcare sector, planning patient menu materials. The results show the importance of materials planning, especially for goods with limited shelf-life. Gozali et al. [14] analyzed raw material planning at a plastic jar company, employing MRP, safety stocks, and lot-sizing methods to optimize cost considerations. Daengs and Soeherman [15] applied EOQ to inventory control, focusing on avoiding raw material shortages in kitchenware factories. Similarly, Rofieq et al. [16] applied MRP to maintain accurate production amounts, and Wardhani & Indrawan [17] analyzed yogurt raw materials control to achieve same goals.

Saptadi et al. [18] used MRP to plan and control raw materials for cement production, while Paduloh [19] used EOQ to control the inventory of raw materials for the iron plate industry, both cases demonstrate its application in a heavy manufacturing context. Wahyuni & Syaichu [7] utilized MRP for raw material inventory management in Shanghai peanut production. Lastly, Suhartini [20] employed MRP to plan material needs for manufacturing, illustrating the method's versatility across different industrial applications. These studies collectively demonstrate the effectiveness of MRP and EOQ in addressing inventory management challenges across diverse manufacturing settings.

3. Methods

This study was focused on analyzing the raw material for ballpoint pens. Data was collected through direct observations and the company's records, covering demand, product structure, and distribution. A literature study was also conducted by collecting similar research to comprehensively understand the appropriate methods for production raw material management problems.

This research utilized the MRP method, a systematic method or procedure to translate the production plan of finished goods into net requirements for the components needed to fulfill the planned demand [7]. This study details the MRP method in four steps: netting, lotting, offsetting, and explosion, as mentioned in research by Tumini & Iis [21]. This approach aims to translate the production plan into specific material needs accurately. The four steps of the MRP method are described as follows:

a. Netting
Netting calculates net requirements, the difference between gross requirements and inventory state. Net needs are considered zero when NR is less than or equal to zero. Mathematically, the calculation of net requirements is formulated as follows:

$$NR_t = \begin{cases} GR_t - POH_{t-1} & if\ GR_t - POH_{t-1} - SR_t > 0 \\ 0 & if\ otherwise \end{cases} \quad (1)$$

Where:
NR_t = net requirement in period *t*
GR_t = gross requirement in period *t*
POH_{t-1} = inventory at the end of period *t-1*
SR_t = planned receipt of goods in period *t*

b. Lotting
Lotting determines the order quantity of each component based on the Net Requirement resulting from the netting process.

c. Offsetting
Offsetting determines each component's processing or ordering time using the lead time of each component's production or usage schedule.

d. Explosion
Explosion calculates each component's number based on the final products produced by determining each component's BOM (Bill of material) and gross requirements.

The MRP calculation template to facilitate the procedure is shown in Table 1.

Table 1. MRP template

Lead Time:	Period
On Hand:	
Lot Size:	
Safety Stock:	
Gross Requirements	
Projected on Hand	
Planned Order Receipt	
Planned Order Releases	

Previous studies have shown that the MRP method is often used in material planning. This method is often combined with other methods, such as Economic Order Quantity (EOQ), Mean Square Error (MSE), and Periodic Order Quantity (POQ). Previous research also shows that MRP can be applied to all components.

4. Results and Discussion

3.1 Data Collection

Data collection is accomplished through direct observation and collection of historical company data. The data collected include product demand forecast, bill of materials, and master records. To enhance the structure of this paper, the MRP calculation will be focused on one of the most popular products: ABC Fine 0.7mm Black.

Table 2 presents the demand projection data for the ABC Black product. This article's primary objective is not to conduct forecasting research, so the forecast data utilized in this study is based on the company's forecast results. The forecast spans seven months, during which the demand varies. September experiences the lowest demand, with a total of 20,160 products, while December witnesses the largest market, with a total of 57,600 products.

Table 2. Demand Forecast of ABC Fine 0.7mm Black

No	Month	Forecasted Demand
1	June	24,480
2	July	28,800
3	August	26,640
4	September	20,160
5	October	21,600
6	November	24,480
7	December	57,600

Figure 3 displays the Bill of Materials, which outlines the product structure of the ABC Fine 0.7mm Black. The product bill of materials comprises five levels: Level 0, Level 1, Level 2, Level 3, and Level 4. The MRP master record contains descriptions of 20 product components that can be identified from these five levels.

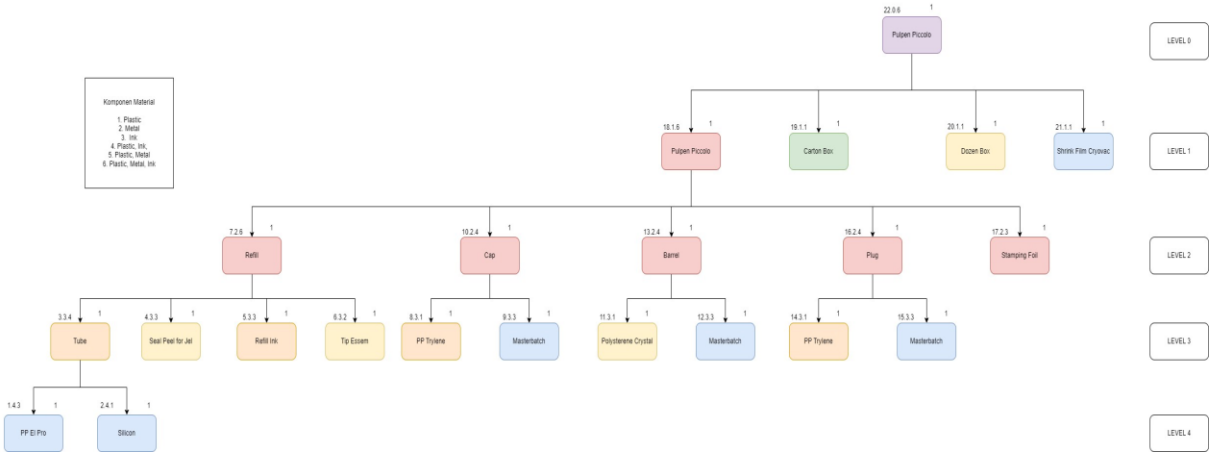

Figure 1. *Bill of Materials*

Table 4 displays the MRP master record, which includes information about material components, lot size, on-hand inventory, schedule receipt, lead time, safety stock, and level.

Table 3. MRP Master Records

No	Item	Lot Size	On Hand Inventory	Schedule Receipt	LT (Month)	Safety Stock	Level
1	ABC Fine 0.7mm Black	3000	9000	0	1	8680	0
2	Shrink Film Cryovac Ct 304 13 Micron (12 Inci)	5000	1100	5000	1	1100	1
3	Carton Box ABC/ABC colors/Pic-Candy (1.728 Pcs)	5000	1460	5000	1	1093	1
4	Dozen Box ABC Black Fine 0.7 (6) Uv Coating-Uv	5000	25000	5000	1	10000	1
5	ABC Fine 0.7mm Black-Msn	1728	7894	0	1	5679	1
6	Stamping Foil Gold Spf-220 "Kurz"	15000	1500	15000	1	800	2
7	Cap Z-ABC Black	15000	13567	0	1	7567	2
8	Barrel Z-ABC Solid Black	12000	8979	0	1	5217	2
9	Plug Z-ABC Black	13420	24371	0	1	6920	2
10	Rf Zss 01 (Es) Bk 0.7mm	8563	5700	0	1	5633	2
11	Pp Trylene Hf 10 – Tq	6000	8000	7500	1	7111	3
12	Masterbatch Black Mp 515 Z	6520	6700	6520	1	4700	3

No	Item	Lot Size	On Hand Inventory	Schedule Receipt	LT (Month)	Safety Stock	Level
13	Polysterene Crystal 1540	7500	9000	7500	2	8654	3
14	Masterbatch Black Hc 88017	8627	7500	9000	1	7225	3
15	Tube Classic-1	7200	6039	0	1	5568	3
16	Seal Peel for Jel Ink Transparent No.3	4000	3200	4000	4	1000	3
17	Refill Ink Cp Ulv Black	800	1165	800	3	553	3
18	Tip Essem Sa 0.7mm (105.A.258/0.70mm)	4533	7784	4533	3	5222	3
19	Pp El Pro P401-S	2000	3500	2000	2	3427	4
20	Silicon Oil Kf-410	3000	2300	3000	4	1000	4

3.2 Calculation of MRP

Calculating MRP involves using Equations 1 and 2 and the MRP template illustrated in Table 1. To enhance the organization of this article, the calculations presented are limited to three specific categories of components: Level 0 components, Level 1 components, and Level 4 components. Net Requirement is calculated by deducting the Gross Requirement with On Hand/Project **on** Hand Inventory.

$$NR_t = \boldsymbol{GR_t} - \boldsymbol{POH_{t-1}} \quad (2)$$

$$\boldsymbol{SR_t} = Lotsize \times X_t \quad (3)$$

$$Lotsize \times X_t \geq NR_t + \boldsymbol{POH_{t-1}} \quad (4)$$

The value of $\boldsymbol{X_t}$ depends on total requirements at period *t* as stated on equation (4).

Further, calculate the new Project Hand Inventory, $\boldsymbol{POH_t}$, by subtracting the value of the Planned Receipt $\boldsymbol{SR_t}$ from the Net Requirement $\boldsymbol{NR_t}$. The Planned Order Releases and lead time will reflect on the Planned Receipt value, as the order is made according to the lead time.

Table 5 displays the MRP calculation for the ABC Fine 0.7 MM black item at Level 0. The inventory for this item is now 9000 units. Additionally, there is a safety stock of 8680 units to ensure availability. The lot size for this item is 3000 units, and it takes 1 (one) month to replenish the inventory. As this item is classified as a Level 0 item or final product, its demand is determined based on the need for the final product, as indicated in Table 1. Given the lead time of 1 month for this item, the company should commence production one month before the needed date. As an illustration, the ABC Fine item is expected to get 33,000 units in month 6. Therefore, 33,000 units are scheduled to be ordered in month 5.

Table 4. MRP Calculation of Level 0 Component

Item = ABC Fine 0.7MM Black	On Hand	9000		Lot Size	3000			Lead Time	1	
Description = level 0	Safety Stock	8680								
Quantity = 1										
Month	3	4	5	6	7	8	9	10	11	12
Gross Requirement				24480	28800	26640	20160	21600	24480	57600
Schedule Receipts										
Project On Hand Inventory			9000	17520	15720	16080	16920	16320	15840	21240
Net Requirement				15480	11280	10920	4080	4680	8160	41760
Planned Receipts				33000	27000	27000	21000	21000	24000	63000
Planned Order Releases			33000	27000	27000	21000	21000	24000	63000	0

MRP computations are extended to the subsequent level. Level 1 comprises four components: *ABC Pen*, *Carton Box*, *Dozen Box,* and *Cryovac Shrink Film.* Table 6 displays the Material Requirements

Planning (MRP) calculation for *Shrink Film Cryovac*, which is one of the components in Level 1. The Lot Size specifications for this component are set at 5,000 pieces. The on-hand inventory currently consists of 1,100 items. The lead time for acquiring this component is one month, and a safety stock of 1,100 units is maintained.

Furthermore, this particular component possesses a quantity value of 1, indicating that producing 1 unit of ABC Black necessitates using 1 unit of Shrink Film. The demand for Shrink Film items is determined by the Planned Order Releases of Fine 0.7 MM black components, resulting from the preceding Material Requirements Planning (MRP) calculation. Upon performing the MRP calculation, it is determined that to fulfill the planned reception requirements of 33,000 Level 0 items in month 6, the *Shrink Film* item at Level 1 must be distributed as a scheduled order in month 4.

Table 5. MRP Calculation of Level 1 Component

Item = SHRINK FILM CRYOVAC CT 304 13MICRON (12 INCI)	On Hand	1100		Lot Size	5000			Lead Time	1
Description = level 1	Safety Stock	1100							
Quantity = 1									
Month	3	4	5	6	7	8	9	10	11
Gross Requirement			33000	27000	27000	21000	21000	24000	63000
Schedule Receipts			5000		5000				
Project On Hand Inventory		1100	8100	11100	19100	23100	27100	68100	5100
Net Requirement			26900	18900	10900	1900	-2100	-3100	-5100
Planned Receipts			35000	30000	30000	25000	25000	65000	
Planned Order Releases		35000	30000	30000	25000	25000	65000	0	

Calculations are extended to Level 4. Table 7 summarizes the scheduled order releases for 20 ABC Fine 0.7 MM black components. To simplify the explanation, the data presented is based on the demand for ABC Fine 0.7 MM black during the first month. The table demonstrates that to fulfill the demand of 33,000 units for ABC Fine 0.7 mm Black (Level 0) in month 5, the production or procurement of Silicon Oil Kf-410 (Level 4) needs to be increased to 42,000 units in month 10 of the previous year.

Table 6. Summary of Planned Order Releases for Level 0-Level 4 Components

No	Component	Level	Lead time (Month)	Month							
				10	11	12	1	2	3	4	5
1	ABC Fine 0.7mm Black	0	1								33,000
2	Shrink Film Cryovac Ct 304 13 Micron (12 Inci)	1	1							35,000	
3	Carton Box ABC/ABC colors/ABC-Candy (1.728 Pcs)	1	1							45,000	
4	Dozen Box ABC Black Fine 0.7 (6) Uv Coating-Uv	1	1							15,000	
5	ABC Fine 0.7mm Black-Msn	1	1							31,104	
6	Stamping Foil Gold Spf-220 "Kurz"	2	1						45,000		
7	Cap Z-ABC Black	2	1						30,000		
8	Barrel Z-ABC Solid Black	2	1						36,000		
9	Plug Z-ABC Black	2	1						26,840		
10	Rf Zss 01 (Es) Bk 0.7mm	2	1						42,815		
11	Pp Trylene Hf 10 – Tq	3	1					36,000			
12	Masterbatch Black Mp 515 Z	3	1					32,600			
13	Polysterene Crystal 1540	3	2				37,500				

No	Component	Level	Lead time (Month)	Month							
				10	11	12	1	2	3	4	5
14	Masterbatch Black Hc 88017	3	1					43,135			
15	Tube Classic-1	3	1					43,200			
16	Seal Peel For Jel Ink Transparent No.3	3	4		44,000						
17	Refill Ink Cp Ulv Black	3	3			42,400					
18	Tip Essem Sa 0.7mm (105.A.258/0.70mm)	3	3			45,330					
19	Pp El Pro P401-S	4	2			44,000					
20	Silicon Oil Kf-410	4	4	42,000							

Table 6 presents the benefits of the MRP technique as a systematic approach, as mentioned in research by Wahyuni and Syaichu [7]. Using the MRP approach, the organization may ascertain the number of units to be manufactured for each component and the specific time when the production or procurement of the element should commence. When the product is produced in-house, the outcomes of the MRP technique can be utilized to develop production schedules using capacity planning. Alternatively, if the company acquires the components from vendors, it is necessary to establish and maintain partnerships with these vendors through a vendor relationship management program. This program ensures that the vendors can deliver the components in the correct quantity and within the specified timeframe.

5. Conclusion

This study has demonstrated the effectiveness of the MRP method in managing inventory for pen production. By adopting MRP, the company could optimize order quantities and timings; therefore, it can significantly reduce the risk of excess or inventory stockout, which is crucial in maintaining continuous production and reducing operational costs. The findings of this research offer actionable insight for industry, particularly in the manufacturing sectors, utilizing the effectiveness of MRP in inventory management. By detailing the steps of the MRP method and the associated benefits, this study serves as a guide for companies looking to enhance their inventory control process. This study also contributes to the literature by enriching the current studies on utilizing MRP in inventory optimization in manufacturing sectors. Future research can be conducted by integrating real-time data analytics with the MRP system; therefore, the company can improve forecast accuracy and increase responsiveness to market changes.

References

[1] M. Salman, H. Akram, Z. Bint-E-Ishaq, M. H. Zaheer and N. Rauf, "The Impact of Inventory Management on Financial Performance in the Pakistani Pharmaceutical Sector: A Multivariate Analysis," *Asian Finance Research Journal,* vol. 5, pp. 97-122, 2023.

[2] M. Ogah, G. Asiegbu and N. M. Lagos, "Effect of raw material inventory on operational performance in an emerging economy insight from the Nigerian manufacturing sector," *International Journal on Recent Trends in Business and Tourism,* vol. 6, no. 2, pp. 31-43, 2022.

[3] S. O. Unyimadu and K. A. Anyibuofu, "Inventory Management Practices in Manufacturing Firms," *Industrial Engineering Letters,* vol. 4, no. 0, pp. 40-44, 2014.

[4] A. P. Pradata and D. Ernawati, "The Influence of ERP-SAP Implementation and Inventory Management on Production Efficiency through Inventory Control Performance Using Partial Least Square (PLS) Method," *Indonesian Journal of Computer Science (IJCS),* vol. 13, no. 3, pp. 4135-4147, 2024.

[5] N. Hasanati, E. Permatasari, N. Nurhasanah and S. Hidayat, "Implementation of material requirement planning (MRP) on raw material order planning system for garment industry," in *11th ISIEM (International Seminar on Industrial Engineering & Management, "Technology and Innovation Challenges Towards Industry 4.0 Era" 27–29 November 2018, Makasar, South Sulawesi, Indonesia*, 2019.

[6] G. P. Gusti and R. T. Yuliarto, "The Role of digital innovation in improving financial performance in MSMEs in Indonesia," *Journal of International Conference Proceedings (JICP),* vol. 5, no. 3, pp. 215-224, 2022.

[7] A. Wahyuni and A. Syaichu, "Perencanaan Persediaan Bahan Baku dengan Menggunakan Metode Material Requirement Planning (MRP) Produk Kacang Shanghai pada Perusahaan Gangsar Ngunut-Tulungagung," *Spektrum Industri,* vol. 13, no. 2, p. 115–228, 2015.

[8] P. Apriliza, S. Supian and J. Nahar, "The Planning for Upper Shoes Raw Material Inventory Using the Material Requirement Planning (MRP) Method (Case Study: PT X)," *International Journal of Global Operations Research,* vol. 4, no. 4, pp. 271-278, 2023.

[9] W. Sudarwati and A. T. Panudju, "Analysis of Fabric Raw Material Inventory Control in Backpack Products Using the Material Requirements Planning (MRP) Method at CV. Metassa," *Formosa Journal of Science and Technology,* vol. 2, no. 8, pp. 1967-1980, 2023.

[10] S. F. Yolanda and A. Kurniawan, "Inventory Control Analysis of Raw Material for Making the Men's Formal Trousers at PT. Dirgayusa Apparelindo," in *Proceedings of the 20th Malaysia Indonesia International Conference on Economics, Management and Accounting MIICEMA*, 2019.

[11] F. H. Badruzzaman and E. Harahap, "Inventory Control of Hijab Raw Materials at RAR Azkia Padalarang," *Matematika: Jurnal Teori dan Terapan Matematika,* vol. 17, no. 1, pp. 35-40, 2018.

[12] A. Chandradevi and N. B. Puspitasari, "Penerapan Material Requirement Planning (MRP) dengan Mempertimbangkan Lot Sizing dalam Pengendalian Bahan Baku pada PT. Phapros, Tbk.," *Performa: Media Ilmiah Teknik industri,* vol. 15, no. 1, pp. 77-86, 2016.

[13] D. Sri, "Raw Material Inventory Planning of Patient Menu Using Material Requirement Planning (MRP) in RSIA Kendangsari MERR Surabaya," *Jurnal Ekonomi dan Bisnis Airlangga,* vol. 31, no. 1, pp. 14-27, 2021.

[14] L. Gozali, D. Marchello, A. Ali and J. Jessica, "Analysis of Raw Material Planning with Optimal Cost Consideration Using Safety Stocks, Material Requirement Planning, and Lot Sizing Methods at Plastic Jar Company," in *3rd Asia Pacific International Conference on Industrial Engineering and Operations Management*, 2023.

[15] A. Daengs and G. Soeherman, "Perencanaan dan Pengendalian Persediaan Bahan Baku dalam Upaya Menghindari Kekurangan Bahan Baku (Studi Kasus pada PT. Kedawung Setia Industrial, Surabaya)," *Journal Online Universitas 45 Surabaya,* pp. 1-11, 2017.

[16] M. Rofieq, J. M. Faradhisa and P. Dalulia, "Raw Material Planning and Control with MRP Method to Maintain Accurate Production Amounts in UKM Allwooden Woodworking," *Tibuana: Journal of Applied Industrial Engineering,* vol. 5, no. 2, 2022.

[17] Y. Wardhani and I. Indrawan, "Analysis of yogurt raw materials control using MRP method at PT. Heavenly Nutrition Indonesia," *The Management Journal of BINANIAGA,* vol. 4, no. 1, pp. 11-22, 2019.

[18] S. Saptadi, H. A. Zahra, A. Arvianto, P. A. Wicaksono and W. Budiawan, "Inventory Planning and Control Method for Cement Raw Material with Material Requirement Planning (MRP)," *International Journal of Applied Science and Engineering Review,* vol. 4, no. 3, pp. 18-31, 2023.

[19] Paduloh, "Analisis Pengendalian Persediaan Bahan Baku Plat Besi Industri Karoseri Menggunakan Metode EOQ (Studi Kasus pada PT. Misitama)," *Journal of Industrial Manufacturing: Jurnal Ilmiah Teknik Industri,* vol. 3, no. 1, pp. 37-44, 2018.

[20] S. Suhartini, "Perencanaan Kebutuhan Material Dengan Metode Material Requirement Planning," *Jurnal Teknik Industri,* vol. 15, no. 2, pp. 190-200, 2014.

[21] Tumini and N. Iis, "Perencanaan dan Pengendalian Bahan Baku dengan Metode Material Requirement Planning (MRP) Berbasis Web di PT YTK Indonesia," *Jurnal Informatika SIMANTIK,* vol. 8, no. 1, 2023.