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Analysis of Raw Material Inventory in Production Planning and Control at PT. XYZ

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ABSTRACT

This study was conducted to analyze the imbalance between the manufacture and use of raw materials in the plastic sheet production process at PT XYZ. As a plastic manufacturing company with an injection molding-based production process, production planning and control (PPIC) plays a crucial role in ensuring the availability of appropriate raw materials to ensure optimal production without shortages or excess stock. Raw material usage data from January to August 2025 showed significant fluctuations and discrepancies between the amount of raw materials produced and used, necessitating an evaluation of material planning methods. This study applied several forecasting methods namely Single Exponential Smoothing and Moving Average to determine the most accurate raw material requirement prediction model. The analysis results showed that the 3-Period Moving Average was the best method with the smallest MAD value and was used as the basis for preparing the Master Production Schedule of 4,585 units per period. The Bill of Material calculation demonstrated efficient material conversion, while the estimation of raw material requirements provided a more accurate picture of procurement planning. Overall, the integration of forecasting, MPS and raw material requirement calculations supports increased production efficiency and more measurable and sustainable decision-making.

1. Introduction

In the manufacturing industry, particularly in plastic injection molding companies, the production planning and control (PPIC) process plays a crucial role in ensuring the smooth flow of raw materials, ensuring optimal production [1], [2]. PPIC is responsible for ensuring that the quantity of raw materials available matches actual production needs, preventing shortages or excess inventory that could hinder production activities [3].

PT. XYZ is a competitive, innovative, and consumer-preferred plastic houseware and furniture manufacturing company. Based in Surabaya, the company has three production locations: Tanjungsari (16 injection machines), Kepatihan (22 injection machines and 2 blow molding machines), and Benowo (5 injection machines), totaling over 41 machines. Originally founded as UD. ABC in the early 1980s, the company changed its name to PT. XYZ in 1994. Today, the company serves customers throughout Indonesia and produces a variety of products such as baskets, bathrooms, containers, racks, and kitchens [4].

The production process starts from the raw material process in inventory, then the process of mixing the color of the raw material or mixing it into the mixer with a composition determined by the company, after which it is sent to the production floor with an injection process or molding of plastic products and when it has produced the best quality output, the finishing is carried out by cutting off the remaining mold attached to the product using a tool in the form of a razor or cutter. This way, the distribution process can be carried out to the packing section and the product is ready to be distributed to distributors [5].

Raw material usage in the production process was recorded from January to August 2025. An imbalance was identified between the amount of raw materials produced and the amount used in the production line. For example, in January, 572 kg of raw materials were produced, while only 625 kg were used. In February, 165 kg were produced and 200

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kg were used. This situation indicates a fluctuation in raw material usage that is not balanced with the production plan.

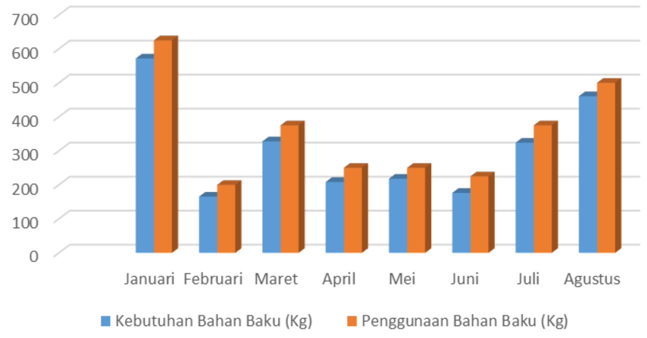

Figure 1. Needs and use of raw materials

This imbalance can lead to problems such as leftover raw materials. This problem indicates the need to evaluate the raw material planning system and control methods used by the PPIC department [6], [7]. The use of data on manufacturing demand and raw material usage can serve as a basis for analyzing and forecasting future raw material needs, allowing for more accurate production planning [8], [9]. However, most previous research has focused more on general inventory control or on companies with relatively stable demand patterns. Few studies have specifically analyzed the mismatch between raw material production and usage in plastic injection companies with high demand fluctuations such as PT XYZ. In addition, previous studies rarely integrate raw material usage gap analysis with multi-method forecasting approaches (Exponential Smoothing and Moving Average) to determine the most accurate model as a basis for preparing a more precise MPS and calculating material requirements. Therefore, this study focuses on analyzing the imbalance between raw material production and usage in the production planning and control system at PT XYZ [10], [11]. In addition, a comprehensive approach from fluctuation data, forecasting, to material control recommendations, which has not been widely discussed in similar studies in the plastic mold injection industry.

2. Research methods

The research stages depicted in Figure 2 include a series of activities starting from problem surveys, field studies, literature studies, problem identification, data collection, data processing, analysis of results, and drawing conclusions and providing recommendations. This research uses a forecasting method. The choice of forecasting method in this study is based on the characteristics of PT XYZ's raw material demand data patterns from January to August 2025. The results of initial analysis of historical data indicate that demand is fluctuating but does not follow a consistent upward or downward trend pattern, and does not exhibit recurring seasonality. More complex forecasting methods such as Holt's Trend Method, Holt–Winters, or ARIMA are not the primary choice because they require the presence of a strong trend or seasonal pattern to produce optimal predictions. Therefore, this study uses the Single Exponential Smoothing (SES) and Moving Average (MA) methods, which are theoretically more suitable for data without trends and seasonality, and are able to capture short-term movement patterns well. The SES method was chosen because of its ability to respond to changes in demand through the smoothing parameter (α), while the MA method was chosen because it is effective in reducing random fluctuations by smoothing data based on the average of several periods. Both methods also have a high degree of flexibility and are widely used in the context of raw material planning in manufacturing industries with unstable demand patterns. Furthermore, the simplicity and transparency of these two methods allow companies to implement them directly in the PPIC process without the need for complex computing systems. By comparing the performance of the two methods based on accuracy indicators such as MAD, MSE, MAPE, and tracking signal, this study can determine the model that best suits the company's actual conditions so that the forecasting results are more reliable and can be used as a basis for preparing a Master Production Schedule (MPS) and calculating raw material requirements more precisely.

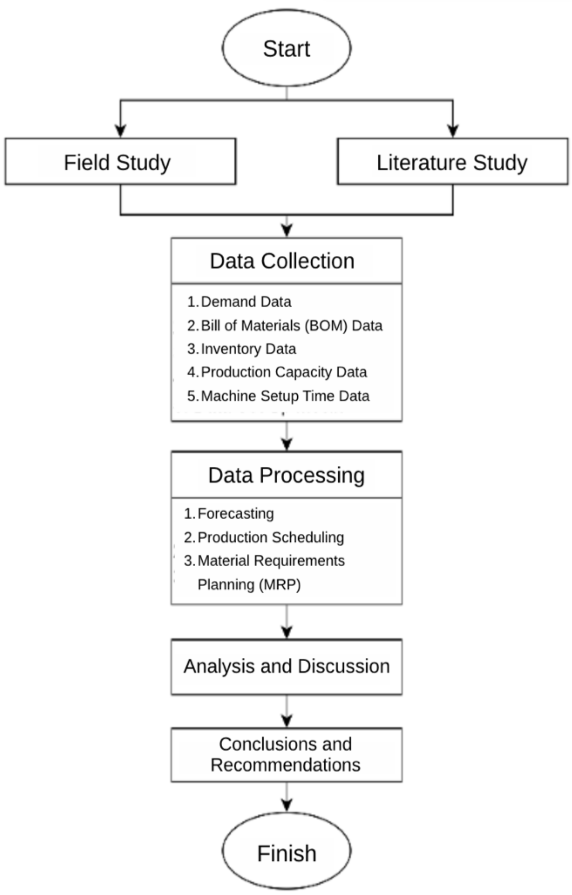

Figure 2. Research flowchart

Identification was conducted based on the findings of field studies, particularly those related to the presence of remaining raw materials in the production process [12] [13]. The field study included direct observation in the production area of PT. XYZ as well as interviews with the head of production and the head of the warehouse. The data collected consisted of primary data from observations and secondary data from company documents [14][15]. All data was processed using relevant research methods and then analyzed to compare conditions before and after repairs [16]. The final stage was compiling conclusions, suggestions, and recommendations to help the company resolve the problems found [17][18].

Exponential Smoothing Calculation Formula

$$F_{t+1} = \propto A_t + (1-\propto)F_t \quad (1)$$

Moving Average Calculation Formula

$$F_{t+1} = \frac{A_{t-n+1} + A_{t-n+2} + \cdots + A_t}{n} \quad (2)$$

Mean Absolute Deviation (MAD) Calculation Formula

$$MAD = \frac{\sum|A_t - F_t|}{n} \quad (3)$$

Mean Squared Error (MSE) Calculation Formula

$$MSE = \frac{\sum(A_t - F_t)^2}{n} \quad (4)$$

Mean Absolute Percentage Error (MAPE) Calculation Formula

$$MAPE = \frac{100}{n}\sum\left|\frac{A_t - F_t}{A_t}\right| \quad (5)$$

3. Results and Discussion

The results and discussion in this study were conducted to obtain an accurate picture of product demand patterns and raw material requirements through forecasting methods such as Single Exponential Smoothing with various α and Moving Average in several periods. The best model was selected based on accuracy indicators such as MAD, MSE, MAPE and tracking signal to ensure that predictions can be properly monitored and controlled. These forecasting results serve as the basis for the preparation of the Master Production Schedule (MPS), the calculation of the Bill of Material (BOM) and the estimation of raw material requirements for each period, so that the production planning process can run more efficiently and directed and is able to minimize the risk of shortages or excesses of raw materials while supporting optimal and sustainable decision making.

3.1 Demand Forecasting

This study presents a demand forecasting analysis using POM-QM software including the Single Exponential Smoothing method with α = 0.3 and α = 0.5 as well as 3 and 4 period Moving Averages to obtain accurate predictions and support production planning.

3.1.1 Demand Forecasting Single Exponential Smoothing Alpha 0.3

Prior to the accuracy analysis, the Single Exponential Smoothing (SES) method with a smoothing parameter value of α = 0.3 was applied to assess how the model responds to short-term fluctuations in raw material demand. A relatively small α value was chosen to provide a stronger smoothing effect, thus making the forecast more stable against random changes. Table 1 presents the results of the forecast calculations, forecast errors, and initial evaluation metrics to assess the performance of the SES model with α = 0.3.

Table 1
Results of forecasting error analysis with ∝ = 0.3

Month	Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	5717					
February	1654	5717	-4063	4063	16507970	2,456
March	3279	4498,1	-1219,1	1219,1	1486205	,372
April	2084	4132,37	-2048,37	2048,37	4195820	,983
May	2180	3517,859	-1337,859	1337,859	1789867	,614
June	1764	3116,501	-1352,501	1352,501	1829260,0	,767
July	3240	2710,751	529,249	529,249	280104,5	,163
August	4607	2069,526	1737,474	1737,474	3018817,0	,377
September	4800	3390,768	1409,232	1409,232	1985935,0	,294
October	4350	3813,538	536,462	536,462	287791,9	,123
Totals	33675		-5808,412	14233,25	31381770	6,149
Average	3367,5		-645,379	1581,472	3486863	,683
Next period forecast		3974,476	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	2117,335	

Analysis of monthly demand forecasting from January to October. The average actual demand is 3367.5 units while the average error is -645.379 indicating that on average the model overforecasts demand. Forecasting performance is measured by several metrics namely Mean Absolute Deviation (MAD) of 1581.472 units, indicating the average magnitude of the error in units, Mean Squared Error (MSE) of 3,486,863 squared units which gives more weight to large errors and Mean Absolute Percentage Error (MAPE) of 0.683% which indicates a very high and relatively good level of forecasting accuracy (although the figure seems very small and may need to be verified because usually MAPE above 1% is considered good in many contexts). The next period's forecast is 3974.476 units.

3.1.2 Single Exponential Smoothing Alpha 0.5 Demand Forecasting

The Single Exponential Smoothing method with a smoothing parameter of α = 0.5 was then used to compare the model's sensitivity to changes in the smoothing value. A larger α value allows the model to more quickly capture actual demand movements, making it suitable for testing the effect of responsiveness on prediction accuracy. Table 2 displays the results of the forecast calculations and errors for each period using SES with α = 0.5.

Analysis of the performance of a monthly demand forecasting model from January to October. The total actual demand during this period was 33,675 units with a monthly average of 3367.5 units. The model performance was evaluated through error metrics with a mean error of -317.989 indicating that the model tends to consistently overforecast demand although the level of overforecast is relatively moderate. The MAD (Mean Absolute Deviation) of 1279.441 units indicates the average magnitude of the forecasting error in units while the MSE (Mean Squared Error) of 2,868,374.0 highlights the presence of some large errors that affect accuracy. Finally, the very low MAPE (Mean Absolute Percentage Error) of 0.552% indicates that the model has excellent percentage accuracy in forecasting demand and the forecast for the next period is set at 4286,049 units.

Table 2
Results of forecasting error analysis with ∝ = 0.5

Month	Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	5717					
February	1654	5717	4063	4063	16507970	2.456
March	3279	3685,5	406 5	406 5	165242,3	,124
April	2084	3482,25	-1398,25	1398,25	1955103	,671
May	2180	2783,125	-603,125	603,125	363759,8	,277
June	1764	2481,563	-717,563	717,563	514895,9	,407
July	3240	2122,781	1117,219	1117,219	1248178,0	,345
August	4607	2681,391	1925,609	1925,609	3707972,0	,418
September	4800	3644,195	1155,805	1155,805	1335885,0	,241
October	4350	4222,098	127,902	127,902	16359,01	,029
Totals	33675		-2861,902	11514,97	25815360	4,968
Average	3367,5		-317,989	1279,441	2868374,0	,552
Next period forecast		4286.049	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	1920,393	

3.1.3 *3-Period Moving Average Demand Forecasting*

Next, a three-period Moving Average method was applied to observe the behavior of short-term average-based forecasts. The three-period method was chosen based on fluctuating data patterns that do not show long-term trends, so this method is expected to smooth out random variations without losing sensitivity to changes in demand. Table 3 presents the results of forecast calculations and forecast errors using the 3-period Moving Average.

Table 3
Results of the 3-Period Moving Average Forecast Error Analysis

Month	Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	5717					
February	1654					
March	3279					
April	2084	3550	-1466	1466	2149156	,703
May	2180	2339	-159	159	25281	,073
June	1764	2514,333	-750,334	750,334	563000,4	,425
July	3240	2009,333	1230,667	1230,667	1514541,0	,38
August	4607	2394,667	2212,333	2212,333	4894419,0	,48
September	4800	3203,667	1596,333	1596,333	2548281,0	,333
October	4350	4215,667	134,333	134,333	18045,36	,031
Totals	33675		2798,333	7549	11712720	2,425
Average	3367,5		399,762	1078,429	1673246	346
Next period forecast		4585,667	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	1530.537	

Analysis of the performance of the monthly demand forecasting model with an Average Actual Demand of 3367.5 units during the period of January to October. The forecasting performance shows a positive bias of 399,762, indicating that this model tends to underforecast actual demand on average. Forecast quality is measured by the MAD (Mean Absolute Deviation) of 1078,429 units which is the average magnitude of the error in units and the MSE (Mean Squared Error) of 1,673,246 which gives more weight to large errors. The level of accuracy of the forecast percentage is measured by MAPE (Mean Absolute Percentage Error) is 0.346% indicating a very high accuracy in percentage terms with the estimated demand for the next period set at 4585,667 units.

3.1.4 *4-Period Moving Average Demand Forecasting*

For additional comparison, a four-period moving average (MO) method was used to assess the impact of increasing the averaging window length on the stability and accuracy of the forecast results. Using four periods allows for a more robust smoothing process, but potentially reduces the model's ability to track dynamic demand changes. The results of the forecast calculations and error evaluation using this method are shown in Table 4 below.

Table 4
Results of the 4-Period Moving Average Forecast Error Analysis

Month	Demand	Forecast	Error	|Error|	Error^2	|Pct Error|
January	5717					
February	1654					
March	3279					
April	2084					
May	2180	3183,5	-1003,5	1003,5	1007012,0	,46
June	1764	2299.25	-535,25	535,25	286492,6	,303
July	3240	2326,75	913,25	913,25	834025,6	,282
August	4607	2317	2290	2290	5244100	,497
September	4800	2947,75	1852,25	1852,25	3430830	,386
October	4350	3602,75	747,25	747,25	558382,6	,172
Totals	33675		4264	7341,5	11360840	2,1
Average	3367,5		710.667	1223,583	1893474,0	,35
Next period forecast		4249,25	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	1685,292	

Analysis of the performance of the monthly demand forecasting model shows an Average Actual Demand of 3367.5 units over the covered period. This model produces a significant positive bias of 710.667, indicating that the model systematically underforecasts actual demand. Forecast quality is measured by the MAD (Mean Absolute Deviation) of 1223.583 units, indicating an average magnitude of absolute error and MSE (Mean Squared Error) of 1,893,474.0 which gives weight to large errors that occur especially seen in August and September. The very low MAPE (Mean Absolute Percentage Error) of 0.35% indicates excellent percentage accuracy with the next period's demand forecast set at 4249.25 units.

3.2 *Forecasting Control*

Forecasting error control shown in Table 5 is carried out to ensure the accuracy of prediction results through error analysis and signal tracking so that the forecasting process can be controlled and used more precisely in production planning.

Table 5
Results of the Mean Absolute Deviation (MAD) calculation

Method	*Mean Absolute Deviation* (MAD)
Exponential Smoothing Alpha 0.3	1581
Exponential Smoothing Alpha 0.5	1279
Moving Average 3 Periode	**1078**
Moving Average 4 Periode	1223

Based on the results of the forecast error calculation, the 3-Period Moving Average method produces the smallest MAD value of 1.078, making it the method with the best accuracy. Exponential Smoothing with an alpha of 0.5 has better accuracy than an alpha of 0.3, but is still greater than the 3-Period Moving Average. The 4-Period Moving Average shows moderate accuracy with a MAD value of 1.223. Overall, these results indicate that the method using short-term averages is better able to follow the fluctuation pattern of plastic packaging demand. Therefore, the forecast value used for the next period uses the 3-Period Moving Average method with a rounded forecast result of 4585 units.

3.3 Master Production Schedule

The Master Production Schedule is prepared to ensure that production planning runs smoothly, as shown in Table 6. Stable demand of 4,585 units per period facilitates the management of capacity, raw materials, and the smooth running of the production process.

Table 6
Master Production Schedule:
November 2025, December 2025, and January 2026

Produk	Periode		
	November 2025	Desember 2025	Januari 2026
Lunch Box Master Bowl	4585 Pcs	4585 Pcs	4585 Pcs

The Master Production Schedule shows stable demand of 4,585 units for three consecutive periods. This consistency reflects consistent forecasting results, allowing for more predictable and efficient production planning, raw material requirements, and machine capacity.

3.4 Product Bill of Material and Raw Material Inventory

The determination of machine setup requirements in the Bill of Material calculation was obtained through direct interviews with the production head and injection machine operators at PT XYZ. This setup value represents the amount of initial raw materials used for the machine setup process, such as barrel cleaning, temperature adjustment, and trial shots to achieve stable mold quality. Based on the company's operating standards, the setup requirement for the body component is 10 kg and for the cap component is 7 kg at the beginning of each production period. The calculation formulation is carried out by adding the machine setup value to the total raw material requirements calculated from the results of converting component weights to production demand. Thus, the total raw material requirements are calculated as:

Total raw material requirements =
(Number of units × Component weight per unit) + Machine set-up requirements.

This approach ensures that the calculated material requirements not only reflect the actual consumption per unit of product, but also accommodate material losses that occur during the injection machine start-up process, so that raw material procurement plans can be prepared more realistically and according to operational conditions in the field.

Table 7
Bill of Materials for lunch box master bowl

Component	Raw material	Component Weight	Result
Badan Tepak	1 Kg PP DXX	100 gram	10 pcs
Tutup Tepak	1 Kg PP TRANS	50 gram	20 pcs

The Bill of Material shows the efficiency of raw material usage, where 1 kg of PP DXX produces 10 flap bodies while 1 kg of PP TRANS produces 20 flaps so that the production structure remains optimal.

Table 8
Inventory of raw materials in the warehouse

Component	Raw material	Supply
Badan	PP DXX	505 Kg
Tutup	PP TRANS	290 Kg

3.5 Calculation of Raw Material Requirements

This raw material requirements calculation is designed to ensure the availability of key materials for the body and flap components. The analysis is conducted to ensure the production process runs efficiently, in a planned manner, and can anticipate changes in demand at each stage.

3.5.1 Raw Material Requirements for Tepak Body Components

The calculation of the raw material requirements for the components of the tepak body is prepared to ensure that the availability of PP DXX remains controlled, so that the production process runs smoothly through appropriate ordering planning according to demand for each period.

Table 9
Amount of PP DXX Raw Material in kilograms

Periode	Demand (Pcs)	Component Weight (gr)	Machine Setup (Kg)	Raw Material Requirements (Kg)
November 2025	4585	100	10	468,5
Desember 2025	4585	100	10	468,5
Januari 2026	4585	100	10	468,5

The demand for PP DXX raw materials for the tepak body shows a stable value of 468.5 kg in each period from November 2025 to January 2026. This consistency in demand facilitates procurement and production planning because the amount of raw materials and machine setup do not experience significant changes.

3.5.2 Raw Material Requirements for Tepak Cover Components

The calculation of raw material requirements for the cap components is prepared to ensure that PP TRANS availability is always met so that raw material orders can be planned on time according to production needs for each period.

Table 10
Amount of PP TRANS Raw Material in kilograms

Periode	Demand (Pcs)	Component Weight (gr)	Machine Setup (Kg)	Raw Material Requirements (Kg)
November 2025	4585	50	7	236,25
Desember 2025	4585	50	7	236,25
Januari 2026	4585	50	7	236,25

The demand for PP TRANS raw materials for tapak lids remains constant at 236.25 kg each period. This consistency reflects stable demand and a controlled production process, facilitating raw material purchasing planning and ensuring consistent availability without the risk of shortages.

3.6 Data Analysis

The analysis results show that production planning and raw material requirements for plastic sheets became more accurate after going through the data collection, forecasting, and error control stages. Fluctuating demand from January to October 2025 required an appropriate forecasting method. The 3-period Moving Average proved to be the most accurate, with the smallest MAD value of 1.078, resulting in a demand forecast of 4,585 units. The use of raw materials for body and lid components showed average differences of 33.2 kg and 29.7 kg, respectively, indicating potential for efficiency improvements. The Master Production Schedule and Bill of Materials (BOM) helped calculate raw material requirements accurately, while the Lot-for-Lot method ensured ordering according to needs without creating backlogs.

These findings indicate that demand fluctuations in early 2025 not only impacted material planning inaccuracies but also potentially impacted long-term production capacity stability. The selection of the 3-period Moving Average method as the best model demonstrates that the company's demand patterns tend to be short-term fluctuations, making the short-term smoothing approach better able to capture the dynamics of data movements than other methods. The low MAD and MAPE values in this model indicate that most demand variations are random and do not reflect any seasonal patterns or sustainable trends. Furthermore, the difference in raw material usage between planning and realization for the body and lid components indicates that material inefficiencies persist, particularly in the machine setup and trial shot processes that are repeated each production period. This condition confirms that integrating forecasting results with the Master Production Schedule (MPS) and Bill of Material (BOM) is not only important in ensuring material sufficiency, but also in reducing the potential for waste of non-value-added raw materials. The implementation of the Lot for Lot method is also relevant to the characteristics of companies that do not have high demand stability, because this strategy reduces the risk of raw material accumulation that can increase storage costs. Thus, the overall results of this study show that forecasting accuracy and material planning accuracy have a direct contribution to the company's operational efficiency, particularly in the context of the injection molding-based plastics industry that is sensitive to changes in production capacity, machine conditions, and material availability. The integrated approach used in this study is proven to provide a more comprehensive picture of raw material needs and helps companies in developing more adaptive, responsive, and data-driven PPIC policies. Overall, the integration of forecasting and material planning provides a strong foundation for efficient, measurable production decisions that are ready to face demand fluctuations.

4. Conclusion

The conclusion of this study indicates that the demand forecasting, error control, and raw material requirements planning processes have provided an accurate and directed basis for the preparation of plastic sheet production plans. Of the several methods tested, the 3-Period Moving Average proved to have the best accuracy with the smallest MAD value, thus being used as the basis for determining a stable Master Production Schedule of 4,585 units per period. The Bill of Material structure and the results of the raw material requirements calculation show material conversion efficiency and consistent needs, facilitating the preparation of purchasing plans and inventory control. The integration of forecasting, MPS, and raw material calculations can improve the efficiency of the production process, minimize the risk of material shortages or excesses, and support more accurate and sustainable decision-making for the company. The integration of demand forecasting, MPS determination, and raw material requirements calculations has been proven to improve the effectiveness of the company's PPIC process. This approach supports more measurable, efficient, and adaptive decision-making to demand fluctuations. In addition, the results of this study can serve as a basis for PT XYZ to make further improvements, such as implementing an automated forecasting system, strengthening process setup control, or periodically evaluating forecast accuracy as demand patterns change. Thus, this research provides a significant practical contribution to improving the performance of production planning and control in the injection molding-based plastics industry.

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