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Original Article

AI-Powered Inventory Optimization in Industrial Manufacturing

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Abstract - *Material Requirement Planning (MRP) is a systematic approach to efficiently managing and controlling the flow of materials within a production or manufacturing environment. It involves planning and scheduling the quantities of raw materials, components, and assemblies required to meet production demands while minimizing inventory costs. The primary objective of MRP is to ensure that materials are available at the right time, in the correct quantity, and of the right quality to support the production process in industrial manufacturing. "Automatic Reorder Point Planning" is a sophisticated system that streamlines inventory management by automatically determining when to reorder products based on predefined criteria. The system employs advanced algorithms and data analysis to calculate the optimal reorder points for each item in your inventory. This article provides a comprehensive guide for organizations seeking to enhance their MRP processes by implementing Automatic Reorder Point Planning and insight into AI-powered MRP with a case study. It provides valuable insights, practical recommendations, and real-world examples to help businesses optimize inventory management, streamline production operations, and improve overall supply chain efficiency.*

Keywords - *Artificial Intelligence (AI), Material Requirement Planning (MRP), Automatic Reorder Point Planning, Industrial Manufacturing, ERP, SAP S/4 HANA, Digital Transformation*.

1. Introduction

Efficient inventory management is crucial for businesses of all sizes, enabling them to meet customer demands while minimizing costs and avoiding stockouts. One key aspect of effective inventory control is determining the optimal time to reorder items to ensure a seamless supply chain. This is where automatic reorder point calculation comes into play, revolutionizing how businesses maintain stock levels.

Traditionally, determining the reorder point has been manual and often labor-intensive. It involves monitoring inventory levels, analyzing historical sales data, and making educated guesses based on experience. However, with the advancement of technology and the advent of sophisticated algorithms, businesses can now automate this process, saving time, reducing errors, and optimizing their inventory control strategies.

This article explains the automatic reorder point calculation [1-2] concept and its significant impact on inventory management. It will delve into the benefits it offers, the key factors involved in its calculation, and the technologies that enable businesses to implement this automated approach. Organizations can gain a competitive edge by understanding and implementing automatic reorder point calculation [3], improving customer satisfaction, and streamlining their supply chain operations.

2. Literature Review

The study [4,5] focuses on automatic reorder point planning in SAP S/4HANA, the next-generation ERP system. It presents a framework that leverages SAP S/4HANA's advanced analytics and machine learning capabilities to optimize reorder points dynamically. The results indicate improved inventory turnover, reduced carrying costs, and increased customer service.

The article [6] proposes a decision support system (DSS) for reorder point planning within SAP Supply Chain Management (SCM) module. It integrates historical sales data, demand forecasting, and service-level optimization techniques to determine optimal reorder points. The study demonstrates the effectiveness of the DSS in improving inventory management and reducing stockouts in real-world case studies.

This research [7] explores the capabilities of SAP's Advanced Planning and Optimization module in automating reorder point planning. The article highlights the integration of demand sensing, inventory optimization, and replenishment planning techniques within SAP APO. The findings suggest that utilizing these features enhances the accuracy of reorder point calculations and reduces stockouts and excess inventory.

The article [8] investigates the challenges organizations face in SAP ERP systems when determining optimal reorder points. It proposes a methodology integrating demand forecasting techniques and SAP's Materials Management module to improve reorder point planning. The study shows significant cost savings and inventory optimization benefits from the proposed approach.

3. Consumption-Based Planning

As the name suggests, consumption-based MRP procedures use past consumption data (historical data) to calculate future requirements using the material forecast or static MRP procedures. Consumption-based MRP procedures have no reference to the master plan.

Therefore, an independent or dependent requirement does not trigger the net requirements calculation. Instead, the net requirements calculation is triggered when a stock level falls below a reorder point or by forecast requirements calculated from consumption data from the past.

Automatic reorder point planning is a system that efficiently manages inventory by automatically determining when to reorder products. It calculates automatic reorder points using a formula that considers historical sales data, lead time, and safety stock.

In addition, the system employs advanced algorithms and data analysis to calculate the optimal reorder points for each item in your inventory.

The calculation of automatic reorder points involves several key factors. Firstly, historical sales data and usage patterns are analysed to identify the average consumption rate for each product. This information helps establish the baseline demand for the item. Additionally, the system considers lead time—the time it takes for a supplier to deliver the ordered goods. Considering the lead time, the system ensures that the reorder point is set to a level that avoids stockouts before new inventory arrives.

The system incorporates a safety stock level to calculate the automatic reorder point. The safety stock acts as a buffer to account for unforeseen demand fluctuations or delays in the supply chain. It guards against stockouts during unexpected surges in demand or longer lead times.

The automatic reorder point is typically determined using Reorder Point = (Average Daily Demand * Lead Time) + Safety Stock.

The average daily demand is derived from historical data. At the same time, the lead time and safety stock are predetermined based on the product's characteristics and the desired level of risk mitigation.

Once each item's automatic reorder point is calculated, the system continuously monitors the inventory levels. When the stock reaches or falls below the reorder point, the system generates an alert or triggers an automatic reorder process, ensuring that new inventory is ordered promptly.

By leveraging automated calculations and real-time monitoring, Automatic Reorder Point Planning optimizes inventory management, reduces manual intervention, minimizes stockouts, and enhances overall operational efficiency.

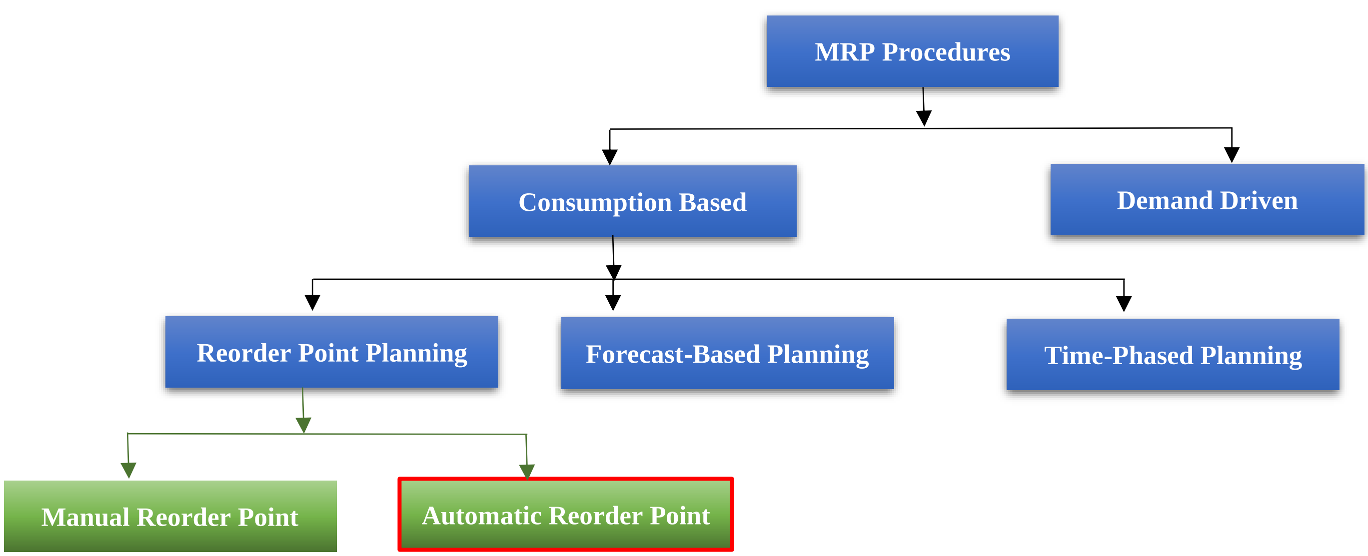


Fig. 1. MRP Procedures

Table 1. Consumption-Based planning recommendation

Consumption/Requirement \ Value	High	Medium	Low
Constant	Demand Drive	Demand Drive	Consumption-Based Planning
Slight Fluctuation	Demand Drive	Demand Drive	Consumption-Based Planning
Considerable Fluctuation	Demand Drive	Demand Drive	Demand Drive

4. Recommendations for Consumption-Based Planning

These procedures are recommended for B and C materials, that is, for comparatively low-value materials with little fluctuating consumption.

Many MRP procedures (i.e., MRP Types) are available within consumption-based planning but for automatic reorder-based planning.

Within Automatic reorder point planning have 2 MRP types available:

1. MRP Type VM: Automatic reorder point planning

2. MRP Type V2: Automatic reorder point with external requirements.

MRP type: VM will consider reservation and sales orders as additional demand on top of reorder point. The MRP-type configuration has a field called "Include ext. reqmt," which determines to follow values and system behavior:

- Blank: No external requirements are taken into consideration

- 1: External requirements like sales orders and manual reservations are considered in the entire horizon

- 2: External requirements like sales orders and manual reservations are only considered within the replenishment lead time.

5. Automatic Reorder Point Calculation and Formula

Automatic reorder point = safety stock + daily requirement * replenishment lead time

As shown above, the Automatic reorder point includes safety stock; below is a formula [10,11] for safety stock.

Safety Stock = R * square root of W * MAD

R = R Means Service Level Factor. The service level defined in MRP-2 has an equivalent factor. For example, the following figure shows that, without safety stock, customer demand can be satisfied by 50%. However, it also indicates that it is almost impossible to meet customer demand 100% of the time. Factor R describes the relationship between forecast accuracy and service level (SL).

W = Delivery Times in Days / Forecast Period in Days

If the material is produced in-house, the delivery time is opening period + in-house production time + goods receipt processing time. It is expressed in workdays. The forecast period is taken from the material master record and expressed in workdays.

If the material is procured externally, the delivery time is goods receipt processing time + planned delivery time. It is expressed in calendar days. The forecast period is taken from the material master record and expressed in calendar days.

MAD = Stands for Mean Absolute Deviation (MAD) measures the accuracy of the forecast by averaging the alleged error [12]. The system uses the original forecast and Ex-Forecast to identify the difference/accuracy of the forecast, and an average of the absolute difference is MAD.

Note: You can specify a minimum safety stock. If the safety stock calculation result is lower than this limit, the safety stock is automatically set to this minimum value. You enter the minimum safety stock in the material master record (the MRP 2 screen).

Table 2. Service level vs Factor R

SL (%)	Factor R
50	0
55	0.16
60	0.31
65	0.49
70	0.65
75	0.84
80	1.05
85	1.30
90	1.60
95	2.06
98	2.56
99	2.91
99.5	3.20
99.8	4.00

6. Solutions Strategy in SAP to Carry Out Automatic Reorder Point Planning

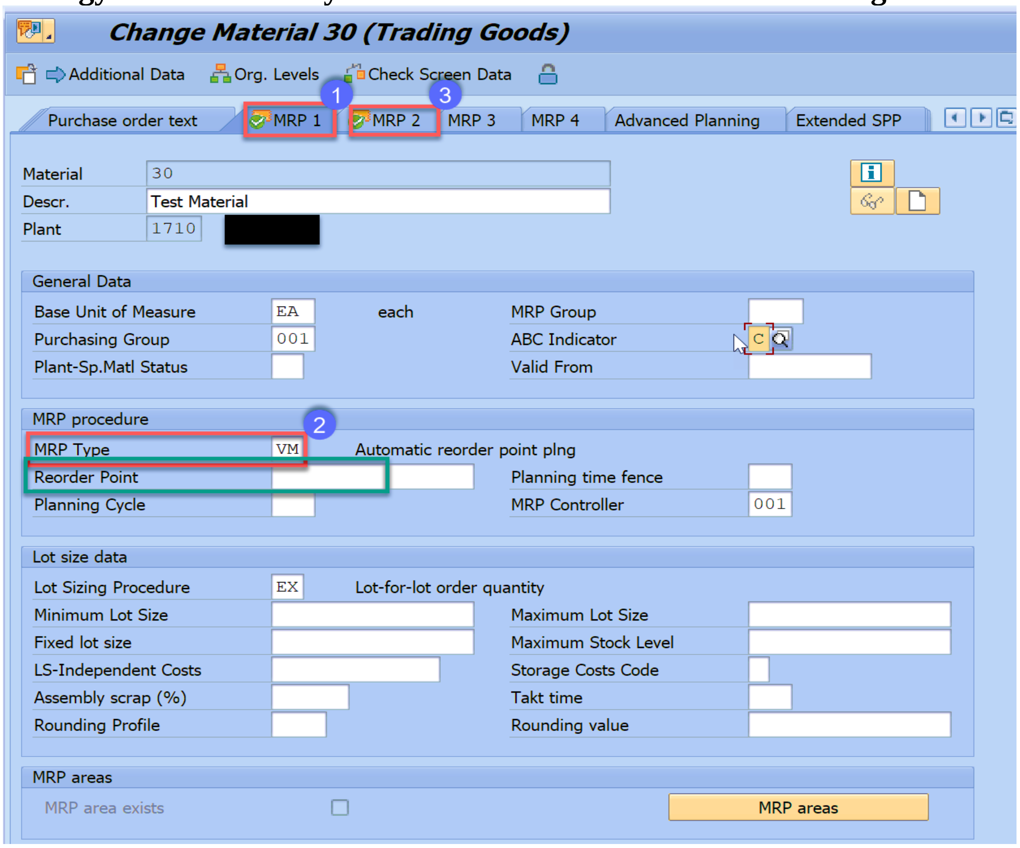


Fig. 2 MRP 1 view

Note: Validate that Reorder Point is blank.

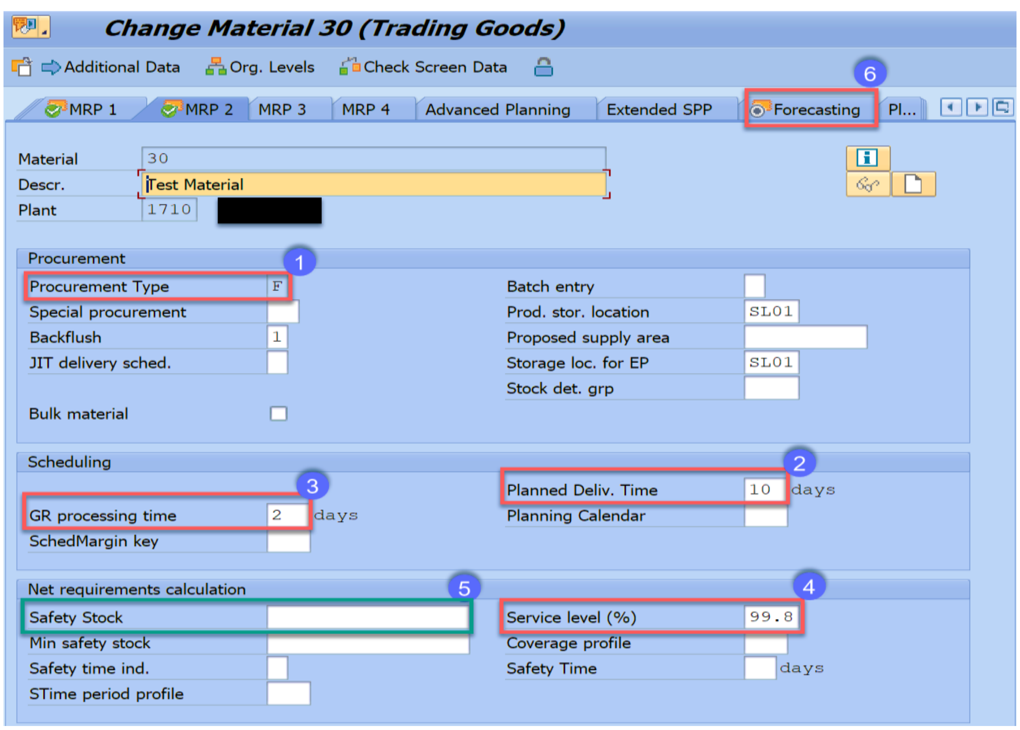


Fig. 3 MRP 2 view

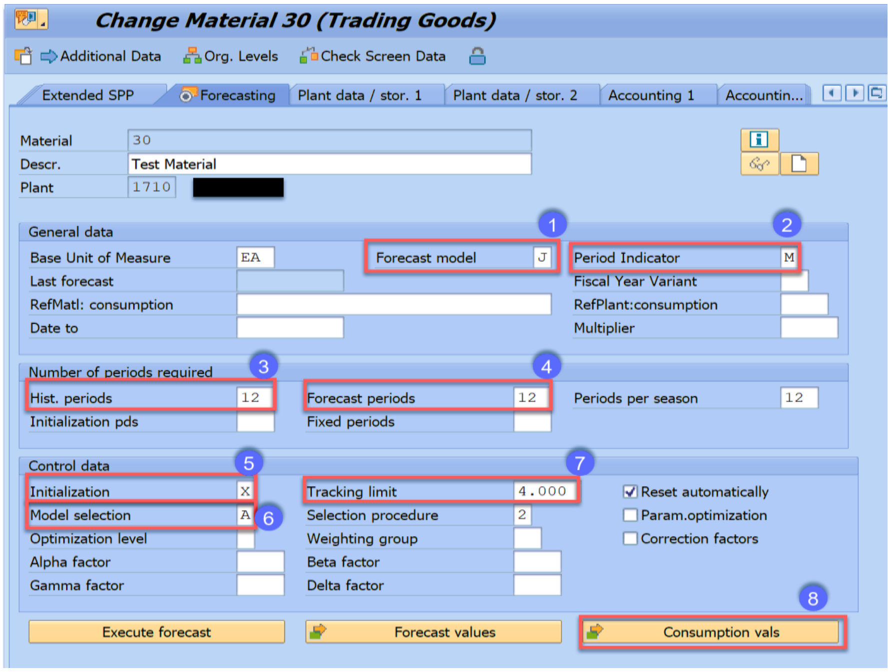


Fig. 4 Forecasting view

Note: Forecasting model: J – Automatic model selection and Initialization: X – Initialization by system

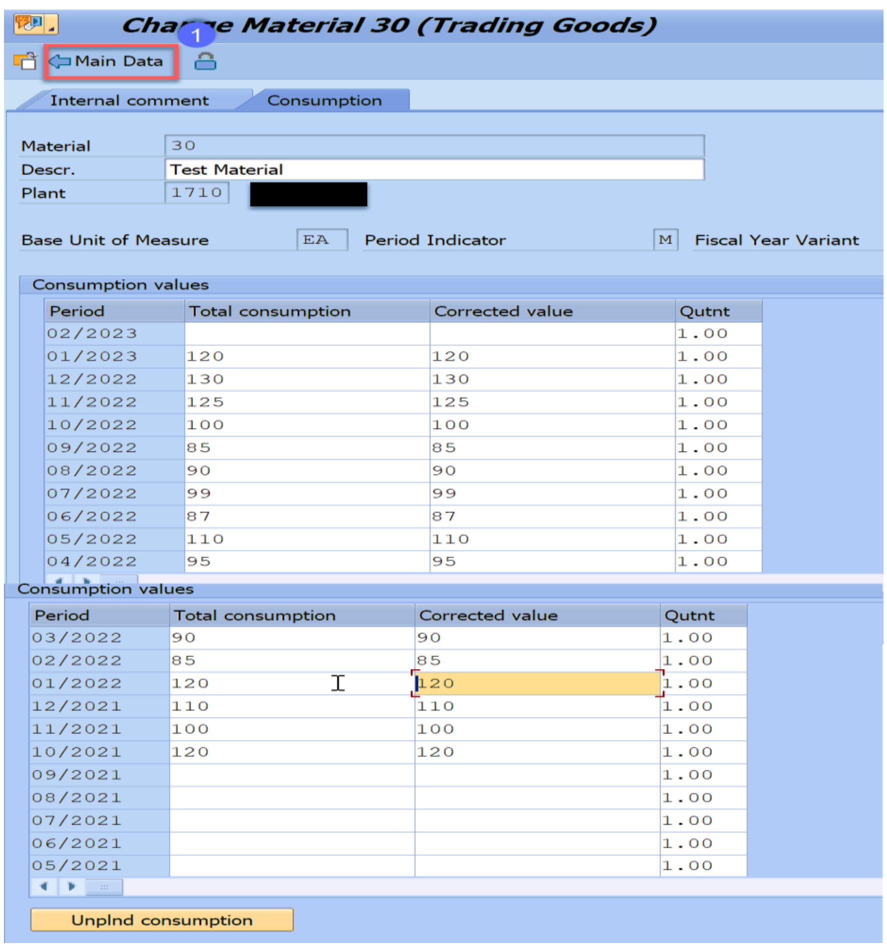


Fig. 5 Consumption data update

Note: Consumption data can be loaded as part of new item creation/migration or auto-captured based on movement types (planned vs Unplanned) [13,14].

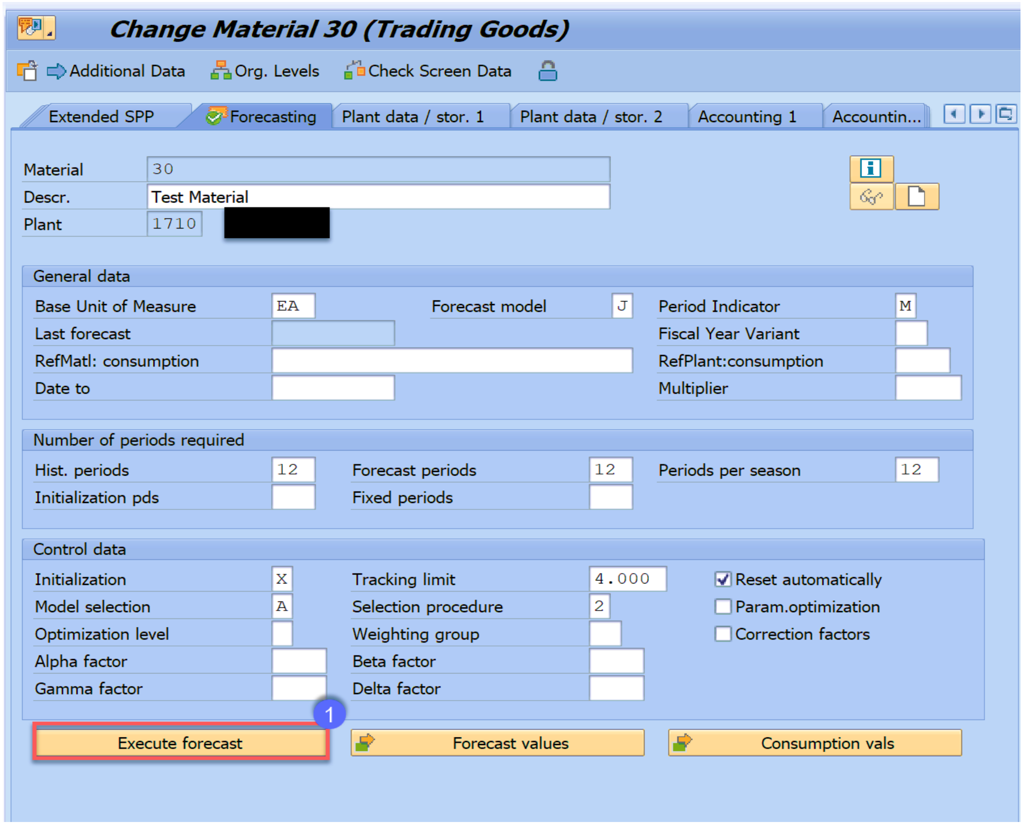


Fig. 6 Execute forecast

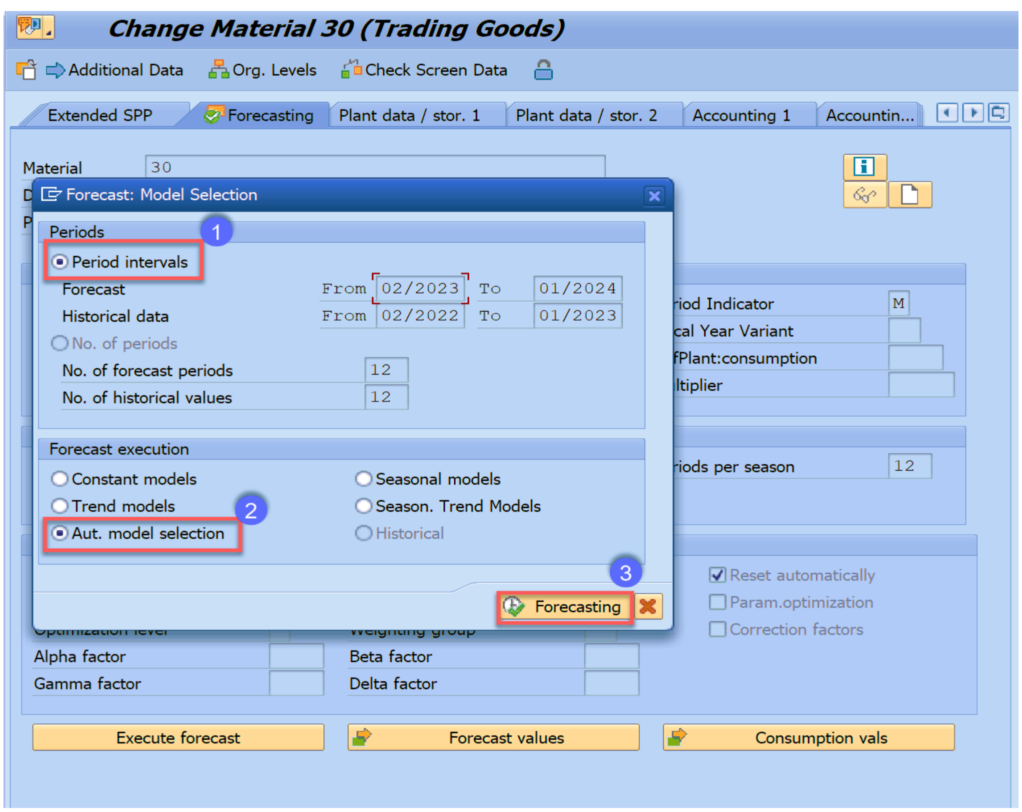


Fig. 7 Forecast: Model selection

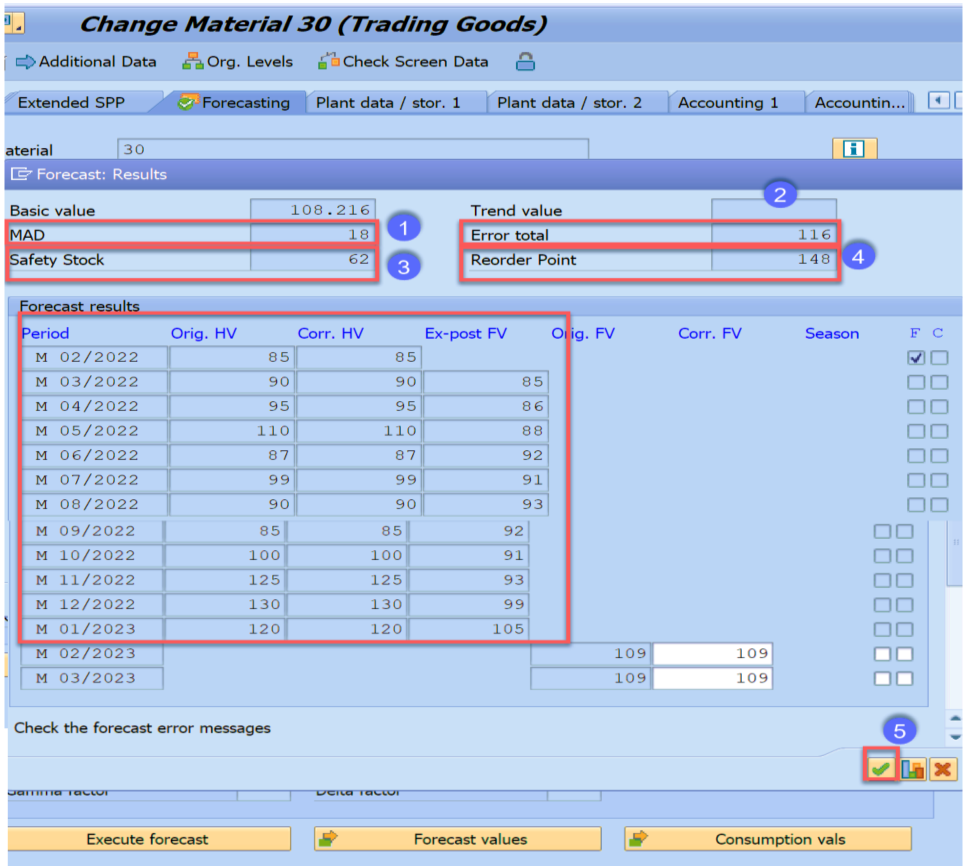


Fig. 8 Calculation of MAD, error total, safety stock, reorder point

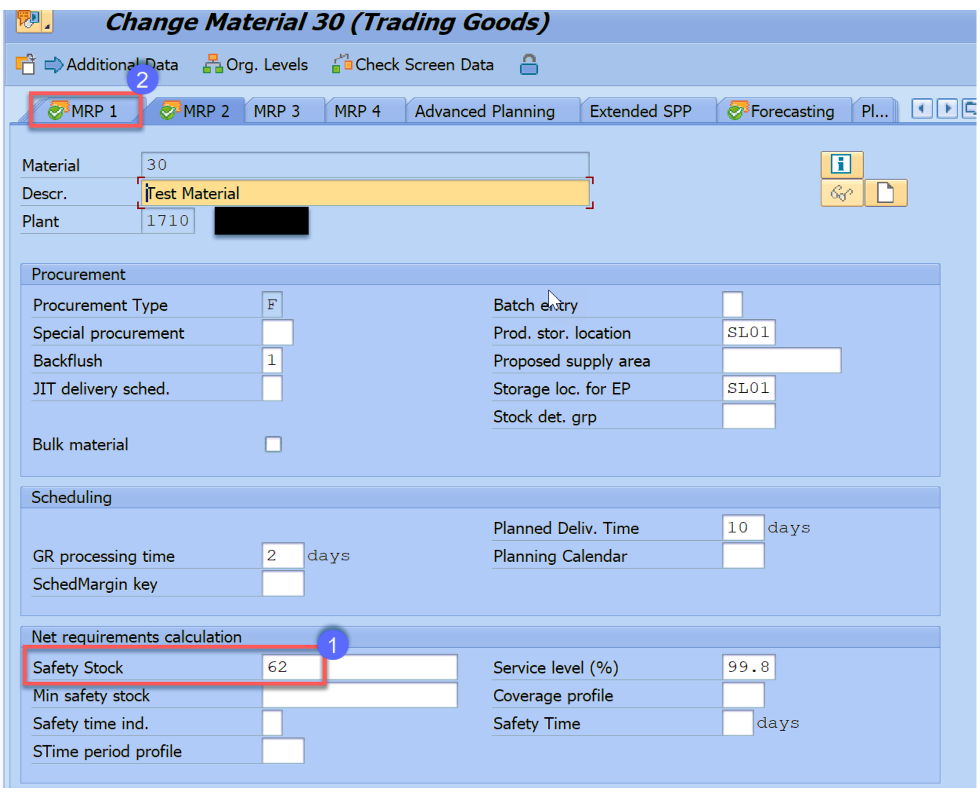


Fig. 9 Safety stock update on MRP 2 view

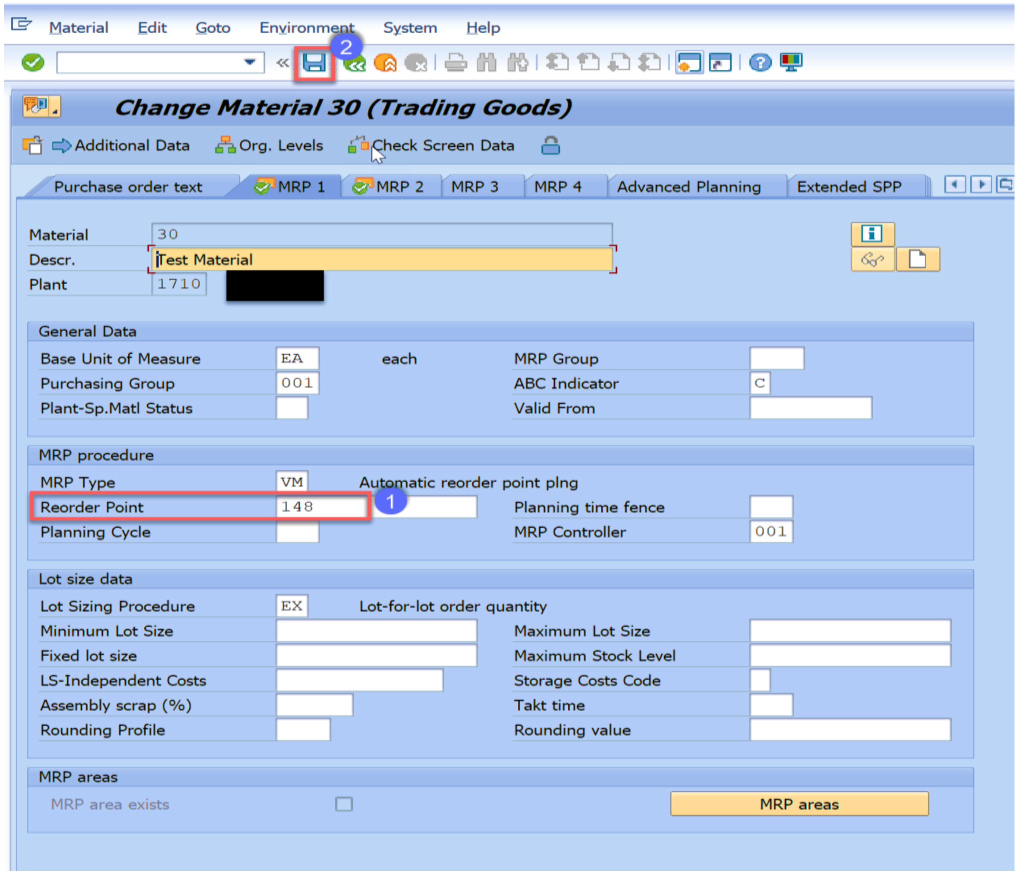


Fig. 10 Reorder point update on MRP 1 view

Below is a detailed explanation of how Error Total & MAD is calculated. The idea is to know MAD calculation because it calculates safety stock and eventually automatic reorder point calculation.

6.1. Error Total

A forecast error is a difference between the same period's forecast and actual consumption values.

The error total [15] describes the sum of the deviations over the periods, considering the plus or minus sign.

The error total helps check the validity of the forecast model in operation. If a model is still valid, you can assume that the error total is distributed normally and has an average of zero.

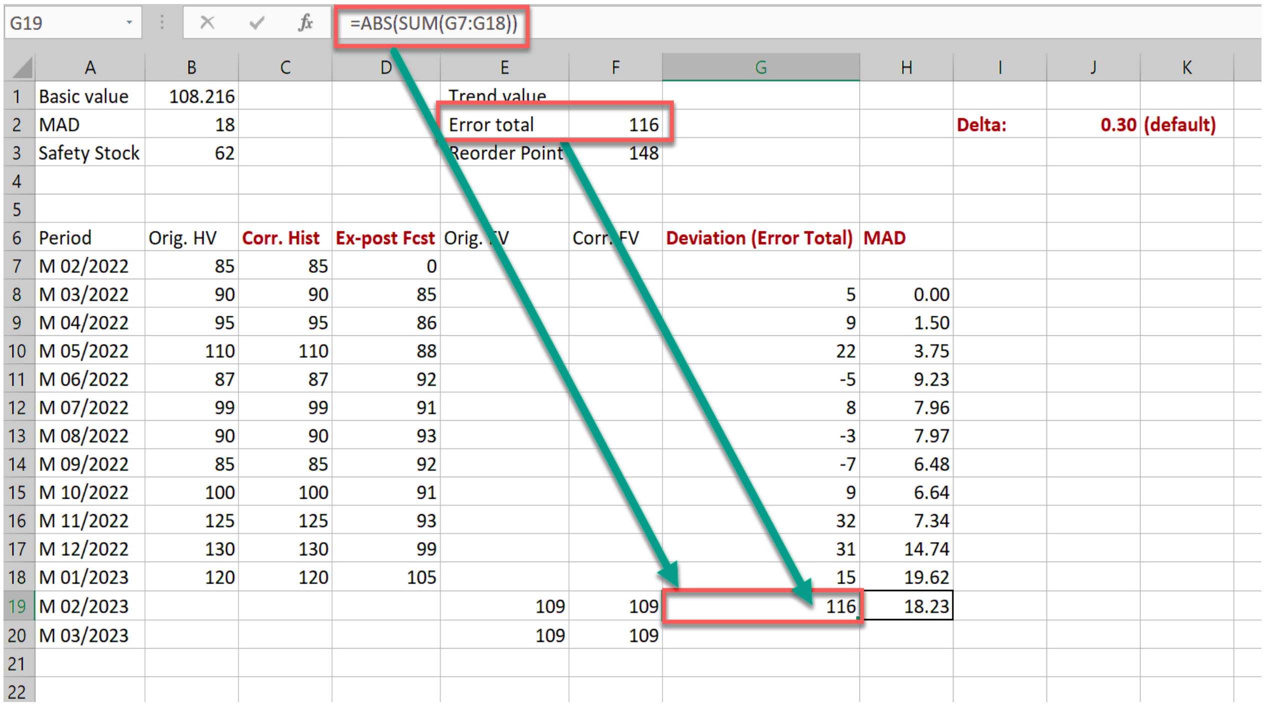
G8 =C8-D8

	A	B	C	D	E	F	G	H	I	J	K
1	Basic value	108.216			Trend value						
2	MAD	18			Error total	116			Delta:	0.30	(default)
3	Safety Stock	62			Reorder Point	14[illegible]					
4											
5											
6	Period	Orig. HV	Corr. Hist	Ex-post Fcst	Orig. FV	Corr. FV	Deviation (Error Total)	MAD			
7	M 02/2022	85	85	0							
8	M 03/2022	90	90	85			5	0.00			
9	M 04/2022	95	95	86			9	1.50			
10	M 05/2022	110	110	88			22	3.75			
11	M 06/2022	87	87	92			-5	9.23			
12	M 07/2022	99	99	91			8	7.96			
13	M 08/2022	90	90	93			-3	7.97			
14	M 09/2022	85	85	92			-7	6.48			
15	M 10/2022	100	100	91			9	6.64			
16	M 11/2022	125	125	93			32	7.34			
17	M 12/2022	130	130	99			31	14.74			
18	M 01/2023	120	120	105			15	19.62			
19	M 02/2023				109	109	116	18.23			
20	M 03/2023				109	109					
21											

Fig. 11 Error Total (ET)

6.2. ET Calculation

As shown above, based on the Original forecast, the system carries out the Ex-Post forecast. Difference between the Corrective Historical Forecast – Ex post forecast gives Deviation in that period. The sum of each deviation converted to absolute value gives Error Total. Below is the formula.

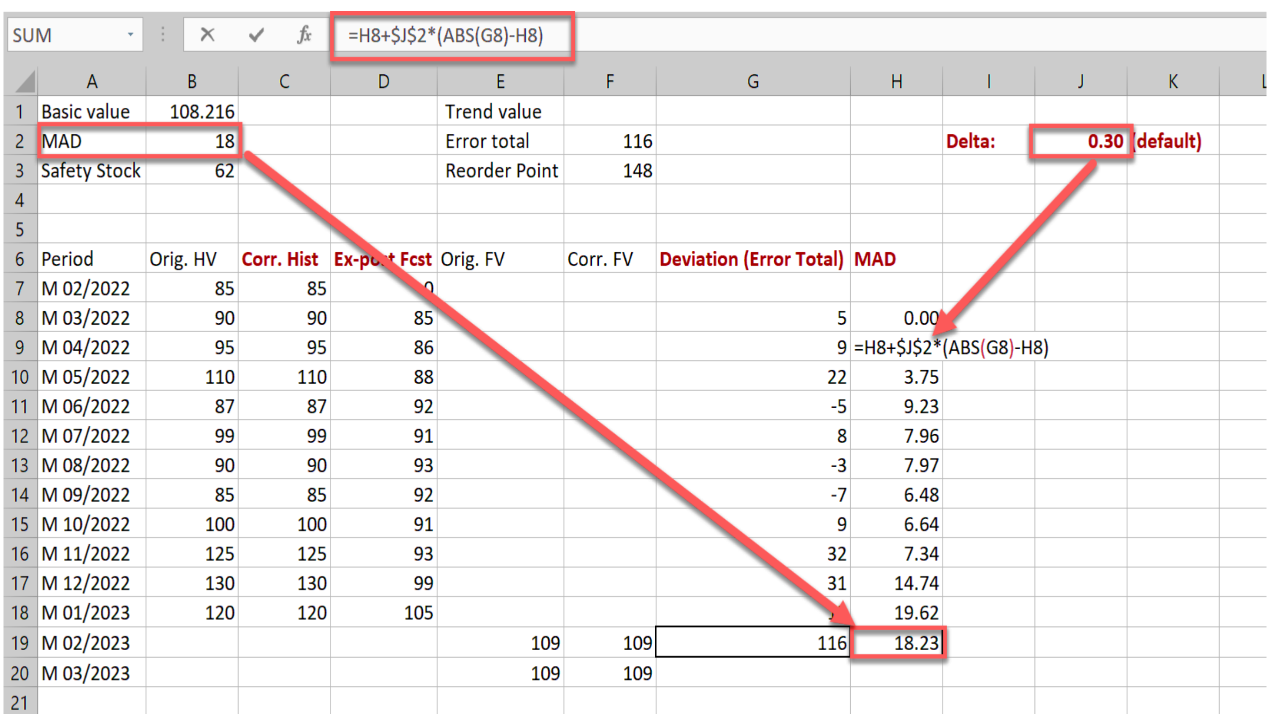

G19 =ABS(SUM(G7:G18))

	A	B	C	D	E	F	G	H	I	J	K
1	Basic value	108.216			Trend value						
2	MAD	18			Error total	116			Delta:	0.30	(default)
3	Safety Stock	62			Reorder Point	148					
4											
5											
6	Period	Orig. HV	Corr. Hist	Ex-post Fcst	Orig. FV	Corr. FV	Deviation (Error Total)	MAD			
7	M 02/2022	85	85	0							
8	M 03/2022	90	90	85			5	0.00			
9	M 04/2022	95	95	86			9	1.50			
10	M 05/2022	110	110	88			22	3.75			
11	M 06/2022	87	87	92			-5	9.23			
12	M 07/2022	99	99	91			8	7.96			
13	M 08/2022	90	90	93			-3	7.97			
14	M 09/2022	85	85	92			-7	6.48			
15	M 10/2022	100	100	91			9	6.64			
16	M 11/2022	125	125	93			32	7.34			
17	M 12/2022	130	130	99			31	14.74			
18	M 01/2023	120	120	105			15	19.62			
19	M 02/2023				109	109	116	18.23			
20	M 03/2023				109	109					
21											
22											

Fig. 12 Error Total (ET) calculation

6.3. MAD

Below shows how MAD is calculated [16]:


SUM =H8+$J$2*(ABS(G8)-H8)

	A	B	C	D	E	F	G	H	I	J	K
1	Basic value	108.216			Trend value						
2	MAD	18			Error total	116			Delta:	0.30	(default)
3	Safety Stock	62			Reorder Point	148					
4											
5											
6	Period	Orig. HV	Corr. Hist	Ex-post Fcst	Orig. FV	Corr. FV	Deviation (Error Total)	MAD			
7	M 02/2022	85	85	0							
8	M 03/2022	90	90	85			5	0.00			
9	M 04/2022	95	95	86			9	=H8+$J$2*(ABS(G8)-H8)			
10	M 05/2022	110	110	88			22	3.75			
11	M 06/2022	87	87	92			-5	9.23			
12	M 07/2022	99	99	91			8	7.96			
13	M 08/2022	90	90	93			-3	7.97			
14	M 09/2022	85	85	92			-7	6.48			
15	M 10/2022	100	100	91			9	6.64			
16	M 11/2022	125	125	93			32	7.34			
17	M 12/2022	130	130	99			31	14.74			
18	M 01/2023	120	120	105			[illegible]	19.62			
19	M 02/2023				109	109	116	18.23			
20	M 03/2023				109	109					
21											

Fig. 13 MAD calculation

6.4. Tracking Signal (TS)

The tracking signal (TS) [17] helps identify structural interruptions by putting the error total to MAD. If the error total rises or falls sharply to MAD, the consumption and forecast move further apart.

- TS = Error Total / MAD
- The TS is compared to the tracking limit specified in the material master. If the TS exceeds the tracking limit, the MRP controller receives an exception message in the form of a note advising that the forecast model should be checked.
- The system automatically sets the tracking limit. The default value is 4. However, you can change it while maintaining the material master record.

The other alternatives are to run the program and calculate automatic reorder points.

- Individual forecast: T-code: MP30 [18] (or T-code: MM02)
- Total forecast: T-code: MB38 [19] or MPBT.

You can print the list online or in the background mode. T-code: MP39 [20] or MPDR [21].

7. MRP Planning with Conversational AI

In the context of SAP MRP (Materials Requirements Planning), the combination of Conversational AI, Robotic Process Automation (RPA), and Artificial Intelligence (AI) [22] can revolutionize the daily planning process. With Conversational AI, planners can interact with the system more naturally and intuitively, using voice or chat interfaces to communicate their requirements and receive real-time updates. This eliminates the need for manual data entry and enhances user experience.

RPA [23] plays a crucial role in automating repetitive tasks involved in the planning process. For example, it can perform data extraction, validation, and consolidation from various sources, ensuring accurate and reliable information for decision-making. By automating these routine activities, RPA saves time and reduces the risk of errors, enabling planners to focus on higher-value tasks.

AI [24,25] algorithms bring advanced analytical capabilities to the MRP context. They can analyze historical data, market trends, and demand patterns to generate accurate demand forecasts. AI can also recommend optimal inventory levels, reorder points, and production schedules based on demand fluctuations and supply chain constraints. This intelligent decision support empowers planners to make informed decisions that result in better throughput and optimized resource utilization.

Integrating Conversational AI, RPA, and AI in SAP MRP aims to transform planning into a more efficient, engaging, and intelligent experience. As a result, planners can navigate complex scenarios, anticipate potential issues, and confidently make data-driven decisions. In addition, this comprehensive solution optimizes the utilization of resources, reduces planning cycle times, and ultimately enhances the overall performance of the supply chain within the SAP MPR framework.

8. Results

8.1. Automatic Reorder Point

The table 3 provides an overview of the financial benefits derived from the implementation of automatic reorder point calculation. It compares the average inventory value before and after the implementation to showcase the incremental improvements achieved. Before the implementation, the average inventory value on hand stock stood at a certain level. However, after introducing the automatic reorder point calculation, there was a significant enhancement in inventory management, resulting in a reduction of 26% in average inventory value. This improvement translates to an impressive average savings of $910 million, showcasing the substantial financial impact of adopting the automatic reorder point calculation system.

8.2. Impact of Conversational AI

Implementing AI-enabled Material Requirements Planning (MRP) [26,27]in manufacturing resulted in a 25% increase in production throughput, leading to annual cost savings of $500,000 and a 15% reduction in idle time [26]. The AI algorithms optimized material planning and scheduling, improving resource coordination and minimizing bottlenecks. This case study showcases the transformative impact of AI in revolutionizing supply chain management and driving operational excellence in the manufacturing industry.

Table 3. overview of the financial benefits derived from the implementation of automatic reorder point calculation

Yearly Revenue ($ Billion)	Average Inventory Value Before Implementation ($ in Million)	Average Inventory Value After Implementation ($ in Million)	% Improvement
$1.2	$900	$660	26.67
$1.7	$1,275	$952	25.33
$2.0	$1,500	$1,120	25.33
Average			**25.78**

Let us consider this practical example of how the integration of Conversational AI, RPA, and AI has enhanced the SAP MRP system in the manufacturing company.

The planner manages multiple products' inventory and production schedules across different warehouses in this study. Traditionally, the planner would have to review inventory levels manually, forecast demand, and decide on replenishment and production orders. This process can be time-consuming and prone to errors, leading to inefficiencies and delays.

With the integration of Conversational AI, the planner can now interact with the SAP MRP system using natural language interfaces. For example, the planner can ask questions or provide instructions using voice or chat, such as "What is the current inventory level of Product A?" or "Create a production order for Product B with a quantity of 100 units."

The Conversational AI system, powered by advanced natural language processing algorithms, understands the intent and context of the planner's queries and commands. It retrieves real-time data from the SAP MRP system, including inventory levels, production schedules, and demand forecasts.

Meanwhile, RPA bots work in the background, automating routine tasks and data extraction. They gather information from various sources, such as sales orders, supplier data, and production logs, and update the SAP MRP system with accurate and up-to-date information. This automation eliminates manual data entry and ensures data integrity throughout the planning process.

As the planner interacts with the Conversational AI system, AI algorithms analyze historical data, market trends, and external factors to generate accurate demand forecasts. These forecasts help the planner make informed decisions on inventory levels, production quantities, and supplier management. In addition, the AI algorithms continuously learn from the planner's actions and feedback, refining their predictive capabilities over time.

The seamless integration of Conversational AI, RPA, and AI within the SAP MRP system empowers the planner with real-time insights, automated processes, and intelligent recommendations. It streamlines the planning workflow, reduces manual effort, and enhances decision-making accuracy. Ultimately, this integration results in improved throughput, optimized inventory management, and increased operational efficiency in the manufacturing company.

9. Conclusion

In conclusion, SAP's automatic reorder point calculation feature presents substantial advantages for businesses seeking to enhance their inventory management practices. By accurately determining the optimal time for replenishing stock, organizations can streamline their supply chain operations, minimize the occurrence of stockouts, and reduce carrying costs associated with excessive inventory levels.

Moreover, integrating this feature with other SAP modules allows for a holistic supply chain management approach, promoting enhanced data visibility and facilitating precise demand forecasting.

Furthermore, utilizing SAP's automatic reorder point calculation significantly improves organizational decision-making capabilities. By providing real-time insights into inventory levels and demand patterns, businesses can make informed decisions promptly, effectively addressing fluctuations in customer demands and market conditions. This enhanced decision-making capacity enables companies to remain agile and proactive in their inventory management strategies.

On the other hand, the goal of AI-powered Material Requirements Planning (MRP) is to elevate inventory management to new heights. Leveraging advanced algorithms and real-time data, AI-powered MRP empowers organizations to achieve optimal inventory levels, improving operational efficiency and gaining a competitive edge in the market. This transformative approach to inventory management also optimizes supply chain operations, enhances decision-making processes, and facilitates seamless coordination among different departments.

However, it is essential to note that the successful implementation of automatic reorder point calculation and AI-powered MRP in SAP necessitates careful consideration of various factors. These factors include ensuring data accuracy, proper system configuration, and alignment with business goals and processes.

Moreover, effectively adopting and utilizing these features requires adequate training and change management initiatives. By investing in these crucial aspects, organizations can ensure a smooth transition and maximize the potential benefits offered by SAP's automatic reorder point calculation and the vision of AI-powered MRP.

Harnessing the power of SAP's automatic reorder point calculation and striving toward the vision of AI-powered MRP can revolutionize inventory management practices within organizations. By leveraging these advanced technologies, businesses can unlock their full potential and drive operational efficiency, cost savings, and improved customer satisfaction. They are embracing these innovative solutions to position organizations to stay at the forefront of the rapidly evolving supply chain management landscape and capitalize on the opportunities presented by the digital era.

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