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A Study On Implementation of Material Requirement Planning (MRP) For Manufacturing Industries

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ABSTRACT - This review paper delves into a detailed exploration of how Materials Requirement Planning (MRP) is implemented in manufacturers catering to Small and Medium-Sized Firms and industries. The study thoroughly discusses the implementation process, associated factors, and the outcomes derived from conducting MRP[20]. The primary objective is to understand the intricate relationships between these factors. The persistent focus of this study is to identify the essential elements of MRP and apply them to address a specific problem selected for investigation. The main aim of MRP, as highlighted in the review, is to effectively manage dependent demand items while achieving high inventory turnover and minimizing payable costs[20]. The study addresses a common yet impactful problem prevalent in Manufacturing and small to medium-sized industries. It strives to comprehend the multitude of factors contributing to this issue, followed by a comprehensive discussion of potential solutions. The subsequent application of the solution procedures leads to the presentation of results that affirm the beneficial nature of executing Materials Requirement Planning (MRP).The review paper concludes with a valuable suggestion for manufacturing industries, emphasizing the importance of consistently prioritizing improvements in aspects that positively contribute to the implementation process factors of Material Requirement Planning (MRP). This recommendation aims to guide manufacturing entities in enhancing their processes and overall efficiency within the framework of MRP implementation.

KEYWORDS-Material Requirement Planning(MRP), Material Requirement Management (MRM), Manufacturing Industries., Demand forecasting, Bill of Materials (BOM), Master Production Schedule (MPS), Demand management, Supply chain management, Work order, Production scheduling.

I. INTRODUCTION

In today's challenging and costly market, industries face the imperative of meeting customer satisfaction. A crucial metric for service quality is the timely delivery of ordered items, as tardy deliveries can lead to a loss of customer goodwill and market share, especially for small-scale industries focusing on custom products rather than standardized parts. To address this, Material Requirement Management (MRM) plays a pivotal role in manufacturing systems. Calculating the quantity and timing of raw material orders involves processing vast amounts of data from various manufacturing functions, necessitatin g reliable and accurate information. In virtually all industrial organizations, materials constitute a significant portion of costs in the production of goods and services. To ensure efficiency, precise information must be available to different industry departments. The adoption of computer-based information systems becomes essential for achieving this efficiency. Recent interest in production engineering has seen the development of Material Requirement Planning (MRP) systems. Raw material inventories play a crucial role in plant operations, directly impacting production processes and company profits. Effective management of raw material inventory is vital, and MRP serves as a method for ordering materials. The current MRP method is not only a material ordering tool but also a planning and management function. Manufacturing industries, with their unique characteristics, require timely scheduling of material, production, and processes. However, practical challenges often arise in material provision. Material Requirements Planning (MRP) has emerged as a widely used method, particularly in manufacturing and medium-sized industries, offering a solution for inventory planning. The review underscores the necessity of collecting data and relevant factors associated with the implementation of Material Requirements Planning (MRP) in manufacturing and small industrial sectors. MRP system development aims to address gross requirements, determine lot sizes, plan net requirements, and establish planned orders for specific parts (item codes) within defined time periods. The MRP system development is carried out for the resolve

(a) To know the gross requirement
(b) Determine Lot Sizes
(c) Net requirement Plan(d) Planned order of a particular part (item code) in a particular period of time.

II. LITERATURE REVIEW

As per Orickly [12], Material Requirements Planning (MRP) encompasses a collection of data, associated tools and techniques, and rational procedures facilitating decisions pertaining to Master Production planning and the scheduling of final products, sub-assemblies, or end items. The net requirements, denoting the quantity of components essential to fulfill the Master Production Schedule, guide the ordering of necessary components. Gaspersz [7] further clarifies MRP as a system designed for planning and controlling orders and inventory related to dependent

demand items, characterized by intermittent and uneven demand patterns.In summary, Material Requirements Planning (MRP) emerges as an information system employing computer-based inventory management to oversee raw materials and components subjected to dependent demand or derived requests. Extensive literature on Materials Management and MRP exists, including review papers, books, and articles in reputable journals. Notable methods explored in the literature encompass the requirements of MRP for Make-to-Order Companies [13] by J. Hoey et al., scheduling and order release [13] by James R. Ashby, optimal positioning of safety stock in MRP [11] by A.G. Lagodimos et al., and product structure complexity [5] by W.C. Benton and R.Based on this literature survey, the authors aim to delve into the factors influencing the implementation process and outcomes of Material Requirement Planning (MRP) in both the manufacturing industry and small-scale enterprises. Their interest lies in establishing the relationships between these identified factors through a comprehensive examination.

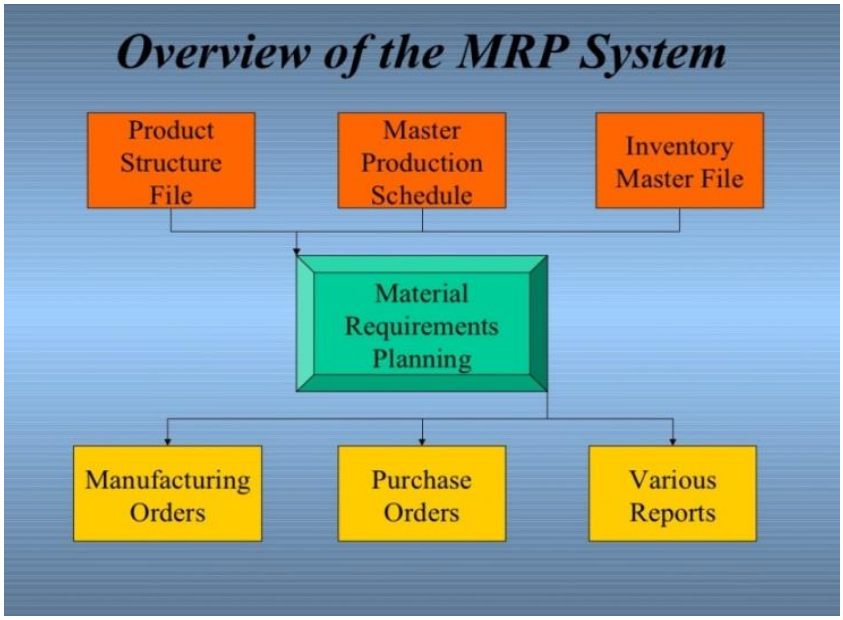

Figure 1: Material Requirements Planning (MRP) Systems [20]

III. THE PURPOSE OF MRP SYSTEM

The terms and logic encompassed by evolving MRPII/ERP systems play a crucial role in enhancing organizational functions. Specifically, these systems provide the following functions concerning inventory management [3].

A. Determining Parts and Materials

Assessing the quantity of parts, components, and materials required for each end item in production. Optimizing Ordering: Identifying the right part, right quantity, and right time to order parts, along with providing time schedules for ordering materials and parts.

B. Maintaining Bill of Materials

Sequencing the assembly parts of the final product through a bill of materials, also known as a "schematic" or "product structure tree."In terms of priorities, the system ensures orders are placed for the correct due date, keeping the due date valid. Capacity planning is another crucial aspect, aiming to optimize the use of plant and equipment capacity accurately. Aligned with the fundamental philosophy of Material Requirements Planning, the system dictates that materials should be expedited when their absence would delay the overall production schedule and de-expedited when the schedule falls behind, postponing their need [10].

MRP systems, when implemented correctly, yield numerous benefits for firms, including the ability to competitively price products, reduce sales prices, minimize inventory, enhance customer service, respond better to market demands, modify the master schedule, reduce setup and tear-down costs, and decrease idle time. Additionally, MRP systems offer advance notice, enabling managers to preview the planned schedule before actual release orders. They guide decisions on when to de-expedite or expedite, delay or cancel orders, and adjust order quantities and due dates. Moreover, these systems aid in capacity planning.MRP is a systematic approach to planning, scheduling, and managing the procurement and production of materials within an organization. Below is an organized review of the literature on Material Requirements Planning:

C. Historical Development

The literature traces the historical development of MRP from its inception in the 1960s, highlighting key contributors and milestones. The evolution from early manual systems to sophisticated computer-based MRP systems is discussed. Basic Principles of MRP:A review of the fundamental principles underlying MRP, such as the bill of materials (BOM), inventory management, lead time considerations, and demand forecasting.

Exploration of how MRP helps in optimizing production processes and reducing inventory costs. Integration with

Information Technology: Examination of the role of information technology in the implementation and success of MRP systems. Insights into the integration of MRP with Enterprise Resource Planning (ERP) systems for a more comprehensive and integrated approach.

- ***Challenges in MRP Implementation***

Identification and analysis of common challenges faced by organizations during the implementation of MRP systems.
Factors such as data accuracy, system compatibility, and organizational resistance are explored.Benefits of MRP:
A review of the benefits associated with the successful implementation of MRP systems, including improved production planning, enhanced inventory management, and better resource utilization.

- ***MRP in Different Industries***

An exploration of how MRP principles are applied in various industries, including manufacturing, retail, and service sectors. Case studies and examples illustrating successful MRP implementations in specific industries.
Advancements in MRP:Review of recent advancements in MRP technology and methodologies, such as the incorporation of artificial intelligence, machine learning, and real-time data analytics. Exploration of how Industry 4.0 and the Internet of Things (IoT) impact MRP.

- ***Environmental and Sustainable Considerations***

An analysis of how MRP can be aligned with sustainable practices and environmental considerations in modern supply chain management. Future Directions: Speculation and discussion on the future trends and directions of MRP, considering the evolving technological landscape and changing business dynamics.

- ***Comparative Studies***

Comparative analysis of different MRP systems, methodologies, and their effectiveness in different organizational settings

IV. LIMITATIONS OF MRP:

The implementation of Material Requirements Planning (MRP) systems has traditionally been based on the assumption of a deterministic environment, where demand and lead times are considered deterministic. However, in actual manufacturing environments, this assumption is consistently violated, leading to challenges in fulfilling MRP's promises. While MRP aims to determine the gross and exact needs of enterprises in inventory units, it exhibits deficiencies in certain areas such as obtaining the Master Production Schedule (MPS), determining lot sizes, managing customer demands, conducting capacity requirement planning, and optimizing inventory levels and locations [5].The APICS literature identifies four primary problems contributing to most MRP system failures:

A. Lack of Top Management Commitment:

The commitment of top management is often lacking in MRP system implementations.

B. Lack of Education

Users of the system may lack the necessary education and understanding of its functionalities.

C. Unrealistic MPS

Unrealistic Master Production Schedules (MPS) can undermine the effectiveness of the MRP system.

D. Inaccurate Data

Inaccuracies in data, including Bills of Materials (BOM) and inventory records, pose significant challenges. Inaccuracy in bills of materials and inventory databases is a common issue with MRP systems, impacting material and capacity plans. Addressing this requires substantial adjustments in strategic management approaches. Coping with uncertainties in the manufacturing environment is an ongoing concern, and MRP systems often treat uncertainties as "controllable" elements [13].Emerging challenges include the use of fixed lead times in MRPII/ERP systems, ignoring real-life uncertainties in supply availability and variability in queue, set-up, and run times on the shop floor. The net requirement patterns generated may not consider the simultaneous availability of resources, and predetermined scrap rates can render due dates uncertain without appropriate corrective measures.
Key shortcomings of MRP systems include limitations on the planning horizon, complexity in generating optimal schedules, and a single-stage approach to lot sizing, which may not align with the multistage nature of the MRP process [7]. Commonly observed deficiencies in MRP systems encompass:

- ***Planning Horizon Limitations***

MRP systems face constraints on the length of the planning horizon over which optimal order schedules can be found, especially when considering alternative schedules and long-term inventory optimization.

- ***Complex Procedures***

The complexity of procedures required for optimal or near-optimal schedules can limit the practical use of MRP systems, making them challenging for operating personnel to understand.

- ***Lot Sizing Challenges***

Existing methods often treat lot sizing as a single-stage process, disregarding the multistage nature of MRP. Lot sizing techniques must consider all items related horizontally and vertically throughout the bill of material (BOM) structures.Ongoing research areas explore the impact of forecast processing frequency, MRP procedure running frequency, and lead time uncertainty [7]. Regardless of the type of MRP/ERP systems used, addressing uncertainty within MRP-planned manufacturing processes requires a comprehensive consideration of all combinations of uncertainties to prevent discrete examinations on uncertainty. Developing an uncertainty categorization structure using systems theory can help categorize uncertainty into input and process, addressing uncertainties in the supply and demand chain of the manufacturing process.

V. USAGE AND APPLICATION MODES OF MATERIAL PLANNING METHODS

Material planning operates at a tactical planning level, aiming to balance supply and demand by initiating, controlling, and monitoring manufacturing and purchasing

orders. This ensures an uninterrupted material flow and value-adding activities in manufacturing. Addressing the "When to order/deliver?" and "How much to order?" questions, which are time-related and quantity-related, respectively, is fundamental in material planning.Several well-known material planning methods, including re-order point, fixed interval ordering, run-out time planning, MRP, and Kanban, are widely used and addressed in this study [12][13][18[19]. While these methods share the common objective of answering the two basic material planning questions, their application varies.Material planning methods utilize specific mechanisms to address both time and quantity-related aspects, considering uncertainties in balancing supply and demand. While the quantity mechanisms are generally similar across methods, the timing mechanisms are method-specific. Proper application involves selecting a method suitable for the context and ensuring correct determination and periodic review of planning parameters, such as lot sizing, safety mechanisms, lead times, planning frequency, and re-planning strategies.
MRP II utilizes the extended BOR to project shortages at specific times, providing advanced notice to departments for necessary remedial actions, such as hiring or training labor or acquiring support resources. MRP II is capable of monitoring machine loads, identifying the need for additional machines or subcontractors. Notably, MRP II treats cash flow similar to materials, calculating the cost of all planned order releases and generating a cash flow forecast. The system includes extra modules beyond closed-loop MRP, creating additional feedback loops

VI. DISCUSSION

The comprehensive solution to the matrix is provided in the form of detailed the findings indicate that, prior to MRP implementation, planned order releases accounted for less than 75% of the total. Post MRP implementation, a significant improvement is observed, with 97% of orders successfully completed on time. Only a minor percentage, 2%, experienced completion within 1 to 2 days after the designated due date.

A. Implementation of MRP Systems

- Challenges and best practices in implementing MRP systems.
- Evaluating the impact of MRP on production efficiency.
- Case studies of successful MRP system implementations.

B. Integration of MRP with ERP Systems

- The role of MRP in enterprise resource planning (ERP).
- Benefits and challenges of integrating MRP with other business systems.
- Strategies for seamless integration and data synchronization.

C. Optimizing Inventory Management with MRP

- Balancing inventory levels with customer demand.
- Just-in-Time (JIT) vs. MRP approaches to inventory management.
- Reducing carrying costs and minimizing stockouts with MRP.

D. Forecasting and Demand Planning

- The importance of accurate demand forecasting in MRP.
- Methods for improving demand planning accuracy.
- Addressing challenges in predicting future material requirements.

E. Supplier Relationship Management (SRM) in MRP

- Collaborative planning with suppliers in an MRP framework.
- Evaluating supplier performance and its impact on MRP effectiveness.
- Strategies for enhancing communication and collaboration with suppliers.

F. Continuous Improvement in MRP

- Lean principles and their application in MRP processes.
- Kaizen and other continuous improvement methodologies in MRP.
- Case studies of organizations achieving continuous improvement through MRP.

G. Risk Management in MRP

- Identifying and mitigating risks in the MRP process.
- Strategies for handling supply chain disruptions in an MRP environment.
- Incorporating flexibility into MRP systems to address uncertainties.

Table 1: Completion and remaining result

Item	State 1	Completion	Remaining
Lot Size 25	1	2	0
Gross Requirements	11	1	1
Scheduled Receipts	12	1	1
Projected on Hand	23	2	1
Net Requirements	24	0	1
Planned Order Receipts	2	5	4
Planned Order Releases	2	4	0
Maple Academy	3	3	2
Pine College	3	4	2
Oak Institute	**4**	**2**	**1**

VII. CONCLUSION

The core principle of Material Requirements Planning (MRP) revolves around ensuring the timely delivery of the correct materials to the appropriate location. It is imperative for companies to adhere to these factors to remain competitive and consistently enhance corporate profits.
Conversely, any neglect or decline in these crucial factors may necessitate the implementation of Material Requirements Planning (MRP), posing potential harm to the company.Emphasize how the MRP system aligns with the broader goals and objectives of the organization. Discuss how it contributes to the company's competitiveness, sustainability, or strategic initiatives.Summarize the overall impact of the MRP project on the organization. Conclude with thoughts on the future outlook, emphasizing the ongoing importance of effective material planning in a dynamic business environment.

FUTURE SCOPE

A. Real-time Data Integration

MRP systems are likely to become more interconnected with other enterprise systems, enabling real-time data integration. This can enhance agility and responsiveness to changes in demand, supply chain disruptions, and other dynamic factors.

B. Cloud-Based MRP Solutions

Cloud computing can offer more flexibility, scalability, and accessibility for MRP systems. Cloud-based solutions can facilitate collaboration among different stakeholders and provide easier access to the latest updates and features.

C. Mobile Compatibility

With the increasing use of mobile devices, MRP systems may offer mobile compatibility, allowing users to access and manage information on the go, enhancing flexibility and responsiveness.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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