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Spare parts inventory management using an MRP-driven approach through minimum-maximum stock strategy in the manufacturing industry

Animek Shaurya

New Jersey, USA

ABSTRACT

Spare parts inventory management is a crucial element of setting up a successful manufacturing operation to meet customer demands by tracking and managing spare parts for critical equipment bought from original equipment manufacturers (OEM) to develop products for whether discrete manufacturing or process manufacturing types. This study focuses on how material requirements planning (MRP) concepts can be applied in establishing spare parts inventory management modules to cater to the company's needs to order parts, ensure adequate storage, monitor, and use an analytical approach to manage stock levels. The theoretical study provides a framework proposed the study that will help an industry set up its inventory department with defined roles and responsibilities of individuals managing the inventory, which includes working with OEM to identify recommended critical spares, setting up safety stock, defining minimum-maximum stock level, managing internal requisitions and purchase orders for spare parts. The vision and evolution of Industry 5.0 to refocus on the human element while applying new technological advancements and systems previously defined in the era of Industry 4.0 is helping companies to understand that sustainable growth can only be achieved by balancing the advantages offered by automation with the abilities of human to manage them effectively and efficiently.

Key words: Kubernetes, Programming, Software Development, Cloud Computing, Google Cloud Platform

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1. INTRODUCTION

Technological advancement in manufacturing for the past few decades has constantly proposed new challenges for any organization to develop innovative solutions to effectively manage their production capabilities to match the ever-changing market trends and ever-growing customer needs. Companies need to manage their resources effectively to always match these requirements while maintaining high standards of operational procedures to deliver quality products. One of the essential elements of running a successful manufacturing plant is how robust its spare parts inventory management program is. Since the last decade, MRP has been seen as the ultimate method to forecast and manage spare parts inventory. The design and operation of a spare parts management system are complex tasks. They require simultaneous consideration of various factors, e.g., demand volume, demand frequency, criticality of parts, cost or value of the part, procurement, production lead times, etc. It is essential for manufacturing companies in various sectors, e.g., consumer electronics, automobile manufacturing, and industrial machinery. To ensure the availability of spare parts for supporting after-sales repair and maintenance of their products and machinery. Inventory management is about maintaining a stock of parts needed for repair and breakdown during production. It provides tools to the maintenance team of an organization to rely on completing repair work in no time using critical parts needed. The inventory management team is responsible for maintaining enough stock of parts to support these activities without overstocking parts on the shelf to achieve lean management principles. Recently, manufacturing companies have been deploying commissioning processes

when a new piece of equipment is installed for a production line. The new machinery is commissioned before it is handed over to the operation team for production runs. This process is being adopted by almost every company in the manufacturing sector, especially the food and automobile sectors, to comply with the standards of regulation set by the governments of the respective countries where the plant is located. In this process, a validation engineer works with various organization departments to ensure the machinery is correctly installed to provide safe operating conditions for the workers and to ensure operational efficiency is fulfilled as the OEM promises. One of the critical aspects of this process is to ensure that recommended critical spare parts are identified through the help of OEMs, as they are the subject matter experts (SMEs). Identifying spare parts and setting up the safety, minimum, and maximum stock levels helps an organization tackle breakdown and return the machines to operation in no time. This allows for improved machine efficiency and production targets. The company is exposed to colossal production and financial losses without a solid foundation of a robust spare parts inventory management program and a proper strategy to replenish consumed parts during repair.

2. MRP AND SPARE PARTS

MRP is a system that uses the target as a driving factor to determine the components and processes that should be involved in achieving a given target. This system is mainly used for planning and scheduling production targets. It consists of three primary steps: taking inventory of the materials and components on hand, identifying which additional ones are needed, and planning their production or purchase. Material requirements planning (MRP) is a digital inventory management system designed to improve inventory planning, scheduling, production, and management. It identifies what is needed, how much, and when. Using MRP software systems, manufacturers can schedule production requirements to meet demand, check inventory, allocate resources, identify bottlenecks, and find solutions. MRP and spare parts inventory management can be utilized together to achieve the organization's goals. The number of similar pieces of machinery can help determine how many quantities of Specific parts should always be in stock. Using the concept of minimum and maximum stock levels, the safety stock can be defined, and parts can be ordered based on that for replenishment.

Spare parts inventory management involves continuous monitoring of the existing stock of spare parts for various types of machinery in the company, creating a list of recommended critical spares for new machines being installed in the company, adequate storage of parts to improve shelf space and improve accessibility during the need to access parts to perform repairs, tracking the usage of consumed parts in the facility. The backbone of this entire process is based upon the fact that the system quantity is accurate vs. the physical amount of a spare part in stock. A lot of time, it is noticed that technicians knowingly or unknowingly forget to capture the usage of parts that they take out of inventory for repair work. This creates an error when an MRP logic is run to re-order the parts using a minimum-maximum stock strategy. To combat this problem, spare parts team members must be involved to perform spot cycle count checks of parts used during the repair activities in a specific time frame. This logic supports the vision of Industry 5.0, which focuses on the human element while using automation: in this case, a computerized maintenance management system that would automatically run MRP and re-order parts based on the stock level defined. The use of spare parts team members in doing cycle counts ensures that the system quantity matches the physical number of parts being used, and the leadership team is notified in case of discrepancies to find the root cause of the problem and rectify it. Some of the benefits of having a robust spare parts inventory management system are as follows –

A. Reduction in Downtime

The availability of critical spares in stock can significantly reduce operational downtime due to breakdowns as it would equip the maintenance team to get the machine back up through repairs quickly.

B. Improved productivity

Employees can be more productive when they have the necessary tools and parts to do their jobs. This can lead to increased output and revenue for the company.

C. Improved safety

When machinery is properly maintained and has the necessary spare parts, it is less likely to malfunction and cause accidents. This can help to protect employees and customers from injury

A robust spare parts inventory management program in an organization can allow the company to improve the efficiency of its production lines, reduce cost through reduction in downtime due to unavailability of critical spare parts, improve customer satisfaction, and help the company to stay in compliance with regulations set up by the government.

For a given spare part A, the following can be defined-
Minimum stock/Safety stock – X
Maximum stock – Y
When the on-hand quantity of spare part A falls below the safety stock, the MRP orders for the replenishment
Case 1: On-hand qty. ≤ X, the system orders (Y- (on-hand qty.))
Case 2: On-hand qty. > X, the system orders do not trigger any replenishment order

3. SPARE PARTS INVENTORY DATA SETUP

The inventory management team usually does part re-ordering and stocking tasks, consisting of the MRO (Maintenance, Repair, and Operations) buyers, spare parts coordinators, and inventory managers. The spare parts inventory management consists of a few pre-requisite tasks that must be completed before setting up the framework using spare parts inventory management software. These are as follows –

A. Parts identification

The first process is to create a list of recommended critical spare parts by working with the OEM. After completing the list, every part is assigned a part number used to manage the spare in the software module to track inventory. These numbers should be used as much as possible as the manufacturing numbers printed on the parts. When a part breaks or fails on a piece of equipment, it helps technicians to search the part in the database by just using the numbers printed or available on the part itself rather than going into the drawings/manual to identify a part number. When no part number is available on a specific part, the number from the OEM manual/drawings can be used.

B. Categorize based on material group

All the spare parts should be categorized based on the family group they belong to. Some of the below groups can be used as a reference to classify them-

- Pneumatic parts – include solenoids, cylinders, actuators, etc.
- Bearings – include all kinds of bearings like ball bearings, spherical bearings, Roller bearings
- Flange bearing – includes all kinds of flange bearings like 2-bolt flange, 3-bolt flange, etc.
- Motors and Gearbox – Include all different kinds of motors/gearboxes based on horsepower, RPM, and ratio, and they can even be sub-categorized based on the manufacturer.

This helps technicians and maintenance personnel identify and search for spare parts needed for repair if no suitable part numbers are available on the damaged or failed part itself.

C. Categorized material based on usage

The steps segregate the material in the system based on past usage. Various available techniques can be utilized like below-

- ABC analysis – "A" represents parts that have high cost but low frequency of use, "B" represents parts having moderate cost and usage, "C" represents parts that have lost cost and high usage
- XYZ analysis – "X" represents parts used most frequently, "Y" represents parts that are used moderately, "Z" represents parts that are used least

This helps the inventory team manage when to trigger orders effectively. It allows them to set up an automated system using software to trigger orders independently, with monitoring and approvals done through human intervention. It also helps lay the foundations for a cycle count program focusing on inventory counts on frequently used parts more often than less frequently used ones.

D. Setting minimum-maximum points

The maximum and maximum points are set up for each spare part and are defined based on the number of parts used in one machine and the number of similar machines available in the company. These levels are set up using the recommendations from OEM, the Maintenance leadership team, and the inventory manager. These levels help the automated system trigger orders for replenishment once the on-hand quantity of a part reaches a defined level.

E. Purchase information records

The steps involve managing each spare part's cost, recommended vendor, and lead time. Usually, these are maintained by the purchasing team, but the responsibilities can be varied based on the organization's structure. It is one of the critical aspects as it can help in cost-saving initiatives when spare parts are sourced through a vendor closer to the manufacturing site rather than overseas. Also, buying parts directly through manufacturers eliminates the margin that gets added up to the original cost when buying through OEM.

F. Storage location and parts labeling

The parts are given a defined location based upon the material group defined above so similar parts can be stored together for easy access. A scannable label is created and pasted on parts with parts and descriptions to be easily linked to work orders when a maintenance technician uses them for repair.

4. PROCESS LAYOUT AND FRAMEWORK

The entire process of parts re-ordering and the steps involved have been laid out in Figure 1. Once repair work is requested through the maintenance department, a maintenance technician is assigned the job. They create a work order using the CMMS (computerized maintenance management system) to track the progress and parts usage. The technicians identify which parts are needed for repair and use the CMMS to search the storage location for the parts. Then, they retrieve the spare part from the area and scan it using the QR labels available on the spare part to link the spare part to the work order. The inventory management team receives a report every 24 hours containing information on the parts taken out of inventory for repair work. Figure 2 explains the data that is included in this report. This report details on-hand stock, quantity on order already on a purchase order, and min-max level. The inventory team performs A spot cycle count using the ABC or XYZ analysis concept to verify if the system quantity matches the physical quantity. Any adjustments are updated, and the team generates the report again. The inventory manager approves the report after adjustment, and an automated MRP is run in the background; the system generates the purchased orders for restocking using the purchase information records available. The purchase orders are sent to vendors, and order confirmation is requested from them with estimated delivery time. The parts are received from the vendor and received by the inventory team. After receiving, the new parts are labeled and put away in their defined location. Following these steps makes it possible to manage spare parts inventory effectively and ensure parts are available when needed to perform repairs.

The below additional steps can also be incorporated to make the process even more robust and accurate-

A. System alerts

The system would not allow them to overstock parts unless the management approves. Also, when a spare part has zero on-hand quantity, the system creates a notification to alert the inventory team to make sure orders are placed on priority.

B. Training

Regular and repeated training of maintenance team members on how to scan parts against work orders will reduce errors and mistakes in not being able to scan parts when being used for repair properly. This will, in turn, help maintain the accuracy of the inventory.

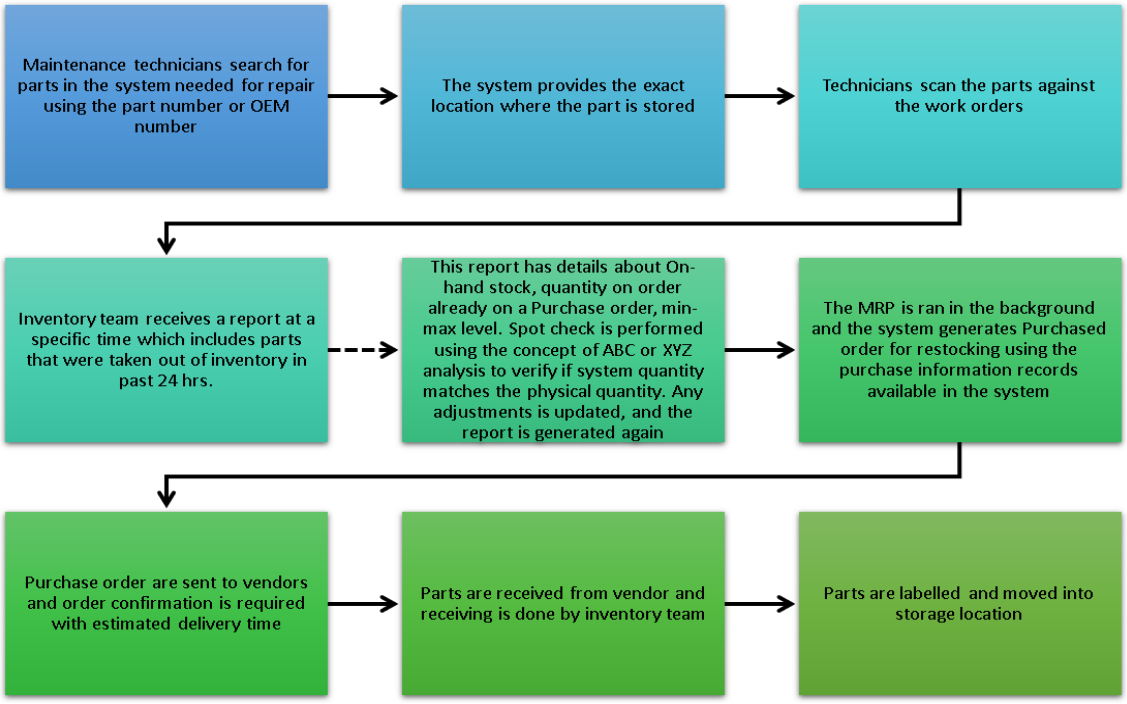

Fig. 1 Process structure for MRP-driven parts ordering

PART NUMBER	PART DESCRIPTION	QTY USED	ON-HAND QTY	STORAGE LOCATION	PO QTY	MIN	MAX	VENDOR
TH11B1AAB31AK	TH11-B1AAB31AK1 RTD THERMOMETER	1	5	0012A12	0	4	6	ENDRESS & HAUSER
DILM2510	EATON DILM25-10 CONTACTOR	2	2	0031C13	6	6	10	GRAINGER
DL1401	FLOWLINE DL14-01 ULTRASONIC LEVEL SENSOR	1	3	0032A20	0	2	2	GRAINGER
TD2833	IFM TEMPERATURE SENSOR WITH DISPLAY	1	4	0033B12	0	4	6	IFM EFECTOR INC.
TP3233	IFM SENSOR AND THERMOMETER SIGNAL CONVERTOR	1	4	0033B13	5	6	10	IFM EFECTOR INC.
IL1000	KEYENCE IL-1000 LASER SENSOR DIN RAIL MOUNT MAIN AMPLIFIER 10-30VDC	1	2	0041A06	0	2	2	KEYENCE CORPORATION OF AMERICA
LRZB240CB	KEYENCE LR-ZB240CB LASER SENSOR OUTPUT- NPN+PNP M12 240 MM DISTANCE	1	1	0041A07	2	3	4	KEYENCE CORPORATION OF AMERICA
2868T97	OIL-EMBEDDED 863 SLEEVE BEARING	6	2	0011B01	0	5	8	MCMASTER-CARR SUPPLY CO.
3749T4	MOUNTED BALL BEARING 1.25 SHAFT DIA	4	4	0011B12	0	6	10	MCMASTER-CARR SUPPLY CO.
W62032ZSSSL	W 6203-2Z SSSL BEARING SS SOLID LUBE	2	15	0011B13	0	11	20	MOTION INDUSTRIES INC.
62042ZJEM	6204 2ZJEM RADIAL BALL BEARING	12	26	0011B07	0	21	40	MOTION INDUSTRIES INC.
VEM3550	BALDOR MOTOR 3500RPM 1.5HP 56C FRAME	1	3	0067A01	0	2	2	MOTION INDUSTRIES INC.
VEM3611T	BALDOR MOTOR 1760RPM 3HP 182TC FRAME	1	2	0067A02	0	2	2	MOTION INDUSTRIES INC.

Fig. 2 Part usage report generated through the inventory management software

5. CONCLUSION AND FUTURE SCOPE

Spare parts inventory management is a critical task that must be set up and managed correctly in any manufacturing company to ensure the proper functioning of day-to-day operations. The best practices mentioned in this study can improve spare parts inventory management and help businesses achieve their goals. The MRP-driven approach helps organizations understand spare parts' requirements and usages to define the minimum and maximum points for the stock levels. Based on this approach, an automated spare parts system can run simulations in the background to advise on parts needed for restocking. Human intervention helps ensure the inventory is accurate, and performing cycle counts at periodic intervals helps manage it. The correct process to set up a new spare part is also critical. It provides digital tools to technicians on the production floor performing repairs to search for parts accurately through the system and use them for repair activities. This process is also beneficial in setting spares for new equipment being installed in a facility. It enables the inventory team to buy and compare critical spares purchased from the OEM against those from the local vendors and manufacturers to reduce cost and lead time. This also leads to achieving standardization through providing recommendations to OEM when planning an equipment order to ensure the brands and manufacturers that are readily and easily available in the market are used for constructing the equipment. Using the process in the study, any organization can easily set up its spare parts management program from scratch. Few challenges will always affect this process and require companies to adapt to ever-changing dynamics to cope with changes in the market. Despite these challenges, it is possible to improve forecasting accuracy, reduce lead times, and minimize costs by using various tools and techniques. This can help ensure that the right amount of inventory is on hand to meet demand while reducing the cost of carrying inventory.

Some of the topics that can be studied and researched further to improve the spare parts inventory management process to make it more robust and agile are negotiating contracts with vendors to lock prices for parts that are used and ordered frequently using bidding/quotations, using the predictive analysis to forecast demand accurately and identify market trends to improve inventory management and reduce costs, implement a continuous improvement program to perform 5S and standardization of parts to reduce storage cost and efficiency.

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