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An overview of the state-of-the-art inventory management in automobile industries

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ABSTRACT
In the post-covid manufacturing scenarios, the world is facing some unprecedented supply chain disruption and inventory problems. Automotive industries deal with large number of parts, components and subassemblies per see. Essentially, inventory management has received considerable attention in present times where cost optimization under make-or-buy decisions is a prime question, given that there are constraints in various terms. The purpose of this article is to figure out the state-of-the-art inventory management incorporating Industry 4.0 concepts in automobile industries with a view to develop some models by reconfiguring the constraints under the given circumstances. Scholarly articles of the relevant researchers and practitioners are reviewed to identify the pertinent inventory optimizing techniques or models for certain crucial parts and subassemblies. They include different journal articles, conference papers, review papers, book chapters etc. especially focused on deterministic type of inventory management system. This systemic review and investigation will locate the gaps in automobile industries' inventory management and guide us to find the appropriate methodology(ies) and technique(s) in different situations for inventory management.

Keywords: Inventory management, automotive industry, optimization, make-or-buy decision, Industry 4.0.

1. Introduction

1.1 Background

Automobile business is emerging and very much competitive one at present time. A good inventory management system is the way to stay on top of the game. Automotive industries deal with a huge number of parts, components and subassemblies by default and inventory management aspect has received considerable attention in contemporary time. The automotive market has become more demanding in terms of cost and functionalities. To guarantee market shares, manufacturers must be responsive, which implies a significant reduction in development, production and logistics times in order to offer the shortest possible time to market (TtM). The products must also be able to guarantee a wide choice of functionalities at competitive prices. The automobile industry is characterized by the importance of its inventories and the diversity of these inventories. Inventories are constituted at various steps of the production chain (raw material, work-in-progress and finished products). They extant both benefits and risks. The primary aim of constituting an inventory of any product is to absorb any possible mismatch between supply and demand. However, if not well managed, stocks can generate higher extra costs for businesses. The effective management of such asset is therefore crucial for a car manufacturer to reduce the loss of money that can be caused by either overstock or stock out. Indeed, the main aim of inventory management is to optimize the size of inventory in a firm, so that smooth performance of production and sales functions may be possible at the minimum cost. So, the automotive entrepreneurs or their managers must have the knowledge of latest and updated techniques of inventory management systems for their betterment. Efficient management of inventories definitely improves the profitability of the organization.

1.2 Purpose of this article

The main purpose of this article is to provide a clear idea of the modern inventory management systems in the existing automobile industries around the world.

1.3 Methodology applied

Relevant and scholarly articles of various researchers and practitioners of contemporary period are reviewed. They include different journal articles, conference papers, review papers, book chapters etc. focused on different methods and techniques of modern inventory system. Those are critically analyzed and investigated for framing this article and to draw fruitful conclusions.

2. Concept of inventory and inventory management

Inventories are the idle material or products utilized to support the future demands; production, supporting activities (i.e., maintenance) and customer services. They vary in form depending on the process they are mean to support such as raw materials, WIPs, finished products and MROs. Inventory appears as an asset in financial account, but a liability in just-in-time production. Inventory is created when their receipts go beyond disbursement and is depleted when the reverse of that occurs. Inventory is one of the most expensive and important assets of many enterprises, representing as much as 50% of total invested capital. Inventory management is the process of ordering, storing and using a company's inventory. Inventory forecasting and setting

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reorder point are the basis of inventory management which implies how much to order and when to order. Reorder point depends on safety stock and lead time. The main purpose of inventory management is to ensure the availability of goods or materials in sufficient amount as and when required.

3. Basic inventory management tools and techniques in automotive industry

These tools and techniques are very common and treat the physical aspect of inventory management system in automotive industries.

3.1 Economic Order Quantity (EOQ)

The EOQ model was first introduced by Ford W. Harris in 1903 and was developed ever since. Most popular and most traditional inventory model is the EOQ model, till significantly practiced in automotive industries. It is an economic model that aims to determine the optimal quantity to order to minimize inventory costs such as holding costs, shortage costs, and order costs. EOQ model focuses on minimizing the inventory costs rather than minimizing the inventory. It is based on the annual demand for a given product, the cost per order, the cost per unit and the holding cost. It assumes that the demand for the company's products remain constant over time and inventory depleted at fixed rate. The EOQ can be calculated using the Wilson formula, is explained as Eq. (1) as follow (Wilson formula):

$$EOQ = \sqrt{(2Dk/h)} \quad \ldots\ldots (1).$$

Here, D = total demand per period (unit), k = ordering cost for one lot or order, h = cost of holding one unit for one period.

3.2 ABC Analysis

Automobile product is made up of thousands of parts in the form of single parts or sub-assemblies. Proper individual management of all these huge stocks is quite difficult and not economically viable. The management of such stocks definitely involves cost. The ABC concept brings a possible solution to this problem. ABC analysis is an approach that aims to classify inventory items based on their consumption values. The consumption value of an item is the value (normally expressed in currency) consumed during a defined period, for example, one year. To do this, the ABC method is based on the Pareto law or the 80-20 rule. This means in this case that 20% of the products generate 80% of the charges. The products are classified into three classes: A, B and C. Class A having lowest items (15%), highest value (70%) and maintains accurate control. Similarly, class B of medium value with moderate control and class C of lowest value with minimum control. The high-value stocks get highest attention to ensure its availability.

3.3 Perpetual inventory review system

A perpetual inventory system is a program that continuously estimates inventory based on the electronic records, not a physical inventory and very much appropriate for the automotive industries. This system starts with the baseline from a physical count and updates based on purchases made in and shipments made out. Perpetual inventory management systems keep track in real-time. It uses software to follow the rules, keep the system up-to-date, and it works great. Perpetual inventory is also a requirement for companies that use a material requirement planning (MRP) system for production.

3.4 FIFO

FIFO means First-In-First-Out. Basically, it is the inventory replenishment system where the oldest stock or the inventory that entered the warehouse first is recorded as out first. FIFO is one of the most popular replenishment techniques applied automotive sector. It is more realistic as it ships older stock first to avoid obsolescence and depreciation.

4. **Modern approaches, techniques and strategies of inventory management**

Inventory management technique is very much linked with the type of production system such as push or pull. The type of inventory control system also depend in large part on what type of product is being produced. The production of large items, such as automobiles, is too complex and takes too long to only produce the amount needed to fulfill specific customer orders. The push system of inventory control involves forecasting inventory needs to meet customer demand. The company will in turn produce enough product to meet the forecasted demand and sell or push the goods to the consumer. All the management tools used in inventory management are interconnected.

4.1 Demand forecasting

Forecasting is the common attribute and the basis of all inventory management tools, especially in the automotive industry where responsiveness to the market is essential and where the supply chain is considerably long. The integration of the whole supply chain is a key factor in the successful cost control of inventories.

4.2 MRP

Normally MRP is a computerized system to manage inventory. The MRP is followed based on the MPS by applying Bill of Material (BOM). The main aim of MRP system is to minimize cost of inventories and maintain customer service level. MRP benefits include the ability to rapidly re-plan and re-schedule in response to change in a dynamic environment. It is flexible and responsive to the customer's needs.

4.3 MRP to DDMRP

Material Requirements Planning (MRP) has deficiencies when dealing with current business environments, marked by a more complex network, a huge variety of products with longer lead time, and

uncertain demands. This drives Demand-Driven MRP (DDMRP) approach to deal with those challenges. DDMRP is designed to connect the availability of materials and supplies directly from the actual condition using bills of materials (BOMs). DDMRP is more effective for controlling the production-inventory than MRP.

4.4 Just-In-Time (JIT):

Inventories are considered to be wastes because not only they do produce added value, but also, they generate additional costs (cost of management, space, risks). This concept is the part of the lean manufacturing developed by the Japanese car manufacturer Toyota during the 20th century. Parts or raw materials are ordered as and when they needed in the production process. The effect of the JIT on the stock is visible in the first place on the finished products and on the WIP. Indeed, the pull system used by the method, only produces what is required, which considerably reduces these inventories. The backbone of this approach is to be able to forecast demand very precisely. It does not need to hold safety or buffer stock. Enjoy continuously low inventory levels and lower inventory carrying costs. It is also based on sharing precise production forecast with suppliers for better synchronization in term of deliveries. This method also presents big risks. The manufacturer becomes more and more dependent on the efficiency of its suppliers and reliability in-between is very important. Entire production process may shut down just because of one supplier to fail to deliver materials on time. Under the ideal condition where all the conditions meet, it is economically better off to choose the JIT over the EOQ because it results in purchase price, ordering cost.

4.5 MRP-JIT

Just-in-Time (JIT), Material Requirements Planning (MRP) and its modified version Manufacturing Resource Planning (MRPII) are well known and the most powerful controlling tools that have a substantial effect upon the failure or success of an entire manufacturing system. In this regard, the important characteristics of material flow are directed toward planning and controlling by MRP and JIT. However, a pure MRP or JIT production system are rarely existing in practice. Even in pioneers of JIT systems like Toyota Japan, production smoothing is planned by the master production schedule (MPS), and the MRP is followed based on the MPS by applying Bill of Material (BOM). This type of hybrid MRP-JIT planning has been especially adopted by automobile manufacturers. In practice, both distribution and manufacturing systems enclose features of pull or push to varying degrees regardless of the identity of system.

4.6 Lean

The development of lean management is based on Toyota's definition which called just-in-time (JIT) initially. Lean inventory management is a combination of a set of tools, philosophy and a system. Lean refers to a systematic approach to enhancing value in a company's inventory by identifying and eliminating waste of materials, effort and time through continuous improvement in pursuit of perfection. Lean inventory management enable business efficiency and increase profits. Current references like APICS (American Production Inventory Control Society) shows that nearly 30 percent of companies are adopting lean principles in their inventory management. Lean inventory management techniques are built upon some principles. The success on any lean inventory management depends on how a company best implements the principles to achieve its needs.

4.7 Vendor managed inventory (VMI)

In VMI, the buyer shares their inventory and demand data and their delivery parameters with the supplier (vendor). By sharing this information, the buyer enables the supplier to determine the order size. Consequently, the supplier is responsible for managing the supply chain from end-to-end and the buyer is responsible for the provision of accurate and timely information necessary for forecasting. Vendor-managed inventory (VMI) is gradually becoming an important element of supply chain management strategy of organizations. Recently, Indian industries, both large and small, have started adopting VMI for their supply chains. Automotive industry using VMI can prevent the financial risk that is associated with traditional inventory management.

4.8 Outsourcing inventory

The outsourcing inventory system is adopted by the firms to reduce the burden of manufacturing the components of the finished goods in-house or within the organization. Thus, a system of buying the products or components from outside vendors rather than manufacturing internally is called as outsourcing inventory. Many companies develop a single source of supply from where the needs of the material can be fulfilled. While many others help in developing the small and medium sized ancillary units to supply the adequate quality components, as required for the manufacturing of the finished goods. This option is exercised majorly because to cut operation costs of a company and focus on its core competencies. It is basically a contract between two companies or concern in which one is getting its business process outsourced from another company offering such services. Tata Motors is the prominent example that uses the outsourcing inventory system. It has developed several ancillary units around its manufacturing plants to get the parts and components in time. This has benefited the ancillary units as well, with the help of Tata Motors they are able to manufacture the best quality components. Likewise, Maruti also uses this inventory system to fulfil it's need for the components.

4.9 Virtual inventory

Here, establishing a virtual warehouse to solve the problem of inventory management, not only reduce this

manufacturer inventory but also optimize the supply chain inventory management. Virtual inventory builds among the member enterprise's trust, mutual benefit, information sharing, collaborative culture of open communication elements. The use of computer technology and network communication technology, supply chain member companies will contribute a portion of inventory to form a virtual inventory. This part of the warehouse inventory not established entity warehouse, physical inventory is still stored in different locations of the members of the enterprises warehouse. Integration of different geographic locations, different ownership of the physical inventory, unified management and scheduling, rapid response to the changing needs of customers. To expand the available amount of material to the lowest cost. Virtual inventory management in favor of balance between production and supply chain enterprises, avoiding use excessive funds. It makes automotive manufacturing companies to some extent to reduce inventory management and maintenance costs, and strengthen cooperative relations between enterprises.

4.10 Online inventory

An online inventory management system to manage inventory stock levels, the software can be programmed to reorder goods when the stock level falls to a minimum quantity. The software automatically orders new stock on a predetermined cycle. Automotive industries use different software and apps which allow for smoother delivery of orders, clear communication between different parties and also limits mistakes caused due to human error. An effective online inventory management system reduces inventory carrying costs minimizes the risk of waste or obsolescence and customer order fulfilment is achieved on time. There are now several powerful software's that are available for businesses to use for this very reason, and serve many functions. Apps like Profit Max now allow us to monitor the ordering and storing of vehicles at our dealership.

4.11 Implication of Industry 4.0 (IoT, Virtual management)

With rapid growth of Industry 4.0 technologies, inventory systems and optimization are being transformed to a new state. The future of inventory management in the automotive industry will focus more on information management to optimize the management of physical inventories as much as possible. This will be made possible with the help of some industry 4.0 technologies as Big data analytics. Automobile manufacturers are at the heart of a value chain that includes auto equipment manufacturers upstream, and dealers downstream. The control of data exchange and the relevance of this data is essential for optimal management of stock levels and therefore better cost control at each stage. The use of cloud technology allows data share in real-time with all the participants in the value chain, which allows the anticipation of peak demand by building up stocks or reducing the production rate to reduce an inventory of a given item in the event of low orders. This information can also be automated through the Internet of Things (IoT) technology to launch item orders at a precise quantity, period and rate directly linked to forecasts. It will consequently reduce the inventory of products and at the same time reduce the cost of managing these stocks. Inventory appears everywhere, in a visible form or non-visible form. The impact of Industry 4.0 on inventory systems and optimization is huge.

Fig 1: Industry 4.0 – Technological pillars

5. Conclusion

Automotive industry inventory management is more than knowing how much inventory on the shelf; it includes tracking and organizing of materials from suppliers, through the manufacturing process and into customer's hands. With an inventory management system, automotive suppliers can get visibility into items across all channels, ensuring the right items are available, at the right time, in the right place. At present automobile manufacturing enterprise's inventory management, the main bottleneck is caused by the low level of information technology. From the perspective of supply chain, application of collaborative management theory and method, the technology of the internet of things, establishing a virtual warehouse, achieve improved enterprises inventory situation and enhance core competitiveness. The future of inventory management in the automotive industry will focus, therefore, more on information management to optimize the management of physical inventories as much as possible. This will be made possible with the help of some industry 4.0 technologies as big data analytics.

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