

Study on Manufacturing Strategy, Capital Purchase & Production System in an Automobile Industry

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Abstract: The automotive industry is continuously evolving with increasing demand for advanced technologies, improved fuel efficiency, enhanced vehicle performance, and better driving comfort. Commercial vehicle manufacturers are increasingly adopting advanced transmission systems and automated manufacturing technologies to meet global standards and customer expectations. Transmission systems are among the most critical components in any automobile because they directly influence vehicle performance, torque transmission, fuel efficiency, and operational reliability. Modern commercial vehicles require advanced transmission systems capable of delivering efficient power transmission while maintaining durability and performance under varying operating conditions.

In the automobile industry, the Capital Purchase (CapEx) and Production System are highly integrated frameworks. CapEx builds the foundation—procuring multi-million-dollar physical assets like robotics, stamping presses, and plant construction—while the Production System manages the day-to-day manufacturing and assembly operations using these assets. This Paper aims to identify the key features involved in Manufacturing Strategy, Capital Purchase & Production system in an Automobile Industry.

Keywords: Automobile, Manufacturing, Capital purchase, Production System

I. INTRODUCTION

The automobile industry is a high knowledge and capital-intensive sector which plays a pivotal role in the socioeconomic development of any economy. Its relevance is associated with road transportation and the resulting multiplier effect on overall growth and development [1]. As a result of the capital-intensive nature of this industry, firms in this sector have throughout its history continuously sought new strategies to enhance and sustain viability. Specifically, critical decisions have bordered on integrating levels of vehicle production and marketing effort [2].

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The automotive sector is characterized by mass production, global supply chains, and rapid technological evolution. As product lifecycles shrink and model variants multiply, manufacturers face the dual challenges of high efficiency and high flexibility. Efficient production management ensures that resources—machines, labour, materials—are used optimally to meet market demands. Scheduling aligns these resources with real-time and forecasted requirements, balancing supply and demand while minimizing costs.

Automated Manual Transmission (AMT) systems have gained significant importance in recent years due to their advantages over conventional transmission systems. AMT systems combine the mechanical efficiency of manual transmissions with the convenience of automation, thereby improving operational efficiency and reducing driver fatigue. To ensure product reliability and manufacturing quality, automotive industries implement advanced quality assurance systems during production. End-of-Line (EOL) testing is one of the most important quality validation processes performed before the final dispatch of transmission assemblies.

Capital purchase is the process of procuring assets that provide long-term benefit to the organization. These assets may include machines, testing systems, fixtures, material handling equipment, utilities, automation panels, safety-related infrastructure, tooling systems, and other project assets. Since such purchases involve significant investment, the process requires structured approvals and careful documentation.

Capital purchase is different from routine material purchase because it generally involves high-value assets such as machines, equipment, utilities, automation systems, tooling, material handling systems, inspection equipment, and project-related infrastructure. Such purchases require technical justification, budget approval, vendor evaluation, commercial comparison, delivery follow-up, installation planning, commissioning support, and proper documentation.

A production system in the automotive industry is a meticulously organized ecosystem of personnel, technology, and information that transforms raw materials into finished vehicles. It optimizes efficiency, synchronizes global supply chains, and incorporates digital manufacturing principles to meet dynamic consumer demands while maintaining strict quality standards.

The evolution of production systems began with Artisanal Production, later advancing to Mass Production. In Artisanal Production, workers were highly qualified and used only simple tools to produce personalized products, reducing production volume without standardization. Faced with the need for the evolution of this system, where the demand for products was growing, Mass Production emerged (idealized by Ford). Specialized professionals designed standardized products manufactured in significant quantities by unskilled or semi-skilled workers, operating expensive equipment for specific purposes. In this system, the idle time was avoided concerning the machinery's high cost, with the use of stocks and extra workers to guarantee the availability of inputs so that the production flow is not slowed down. Due to the high cost of investment in machines, adaptation to the manufacture of new products is impeded, and the consumer benefits from low prices at the expense of variety (Womack et al., 1990). [3]

II. LITERATURE SURVEY

Leong et al. (1990), Hayes et al. (2005), characterize Strategy of Production as a collection of individual decisions that affect the capacity of the company in finding their long term objectives. According to these authors, the necessary competitive priorities to successfully compete should reflect the strategy of businesses and also to supply the criterion or mission that, together with the areas of decision, would be appraised. These priorities should guide all of the actions of the structural and infra-structural areas of decision. The manufacturing strategy is constituted, therefore, of the plans, policies and programs of actions implemented by the company, more specifically by the function production (in the areas of decision and in the processes of businesses), so that the competitive priorities are reached. [4][5]

Ahmed Belkaoui (1975) in the article "A Canadian Survey of Financial Structure", concluded that debt ratios do not vary significantly among industries and the evidence does not prove that optimal financial structures are functions of their business risk[6]. Paul Marsh (1982) in the article "The Choice between Equity and Debt: An Empirical Study revealed that companies are heavily influenced by market conditions and the history of security prices in choosing between equity and debt [7]. Jianchen and Roger Strange (2005) in their article "The Determinants of Capital Structure: Evidence from Chinese Listed Companies", revealed that profitability is negatively related to the capital structure[8]. Vukasin Kuc& Dorde Kallcanin (2021) in their article entitled "Determinants of the capital structure of large companies: Evidence from Serbia", studied the capital structure and reported that the country specific determinants, such as inflation and development of the banking sector, have significant impact on the capital structure of the largest companies in Serbia

[9]. Aamer Shahzad, Muhammed Azeem, Mian Sajid Nazir, Xuan vinh vo. Nguyen T.M.Linh (2021) in their article entitled “The determinants of capital structure: Evidence from SAARC countries”, suggested that firms in the region are more likely to make their capital structure decisions following Pecking order theory[10].

Many studies focus on production planning and optimization, in the literature. Bueno et al. [11] review a high number of studies, which consider smart abilities ensured through Industry 4.0. In their study, they consider the production planning and control and performance indicators with the environmental factors discussed. Bendul and Blunck [12] review the literature considering the multiple research fields and different theoretical indications for production planning and control in industry 4.0. Li et al. [13] study the production planning and control problem considering additive manufacturing. They proposed a mathematical model for the problem and solved it by using CPLEX. Additionally, they also suggest alternative heuristic methods. Altaf et al. [14] develop a discrete event simulation model. Additionally, they use the random sample consensus algorithm that is integrated with particle swarm optimization and simulated annealing algorithms. They aim to minimize production time by generating optimal production schedules. Aouam et al. [15] discuss the acceptance of the order in production planning assuming that the quantity of the order is uncertain. The integrated production planning problems are formulated and solved by the proposed heuristic algorithm.

III. STUDY ON MANUFACTURING STRATEGY AND END OF LINE TESTING DEVELOPMENT

Manufacturing strategy is regarded as one of the most important decision areas within the manufacturing management function. Traditionally, manufacturing management has influenced manufacturing technology to a much greater extent than the other way round.

Just-In-Time (JIT) manufacturing is an approach to designing, scheduling, and managing manufacturing processes that minimize inventory levels while maximizing production efficiency. By employing a just-in-time inventory management system, manufacturers can reduce costs by eliminating unnecessary inventory and optimising their production processes.

Jidoka is a principle that focuses on problem solving and continuous improvement by empowering employees to quickly identify problems and take action to eliminate them. This is designed to prevent defective products from being produced – reducing waste.

Kaizen is another key component of lean manufacturing principles that focuses on improving quality and efficiency through continuous improvement. It aims to eliminate waste by creating a culture focused on identifying where improvements can be made, and then taking action to make those improvements. Kaizen has been used successfully in the automotive industry to reduce lead times, increase productivity and decrease costs.

In recent times most of the Automobile Companies are working on Advancement of 12-Speed I-Shift AMT transmission manufacturing line. This transmission system is generally designed for commercial vehicle applications and requires high precision in manufacturing, assembly, and testing processes. The process start with system designs, supplier selections, and technical specifications are reviewed and finalized before implementation. At this stage, the focus was primarily on planning, technical evaluation, and supplier coordination rather than physical installation or production activities.

A major component of the study was the development of the End-of-Line (EOL) testing system, which is essential for ensuring the functional quality of the transmission before it is approved for vehicle integration.

The EOL testing system is designed to validate:

- Gear shifting performance under different conditions
- Functionality of sensors and actuators
- Pneumatic and hydraulic operations
- Mechanical integrity of the transmission system
- Leak detection and sealing quality

- Overall system reliability and operational behavior.

The system is also designed with considerations for:

- Production cycle time requirements
- Automation integration with assembly lines
- Safety standards for operators
- Data traceability and recording systems
- Repeatability and consistency of test results

IV. STUDY ON CAPITAL PURCHASE PROCEDURE IN INDUSTRY

Capital purchase in an automobile industry involves a project team which coordinates with various departments such as Production, Maintenance, Quality, Purchase, Finance, Safety, Stores, and external vendors. There is an importance of systematic planning, cost control, technical documentation, negotiation support, and timeline monitoring in successful project execution.

It is observed that capital purchase is a disciplined process that requires both engineering understanding and management skills. A purchase decision is not based only on price; it also depends on technical suitability, reliability, safety, service support, delivery commitment, and long-term value for the plant.

- The Project Team works as a coordination center for multiple departments.
- Proper technical specification reduces confusion during quotation and vendor selection.
- Vendor follow-up and communication are very important to maintain project timelines.
- Finance and budget approval ensure that capital investment is controlled and justified.
- Stores and receiving teams are important for material entry, verification, and record keeping.
- Installation and commissioning require readiness of utilities, space, safety clearance, and user department support.
- A small delay in documentation or clarification can affect the project timeline.
- Hard work in the project department is mostly reflected through timely follow-up, accurate records, and disciplined coordination.

Figure 1 shows Flow chart for Purchase Procedure normally adopted by an Automobile Industry.

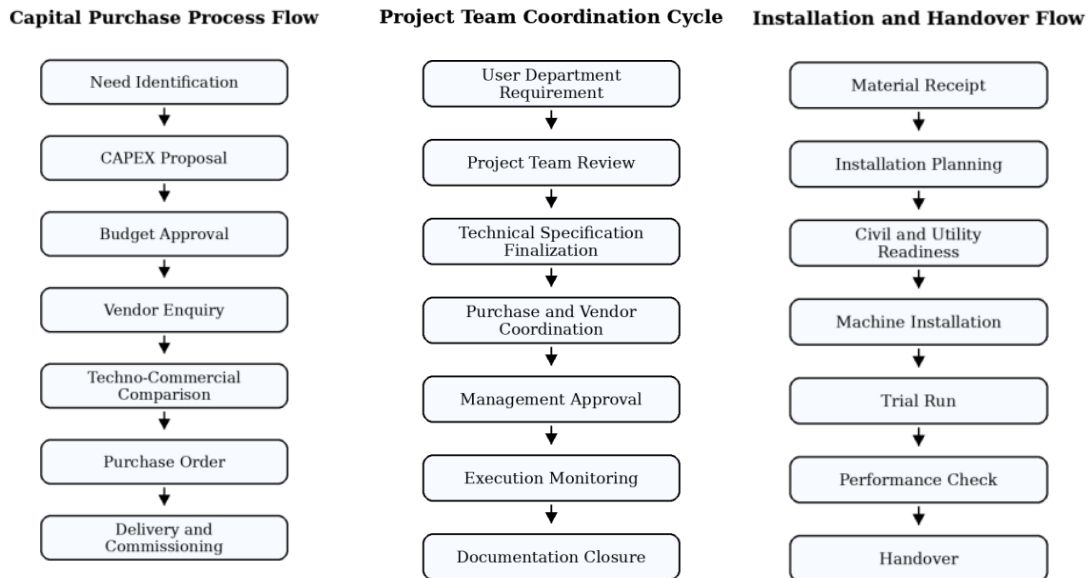


Figure 1: Flow chart for Capital purchase procedures.

Table 1 Shows the detailed Procedure adopted in the Capital Purchase Process.

Capital Purchase Process		
Stage	Main Activity	Purpose
Need	Identification Requirement raised by user department	To identify improvement, capacity, quality, or safety requirement
CAPEX	Proposal Cost estimate and justification prepared	To obtain approval for long-term asset investment
Vendor Enquiry	Quotations and technical details collected	To understand available options and market cost
Comparison	Technical and commercial comparison prepared	To select the most suitable and cost-effective vendor
Purchase	Order PO released after approval	To formally place order with agreed terms
Execution	Delivery, installation, and trial monitored	To ensure the asset is ready for operational use
Closure	Documentation and handover completed	To close the project with records and accountability

Table 1. Detailed Capital Purchase Process

V. STUDY ON MAJOR PARAMETERS IN PRODUCTION DEPARTMENT

A detailed study is needed in Teeth Cutting Section (Soft Cell) of an automobile industries, which is involved in precision gear manufacturing. The work was concentrated on gear cutting processes — hobbing, shaping, and shaving — which are core operations in the drivetrain component manufacturing line.

Gear cutting operations — hobbing, shaping, and shaving — are done on unhardened (soft) gear blanks before they proceed to heat treatment. It works to ensure that all gears meet dimensional and profile accuracy before further processing. Various Tools and Techniques which were used are discussed below

Hobbing Machine - A Gear Hobbing Machine is a specialized machine tool used to manufacture gears by cutting gear teeth with a rotating cutting tool called a hob. It is widely used for producing spur gears, helical gears, splines, and sprockets with high accuracy and productivity.

Gear Shaping Machine - A Gear Shaping Machine is a machine tool used to manufacture gears by cutting gear teeth with a reciprocating cutter called a gear shaper cutter. It is mainly used for producing internal gears, external gears, and gears close to shoulders where hobbing is difficult.

Gear Shaving Machine - A Gear Shaving Machine is a finishing machine used to improve the surface finish, accuracy, and tooth profile of gears after hobbing or shaping. It removes a small amount of material from the gear teeth using a rotating shaving cutter to reduce noise and improve gear quality.

Broaching Machine - Gear Broaching is a machining process used to cut internal gear teeth or splines by using a multi-tooth cutting tool called a broach. The broach moves linearly through the workpiece and removes material step by step to produce accurate and smooth gear profiles.

Measuring Instrument – • Vernier Caliper • Micrometer • Dial Gauge • Gear Measuring Instruments

Following parameters & Procedure need to be adopted in Teeth Cutting Section (Soft Cell) for getting good Results.

- Production activities need to be carried out in a highly systematic and disciplined manner to maintain productivity, quality, and safety standards.
- Proper process planning and workflow management helps to achieve smooth material movement and continuous production.
 - Operators should strictly follow standard operating procedures (SOPs) during machine setup, loading, unloading, and inspection activities.
 - Safety practices such as the use of PPE, machine guarding, coolant handling, and safe material movement should be given high importance on the shop floor.
 - Fixture changeover activities need to be carefully monitored because changeover time directly affects machine utilization and production efficiency.
- Gear manufacturing requires very high dimensional accuracy, profile accuracy, and surface finish to meet quality standards
- Continuous inspection and in-process quality checks need to be performed to minimize rejection and maintain consistency in production.
- Safety rules and PPE usage need to be strictly followed on the shop floor.
- Preventive maintenance activities helped improve machine reliability and reduce breakdowns during production.
- Team coordination between production, quality, maintenance, and tool room departments improves overall operational efficiency.
- Continuous monitoring of machines and process parameters helps to reduce defects and improve efficiency.

VI. CONCLUSION

Study shows that long-term success requires the strict alignment of manufacturing strategy, capital expenditures (CAPEX), and production systems. Since automotive manufacturing involves intense fixed-asset investments, purchasing decisions must balance long-term equipment capacity against maintenance costs and technological obsolescence. The Manufacturing Strategy and Sustainability Department plays a strategic role in planning and executing manufacturing-related projects across various production units. The department is responsible for the development and implementation of new manufacturing lines, process improvements, and capacity expansion initiatives. It ensures that manufacturing systems are designed and executed in alignment with business goals, quality standards, and operational efficiency requirements.

Capital purchase is not merely a buying activity; it is a structured engineering and management process. It involves requirement study, technical specification, budget approval, vendor coordination, quotation comparison, purchase order release, delivery tracking, installation, commissioning, and documentation closure

The production team works relentlessly under production pressure and in full capacity to deliver products meeting the required dimensional and quality specifications within cycle time. Clear communication is needed between operators, setup men, and quality inspectors to ensure smooth flow of the production.

Conflicts of Interest: The author declares no conflict of interest.

REFERENCES

- [1] B. Saberi, "The Role of the Automobile Industry in the Economy of Developed Countries," *International Robotics and Automation Journal*, vol. Vol.4, no. No.3, pp. pp:179 - 180, (1 May 2018).
- [2] P. S. McAlinden, "The Future of Modular Automotive Systems: Where are the Economic Efficiencies in the Modular-Assembly Concept," (1999).
- [3] Womack, J. P., Jones, D. T., & Roos, D. *The machine that changed the world*. New York: Rawan Associates, McMillan. (1990)
- [4] Leong, G. K.; Snyder, D. L. and Ward, P. T. , "Research in the Process and Content of Manufacturing Strategy", *OMEGA, International Journal of Management Sciences*, Vol. 18, No. 2, pp. 109-122. (1990)
- [5] Hayes, R. H.; Pisano, G. P. and Upton, D. M., "Operations, Strategy, and Technology – Pursuing the Competitive Edge", John Wiley & Sons, Inc., USA. (2005)
- [6] Ahmed Belkaoui , "A Canadian Survey of Financial Structure", *Financial Management*, Vol.4, No.1, pp. 74-79. (1975)
- [7] Paul Marsh "The Choice between Equity and Debt: An Empirical Study", *The Journal of Finance*, Vol.XXXVII, No.1, pp. 121-144. (1982)
- [8] Jian Chen and Roger Strange , "The Determinants of Capital Structure: Evidence from Chinese Listed Companies", *Economic change and Restructuring*, Vol.38, Issue 1, pp. 11-35. (2005)
- [9] Vukasin Kuc & Dorde Kalicanin "Determinants of the capital structure of large companies: Evidence from Serbia", *Economic Research – Ekonomska Istrazivanja*, Vol. 34, Issue 1, PP 590-607 (2021)
- [10] Aamer Shahzad, Muhammed Azeem, Mian Sajid Nazir, Xuan vinh vo. Nguyen T.M.Linh (2021) " The determinants of capital structure: Evidence from SAARC countries", *International Journal of Finance & Economics*, Vol 26, Issue 4, PP 6417-6487. (2021)

- [11] Bueno, A.; Godinho Filho, M.; Frank, A. Smart production planning and control in the Industry 4.0 context: A systematic literature review. *Comput. Ind. Eng.* , 149, 106774. (2020)
- [12] Bendul, J. C.; Blunck, H. The design space of production planning and control for industry 4.0. *Comput. Ind.* , 105, 260–272. (2019)
- [13] Li, Q.; Kucukkoc, I.; Zhang, D. Z. Production planning in additive manufacturing and 3D printing. *Comput. Oper. Res.* 2017, 83, 157–172. (2017)
- [14]. Altaf, M. S.; Bouferguene, A.; Liu, H.; Al-Hussein, M.; Yu, H. Integrated production planning and control system for a panelized home prefabrication facility using simulation and RFID. *Autom. Constr.*, 85, 369–383. (2018)
- [15] Aouam, T.; Geryl, K.; Kumar, K.; Brahim, N. Production planning with order acceptance and demand uncertainty. *Comput. Oper. Res.* , 91, 145–159. (2018)