Abstract

This article deals with management of supply logistics in automotive industry. There are also some actual trends in automotive and supply sector based on flexibility principles. Section 1 presents the scope of automotive supply chain characteristics, provides an overview of component suppliers’ structure and focuses on Just-in-Sequence way. Next part relates to application of build-to-order supply management and the example is presented in conditions of automotive plant with direct customer purchase impulses. The closing part of the paper presents a reason for the need of using support information technologies tools to control suppliers’ production and logistics processes in flexible car assembly line for continual material flow.

Key words

Logistics systems, automotive production, Supply Chain management, build-to-order principle.

1. INTRODUCTION

Efficient logistics management is increasingly becoming a survival factor for the automotive sector. In conditions of post-crisis impacts to automotive industry and very strong competitive pressure of automakers in global market, the flexibility to management of materials and information flow in automobile assembly plants is declared as the key specification to future growth.

The fragmentation and segmentation of vehicle models (such as hatchbacks, sedans, vans, and pick-up are derivates to minivans, cross-over coupes, roadsters, two-seaters vehicles, SUV etc.) are growing. The complexity of customised models and variants is on the
increase, especially with regard to how individual vehicles are equipped. Automobile manufacturer must schedule the supply at few thousand sub-assemblies and components in vehicle, with billions of possible combinations to car outfit. Key trend in the automotive production is standardisation of modules of construction to common platforms (Oughton, 2007). Modules refer to groups of related components and systems serving for the same or connected tasks (e.g. the front/rear axle, complete front-section of a body or the steering system). Interrelated modules constitute the platforms, on which products for different car brands are developed. This means that vehicles can be adjusted to the individual requirements of customers and delivery schedules enable OEMs (Original Equipment Manufacturer) to produce multiple models (based on varying platforms), at the same manufacturing facility in assembly plant. This sharing of components is crucial for reducing costs (Project MyCar, 2006). The model diversity is an important sales argument and order-to-delivery time is the key factor to the automotive market and manufacturing process. These require changes in assembly operations and working logistics and for that reason automotive supply chain needs to be managed more flexible and agile.

2. RELATIONS IN AUTOMOTIVE SUPPLY CHAIN

Automotive supply chain includes (Charter, 2001) all managing business activities to relationships between the sales channel, distribution, warehousing, manufacturing, transportation, and suppliers, and related functions and facilities (directly or indirectly) in the flow to transformation of goods and services from the raw materials stage (metal - steel, alloys, plastics) to the sub-assembly modules (components, parts, accessory) and to the finished products (vehicle) and deliver them to end user – customer.

Members in every tier of supply chain integrate all aspects of logistics (Reichhart, Howleng, 2007):

- internal logistics focus on the relationship linking procurement, transportation, inventory control with information systems, planning, production, inspection, and delivery of goods in a seamless process, and
- external logistics links the collaborative operations with sub-suppliers, sales, warehouse management, distribution networks, service providers, contractors, and customers.

Supply chain management focuses on the processes that are needed to synchronise supply to customer demands, allows the optimisation of inventory held, and minimises waste. Typical supply chain in automotive production may include components or modules suppliers (Tier 1 - 3), OEMs (car manufacturers), distributors, dealers (retailers). Traditional vertical integration of automotive supply chain system is presented at fig. 1.

Hierarchical network of suppliers is divided generally into 3 levels (Project MyCar, 2006):

- 1st tier suppliers - are global located world producers of completed modules (e.g. dashboard, engine, seating etc.) with own manufacturing or assembly capacities establish mainly near to automakers plant considering to logistics way in condition of JIS (just-in-sequence) or JIT (just-in-time) delivery specifications; they are incorporated into the OEMs product development projects and innovation process - this means that they make their own engineering decisions and designing solutions with establishing local engineering or development centre.
- Tier 1 suppliers have their own 2\textsuperscript{nd} tier suppliers who procured parts for these modules (assembly units, e.g. welded framework of seating); they are the companies with own production or assembly plants establish near to 1-Tier suppliers (global or regional players).

- Tier 3 suppliers are raw material producers and companies of manufacturing capacities for small simple parts and individual components (e.g. plastic parts, metal parts, aluminium parts), which fulfil mainly quality and volume conditions of 2-Tier suppliers, some delivers for 1-Tier suppliers (e.g. coiled sheet).

![Model of vertical structure in automotive supply chain](image)

Fig.1 Model of vertical structure in automotive supply chain. Source: author’s adaptation

OEMs reduced their number of direct suppliers, and persuaded their suppliers to be more involved in product development. Today, OEMs outsource not only the manufacturing, but also the development of complete modules to suppliers across the several brands they own. Thus engineering service companies play an increasingly important role in the network of actors involved in new car development - engineering firms often become third partners in the cooperation between suppliers and OEMs for new product development (Pampillón, 2005).

Each member of the automotive supply system is connected to other parts of the supply chain by the flow of materials, orders and money and coordinated by flow of information. A change in any transmission link of the chain usually creates waves of influence that propagate throughout the supply system. Consequently, flexibility and agility factors are considered as the new differentiator in strong automotive competitive environment. Flexibility is required at many different levels in a firm of supply chain, including (SYSPRO, 2012):

- The ability to change the volume of aggregate output based on the fluctuation of demand;
- The capability to alter the variety of products that can be produced;
- The speed and number of new products that can be introduced;
- The ease of product modifications;
The operational as well as functional ability to adjust and deploy the resources to match requirements.

The level of flexibility that a company has directly reflects its ability to anticipate, adapt or react to changes in its environment of supply chain system.

The major automotive manufacturers and Tier 1 suppliers have been in the forefront of adopting new management and manufacturing practices (e.g. lean production, excellent production, intelligent manufacturing, sustainable manufacturing, learning organization, Just-In-Time inventory, e-commerce...). These practices are being driven down to Tier 2 and Tier 3 suppliers in order to improve cost and production efficiencies.

**Just-in-Sequence delivery schedule**

By adopting a JIT approach to inventory, component manufacturers can ensure they have enough stock to meet current and expected customer requirements. The supply chains are becoming demand-driven rather than forecast-driven in order to effectively respond in real-time to car manufacturers demands.

Suppliers have to manage a complex component life cycle to the OEMs and to the after-market (parts and accessories). Component makers must demonstrate that they can deliver the required design, quality, service and price. In automotive supply chains, components tend to move forward in a “pull” system which brings stock to the point of consumption only when it is needed for replenishment (Ericsson, 2010). The easiest method is to continue producing components in batch, creating little impact on manufacturing. Components are then warehoused, usually at a location in close proximity to the final assembly plant. A supplier or the warehouse will only deliver the parts to the point of use as needed. Assembly units or delivery of components are issued directly to the production line in OEM plant (fig. 2).

![Logistic concepts in automotive supply chain](image)

**Fig. 2: Logistic concepts in automotive supply chain. Source: (Palm, 2008)**

Ability to deliver on-time is a critical requirement for component suppliers, but just as important is the sequence of delivery. The requirements of automobile manufacturing are geared towards delivery of parts in tandem with the assembly process – termed Just-In-Sequence (JIS).
Just in sequence is an inventory strategy, it is an approach to manufacturing where components arrive at an assembly line in a specific order at the precise moment they are needed, and not before (Palm, 2008). In car producing, components from a variety of sources must be pulled together to create a complete vehicle. Parts come in a specific order, and workers on the assembly line can unpack them directly from shipping containers and install them, without a stop in storage or the need for sorting. Each component reaches the “customer” at the right time, in the right sequence, and in the appropriate version. Each parts and sub-assemblies received in sequence to be delivered to production stations in assembly line as they are needed, in the sequence they will be consumed.

The employees in logistic supply centre have to line up each part as it is called up by the computer – according to the series or car model, and in keeping with the vehicle type, colour and specification. Products are then placed in special transportation units. Parts must be delivered to the final assembly lines within a specified time frame. In addition, quality inspection must be implemented in the sequencing step to guarantee that the sequenced components match the assembly sequence perfectly. A single wrong delivery or interruption of supply can have serious consequences.

The result of JIS conceptual principles application is: inventory levels are never overstocked, material flows is perfectly synchronised, processes are leaner, and consumers enjoy customised configurations (Hebeler, 2003). The basic idea is to hold inventory in some modular form and only complete the final assembly or car configuration when the precise customer order to OEM is received (Reichhart, Howleng, 2007). This allows a small number of components to be available at the point of assembly, with a small amount of safety stock off-line for use in emergency situations such as a component being damaged during assembly. Without sequencing, every possible variation of a component needs to be stocked at the production area of OEM plant.

3. AUTOMOTIVE PRODUCTION BASED ON „BUILD TO ORDER“ PRINCIPLE

Logistic strategy of automotive manufacturing, relates to suppliers parts delivers in OEMs assembly plant, can be explained by various ways: make-to-stock; build-to-forecast; build-to-order: engineer-to-order, assembly-to-order, configure-to-order (customise-to-order). In this section of article is simplified explained build-to-order (BtO) car production methodology (this practice is for example applied in automotive plant VW Bratislava for the production of customised vehicle models VW Touareg hybrid and Audi Q7). BtO is appropriate for parts and components, which exist in a large variety, are visible to the end-customer, and are cost-intensive (Ericsson, 2010). The BtO approach offers the customer the possibility to configure the desired car of their dreams at an extra cost.

Material flow in automotive plant is in the run of press shop, body shop, paint shop, assembly lines and inspection stations, as symbolise fig. 3 by conception of Toyota Production System. BtO practice can be explained as follows: customers make their requests for auto features through the dealers and specification is then communicated to OEM. The information is captured in a central database and bill allocation is done to determine cost of production and deciding place where the car will be manufactured - is stated the nearest location of customers vehicle model production plant. All parts are supplied, imported and received by logistics ways. Just in time (JIT) or Just in sequence (JIS) supply principles ensure that certain part of the vehicle (the right component) arrive to the right point on the assembly line and at the right time has to be ready for installation on the respective body (to be inserted to the particular vehicle they are made for). Based on a fixed production sequence
planned several days in advance (or on the order in which vehicle bodies leave the paint shop), OEMs ask suppliers to deliver components to match the production sequence. Suppliers can ensure this OEMs requirement of sequence delivery to continue producing components in batch, they are warehoused, usually at a location in close proximity to the final assembly plant. When sequence orders come from OEMs to the supplier, components at the warehouse are simply repackaged (often aided by information-based tools) in the right sequence and quickly delivered. Once car is assembled, it is transported to the dealers ready for the specific customer.

Fig.3  Schematic formulation of logistic process in automotive plant (Source: Toyota, 2012)

Building cars is not a parallel process, it is largely sequential. The aim of the pull orientation in automotive manufacturing is to keep material flowing on a permanent, continuous basis without interruptions in order that all workstations in the flow just produce the quantity which is required from the next workstations (Toyota, 2012).

4. ICT SUPPORT OF LOGISTIC IN SUPPLY CHAIN

The automotive industry has pioneered the use of information and communication technology (ICT) tools to increase the level of global communication between OEMs and suppliers. A key role of newer technology is to ensure that schedule information from multiple customers in multiple regions with various production systems can flow accurately and consistently into a supplier’s internal business systems to streamline processes and make it easier to react quickly. For example, electronic data interchange (EDI) was adopted as an industry standard in the 1980s (Hebeler, 2003). OEM sends the long-horizon forecasts and short-horizon JIT delivery schedules to its suppliers, they receive the information via electronic data interchange (EDI order). Other suppliers access portal, where OEM posts the requirements to provide up-to-date information on delivery needs. Using only an Internet browser, suppliers can view all information in real time (including release schedules, purchasing documents, invoices, and engineering documents). Effective data exchange between automotive trading partners, OEM to Tier 1 or Tier 1 to Tier N, can significantly
enhance operational and financial performance (Schwarz, 2008). Giving suppliers’ access to original market demand data, broken down by part or component, would be a major instrument for reducing inventory and reducing lead-time. But there are multiple barriers in realising these benefits, including information lag, data misinterpretation/translation, and process inefficiencies.

To maintain delivery excellence, automotive suppliers must cultivate information systems that are comprehensive, scalable, secure, and integrated. Collaborative engineering of OEMs with automotive suppliers opens new possibilities for more efficient and faster product development with suppliers via the internet (Hebeleer, 2003). Best in Class automotive companies used support information technologies tools (e.g. mySAP Automotive that covers business processes from engineering design, planning, production, procurement, sales and service) to monitor production status in real time. As vehicles are built, inventory data from plant systems is shared with ERP (enterprise resource planning) systems and communicated to suppliers. Access to real-time production information improves visibility and responsiveness, facilitating demand-driven manufacturing and supply chain operations. Timely communications help suppliers produce and deliver the right inventory when and where it is needed, eliminating out-of-stock incidents that impact factory throughput (Brandt, Taninecz, 2008).

Additional supporting solution is for example RFID (radio frequency identification systems) technology that will help collecting accurate and reliable data and therefore enables the producers to have a supply chain with higher transparency.

5. CONCLUSION

Today, as OEMs design and build their vehicles globally, automotive industry supply chains have become increasingly complex. Automotive supply chains need to become more responsive and flexible to remain competitive.

Automotive OEMs and suppliers require capability to manage shorter production lifecycles using processes such as Make-To-Order, Assemble-To-Order, and Configure-To-Order. Production sequencing is especially important for car manufacturing companies where multiple products are being built from the same base platform. As automotive production can also vary according to product model or customer demand, component manufacturers also need the ability to dynamically plan, control and synchronise production runs of differing length operating independently.

The ultimate goal is to synchronise demand through the supply chain by generating precise, timely orders at each tier. Improving the quality and timing of information flow has enhanced their ability to respond to the dynamic changes of the automotive business environment.

REFERENCES


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Resumé

Efektivní řízení složitých materiálových a informačních toků v dodavatelském systému pro automobilovou výrobu je považováno za ultimativní faktor rozvoje tohoto sektoru v podmínkách značné konkurence v globálním trhovém prostředí automobilových producentů. Fragmentace modelů a variant nových automobilek do různých segmentů vyvolává potřebu neustálého zvyšování flexibility a agilitu dodavatelského řetězce. Rovněž narůstá individualizace požadavků zákazníků na výbavu vozidel, což dodavatelé řeší pomocí různorodých modulů a zkompletovaných funkcionalních systémů a autovýrobce konstruují společné platformy vozidel pro zajištění variability při současně redukci nákladů.

Příspěvek uvádí přehled struktury dodavatelských řetězců v automobilovém průmyslu a mapování této problematiky - úvodní část se zaměřuje na klasifikaci dodavatelů v tradiční...
formě specifikace do 3 úrovní, která je prezentována schematickým modelem, a charakteristiku sekvenčního způsobu zásobování montážní linky automobilového závodu (Just in Sequence). V další kapitole je uveden princip výroby automobilů adresně na objednávku zákazníka (build to order) v režimu z před-kompletních modulů od dodavatelů. Závěr se týká možností využití nových prostředků informačních a komunikačních technologií pro zvýšení efektivnosti logistických procesů dodavatelů v automobilové výrobě, kdy je klíčovým požadavkem sdílení informací v reálném čase o výrobních objednávkách od OEM v celém řetězci zásobování a zabezpečení synchronizovaného materiálového toku napříč všemi články komplexního dodavatelského systému.