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A conceptual model to manage supply sequences in automotive industry for Nissan Barcelona

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Abstract This paper presents an action research experience in *Douki-Seisan* in cooperation with the Nissan Factory in Barcelona. Three suppliers are involved in the experience to improve the way they perform *synchro* deliveries of parts to Nissan. Supplier issues are analysed and a decision making tool is developed for a supplier.

Keywords: Lean Manufacturing; *Douki-Seisan*; Supply Chain Management

1 Introduction: the world of lean manufacturing

This paper discusses an action research experience in three suppliers of the Nissan factory in Barcelona. Each automaker may have a different manufacturing philosophy but currently all relate to the lean manufacturing paradigm. In order to rebuild the Japanese economy after World War II, with none of the financial resources or economies of scale available to the American auto giants, the Japanese automotive industry realized that, if they were to take on the American automakers, they would have to work in a different way. Toyota developed the Toyota Production System (TPS), a low-inventory, mixed-model approach in which material was pulled “just-in-time” (JIT) through the manufacturing process, without

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wasteful activities and with a set of employees engaged in improving the system. (Sugimori et al., 1977; Ohno, 1988). The term “lean manufacturing” -famous through “The machine that changed the world” (Womack et al. 1990)- is a generalization of the TPS that can be extended to other contexts. The core of lean is founded on the concept of continuous improvement and the elimination of unproductive manufacturing practices or *waste*.

Adopting lean manufacturing affects the way a company is managed and how it structures its relations with employees, customers and suppliers. When a firm has achieved a certain degree of leanness, it tries to extend lean manufacturing practices to its suppliers (David and Eben-Chaime 2003). However, different automotive suppliers have different capabilities and therefore they may require a significant reorganization in order to implement management methods prescribed by the client company. In consequence, the aim of our research is the development of a methodology to (i) identify the level of leanness in three suppliers and their capability and willingness to adopt lean tools in order to cut waste and unevenness in their relations with Nissan; (ii) identify the necessary conditions to extend lean manufacturing to suppliers; and (iii) develop the tools to fulfil such conditions (processes used within a facility and over distribution connections in order to improve delivery and manufacturing of parts). This methodology can be extended to the suppliers of the suppliers in order to guarantee a real supply network management.

2 Understanding *Douki-Seisan* and the Nissan Production Way

This paper is based on a research project conducted at the Barcelona School of Engineering (ETSEIB) promoted by Nissan Motor Ibérica. The Nissan production system is far less popular than TPS, and thus, the first step of our methodology is to understand the particularities of lean manufacturing at Nissan. Beyond a theoretical background, section 2, mostly written after Bautista (2004), corresponds to qualitative research methodology based on interviews with engineers and area managers at Nissan’s Barcelona plant in order to adjust our investigation to the needs of the company. Following Schwandt (2000), academics were directly involved with Nissan’s participants in an attempt to fully understand the *Douki-Seisan* concept (DS) by means of collaborative work on this project.

The postwar aim of Nissan was the same than that of Toyota, but these companies developed different tools based in different principles, and therefore in the 1980s both manufacturing systems were different although some methods were the same (Cusumano, 1989). The differences include a preference for automation and information systems in Nissan. In 1971, Nissan started using a computerized system to coordinate vehicle orders with materials and component procurement, in house parts production, transport and final delivery of completed automobiles to dealers (Cusumano 1989).

In the 1990s, Nissan developed the Nissan Production Way (NPW) to outline its synchronized production philosophy: to manufacture according to the real consumer order while coordinating all operations and materials. The two pillars of the NPW are (De Goldfiem 2003):

1. Never ending synchronization with the customer in terms of Quality, Cost and Time. The term *Douki-Seisan* means synchronous manufacturing. It involves sequenced and simultaneous/synchronized production: After a customer places an order with a dealer, there has to be synchronization between the manufacturer, the supplier and the dealer with an efficient process flow without any disruptions. This requires sharing information and an efficient procurement and manufacturing system.
2. Never ending quest to identify problems and put in place solutions: Identify gaps between desired manufacturing state and present manufacturing settings.

At Nissan, DS is an ideal state of a production plant where all the processes get information from the customers at same time, in order to establish a continuous flow, free of defects without changes in the scheduled sequence. This means that all processes can have advanced information on demand and therefore types and quantities of products can be scheduled and sequenced. Then, all processes can start their setup operations. In conclusion, DS can be described as a manufacturing methodology that transfers customers' orders to all the processes at same time in order to achieve a continuous and smooth production flow with zero product defects, zero equipment breakdowns, minimal setup time, minimal inventories and no bureaucracy in the manufacturing process.

DS has two important targets: (i) products must be manufactured following the scheduled order and (ii) existing defects must be detected before products leave the manufacturing process. These features allow a reliable and smooth operation of the manufacturing process, without much delay and with fewer inventories between stations. If all the steps of the process could be synchronized, then work in process inventory would disappear.

Nissan insists on the importance of keeping the manufacturing sequence that was previously scheduled for its mixed-product assembly lines. This way, all processes can manufacture parts and subassemblies according to the same schedule and inventories are not necessary. Nissan has some indicators to track the performance of the manufacturing process:

Actual Production Lead Time (*APLT*). This term refers to work-in-process inventory (*WIP*) and is measured as the time that the manufacturing process can be fulfilled with the available inventories (Equation 1).

$$APLT = \sum_{\forall \text{ process}} \frac{WIP_{\text{process}}}{\text{Daily_production}_{\text{process}}} \quad (1)$$

Scheduled Sequence Achievement Ratio (*SSAR*). Equation 2 shows the percentage of vehicles that keep the scheduled sequence (vehicles not overtaken by other vehicles).

$$SSAR_{Line} = \frac{Vehicles_not_overtaken_{line}}{Total_Vehicles_{line}} \quad (2)$$

Scheduled Time Achievement (*STAR*). Equation 3 shows the percentage vehicles that reach the end of the process on time (less than ± 1 hour margin with respect to the scheduled time).

$$STAR_{Line} = \frac{Vehicles_on_Time_{line}}{Total_Vehicles_{line}} \quad (3)$$

DS encompasses five different types (or categories) of activities that refer to different elements:

- Category 1: The assembly line sticks to the scheduled deadline and scheduled sequence.
- Category 2: Parts and subassemblies manufactured in the assembly plant flow toward the assembly line as they are processed in perfect synchronicity.
- Category 3: Suppliers produce and deliver according to the schedule. The assembly line and the suppliers are synchronized.
- Category 4: Transportation facilities (ships, trucks) are managed in order to avoid delays in delivery and final products waiting to be shipped.
- Category 5: DS aims at synchronization with the customer. Order Lead Time (Time from customer order received to customer order delivered) has to be short (Car assembled and delivered to customer within two weeks of order). This requires a flexible manufacturing system and the cooperation of the dealers and the sales department.

3 Improving the capabilities of suppliers

According to the DS concept, the following step is to extend synchronous manufacturing and synchronous delivery to suppliers, aiming at the achievement of DS category 3, which is about improving the capabilities of suppliers in order to remove the risks associated with batch manufacturing (inventories and shortages).

This improvement project requires assessing the present situation, defining the desired situation and finally discovering how to reach the final situation from the starting point. The assessment of the level of leanness of the suppliers was done

by means of interviews. Currently, some models (See Almomani et al, 2014) are available to formally evaluate practices that refer to inventory, team approach, processes, maintenance, layout/handling, suppliers, setups, quality, and scheduling/control. Depending on the results of the survey, it may be necessary to extend lean thinking to suppliers in order to help them understand lean manufacturing and develop the necessary work procedures. Examples on how to do it can be found in MacDuffie and Helper (1999) who describe the experience of six suppliers of Honda in North America. The methodology can be used by any lean company. Once the supplier is on the maturity path towards lean manufacturing, the car manufacturer may implement a supplier management system that includes supplier selection, improvement, certification and evaluation, for the objectives of continuous improvement, cost reduction and elimination of wasteful activities (Guo and Xu, 2007).

Taking into account the importance of synchronization and keeping the scheduled sequence, the desired situation can be expressed as: (i) The scheduled sequence should not have to be changed and *SSAR* (Equation 2) should be over 90%; (ii) If suppliers should know the information about the scheduled sequence in advance then suppliers could manufacture their products according to their client's sequence and put them in bins; (iii) Transportation to the client's plant would be done in sorted containers, full of sorted bins -thus, workers on the assembly line would easily find the parts that they need, and in the necessary order-.

Besides, the consecution of the above objectives would help to attain measurable results such as: (i) Inventory reduction; (ii) Reduction in the amount of plant space taken up by the inventories; (iii) Reduction in logistic costs (Gudehus and Kotzab 2012); (iv) Product availability and wait time; (v) Reduction in the number of stock-outs (due to the synchronization between supplier and automaker); (vi) Flexibility of the production process; (vii) Flexibility for new product launch.

Given the above requirements, a tangible outcome of this project should be an innovative model to sequence supplies such as a management system focused on achieving the desired synchronicity objectives to meet customer requirements by means of a certain organizational structure; sets of policies, procedures and processes; and human, material and financial resources needed to deploy supplies management.

4 Defining a conceptual model and a decision making tool

A task force made up of academics and Nissan's area managers, visited Nissan's plants in Barcelona and also visited suppliers A, B and C. For the aim of our project, suppliers are classified depending on their capability to manufacture and deliver part in synchronicity with the car manufacturer:

1. Suppliers such as company A, which is devoted since 1980 to manufacturing complete seats, which are manufactured in synchronicity with the automaker and delivered in synchronicity. Company A, a subsidiary of an American company, has more than 250 employees and is located 5 km away from Nissan's plant.
2. Suppliers that deliver parts in synchronicity although they do not manufacture in synchronicity with the automaker's schedule. Company B, performs "synchro" deliveries of plastic parts from a warehouse that keeps a couple of days in inventory. The warehouse is replenished from the supplier's plant, where parts are manufactured in batches. Company B, a subsidiary of a North American company since 1999, is located 69 km away from Nissan. With 200 employees, Company B manufactures plastic parts for Seat and, mainly, for Nissan.
3. Suppliers that neither manufacture nor deliver in synchronicity. Company C is a company born in Barcelona in 1947. Since 1991 it has been stamping parts for Nissan (and other companies). Currently it delivers chassis from its facilities 27 km away from the Nissan factory. It has 500 employees.

Four different questions of practical interest seemed to be feasible:

- To compute the lot size that would yield a better synchronicity for a given demand and for a known production rate and setup time.
- To compute the transfer lot size taking into account the existing constraints about transportation from the supplier manufacturing plant to the buffer warehouse in order to improve synchronicity.
- To compute the transfer lot size (and the response time between call off and the delivery in place) taking into account the existing constraints about transportation from the buffer warehouse to the car assembly plant in order to improve synchronicity.
- To compute WIP in the manufacturing plant and in the buffer warehouse as a function of the degree of synchronization between the supplier and the car-maker.

The relationship between the automaker and any supplier can be modelled as the relationship between two systems (Figure 1).

The automaker is considered the Main system (M) while the supplier is considered the Supplier system (S). The Main system has several attributes such as a sequence of units that has been previously scheduled (Sm), a vector of time values (tm), including cycle time, process time, setup time. In turn, the Supplier system has a sequence of units (Ss) that can be similar or not to Sm ; and their own time vector (ts). Between both systems, there is a flow of information and a flow of physical products. The Main system has to send information about Sm to the Supplier sufficiently in advance (tms), where tms is the response time of the Supplier.

t_{sm} is the transfer time vector from the Supplier to the Main system and q_{sm} is a vector of transfer lots from Supplier to Main.

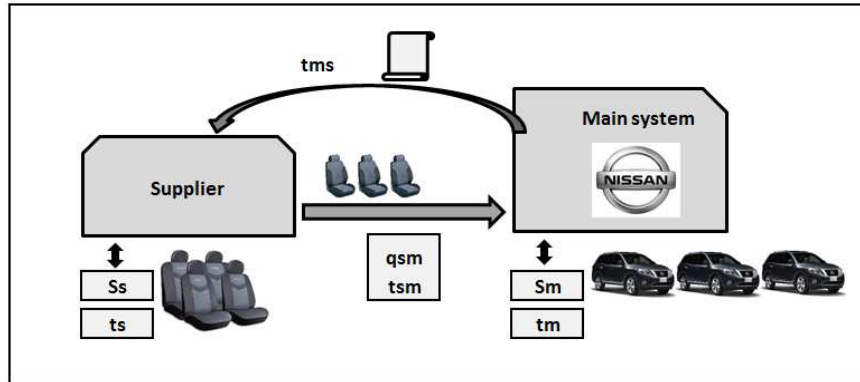


Fig. 1 Conceptual model of the relationship between the automaker (Main system) and its suppliers (Supplier system). Relevant variables are shown

This conceptual model is really practical: Company A is very close to Nissan's factory. Then, frequent deliveries are possible because t_{sm} is small (a 10 minute trip). t_{ms} can be small too (every 15 minutes, a 15 minute-sequenced schedule for the following 15 minute time cube is available) and synchronization is possible. Short production runs and small delivery lots are possible too. However, Company B is further away. One hour is necessary to take parts to Barcelona. Besides, some processes have long setup times (ts). In consequence, the response time (t_{ms}) of this supplier is higher and thus the Main system has to send information enough in advance. This hinders synchronization. It is necessary to reduce the setup time in order to reduce lot size and response time. Meanwhile the information on S_m should be distributed sooner, because the required lead time, at the time of the study, was shorter than t_{ms} .

A final outcome of the research was a piece of software for company C. The aim of the program was to help company C take better decisions related to smooth-synchronized manufacturing problems. The program can accept a bill of materials (BOM) coming from any process in the system; display a multi-level BOM explosion; compute a manufacturing sequence of units that ensures a constant rate of consumption of all the necessary components using a variant of the Toyota Goal Chasing Method; compare the resulting sequence with a user defined sequence; compute when each component is needed; display the consumption of a component over time for a particular sequence; display the deviations from regular consumption in order to compute the necessary inventories of parts and the amount of inventories generated by regular manufacturing; compute the *SSAR* and *STAR* indexes of a sequence and compare them with another sequence.

5 Conclusions

Douki-Seisan aims at the total synchronicity between all the processes along the supply chain. Some internal processes make it difficult to keep the sequence because they are performed in batches. Besides, it is very complicated to keep the scheduled sequence beyond tier 2.

All the steps of the methodology described in this paper can be used by any company that wants to involve their suppliers in lean management. The conceptual model to study the degree of synchronicity between two companies is a first step in the definition of the necessary conditions to allow synchronicity between companies. The completion of the model requires a full list of conditions or constraints to be logically derived. Then, it would represent either an optimization problem or, at least, a constraint satisfaction problem (CSP), which asks whether there exists a feasible solution, or otherwise, gives clues on where the processes should be improved (time management, transportation means selection...).

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