Application Research of Lean Thinking in the Birth Process of Product

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Abstract The process of vehicle products birth for modern automobile manufacturing enterprises includes five stages: project planning, product development, production arrangement, trial production and mass production. Many of the outstanding companies applied lean thinking in the entire birth process of product to organically integrate people, processes, tools and techniques together, which gave the enterprises strong competitiveness and created significant value for customers and the society at the same time. The concepts, methods and ideas of lean thinking were proposed in some important application stages like product development, production arrangement and trial production on the basis of analyzing the status for the production process of an independent domestic automobile manufacturing enterprise. The results of practical case studies show: the implementation of lean thinking in the birth process of product has a positive effect on the realization of large-scale, low-cost and high-efficiency production. The experience on promoting the application of lean thinking in the birth process of product was shared.

Keywords Lean thinking • Production arrangement • Product development • The birth process of products

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1 Background, Purpose and Meaning

The birth process of automotive industry products includes five main stages: project planning, product development, production arrangement, trial production and mass production. The application of lean thinking in the birth process of product is to utilize the ideas, methods and tools of lean thinking in all stages of the production and in aspects like project management, product design, procurement, production, manufacture and sales management for the manufacturing of products according to users' requirements. The requirements include the right product, right time and right price for users. Enterprises achieve overall improvement by lean thinking in three areas: T (Time), Q (Quality) and C (Cost). Where T refers to constant requirement of adapting to the intense competition brought about by the fast product development of international advanced enterprises; Q is defined as the quality improvement in the whole process from product drawings to physical vehicles; C refers to bring forward the changes in product design and process development that occur in late processes, which could avoid a lot of waste in cost caused by design changes, repeated renovation and production arrangement in late processes (Womack and Jones 2011; Qi Ershi 2006).

Many outstanding companies apply lean thinking in the entire birth process of product: integrate the staff, processes, tools and techniques closely together to win strong competitiveness for enterprises and provide customers and the society with significant value (Morgan and Liker 2008). As a traditional large manufacturing country, Chinese independent innovation capability of manufacturing has been continuously improved in recent years, with much innovation products continuously emerging. But research and practice on the development process of product especially the birth process of product still could not meet the conversion of enterprises from "made in China" to "made in China with wisdom" and "created in China" (Zhai Wenbin et al. 2004; Qi Ershi and Zhang Hongliang 2009; Ma Tongbing and Ma Ke 2005; Chen Shaowen 2002; Huang Bin and Zhou Wanting 2004; Pan Shengping 2012). The improvement for the organization of production process with lean thinking, namely the birth of lean product, is an important way to solve this problem.

2 Problems on the Birth Process of Independent Enterprise Products

In recent years, many car manufacturers have established a number of production lines and multiple plants (local factories, remote factories and even overseas factories, etc.) in order to expand production capacity, and a lot of new vehicle models have emerged. Cross exists in the process of several new products, and many independent companies are facing serious problems due to the limited level of resource, management and technical. These problems mainly reflected in (from the aspects of T, Q and C):

1. *Fast means poor* (*T*). Although the work is required to be completed on schedule node at some stages of a project, some missing problems may be brought to the next stage in project management for the birth process of many vehicle models, and some issues directly affect the quality of late work. For example: if the pre-validation in product development is not sufficient, a lot of design changes may occur at the physical manufacturing stage. Changes of some models could be up to several hundred items.
2. *Good means slow* (*Q*). Only if all the major issues are solved, the process would enter the next stage of the project, which may lead to some tardiness and the overall schedule delay. For example: 6,254 items of problems were found and solved in mass production of a car mode before entering the next node, which resulted in 7.5 months of tardiness in this stage. For the entire birth cycle of the product, an independent company is 52 months while Toyota is 38 months, Mazda is 40 months and Volkswagen is 48 months.
3. *High cost of the vehicle mode* (*C*). The high proportion of special parts of the vehicle model leads to more new equipment and tooling, high investment and high cost in one car; the problems and errors caused by unsmooth process result in reworking, and the delivery cycle of products will be extended; irregular product development plan leads to fluctuation of production capacity, and the unbalance causes a lot of waste.

These issues do not meet the requirements of lean thinking (T, Q, C).

3 The Management Model for the Application of Lean Thinking on the Birth Process of the Product

FAW Car Co., Ltd. (hereinafter referred to as FAW) is one of Chinese major independent companies. FAW is facing with enormous challenges and pressures in the implementation process of "twelfth-five" development strategy, and there were four new models and two new models into production in 2012. In order to improve the market competitiveness and the management and monitoring capabilities in the birth process of product, the management model for the application of lean thinking on the production process was established based on the benchmark of international advanced enterprises like Toyota, Volkswagen and Mazda (Fig. 1). Based on the development system of Toyota lean product, the application of lean thinking was extended from product development to the whole birth process of products, and lean thinking was regarded as the core of establishing subsystems of tools and technologies, processes and personnel. The three subsystems were interrelated and dependent on each other and formed the birth process system of lean products. From the two dimensions of project management and functional departments, lean thinking, methods and tools like such as the systems engineering, concurrent engineering, virtual simulation, network technology, balanced production, modularization, platform and information technology were applied to the various stages of

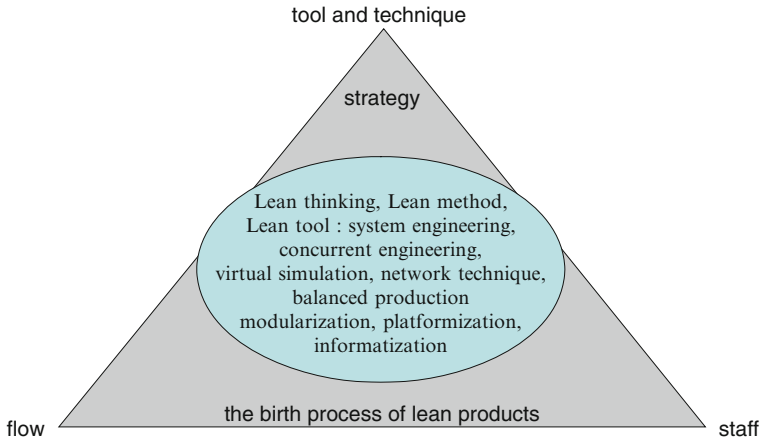

Fig. 1 The management model for the application of lean thinking on the birth process of the product

the birth process of products. The realization of enterprise development strategies could be ensured through the project implementation in the birth process of various new vehicle models and upgrading products.

4 The Application Innovation Case of Lean Thinking

In order to solve current problems and enhance capability in birth process system of products, FAW applied application management model of lean thinking to the project management of vehicle models and systematically took lean management measures in aspects like technique, process and personnel management. Remarkable results have been achieved. There are many examples of innovation that enhanced the overall capacity of lean management system.

4.1 A Typical Case for the Application of Lean Thinking at the Product Development Stage

FAW applied CAE simulation optimization technique to the field of product development and utilized finite-element simulation software like LS-DYNA, NASTRAN, STARCCM+, DesignLife and Abaqus for the digital simulation of body structure and performance, collision safety performance, body fatigue, NVH performance, vehicle flow field, etc. By means of finite element simulation, the evaluation and optimization for each performance of vehicles in the product design stage could shorten the project development cycle and save the cost of the project.

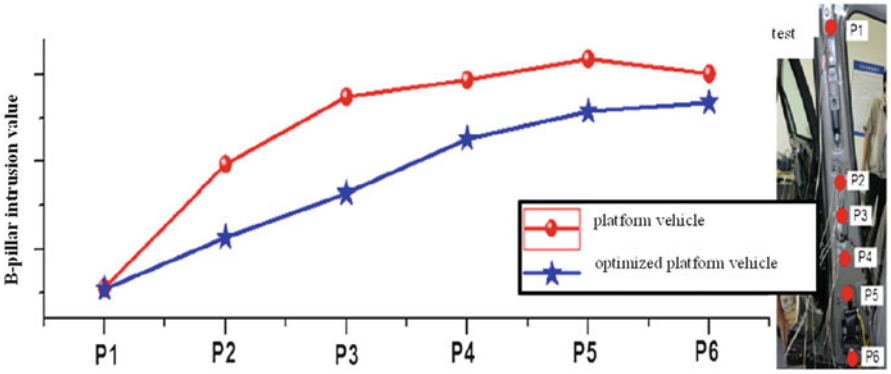

Fig. 2 The data comparison between the side impact tests of platform models and target vehicle modes

In the process of developing new models, platform models were regarded as reference, and the security of body development was ensured through the rational optimization for the body structure of platform modes. High-precision and digital-simulation models were established; through the simulation analysis of platform models and target models: the intrusion for the underneath of B-pillar and the threshold of platform models was too big, which led to mark loss in side impact. Therefore, the side structure was strengthened based on the simulation model including changes in the stiffener structure of B-pillar outer panel, improvement in the strength for the middle reinforcement material of B-pillar, increase in the size and thickness of threshold reinforcement, etc. Through side crash simulation analysis, side intrusion value of target models was significantly improved by the above structural reinforcement (Fig. 2). The follow-up real vehicle tests showed that side collision deformation was effectively improved.

This case showed that the utilization of lean thinking for guiding the development of new models and digital simulation means at the engineering design phase shortened the project development cycle and reflected the collision mechanism in the most intuitive way. The number of real vehicle collisions was minimized. The development cost of new models was saved. Further statistical analysis found out that the promotion and application of digital simulation in product development could shorten the new model development cycle by 10–16 months; the late design changing rate in product development reduced by 30 %; the cost of prototype manufacturing and testing reduced by 40 %.

4.2 A Typical Case of Simultaneous Engineering at the Stage of Production Preparation

The supporting simultaneous engineering of virtual simulation technology was utilized in welding workshop at the production preparation stage. 3D design and

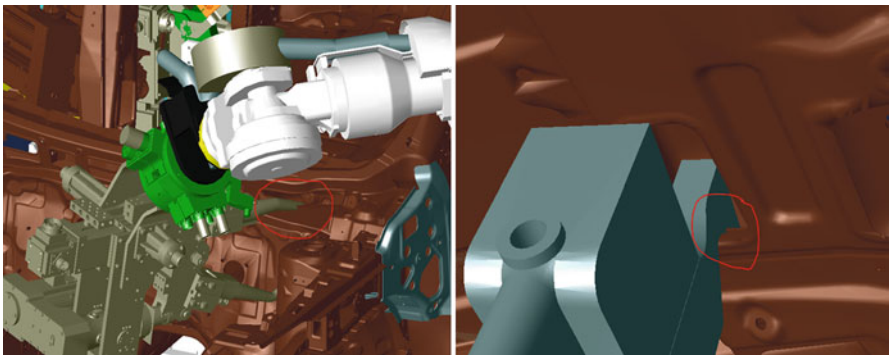

Fig. 3 The effect diagram of welding clamp interference before and after simulation

simulation of process planning were conducted to shorten the equipment installation and commissioning cycle in production preparation process of welding new models. The workload of each station in the production line was effectively balanced; the feasibility and reliability of equipment and technology was enhanced; the number of process changes in the workshop was reduced; the efficiency and quality of body process planning were improved; the production preparation period was shortened. Began in October 2007, FAW utilized the process planning software of Tecnomatix, robot offline simulation software of RobCAD and logistics simulation software of Plant to carry out the concurrent engineering of welding virtual simulation.

In the concurrent engineering projects of D1 models, in the product design stage, virtual simulation technology and RobCAD software of Siemens were utilized to verify the passing characteristic and changing amount of M3 main weld wire from a factory and the main weld wire from Red Flag factory. The process of products was evaluated to determine the changing amount of the production line based on simulation technique; and some optimization suggestions were proposed through the evaluation of process to reduce the changing amount of production lines, reduce costs. There were some big problems before application: (1) The model was more inclined to be manufactured in Red Flag factory in terms of production capacity, and there was no specific figure for the comparison of the changing amount and investment. (2) The simultaneous engineering of previous models was generally outsourced to foreign teams with high cost. (3) The larger models led to more new welding tongs. After virtual simulation technology applied on D1, the interference problems of welding clamp were found out (Fig. 3), and remarkable results were achieved: (1) Through simulation, better passing ability of M3 main weld wire was verified in the models from a factory; four robots, eight welding clamp and the corresponding ancillary equipment were saved through this scheme, which lowered total costs by 3.2 million yuan. (2) The concurrent engineering of the body frame was independently completed, and 32 technology assessments were output at the frame level. (3) Several optimization suggestions of products were put forward through simulation and ultimately reflected in the

product. Through these optimizations, eight welding tongs and ancillary equipment for the final transformation of main welding wire were saved, which costed a total of 960,000 yuan.

4.3 The Management Case in the Early Stages of Mass Production

FAW initial flow management is a quality management activity to quickly stabilize the quality of initial mass production and the market quality of the initial launch, enhance the assurance ability of organizing process and market competitiveness of products and ensure that the organization can continuously provide products that meet the quality requirements.

The content and indicators that the initial flow management focuses on: (1) the left items at PP stage, quality problem added at MP stage after sales; (2) the quality status of changing point like new process, new equipment and new component; (3) the capability index of the process. The focused content of the management early attention is broader and more systematic.

The initial flow management activities were divided into two types:

1. The initial flow of production: the early mass production was 1,000 mass production cars in 1–3 months.
2. The initial flow after sale: the initial launch was at least 6 months.

FAW Car established a process and set up a special organization. Three times of quality committee, 17 times of weekly meetings of working group, 63 times of day meetings and special meetings were organized. The markets in the regions of northeast, north, southwest and northwest were visited: two market visit activities were organized, and 137 problems, needs and improvement plans for formation quality were collected and implemented. Finally the failure rate of the sold thousands of cars showed a clear downward trend with each production month. The average failure rate after 1–6 months fell by 80.5 %, reaching the intended target.

5 Experience on Application of Lean Thinking on the Birth Process of Independent Products

5.1 Lean Thinking Runs Throughout the Entire Birth Process of Products

FAW firstly recognized that the essence of lean thinking was to combine the right business concepts and methods, industrial engineering and people-oriented corporate culture together. Lean thinking was put in the entire birth process and

the establishment process of three subsystems: technology, process and personnel. Pursuit "zero defect". Regard "Customers first" as the origin of enterprises. The concept "Do it right at the first time" should be established in project planning. The requirement "A viable product should be designed at the first time" should be met at the product development stage to reduce and avoid engineering changes in the downstream product development processes. Concurrent engineering method was applied to make tooling equipment like molds and process planning at the production arrangement stage, which could reduce the changes of plant, production line and the debugging and restructuring of tooling after production. The quality of the productions should be checked at the early pre-production and mass production stages. The usual critical problems were eliminated them one by one with lean thinking to avoid recurring quality problems in mass production. Lean thinking is the core idea to promote the continuous improvements for the birth process system of independent products.

5.2 Lean Culture and Lean Enterprise Soul

Senior leadership of FAW actively participated in the internal lean transformation and promoted Red Flag spirit "Gritty and Striving to Be Stronger" in the implementation of lean manufacturing process: projects for the improvement of the personnel quality, 3-years quality, management and system capacity were carried out; the enthusiasm and initiative of each employee were mobilized to carry out rationalization proposal, self improvement, QC (quality control) group activities and form the improvement mechanisms of the whole staff. HPS (Hongqi production system) was built from ten elements: the target management, team management, the whole staff improvement, standard operation, quality control, leveling production, punctual logistics, 6S on site, efficiency preservation and talent incubation. Continuous learning and improvement of the whole staff were guided to create new values for customers constantly, and lean thinking became habits and formed lean DNA from the superficial management activities of enterprises.

5.3 Lean Means for Accelerating the Birth Process of Lean Products

Lean tools and methods of learning – digestion – absorption – application – innovation such as large schedule management, five-step working method, matrix project team management, process standardization, concurrent engineering, virtual simulation, modularization, platformization, digitization of TTO, personnel quality and competency model were utilized by FAW to continuously promote the working quality of the whole system, the staff and the whole process. The practical

experience of lean thinking was continuously accumulated through the birth process of multiple models. The overall working quality, product quality and perceived quality were enhanced during the birth process of products. Lean means accelerated the birth process of independent products.

6 Conclusion and Outlook

The methods and importance of applying lean thinking on the birth process of FAW products was explained in this paper, and useful reference for other car manufacturers based on the model and the case was provided: (1) The system of lean tools, techniques, processes and staff composition is the guarantee for the birth of lean products; (2) Lean enterprise culture is the soul of Lean enterprise, and the birth process of independent products is also the formation process of lean culture; (3) The application of lean thinking effectively guarantees the achievement of "increment and efficiency" for enterprises.

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