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Implications of Just-In-Time System of Toyota: A Case Study

By

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Master of Innovation and Operations Management

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Certification of Originality

I, **Mahajan Sahil (52115001)**, hereby declare that the contents of this Independent Final Report are original and true, and have not been submitted at any other university or educational institution for the award of degree or diploma.

All the information derived from published or unpublished sources has been cited and acknowledged appropriately in the references listed in this Independent Final Report.

Mahajan Sahil

2017/03/01

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Summary

The aim of the research is to understand and analyze the impact of Just-in-Time (JIT) system in Toyota Motor Corporation. We also discuss about the different scenarios like natural and unforeseen disasters involving its efficiency in Toyota's system.

In this report, philosophy of eliminating wastage through the successful application of Just-in-Time (JIT) system and origin of "Kanban System" is discussed in depth. Moreover, this report will help you understand the overall working of Toyota Production System (TPS).

Furthermore, we will look into three cases from the past experiences of Toyota's struggle and incorporate its Just-in-Time (JIT) philosophies into real-life situations. Which will help in answering the question, whether "Toyota should look into new management system for maintaining continuous supplies to combat these stoppages"?The three cases that will be studied are:

1. AISIN Seiki Fire (1997)
2. Niigata Earthquake (2007)
3. Kumamoto Earthquake (2016)

Keywords: Toyota Production System, Just in Time

CHAPTER - 1

Introduction

Toyota Motor Company is very well known around the globe for manufacturing high quality automobiles. Toyota has been in the automobile industry for a long time now and every time they introduce new automobiles, they introduce newness and innovation of its own kind. But manufacturing automobiles is not the only contribution from Toyota Company. Over the years, after World War II, Toyota has put in a lot of efforts to meet the advancement required in the Japanese automobile to give a stiff competition to its western nations. Toyota introduced many techniques for its famous Toyota Production System like Just-in-Time System, Kanban System and Jidoka. The main goal was to lower down production costs and increase in productivity by simply removing the unwanted functions and practices in the factories. But these systems were so unique in its own way that other companies around the globe in manufacturing sector implemented the Toyota Production System strategies, but very few were able to reach the success of Toyota. The sole reason for the failure of implementation of Toyota Production System in overseas companies was the difference in industrial relationship, many small social systems and its business climates available in Japanese firms.

Moreover, the whole Toyota Production System took many years of patience and struggle to form this successful system, which is currently the heart of Toyota Company. There were no scholars who formed and laid out rules and structure for this Toyota Production System, it was the regular practice and daily situation occurrences in the

Toyota factories which laid down these methods by trial-and-error processes in manufacturing sites of Toyota Motor Company. Lately, there has been a lot of criticism for Toyota for sticking to its decades old production system, which has led to shut down on various occasions in the past, mainly due to its Just-in-Time System.

The purpose of this research is to determine the various implications that are faced by Toyota Production System based on theory of Just-in-Time System. Just-in-Time system stresses the importance to increase production efficiency and decreasing the wastage of goods only if they are required in the production process, which helps in lowering down inventory costs[Monden, 2012]. While it can be argued that due to Toyota's Just-in-Time System, in the past there have been situations which ultimately lead to closure of Toyota factories only because of lack of inventory for its production.

The output of the research will take the form a case study of three major shutdowns of Toyota Company in Japan. The three cases chosen were AISIN Seiki Fire in 1997, Niigata Earthquake in 2007 and Kumamoto Earthquake in 2016. All of these three cases were major shutdowns in the history of Toyota Company.

Research Objective

Hypothesis

Does Toyota's Just-in-Time System in Japan have any limitations or not?

Objective

The objective of this research is to analyze the Toyota's Production System and its core element of Just-in-Time System in Toyota factories which are located in Japan with the help of three cases.

Literature Review

Studies regarding Just-in-Time System activities of various firms are mainly focused on large companies. This research is mainly focused on the overall production system of Toyota and its essential strategy of Just-in-Time.

In plain words, Just-in-Time is basically an inventory strategy deployed by companies to decrease its waste, allowing it to increase its efficiency in the production process. By doing so, it allows the company to receive goods only in hour of actual requirement. This further lower downs the cost of maintaining the inventory and requires accurate forecast of demand from the top management. The main advantage of this strategy is to allow manufacturers easily move from one type of product to another by keeping the production run span short. Moreover, this allows complete removal of

warehouse storage requirements and lowering the spending on raw materials, resulting in lower cost of production. But Just-in-Time inventory strategy has also received a lot of criticism due to disruptions in the supply chain. For instance, a single supplier of raw material faces some sort of challenge and is unable to deliver the required goods on time, it could lead to shut down for the production house. To make this strategy work in a positive way, manufacturers and retailers should work together, so that they can monitor the supply of resources from manufacturers and meet the demand from consumer end (JIT, 2016).

On February 24, 2010, Mr. Akio Toyoda in his testimony mentioned, "At Toyota, we believe the key to making quality products is to develop quality people. Each employee thinks about what he or she should do, continuously making improvements, and by doing so, makes even better cars" (The Guardian, 2010). Furthermore, Mr. Toyoda also discussed the philosophy of Toyota's quality control. "I myself, as well as Toyota, am not perfect. At times, we do find defects. But in such situations, we always stop, strive to understand the problem, and make changes to improve further. In the name of the company, its long-standing tradition and pride, we never run away from our problems or pretend we don't notice them. By making continuous improvements, we aim to continue offering even better products for society. That is the core value we have kept closest to our hearts since the founding days of the company" (The Guardian, 2010).

Yasuhiro Monden, an author of Toyota Production System, said “This explains the basic idea of “continuous improvement” in the Toyota Production System and in Toyota’s quality assurance activities” (Monden, 2012).

Moreover, Monden specified that, “strength of Toyota Production System lies in the fact that it is a system of supply chain management in the industry as a whole. Inter-firm coalitions are well-executed in Japanese industries. These inter-firm networks work well in the product development phase as well as in manufacturing. The Toyota Production System is equivalent to the management system of inter-firm relations” (Monden, 2012).

According to David Hutchins, “nature of the Japanese quest for continuous project by project improvement. Every deviation is examined, the causes identified and remedies applied. Nothing is left to chance, and no deficiency, no matter how rare, is ever regarded as a purely random event which should be ignored. This mentality is essential to the achievement of real Just-in-Time. All attention is focused on the continued uninterrupted flow of operations. In the calendar 1986, from a labor force of 60,000, Toyota received 2.6 million improvement proposals, 96 per cent of which were implemented either by management or by the employees themselves” (Hutchins, 1999).

The literature discussed in this research stresses on the overall working and importance of Toyota Production System and its most valued element “Just-in-Time” system.

CHAPTER – 2

TOYOTA's JUST-IN-TIME SYSTEM

History and Evolution of TOYOTA

Toyota Motor Corporation was founded by Kiichiro Toyoda in the late 1930's. It was Sakichi Toyoda, father of Kiichiro Toyoda, who was aiding his father in his loom work, got an idea to improve the batten-equipped tall loom.

This lead to an invention of first hand loom in Japan and Sakichi Toyoda patent his hand loom design in May 1981 in Yokohama City. It was not over for Sakichi Toyoda, in his mind he was aiming to design a loom which runs by electricity.

After 17 years of his hardship, he came up with successful working design of electric loom in Japan. This was also the first power loom invented in Japan and he rightfully received the patents for his invention.

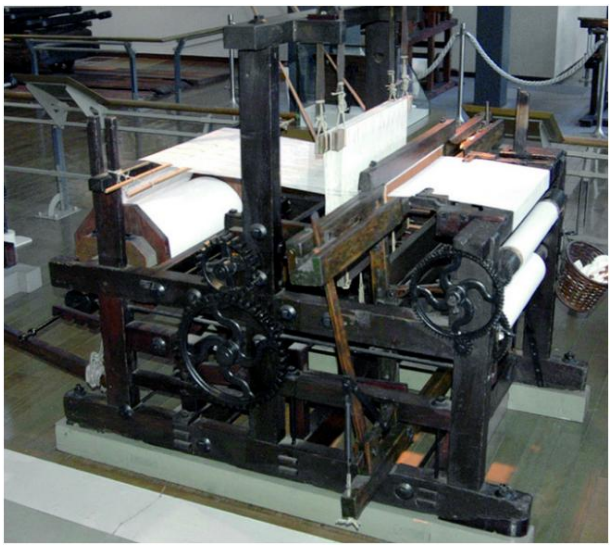

Figure 1 - First Toyoda Power Loom(Toyoda Power Loom, 2016)

Sakichi Toyoda was awarded with many patent rights, utility model rights and industrial property rights during his life time. When he died in 1932, his son Kiichiro Toyoda took over his father's reign.

Kiichiro Toyoda took his father's invention and works from being electric to automatic loom. Kiichiro Toyoda also invented various automatic looms and received patents for his invention in Japan.

Kiichiro Toyoda inventions were moving into automobiles at a fast pace and by May 1935, he had his first completed passenger car prototype, named as "Model A1". The company name was finally changed to "Toyota" from "Toyoda" in October 1936. Kiichiro Toyoda's works lead to further heights in the core establishment of Toyota.

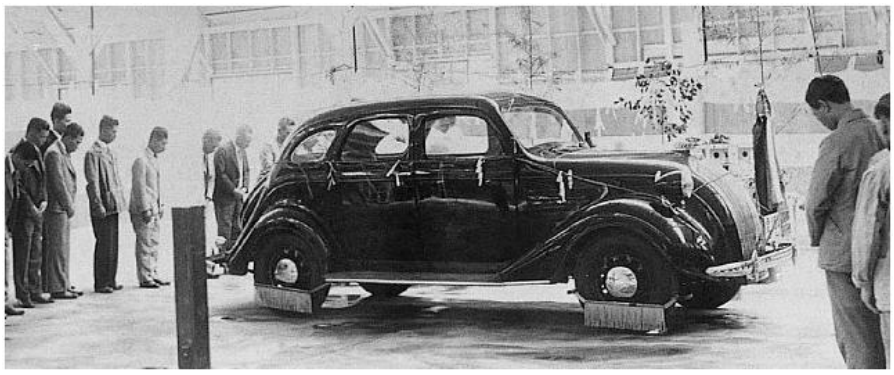

Figure 2 - First Passenger Car Prototype Model - A1**(Passenger Car Prototype, 2016)**

Today, Toyota has emerged into one of the biggest giants in automotive manufacturer. Its headquarters are in Toyota City, Aichi, Japan. It also has employee strength of 348,877 as of 31 March, 2016(Toyota Overview, 2016).

Toyota has come far from making passengers cars that run on petrol or diesel to electric vehicles known as “Hybrid”. Toyota is a global leader in hybrid passenger vehicles in terms of sales. Toyota Prius is one of the top selling hybrid passenger cars in the whole world as of 30 April, 2016 (Toyota, 2016). Toyota went on producing more than 10 million vehicles annually in 2012 and 2013 (OICA, 2012) (OICA, 2013).

Toyota has also implemented and developed world renowned systems like “Just-in-Time” and “Kanban”. Moreover, this lead to branding of its practices known as “Toyota Production System”. Many parts of the world recognize these managerial practices and willingly look forward to implement in their respective workplace. During 1948 to 1975, TaiichiOhno and Eiji Toyoda, who are well known Japanese industrial engineers, both developed this famous “Toyota Production system” through their rigorous attempts for improvement.

Toyota Production System

Toyota Production System is a well-known production system not only within Japanese community, but worldwide as too, for its distinctive feature – reducing the production cost. Japan has fewer natural resources as compared to other big countries like USA and European countries, which leads to increase in its costing of raw materials in many ways. This was well recognized by Toyota in order to reduce its costs towards wastage. Toyota Production System has taken many years to establish it-self by continuous rigorous improvements. The main motive behind its success is to generate

more profit through cost reduction. This also means producing vehicles and delivering it to customers quickly and efficiently.

The concept of cost does not confine only to production cost in Toyota Production System. It has a broader context, so in Toyota Production System, cost also refers to sales costs, administrative costs, capital costs, etc.

In manufacturing workplace like Toyota, the principle of Toyota Production System is to reduce costs by simply removing waste. Normally, there are four kinds of waste found in manufacturing production operations:

1. Excessive Production Resources
2. Overproduction
3. Excessive Inventory
4. Unnecessary Capital Investment

Firstly, *Excessive Production Resources* waste can be found in most of the manufacturing workplaces. It basically comprises of excessive man labor, excessive facilities and excessive inventory. If you combine these elements together and their existence exceeds the actual requirement like people for work, equipment, materials and products, it leads to increase in overall cash costs without adding any value. For example, more number of people in the form of workforce will increase wages, having more facilities will lead to depreciation costs of those facilities provided and excessive

inventory leads to high cash outlays like capital costs and need to increase inventory investment.

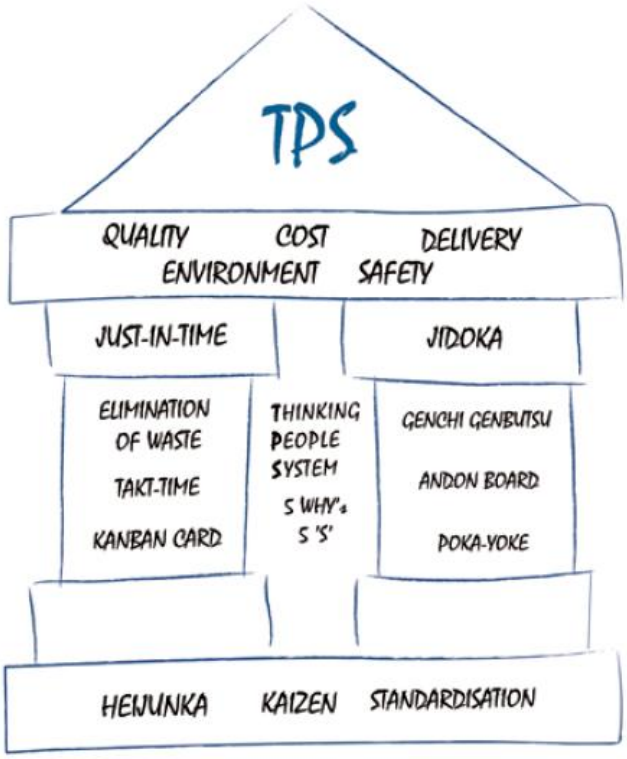

Figure 3 - Toyota Production System**(Toyota Overview, 2016)**

Secondly, Overproduction which is the secondary waste. In Toyota Production System, it is regarded as the worst type of waste because it keeps on working on the essential resources continuously, even if there is no requirement. This leads to the third type of waste in Toyota Production System – Excessive Inventory. This leads to requirement for more labor, equipment's, space of keeping inventory and transport.

Lastly, above mentioned three wastes create the demand for fourth type of waste named as Unnecessary Capital Investment. In Toyota Production System, this fourth type of waste leads to building of warehouses to meet the requirement of keeping extra stock,

more labor for moving stock from one warehouse to another warehouse, purchasing more machinery like fork lift for every single transporter, hiring more inventory control personals for new warehouses, requirement for operator to work on damaged inventory, new processes will be required to follow in order to manage the conditions and quantities of various types of inventory, and in the end, hiring of an individual to do the computerized inventory for the whole new warehouse.

All the above mentioned sources of waste, give unnecessary rise to administrative costs, depreciation costs, direct material costs, etc. Moreover, Excessive Production Resources waste is the first one to appear in the whole cycle and also provides path to other subsequent wastes.So it becomes essential to remove that waste as shown in Figure 3. Excessive workforce only leads to more idle time, which is also called waiting time.A worker can be re-allocated with new job responsibilities, which results in less work force and labor costs. In addition, the costs raised by other three wastes: Overproduction, Excessive Inventory and Unnecessary Capital Investment, will be reduced.Such an ability to control overproduction is the primary structure of Toyota Production System.

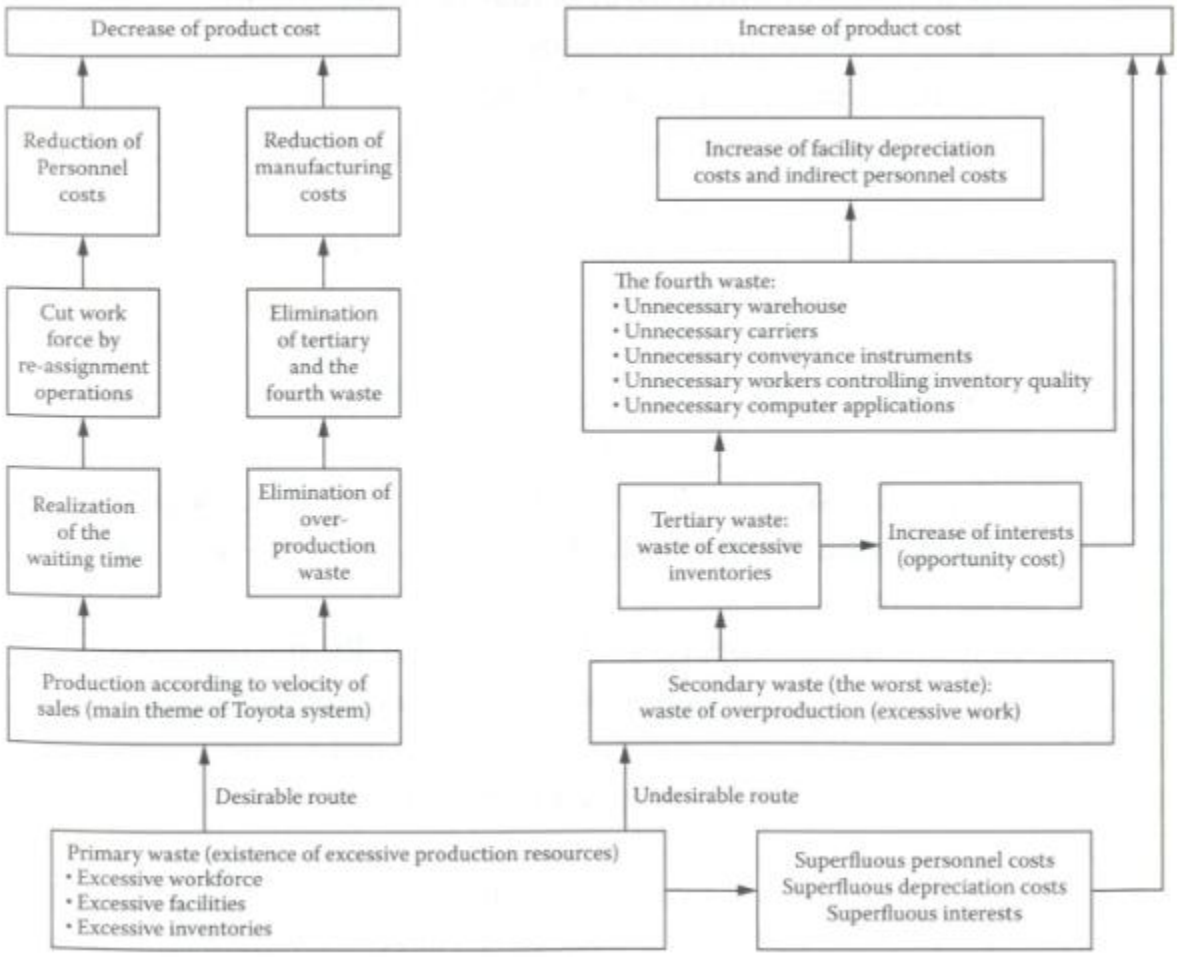

Figure 4 - Process of Waste Elimination **(Monden, 2012)**

Toyota Production System (Sub-Goals)

Cost reduction has been given the highest priority in Toyota Production System, but there are another three sub-goals too, which need some lightening on it. They areQuality Assurance, Quantity Control and lastly, Respect for Humanity.

1. *Quantity Control*– It allows the Toyota Production System to adapt to demand of quantity and variety as per daily and monthly requirements.

2. *Quality Assurance* – It assures the Toyota Production System of supplying of only good units to subsequent process.
3. *Respect for Humanity* – It helps in cultivating a system of respect in Toyota Production System towards the utilization of human force to meet its cost objectives.

Toyota Production System makes sure that proper emphasizes are given to these three sub-goals because they cannot exists or can be achieve on their own. This also requires influence from the primary goal of cost reduction. Moreover, it makes a special feature of Toyota Production System that primary goal will be hard to achieve without realization of its sub-goals and vice versa.

Toyota Production System and its Basic Concepts

After recognizing above related topics, two concepts that Toyota is able to plan and run its production system. Firstly, recognition of efforts that are put in to reduce the production cost by eliminating waste. This allows generating a system which thoroughly eliminates waste on the basis of assumption that anything which exceeds the minimum amount of required things like materials, workforce, machines, etc. essential to complete the production task are merely excess, which will only lead to increase in cost. Secondly, recognition of hard work of the Japanese people, working environment, workforce ability and diligence. Allowing the workers to showcase their full potential by themselves and giving due consideration. Also, treating their workers as human beings.

In order to attain such a system, Toyota has given special importance to *"JIDOKA"* and *"JUST-IN-TIME PRODUCTION"*.

Just-in-Time System

In automotive industry, efficient production system is only possible by removal of following three distinguished problems.

The typical automotive industry will consists of mass production assembly type, which will involve assembly of each vehicle from several thousand parts which have also gone through numerous processes. So removal of any obstacle in any of these processes will keep the proper functioning of the production system. Otherwise, it may create a huge mess in whole production system if any of these processes are having trouble.

Huge fluctuations as per the demand of a particular model. Whereas, the production house consists of numerous types and variations in other models.

After every couple of years, the vehicle is completely remodeled. This also leads to change of various other small and big parts to complete a particular model.

In automotive industry, the ordinary production control system allows fulfill the schedules of production by holding work-in-progress inventory. It allows in absorbing troubles of processes and fluctuation in demand for all the processes. On the other hand,

such a system also creates excessive and unbalanced inventory within many processes, which are mostly not sold at the same time.

Moreover, such a situation in production house will lead to condition of excessive equipment's and more than required labor, which does not match up with Toyota's expectation.

Just-in-time production system helps in avoiding such situations, where problems related to unbalanced inventory and excessive equipment's and labor are due to troubles and demand fluctuations. In order to achieve this, all efforts are put in to develop a production system that will reduce the lead time from the moment materials are entered to the completion of vehicle.

Important Points in Just-in-Time

In just-in-time production method, the production lead time can be greatly reduced with due respect to maintain the conformity to changes by making sure that – all processes are producing only the necessary parts at the necessary time and have only minimum stock in order to hold all the processes together.

After checking the required number of inventory quantity and production lead time, this production system still needs to look into excessive labor and equipment's. This also leads to initiating the second most important concept of Toyota Production System,

which leads to maximum usage of labors potential. As per the above, following points are to be implemented in the production system: n

1. *Withdrawal by Subsequent Processes:*

The first and the foremost important part of just-in-time production, to gather accurate knowledge related to timing and quantity required. Normally, every production system, but in case of Toyota Production System, follows the production schedule of a particular product in automotive plant which is based on the various parts schedules and instructions given to all the processes.

The production of these parts as per their schedule, lead to the implementation of preceding process of supplying the parts to its subsequent process. But this process could only make it worse and difficult to adapt the constant changes to meet the production targets. On the other hand, Toyota adopted the opposite of preceding process of supplying the parts to its subsequent process.

In just-in-time production, parts are being produced as per various processes in the exact required numbers and exact timeline for completing the assembly of a vehicle, which is regarded as the final product of Toyota. In such a scenario, it won't be wrong to say that the final assembly line will be able to judge the number of parts it requires and how much time it will take to finish the vehicle.

After connecting the above discussed processes and put into the chain fashion process, it would be right to say that whole production process of the company is engaged in just-in-time production without making unnecessary bulky production orders.

2. One Piece Production and Conveyance:

This is the second important part of just-in-time production. In this, all the processes must be able to fulfill the criteria of producing one part in their respective process, so that, they are only left with one piece as stock and the other part is moved to subsequent production processes to complete the vehicle.

Therefore, no process in the production is allowed to produce more number of parts and maintain surplus inventory between the processes. So it was necessary to understand this by every process and keep their approach in such a way, that it only produces and conveys a single piece of unit for the final assemble line. All in all, it meant no lot production and no lot conveyance.

Reduction of lot size by shortening the setup time, leads to improvement in production methods which also includes the elimination of inventory within the processes. By following this, it results in ordering of multipurpose vehicle equipment adhering to processing requirements for a single product line. Toyota successfully carried out all of these with its Toyota Production System and also with its large number of sub-contractors.

3. *Levelling of Production:*

To meet the requirements of this important point in just-in-time production, all the processes must have small lot of production and conveyance. If the situation arises and the huge quantity for the following processes is withdrawn. This will lead to have excessive stock within the company and with sub-contractors all the time. To make just-in-time succeed, priority should be given tofinal assembly line, so that it can level the production.

Figure 5 - Heijunka - Levelling the Flow**(Toyota Overview, 2016)**

To meet the requirements of levelling of production in just-in-time, assistance from managerial positions is very much required. Firstly, the final assembly lines at Toyota are mixed product lines. Furthermore, the production per day is calculated by the average number of vehicles produced in the monthly schedule divided by the number of working days. Secondly, calculating the cycle time of different vehicles on daily basis in the production sequence, so that all the different vehicles appear according to their own cycle

time. Once the assembly line levels up with production, then the production of process of withdrawal and once piece production and conveyance are also leveled.

Another important point of levelled production is to satisfy the basic rule of just-in-time production, that is, to produce what is required to be sold without exceeding the limit. It also needs to adjust its production level as per the market changes and is able to produce as smoothly as possible. Once the monthly schedule for production is rolled out, Toyota still keeps on making the changes for different vehicles on daily basis orders. If the market situation changes, it will force Toyota to make further changes for monthly schedules, so that Toyota is able to lower down the drastic changes in demand.

Therefore, when the above mentioned production system is compared to general schedule production system, it will be easier to operate with former system with minimal changes to production than the latter system. Hence, it will allow in completing the task with less equipment's and more stable numbers. Practicing the above three general rules in production control system is called *KANBAN SYSTEM*.

4. Elimination of Waste from Over-Production:

Derecognizing the value of existing inventory is the most essential part of just-in-time production system. As per the classical production control system, availability of inventory is very much appreciated in order to combat the troubles and fluctuations of demand, and to smoothen the fluctuations in load of processes.

Whereas, Toyota sees this stock on hand, leading to collection of troubles and bad causes. Most of the unwanted stock on hand is caused by over-producing the particular item than the required amount, which is considered as the worst waste in Toyota Production System, leading to overall increase in the production cost.

There is a reason behind for terming over-producing as the worst waste in Toyota Production System because it hides away the actual causes of waste like trouble in various processes, unbalanced between the workers allotted to a particular process, workers being idle, excessive labor, insufficient preventive maintenance, etc. Now this prospect of waste makes it harder for employees to display their actual potential and also leads to hamper the overall growth of the company.

Jidoka

The term *"JIDOKA"* means application of automation with the essence of human touch to it. Toyota used it in equipment's or operations, which allowed them to stop the whole production process if they found any defect in the relevant process. It can also be described as a distinctive feature, which leads to stoppage of equipment or entire line, if there is a defect found in it.

Figure 6 - Andon Board **(Toyota Overview, 2016)**

Features of Jidoka

The reasons "JIDOKA" being an important feature of Toyota Production System are as follows:

1. *It helps in Preventing Over-Production:*

Once the equipment has achieved the desired target for number of amount, it stops. Thus, reducing the over-production waste. Moreover, it carries out the just-in-time production without any errors.

2. *It also helps in controlling any sort of abnormality:*

It will allow the production system to look into the defect founded by the worker in the equipment or an item. It also makes the other processes aware about the situation as

well. This leads to full utilization of worker's capabilities and is also considered as the important aspect when making up the system.

Emphasizes of Jidoka in Toyota Production System

Toyota Production System has made number of improvements to apply "JIDOKA" in their production system. Toyota also emphasizes on its workers capabilities and its full utilization. Toyota also has a concept, which allows it to utilize the full potential of Japan's favorable working environment and hardworking workers. Toyota has also created a built up system for the respect for human workers. Following points are emphasized:

1. *Elimination of Waste Movement by Worker's:*

Hardworking workers in the organization can help in raising the awareness of their work being worthy only if they add some value to the products. Workers movement in the working space is also considered as waste. This is mainly due to movement of materials from one place to another in the operations. It is mostly caused by large inventories. Toyota is now able to effect large reductions in this kind of waste with the thorough application of just-in-time production.

However, this will help in reducing too much waste. Due to this, it will do no good to workers and the production system, if their waiting time is increased. Production system should avoid the situation where workers and equipment are tied to each other. It

will only increase the idleness of the workers in the production system and to avoid creating such scenarios in the production system, following changes are been made by Toyota:

- Keeping labor occupied to multiple machines instead of attaching him to single equipment.
- Workers concentration level is also checked in such situations. The worker has to concentrate on certain parts of the equipment for producing acceptable items without any faults.
- Lastly, creating such lines in the production system which requires minimum supervisory.

Workers sometimes perform such a waste in operations system which is not required by the other workers. These are waste in operations involving the physical danger, operations which are injurious to health, requiring hard physical labor, etc. Moreover, waste in workers movements which results in troubles of defect. Toyota is largely able to benefit from this kind of wastes through the application of "JIDOKA".

2. Considerations to Worker's Safety:

Workers at Toyota are very hard working and are very enthusiastic for attaining the production target. This allows the workers to continue his work, even if there is a problem detected in operations has no serious issue to the production system working. The worker will end up taking a non-standard method, so that the line keeps on running.

However, such unwanted operations or extra work arises due to accidents, defects, malfunctioning or troubles.

Toyota has advanced it production system through the application of "JIDOKA" and elimination of waiting time to such an extent, that not only it helps in reducing the overall production cost, but it has also emerged as effective way of measure of safety for workers.

3. Self-Display of Worker's Ability:

Nowadays, respecting the humanity of workers in most of the production shops are gaining the international interest. Toyota believes in creating an environment of the highest order that would be the foundation of human respect. Toyota also believes in creating a system which allows its workers to showcase their potential through active participation.

Working towards the step in this method, as mentioned above, Toyota has given the rights to all his workers, to stop the line on which they are performing their work. Regardless of the length of line, like in final assembly, they are entitled to stop it if they found any issues. Not only issues or errors, if the worker is not able to keep up or finds a defect, he can stop the entire assembly line by simply clicking on the stop button. In order to respect the human independence, it's not the conveyer belt that is operating the human worker, while it's the human worker who is operating the conveyer.

Secondly, workers at all Toyota shops are well informed about the priority order. This allows the workers to process those parts first which belong to the priority list and also leads Toyota Production System into state of production advancement. Moreover, it allows workers at each Toyota shop to follow his daily routinework without taking any orders from the control department. It's the responsibility of foremen in all Toyota shops to authorize the decisions for job dispatching and overtime.

Toyota has also introduced a system in all the Toyota shops, which allows all the workers to contribute towards the improvement in the system. Even a single employee at Toyota, who found the waste, is entitled to use his right to remove that waste he has found from the system.

In the just-in-time production system, necessity to improve the system can easily be understood by all those working in the system. If all processes and shops are kept just like that without any monitoring and there is no excess to be worried about, but if the trouble part is left unmonitored, it will shut down the whole line automatically and will further affect the entire plant.

Therefore, Toyota is making an effort to create a working place where all workers can detect trouble. It will no more be the managers and foremen detecting the trouble, but as a production system, its responsibility of every individual working in the Toyota Production System. The above mentioned is also known as "visible control". By implementing such control in the working system, all workers in the Toyota Production

System have taken positive actions to remove the unwanted waste. This gave the delegation to exercise its control and accountabilityfor operating and constantly making things better for the workers in the workshops.

Kanban System

Kanban system is a production control system which allows workers to fully utilize their capabilities using the just-in-time production system. Thanks to Kanban system efficiency, all Toyota workshops are in no longer in need of an electronic computer.

There can be various reasons for applying Kanban System as compared to electronic system. Following are few important reasons which justify it:

1. *Reduction in Cost Processing Information:*

By adding electronic system, it will require a huge cost to implement such a system, which gives you the real time control of production schedules for all the processes and suppliers.

2. *Rapid and Precise Acquisition of Facts:*

Managers working in the Toyota workshops believed in the Kanban System because it continuously provided the real-time facts on various things like man power, production capacity, and operating rate. Moreover, the data collected corresponding to the change was accurate enough to make managers and workers to further improve the promotional activities and responsibility.

3. Limiting the Excess Capacity of Preceding Shops:

Since Toyota being an automotive industry, it will have many multistage processes where demand for a particular item will gradually become more regular. This allows the preceding processes to have more items in excess capacity. Hence, it will lead to waste of over-producing.

Kanban system is also considered as a tool to achieve the just-in-time production system. The normal appearance of it is just like another card which is kept inside a rectangular vinyl envelope attached to the item. Normally, there are two versions of Kanban that are mainly used: a withdrawal Kanban and a production-ordering Kanban. A Withdrawal Kanban specifies the kind and quantity of product which the subsequent process should withdraw from the preceding process. Whereas, Production-Ordering Kanban specifies the kind and quantity of product which the preceding process must produce. The production-ordering Kanban is often called as in-process Kanban or simply a production Kanban(Monden, 2012).

We define Kanban scheduling as demand scheduling. In processes controlled by Kanbans, the operators produce products based on usage rather than forecasted usage(Mclnnis & Gross, 2003). Therefore, for a scheduling process to be considered a true Kanban, the production process it controls must:

- Only produce product to replace the product consumed by its customer's.
- Only produce product based on the signal sent by its customer's.

Description of Kanban System

In Kanban System, a form of order card is called Kanban(Sugimori, Kusunoki, Cho, & Uchikawa, 2007). Normally, there are two versions of Kanban. The first one is called "conveyance Kanban" which deals in going from one process to preceding process. And the second one is called "production Kanban" which is used only for order production purposes by simply withdrawing through subsequent process. Both versions of Kanban – Conveyance and Production are always attached to the boxes of the parts required by the processes.

Figure 7 - Kanban Card**(Toyota Overview, 2016)**

When the worker wants to use the content of a box or container, he simply removes the conveyance Kanban from the container or box. A worker than takes this conveyance Kanban to the stock point of preceding process to collect his required part. The worker will simply attach his conveyance Kanban to the box which will consist of his completed part.

Once the box or container is received by the production process, they remove the conveyance Kanban and replace it with production Kanban. After this, the production Kanban is removed from the box or container and is sent directly to dispatching process.

Hence, the production activities of the final assembly line are all inter-connected, just like a chain, which contributes largely to just-in-time production system of the entire process which alter on goes through preceding processes or to sub-contractors and then materialize.

Finally, when all the parts are assembled and processed in vehicle, it increases the overall value of the product. Gradually, one by one all the vehicles are rolled out from the workshops. If any trouble is found, it will stop the whole line straight away, but immediately it will start and rolling out the vehicles.

Toyota Production System is a kind of a set-up which helps in creating the awareness of such an ideal conveyor line system for businesses around the world and Kanban system also contributes in this conveyor by simply connecting all the processes.

Rules of Kanban

If you have better tools, it increases your chances of being more effective. But, if you use them in wrong way, it will decrease your chances of reaching your goals and will defeat the purpose for which they were created.

Same goes for Kanban system as well because it's a tool created to manage the workplace effectively. Following is the explanation of rules of Kanban system in order to achieve the desired effectiveness:

1. *Never Send Defective Items to the Subsequent Process:*

If you generate an item which involves investing your time as labor, using the equipment's and materials for generating a defective item which cannot be sold, leads to the greatest waste of all. Moreover, it will be labeled as the worst offense towards the cost reduction for any organization. If you come across any defective product, preventive measures are required to be taken straight away so that it doesn't repeat itself. The above explanation simply means that you need to avoid sending defective products to next process at any cost. It is important to raise the awareness of such defective product to every individual working in the process. If the awareness is not created, it may lead to pile up of defective products, which will lead to stoppage of the entire process. In order to abide by this rule successfully, the machines should be able to stop the production automatically when they encounter defective product. This also highlights the automation with a human touch.

2. The Subsequent Process Comes to Withdraw Only What is Needed:

The second rule simply states that the subsequent process will let know the preceding process about the withdrawal of parts as well as materials in a given period of time and required quantity. It will lead to generating of loss if subsequent process receives the parts and materials from preceding process at the time it doesn't need them or it exceeds the quantity as per the needs. Moreover, if proper application of this rule is not done, the losses can be incurred from anywhere within process like loss from excess of overtime, loss from high inventory and losses incurred from investing new facilities without knowing that the existing facility is actually sufficient.

3. Produce Only the Exact Quantity Withdrawn by the Subsequent Process:

The third rule is guided by producing only the quantity withdrawn by the later process; it is somewhat loosely inferred from the second rule. It is based on the absolute condition that the process must restrict its stock to the absolute minimum. To adhere to the above policy the following things should be taken into consideration-

- Do not produce more than the number of Kanban
- Produce in the order in which the Kanban is received

Observing the above rules or operational guidelines will help in functionally applying the third rule. It is also important to keep in mind that the second and the third

rule goes hand in hand, which leads to the formation of unison and simultaneity in the production process.

4. Equalize Production:

In order to ensure the successful continuation and implementation of the third rule, it becomes important for all processes to maintain equipment and workers in a way that materials can be produced when needed and in the amount needed.

In the above situation, even if the later process comes to withdraw materials unevenly in terms of quantity and time, the first process will get enough time to arrange extra personnel and facilities to accommodate request of the later process. The end result shows that the earlier process stands in the total production system, the greater the need for excess capacity emerges.

In normal cases the preceding process has no excess capacity at all, it may not be able to meet the requirements of the later process, and can only manage to deal with their requirements by producing materials ahead of time whenever they have enough capacity and time. Doing this is a clear violation of the rules. In order to avoid the above situation to arise the technique of Load smoothing (equalizing) in production comes in handy.

5. Kanban is a Means to Fine Tuning:

The core function of Kanban is described as an automatic directional device consisting detail and information for the ease of workers concerning their work order(Lu, 1989). When the Kanban is brought into play we can distribute the info. Initially with the startup plan chart and the transportation plan chart which are provided for the workplace.

For workers it becomes a vital source of information for the production and transportation of work order.

There are two kinds of Kanban which are withdrawal and production- ordering Kanban. The withdrawal Kanban specifies the kind and the quality of the product which the later process should withdraw from the first process, whereas the production ordering Kanban specifies the kind and quantity of product which the later process must produce.

6. Stabilize and Rationalize the Process:

The sixth rule emphasizes on the fact of stabilizing and rationalizing the production process which is not possible with merely load smoothing or Jidoka. In order to stop the production of defective parts the company needs to go into the root cause of defects. Defective work exists because of the presence of 3M's in the work methods and work hours. This 3M's that are *Muda* (waste), *Mura* (unevenness) and *Muri* (unreasonableness) in the work methods need to be addressed in order to ensure smooth supply and inexpensive production of goods.

CHAPTER – 3

Case Studies

Case Study – I: AISIN Seiki Fire (1997)

Background

Aisin Seiki Co., Ltd. is a Japanese corporation in the automotive industry which deals in development and producing the automobile systems and components. It was established on August 31, 1965. Its Head Office is located in Aichi, Japan. It has a employee strength of 99,389 (as of March 31, 2016). AISIN Group currently deals in three business lines as mentioned below:

Manufacture and Sales of Automotive Parts: Adhering to the principle of "Quality First", the AISIN Group provides high quality automobile parts which are very essential towards the completion of a vehicle like brake system, chassis, body, engine and information technology.

Lifestyle and Energy: AISIN Group is also related with the lifestyle products that help in contributing towards more comfortable living environment, energy-related products that maximum efficiency and minimum resource consumption.

Wellness: AISIN Group offers welfare-related equipment's which ultimately help senior citizens in leading fulfilling lives which includes. Most of its equipment's are based as per the ergonomic principles.

Disruption in Supplies of P-valves to Toyota – AISIN FIRE (1997)

AISIN Seiki is a major and trusted supplier of automobile components to Toyota. During 1990's, Toyota was largely depended upon AISIN Seiki for its proportioning valves; also known as P-valves, used in Toyota vehicles for break-related part.

On February 1, 1997, a fire erupted at one of the AISIN Kariya plant number 1. This leads to halt in Toyota Group operations for couple of weeks. Both Toyota and AISIN Seiki were dedicated towards the principles of just-in-time production, which allowed both of them to have a stock of two or maximum three days available. A Toyota plant at that time was in full capacity which had a lot of temporary workers. Everyday lost was potentially huge in financial losses in sales and profits for Toyota.

P-valves control the pressure on rear brakes which helps in preventing skidding. It was no bigger than a pack of cigarettes. It was produced in mass quantity using the dedicated transfer lines, which helps in lowering down the costs and resulting in higher productivity and reliability. AISIN Seiki was the only sole supplier at that time in Japan of such a part.

Toyota on February 3, 1997, suddenly found itself in deep trouble. It forced, Toyota shut-down its 20 lines out of 30 lines. February 4 and February 5, both days the Toyota plants and its related firms were shutdown.

Toyota's Tahara and Hino's Hamura plants were reopened on February 6. It was the delivery of first alternative to P-valves which lead to stabilizing the whole crisis. By February 6, all Toyota plants were back to normal. But the number of P-valves produced by AISIN Seiki was less than 10% as compared to actual demand. Although, it gradually increased, but it took more than a month to reach 60% by March 14 and 100% by the end of March.

The overall cost to AISIN Seiki was 7.8 billion yen and Toyota was around 160 billion yen in revenues. Toyota was able to lower down the losses amounting between 20-30 billion yen by recouping through increased production through overtime and holiday shifts.

Outcome

It was very difficult to meet the target of 32,500 P-valves per day. Then six firms jointly took up the initiative, they were Toyota, Koritsu Sangyo,AISIN Seiki, Kayaba Industry, Taiho Kogyo and Denso. They were very different in respect to position in value chain, specialization, and size. But all these firms had same characteristics of commitment, capabilities, Just-in-time production and problem solving ability.

All the firms from outside and within Toyota Group set up another P-valve production site. AISIN Seiki on the other hand respected this initiative and provides the design drawings, jigs, technical specifications, machine tools, and raw materials which were salvaged from the fire.

Another 62 firms also responded to AISIN Seiki call and immediately began the preparations for manufacturing. Around 150 more firms joined including 70 machine-tool makers. AISIN Seiki gathered all machines through exhibitions, showrooms and readily available near the plant.

Many firms were requested to produce necessary parts required by looking into the drawings of design models and forged blocks. They were also responsible for delivering them back to AISIN Seiki for final assembly. Moreover, AISIN Seiki was also responsible for quality control check and delivery to all firms including Toyota.

Many firms cross checked their production with the design drawings, equipment's and technical specifications and every firm had to confirm AISIN Seiki about their participation in the recovery effort. It was difficult for all the firms because they never produced P-valves and also had less knowledge.

It was very difficult for AISIN Seiki to transfer the knowledge and technical equipment's to every firm. Due to this, many firms left the initiative due to lack of machinery and know-how. Toyota instructed its Honsha plant site for producing P-valve.

Once the prototypes from various firms were approved by AISIN Seiki, every firm started producing large number of volumes.

Once the major problems were handled, the firms picked up speed in production of P-valves. All firms, including Toyota,started working towards shortening set up times. Resuming to full just-in-time production shows Toyota Production System is integrated into these firms working in depth.

These examples showcase the successful outcome of the P-valve recovery effort, which involved many measures taken to set-up alternate sites. Flow of employees from one site to another for providing technical solutions and drills were performed constantly.

Summary of the Study

AISIN Seiki fire incident showcases the benefits of Toyota and its partner firms for self-organized, response in crisis and routine problem solving. Many known practices like just-in-time system and proper application of Kanban and Jidoka system helped in finding the defective products and solving the relevant problem before it got too late.

It can also confirm that these practices are very essential part of Toyota and it will help Toyota only reaching new heights. Moreover, managers and workers learned and inherited capabilities for effective problem solving skills. Furthermore, the AISIN Seiki fire incident also confirms that just-in-time system is not vulnerable to small disruptions.

Case Study – II: Niigata Earthquake (2007)

Background

RIKEN is a 100 years old research organization. It is the largest research organization in Japan. RIKEN has world-class research centers over whole Japan. Its main research center is in Wako, Japan. Since 1917, RIKEN has mastered itself in the fields of natural sciences, biology, neuroscience, quantum physics and computer science.

RIKEN also deals in automotive and machinery parts like Piston rings, camshafts, seal rings, brake parts, valve seats and lifters, and parts for suspension systems and steering systems.

RIKEN has also indulged itself in other products and services like EMC products dealing in radio frequency, shield rooms. Moreover, it has also got into thermal engineering products like industrial furnaces and electric heating materials.

Disruption in Supplies of Piston Rings to Toyota – Niigata Earthquake (2007)

In 2007, if you wanted to buy a piston ring from RIKEN would only cost you around 1,500 yen in the market. But due to its lack of availability during the Niigata earthquake, it paralyzed the whole automobile production sector in Japan for a week.

On July 16, 2007, Central Japan was struck with a massive earthquake of 6.8 Richter scale. It damaged the most of the plants in RIKEN, who supplies piston rings for most of the major car makers in Japan like Toyota, Honda, Mazda, and Mitsubishi. Due to non-availability of piston rings which are specifically designed as per the car model, closure of plants was the next step because all the Japanese firms follow the philosophy of just-in-time production system. All the car makers were left with low stock of available piston rings.

In 2007, RIKEN with a market share of more than 50%, employee strength of 1,500 and revenue of more than 600 million dollars, made huge impact on the industry. RIKEN also maintained its reputation for quality in products and relationships with major car brands in Japan.

Due to closure of RIKEN, it also forced many car makers to cease its cars production. Toyota, the No.1 car maker, closed all of its 12 domestic plants for at least couple of days, which lead to overall loss of more than 20,000 vehicles and more than 55% of it were made for export purpose. Honda was also forced to close that plant which produced well known Fiat and Civic models. Nissan also felt the heat of non-availability of piston rings, leading to closure of its all four plants too. Mitsubishi, Mazda and Suzuki also joined the rest by either slowing down the production or completely shutting down.

This sudden blow to the automotive industry came swiftly and no one had an idea of impact it will leave to U.S production segment of Japanese cars. Toyota also

confirmed that such a disaster was a big worry, “In the case of special parts like piston rings, there is no back up” a company spokesperson made this statement(Chozick, 2007).

RIKEN was a crowned king in piston ring market since 1940s. Two of its plants and nine facilities were hugely affected by the earthquake. A week later after the earthquake, RIKEN confirmed that it will start resuming its production for piston rings. RIKEN further emphasized that it will need at least another week to reach its full potential in production.

Outcome

It was really hard to come out of such situation, where your enemy is nature and you cannot fight or control the laws of nature. Similarly, RIKEN was also in spot of bother due to natural disaster.

Toyota, Mitsubishi and other firms came as one force to help RIKEN to get back to normal operations. Around 500 employees from Toyota and 650 from other companies were sent to resume the production at the disaster site. Kashiwazaki plant, piston rings main plant for RIKEN, was restored on July 23 and Toyota also resumed its operations on the same day. The other car makers resumed to normal operation on July 25.

Summary of the Study

RIKEN Piston Rings was a crucial part required to complete the vehicle. But due to the natural disaster occurrence and non-availability of piston rings, it halted the whole Japanese auto production industry. As it has happened in the past, once more Japanese firms collectively come together to support RIKEN in best possible way to restart much more quickly than it would have been able to on its own.

This natural disaster scenario raised many questions and exposed vulnerabilities in Toyota Production System, Just-in-time system philosophy, Jidokaand Kanban system, for keeping little and only required level of inventory to work. By now, we know that just-in-time system allows keeping the production cost low and gives high quality products. But in addition to specialization, "Just-in-Time" had stopped productions of automobile in Japan. And to some extent, Jidoka, which means stopping immediately if there is any defect or problem encountered in production, also led to shut-down.

After the disaster restoration, RIKEN planned to open production plants across whole Japan. Moreover, keeping in mind the future disasters, RIKEN has initiated to at least a week's inventory nearby its customers factories.

Case Study – III: Kumamoto Earthquake (2016)

Disruption in Supplies from AISIN Seiki to Toyota – Kumamoto Earthquake (2016)

Couple of earthquakes in April, 2016, rattled Toyota and many other car makers. Earthquake measuring to 6.5 and 7.3 on Richter scale struck Kumamoto city in Japan, leaving more than 30 people dead and causing disruption to many crucial supplies.

Toyota again had to shut down more than 20 vehicle assembly lines across the whole Japan. The main reason behind this move from Toyota was due to AISIN Seiki as a supplier, was not able to provide with the supplies like doors and engine components from its Kumamoto plant.

It's twice in three months that Toyota was forced to stop production due to supplier troubles. In February, 2016, due to explosion in one of the steel plants of Toyota's supplier, Aichi Steel Corp., productions lost numbers were as high as 90,000 vehicles. The steel plant shutdown hampered the entire industrial output for supplies related to engine, transmission and chassis components.

Toyota's operational profits were reduced by 30 billion yen in the first quarter of 2016. It was quite evident from such a big loss, which will leave its impact on the second and third quarter too. Toyota's shares plumbed down by 25% this year only.

Summary of the Study

These shutdowns mainly occur due to Toyota's famous and world-wide adopted policy of just-in-time system philosophy. Toyota resumes production by April 25, 2016, which is a week later from the first earthquake struck in Kumamoto City, Japan.

AISIN Seiki moved its production to other plants in Japan and overseas to meet it consumers demand and get over from this halt as early as possible. But it couldn't wash away the vulnerabilities shown by the famous just-in-time system. Many online portals are criticizing the Toyota's most valued system, but no matter how many preparations you do or infuse new systems, any natural disaster will tear it down.

CHAPTER – 4

Conclusion

This report has helped us understand properly all about Toyota Production System andmore importantly its core elements “Kanban” and “Jidoka” systems. Also with the help of cases discussed in this report, it reveals that the multiple shutdowndecisions were due to influence from either Just-in-Time or Jidoka system. But in the end, the decisions taken at the right time for closure of production lines were not wrong.

Moreover, as per the initial hypothesis and objective set out for this report, it clearly makes sense that, there are some limitations for Just-in-Time system only due to disruptions in supply of small but crucial parts from its suppliers required for the production during severe disaster situations. Otherwise, Toyota Production System has not encountered many such incidents which directly pose a threat to the existence of Just-in-Time System in Toyota and other manufacturing firms in Japan.

Most of the time, Toyota has suffered a lot due to these shortages from its supplier. But no one is to be blamed for it because most of the shortage occurrences were due to natural disasters or unforeseen events. Japan is located on one of the most active seismic plates of earth crust. So it will naturally make it prone to such disaster events across Japan. This has also given a spark by respected scholars in Japan and across the globe, why Toyota is not making any efforts to combat such situations for future and secondly, it should move towards other production systems.

Toyota's Just-in-Time system, Jidoka and Kanban system are very well known across the globe because Toyota showed huge success in most of its production department. Since 1950's, Toyota has been using Toyota Production System and it has made it better and better over the time. It will be wrong to say usage of such old system shall be abolished and replaced with something else, just because it only proves it's insufficiency during unforeseen disasters.

Moreover, in 1997, when AISIN Seiki plant caught fire, it was Toyota's production methods which helped AISIN Seiki to recover sooner because most of the firms, who lend their hand for help, were aware about the Toyota Production System, Just-in-Time, Jidoka and Kanban System. This further allowed getting it perfected as per the requirements sooner than expected.

Same thing happened during Niigata earthquake in 2007, but there was no alternative for the RIKEN Piston Rings at that time, which lead to stoppage of all the assembly lines in Toyota. Furthermore, during Kumamoto city earthquake in 2016, it again faced the same back-clash against its prestigious production system and leads to halt of 20 assembly lines in production across Japan.

Toyota used and still uses day-to-day supplies as per just-in-time system in all the above cases. Toyota has more faith in long term benefits of quality, learning, efficiency and low cost of production, so that it can have bigger impacts than the risks of rare

disruption. But one should consider that increasing production costs for the sake of increase in inventory, during natural disasters, only to meet the demanding requirements lacks a rational explanation.

Interestingly, Toyota has looked into inventory system and adjusted accordingly when it comes to forecasted events. For instance, Toyota's plants across Toyota city have gathered long stockpile of parts during its winter season for west of Seki-Ga-Hara, Japan.Moreover, Toyota has emphasized more on multiple suppliers are able to manufacture the same part.

After observing such changes in Toyota, experts and scholars are saying that Toyota will now be able to recover sooner than expected from any natural disaster occurrence in future as compared to past. But said that, it will still pose a challenge to bring the necessary parts or equipment's, if the highways are closed and restrictions are put in for earthquake affected zones.

Takaki Nakanishi, an auto analyst who runs his own research firm in Tokyo, said "They can't simply switch production from one site to another immediately. It's not a flaw in Toyota's Production System. It's that Japan's manufacturing is built on a land that is prone to earthquakes" (Kubota, 2016).

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