



How are lean manufacturing principles adopted by Toyota and to what extent are such principles applicable to Tesla (an electric automobile manufacturer)?

*Ayasya Gupta
Student*

Step by Step School, Noida

Abstract

Lean manufacturing is a production practice that aims to eliminate waste, reduce the need for managing large inventories, and provide optimum quality at the least cost. Sakichi Toyoda, the founder of Toyota, created several concepts which formed the pillars of the Toyota Production System or 'TPS'. As the years went by, experts across several industries began to be acquainted with the key systems of the TPS i.e. 'Jidoka' and 'Just in time' systems. Evidence of lean manufacturing principles being successful for a traditional automobile manufacturer like Toyota exists, but the biggest underlying question is whether such an approach to manufacturing is capable of enabling the same benefits for a more modern automobile manufacturer like Tesla. Elon Musk initially aimed to disrupt the automotive industry with Lean manufacturing methodologies but faced challenges with productivity and quality issues, after which Musk's background in software led him to apply an 'agile' approach to the car industry. Per the aforementioned, this research paper aims to answer the question 'How are lean manufacturing principles adopted by Toyota and to what extent are such principles applicable to Tesla'.

Introduction

Has the thought of how companies achieve their high productivity while ensuring efficiency and minimizing waste production ever crossed your mind?

Lean manufacturing or just 'Lean' is one such production practice that holds this virtue above all other principles.

Its main goals are to eliminate waste, reduce the need for managing large inventories, and provide optimum quality at the least cost by making quality control decisions an immediate part of the manufacturing process (Dave, 2020). The root of this management philosophy dates back to the beginning of the 20th century when Henry Ford took production to a whole new level by creating the famous 'Model T' in 93 minutes, which was also the first automobile to be manufactured on a conveyor belt. This was a turning point for the automobile industry and Toyota was in the driving seat (Iuga and Kifor, 2013).

Toyota, at that time, was producing loom machines and not yet automobiles. Sakichi Toyoda the founder of Toyota was referred to as the 'King of Japanese inventors'. He created several concepts which formed the pillars of the Toyota Production System or 'TPS'. Soon after, Kiichiro Toyoda the son of Sakichi Toyoda travelled to the US, and much amazed by his studies of the company Ford, he created the "Toyota Motor Corporation" (Murad, 2019). As the years went by and the TPS was continuously improved, experts across several industries began to be acquainted with the key systems of the TPS i.e. 'Jidoka' and 'Just in time' systems - both of which further emphasized and helped enable the quality management and waste minimization (the key principles of lean manufacturing) (Dekier, 2012).

Whilst evidence of lean manufacturing principles being successful for a traditional automobile manufacturer like Toyota exists, the biggest underlying question is whether such an approach to manufacturing is capable of enabling the same benefits for a more modern automobile manufacturer like Tesla. In light of the aforementioned, this research paper aims to answer the question **'How are lean manufacturing principles adopted by Toyota and to what extent are such principles applicable to Tesla (an electric automobile manufacturer)?'**

This research paper aims to analyse and evaluate the key principles of TPS to understand how their employment has driven the success of Toyota and further argue that Tesla, a relatively newer automobile manufacturer, may not have been able to advantage of lean manufacturing to the same extent.

Review of Lean Manufacturing

As mentioned in the introduction, Lean manufacturing is based on several core principles. This system of continuous improvement developed a management philosophy called 'Lean thinking' which emphasizes three central elements - identification of value, elimination of waste and generation of flow (Melton, 2005). Other than these three principles, this ideology also highlights how fostering a culture that respects individuals is key to a successful business. Creating an environment where every employee is valued, empowered and treated with dignity, emphasizes that employees are not just cogs in a machine but essential contributors to a company. As time progressed several new tools and methodologies, with the underlying principles of lean manufacturing and thinking, came to light - the poka-yoke technique, Kanban systems and value stream mapping were few of the

most eminent amongst many others, including an ideology which first revolutionized Lean manufacturing - The “5S” system developed by the founder of Toyota, Sakichii Toyoda. The aforementioned techniques have been elaborated below.

5S framework

This framework included 5 steps being (Bland, 2022):

1. **Seiri meaning sort** - the idea of sorting the workstation to eliminate anything that is not needed in the space.
2. **Seiton meaning set in order** - ordering the items that are required and ensuring they are placed in a way that allows for easy identification and access.
3. **Seiso meaning shine** - ensure the ‘shine’ of the workplace, keeping it tidy, uncluttered and visually appealing to work in, with all rubbish removed.
4. **Seiketsu meaning standardize** - ensures the standardization of activities by ensuring a regular schedule of maintenance and cleaning for the workspace.
5. **Shitsuke meaning sustain** - ensure the 5S system is continued and maintained as it is designed to be.

Poka-yoke technique

Preventing errors with simple lean mechanisms is a principle derived from the lean concept of Poka-yoke also known as the ‘mistake proofing system’. This technique has resulted in many examples around the world, where preventive safety measures such as switches that turn off automatically when the circuits are overloaded or appliances that turn off when doors are opened are some of the most noteworthy implementations of this concept (Bland, 2022).

Kanban systems

The Kanban system is a lean and visual approach to managing production and workflow efficiently. Using a “pull” system where work is initiated based on demand rather than being pushed into the system. The idea of Kanban in lean manufacturing is to cut wasted inventory by carrying only what you need to cover lead times, while at the same time improving communication on customer orders to ensure everyone is aware of what’s going on at all times (Bland, 2022).

Value stream mapping

The concept of Value Stream Mapping holds a particularly important role in the lean process. Using this concept, you can map each step you use to add value for the customer starting right from production to the final delivery. The results of this analysis are represented on a value stream map, which allows the steps to be visualized and means the entire process can be easily shown in reports and other visual mediums (Bland, 2022).

With all this being said, Lean manufacturing brought efficiency to several supply chains. Focusing on the actual

needs of customers by ensuring the prevention of 'non-value adding processes'. The many benefits of this thought exploration can be categorized into specific subheadings.

Improved Customer Service

The first principle of identifying value from the eyes of the client is the key essence of improved customer service. Ensuring customers are provided with what they want, when they want and where they need it, results in a satisfied audience that will keep on returning, guaranteeing a thriving business (Thomas, 2015).

Financial Benefits

Lean principles showcase significant financial benefits once set in an organization. Reduction in waste and defects adds additional money to the company's stride for better product quality. Saving on product storage and inventory management also creates cash flow paving the way for satisfied workers, which makes any business prosper in the long run (Thomas, 2015).

Easy management

Getting more done with fewer people is one of the major advantages of Lean manufacturing. The created workflow gives rise to an organized and systematic way of putting together a machine with the main task of the workers being to enhance their skill level and maintain the system once implemented. This approach starts at the bottom and proceeds upwards with motivated workers working on their own performances and in accordance with providing additional training, promotion and learning (Thomas, 2015).

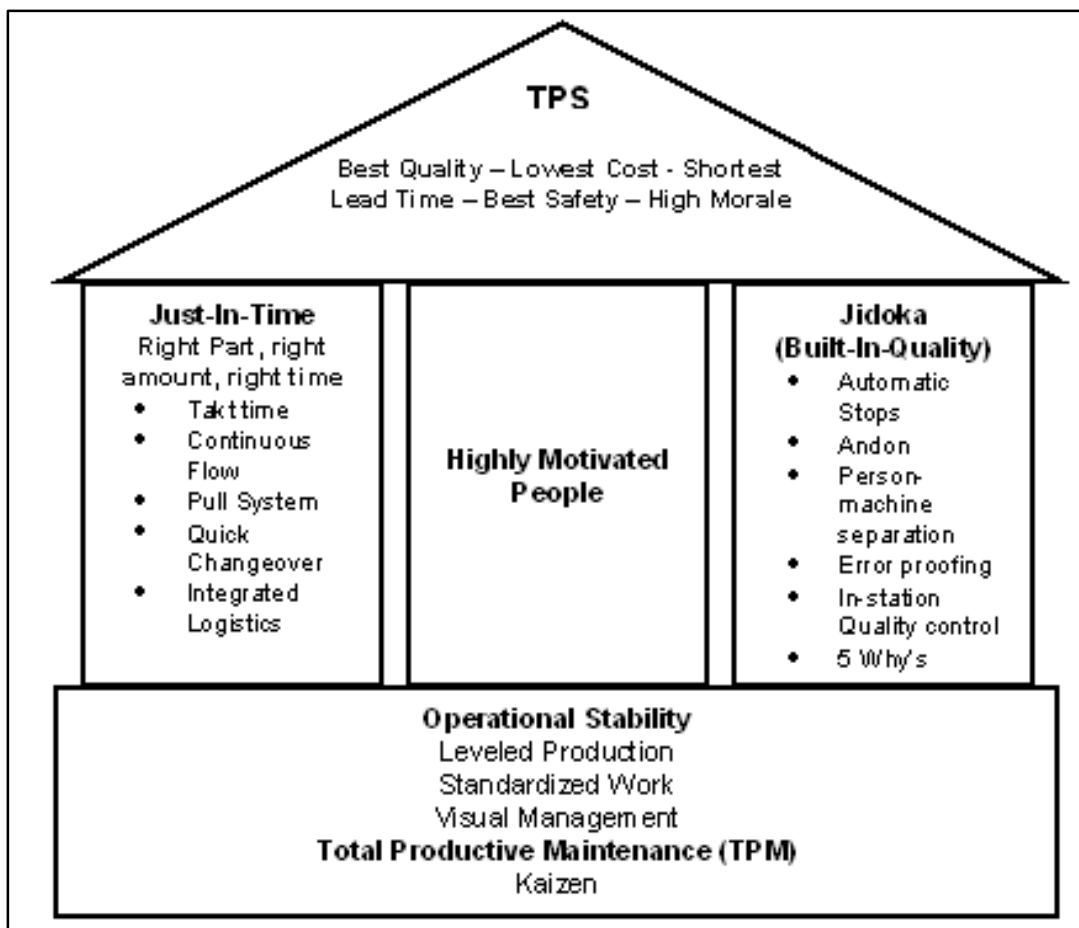
Lean Manufacturing at Toyota

In today's date, there are numerous methodologies derived, implemented and created from Lean manufacturing. With all the credit going to Toyota - Lean Manufacturing was often associated with the TPS (Toyota production system), as in the post-World War II era, it was a response to the company's need for cost-effective and efficient production. Inspired by the principles of 'Just in time' production and 'Jidoka', which encouraged optimal resource utilization. Toyota's success in implementing these concepts not only led to a transformation of the company but also set a standard for the entire world, emphasizing the need for Lean (Dave, 2020).

This entire system is a paradox. On one hand, every activity, connection, and production flow in a Toyota factory is rigidly scripted. Yet at the same time, Toyota's operations are enormously flexible and responsive to customer demand. How is this possible? TPS has been growing over the past 50 years, which has culminated into 4 principles that have been tested and proven to signal problems immediately once detected. The first rule governs the way workers do their work. The second is the way they interact with one another. The third governs how production lines are constructed. And last, how people learn to improve. Toyota's continual response makes this

seemingly rigid system so flexible and adaptive to changing circumstances (Spear and Bowen, 2015).

The TPS was established based on many years of continuous improvement. The basic philosophies of ‘Jidoka’ and ‘Just In Time’ enabled TPS to efficiently and quickly produce vehicles of sound quality, one at a time that truly satisfied the customers. TPS and its approach to cost reduction are the wellsprings of competitive strength and unique advantages for Toyota (TOYOTA, 2023).



(McBride, 2007)

Jidoka (Toyota, 2016)

The full application of the Jidoka system means that the process which created any issue in the entire manufacturing process is subsequently evaluated to remove the possibility of any recurrence. In the TPS, operators are equipped with the means to stop the production flow whenever they note anything suspicious (human *jidoka*), thereby preventing the waste that would result from producing a series of defective items. It also liberates operators from controlling machines, leaving them free to concentrate on tasks that enable them to exercise skill and judgment instead of monitoring each machine continuously.

Just In time (Toyota, 2016)

The ‘Just In Time’ production can be referred to as a ‘pull’ system of providing all different processes in the

assembly sequence with their respective hardware and items that they need only when they need it. The primary objectives of just-in-time production are to save warehouse space and unnecessary cost-carrying and to improve efficiency, which means organizing the delivery of component parts to individual workstations just before they are physically required. The use of JIT within the TPS means that individual cars can be built to order and that every component has to fit perfectly first time because there are no alternatives available. It is therefore impossible to hide pre-existing manufacturing issues; they have to be addressed immediately.

Toyota's production system is many things but one of the more prominent ways to describe it is to call it a true learning process. Quite often overlooked about TPS is how it is designed for learning. On the shop floor, the emphasis is on frontline problem-solving skills. This is supported by a hierarchy of team and group leaders with greater expertise and the ability to teach. Many people who see a Toyota vehicle assembly line view the number of layers as inefficient, but the reality is the opposite. The rapid problem-solving drives improvement and enables tight just-in-time systems to work efficiently. So the staffing more than pays for itself. The learning extends to supplier support as well. When Toyota invests the effort to help suppliers fix problems, it also learns their production processes. Then, the next time a problem comes up, it is better able to help. And because the company often works with suppliers two to three years before the launch of new products, it is well-positioned to help with start-up problems (Shih, 2022).

Apart from all these methodologies The TPS system still seems to have a multitude of layers that are inspired by various other ideas. The 5S system that has been discussed earlier also plays a very important role in building the foundation of lean and is the essence of the fundamental components of Lean manufacturing. *The Kaizen System* is another such philosophy that is highly integrated into the TPS. Kaizen encourages the active participation of all employees in the improvement process. It recognizes that employees at all levels of the organization are valuable sources of knowledge and ideas. Kaizen emphasizes making small, incremental changes rather than large, disruptive ones. This approach along with the other lean practices helps in avoiding resistance to change and allows for steady progress over time - explaining the company's success over the years.

Lean Manufacturing at Tesla

Tesla, being founded in 2003 is a trailblazer in the automotive industry and is also renowned for embracing the principles of Lean to enhance its overall manufacturing process. Tesla's manufacturing revolution is characterized by the use of technology in a variety of ways, including automation with artificial intelligence for robots, large-scale die casting, and additive manufacturing.

Mainly being an EV (electric vehicle) manufacturer, Tesla was the first of its kind to adopt these methodologies. Since its foundation, they have been observed to use the well-known system of *JIT*. Tesla's early use of JIT

helped the company rapidly ramp up production of its first car, the Roadster while keeping costs low (TheSharpener, 2021). The company has continued to use JIT as it has expanded its product line and grown its manufacturing scale. JIT has been key to Tesla's success in delivering high-quality cars quickly and efficiently. There are some challenges associated with JIT, such as the need for tight coordination and the potential for disruptions to the production process. However, Tesla has shown that JIT can be an effective production strategy for a high-tech manufacturing company.

Tesla's strategy is based on technology, design, engineering, development, manufacturing, and distribution. In the case of these elements, their goal is to increase market share and reduce vehicle costs. The company produces hundreds of thousands of vehicles each year, millions of batteries, and billions of lithium-ion cells. Tesla's strategy focuses on a more sustainable future, and the company operates on a constant schedule. Musk envisions the world's most automated manufacturing plants, where robots will produce cars (and battery cells and solar panels) with little human intervention, at unprecedented speed. Whereas current auto assembly lines move at the speed of "Grandma with a walker," someday Tesla's Gigafactories will be cranking out battery cells as fast as "bullets from a machine gun" (Morris, 2018).

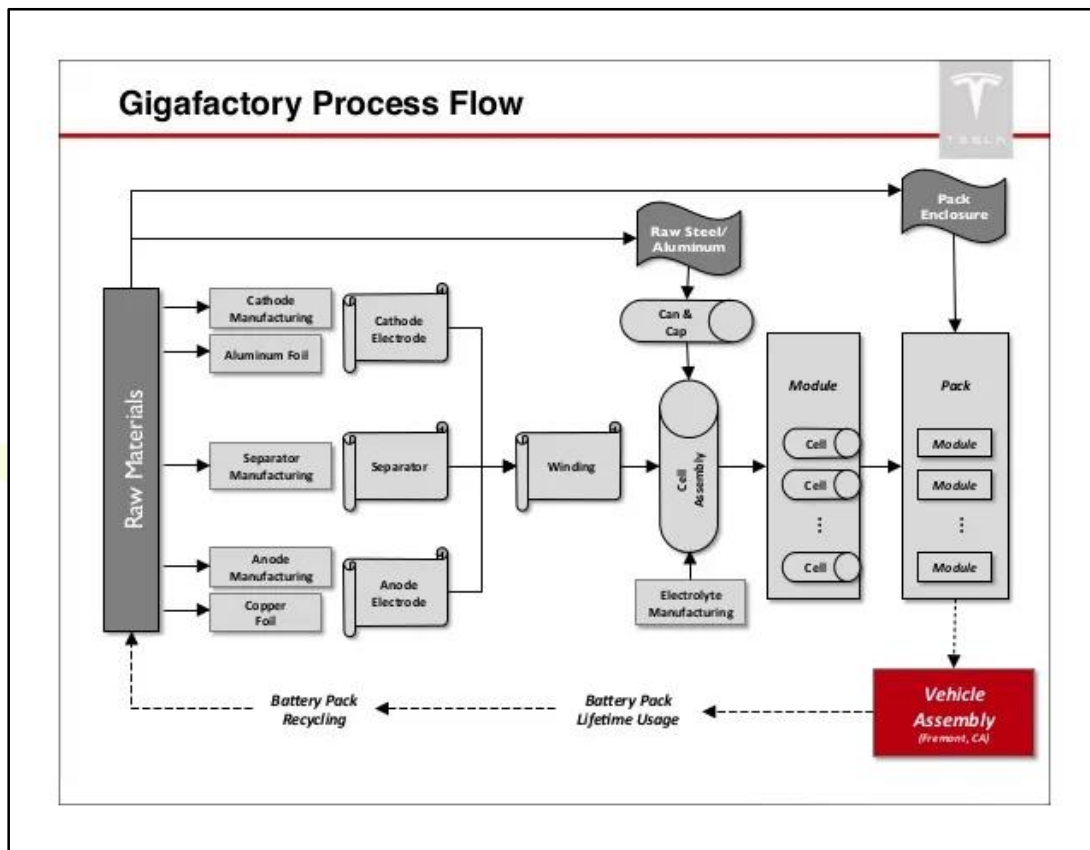
Elon Musk has been recorded talking about how he envisions Tesla to have a much more efficient production system that is eco-friendly, all by implementing Lean manufacturing processes, much inspired by Toyota. Ironically, Tesla's Fremont factory was bought from Toyota and was formerly an icon of the company's vaunted TPS. In Tesla's early days, Toyota was a partner, and the two companies worked together on several levels. However, Jefferey Liker - a renowned professor of industrial and operations engineering at the University of Michigan and a well-known author in the field of Lean manufacturing says, "So much of Tesla's vision of manufacturing is completely contrary to TPS: Spend large amounts of capital to automate everything possible. Rely on hiring many engineers to make it work rather than carefully developing talent from within. Repair in quality rather than designing and building in quality. Aim for an ultrafast assembly line instead of building to the rate of customer demand" (Morris, 2018).

Musk believes he can 'out-Toyota' when it comes to lean manufacturing. With his futuristic thinking and aspirations, he believes that by using traditional methods he can create an unstoppable force in the automobile industry. One such example is the *Kaizen system*. One problem faced by Tesla was the 'Model 3' production, including quality control, cash flow pressure and supply chain issues, which were all resolved to a great extent using Kaizen. Creating a rapid problem-solving team and increasing employee involvement fostered an environment of continuous improvement, which is the key essence of Kaizen (Muller, 2018).

Tesla Batteries (Forfar, 2018)

A key factor in the Tesla production system is its recycling and waste management which can not be overlooked.

Tesla has very openly made statements, reassuring the world that they recycle their car batteries and minimize their waste disposal. Before their giant Gigafactory in Nevada was built, Tesla's batteries were primarily manufactured in Japan and compliant with strict environmental laws. The batteries are mostly made from lithium metal oxides. Specifically, the anode from graphite, the electrolyte from lithium salts and the cathode from lithium, nickel, cobalt and aluminium. They do not contain nasties like lead, mercury, cadmium, hexavalent chromium, PBBs, and PBDEs. Tesla has stated in the past that their batteries are safe to be landfilled, however, their Tesla battery recycling program does a lot better than that.



(Forfar, 2018)

The Tesla vehicle batteries get recycled once they reach the end of life. Truth be told, no one really knows the battery life of Tesla cars, but professionals weigh the guess that approximately 100,000 miles or 7-10 years of usage is their life span (Forfar, 2018).

The key stats for Tesla battery recycling are (Early 2000s data):

- 60% of Tesla's batteries get recycled
- 10% get reused (battery case and some electrical components)
- All the fluff goes to landfill due to excessive costs in recycling it

At the end of the day, the only question that contains meaning is whether Tesla and Elon Musk really followed Lean manufacturing methodologies or was it all just a hoax. From the beginning on out, Tesla, through its founder and CEO Elon Musk, wanted to disrupt the automotive industry paradigms with a futuristic view of production processes. Elon Musk fuelled this vision and mentioned it in a press conference in 2016: “We are pushing robots to their maximum operation speed, we are asking our suppliers to build much quicker robots and they are shocked by our requests as nobody had ever made them before”

But soon Elon Musk realized the underlying problems, which were not only productivity-related but had also been about heavy quality issues. To reach the production capacity requested by the market for years and that Tesla had never managed to reach, they are currently assembling cars in tents in the desert - Lean production experts will notice how far this assembly line is from lean principles and methodologies. Musk made his first millions with software and therefore wanted to apply the same ‘agile’ approach to the car industry. Following a method where everything was supposedly ‘quick’. From the car to the production processes to the launch. Their motto was to start the production of the car even before finishing its final design. However, many would question the feasibility of this move as agile manufacturing may work in the software industry, where a programmer can change a line of code and then reconstruct the whole product by pressing a button but not in the automobile industry where even a slight change can impact all other car components.

Therefore, agile manufacturing and lean manufacturing are both production philosophies that aim to enhance efficiency, but they have distinct principles and approaches. The key difference lies in their focus: agility prioritizes flexibility and quick response to change, while lean emphasizes waste reduction and continuous improvement in a more stable and predictable production environment. This can be seen as the key difference between Tesla and Toyota (Mazzolini, 2018).

Conclusion

As the research has demonstrated, lean manufacturing, with its focus on eliminating waste, reducing inventory, and ensuring quality, has been successfully implemented by Toyota through the TPS. The principles of lean manufacturing, such as the 5S framework, poka-yoke technique, Kanban systems, and value stream mapping, have brought unparalleled efficiency and financial benefits to Toyota. The TPS, with its emphasis on Jidoka and Just In Time, has made Toyota's operations flexible and responsive to customer demand. The TPS is a true learning process that encourages problem-solving skills and continuous improvement. Overall, lean manufacturing principles have been instrumental in Toyota's success and were also claimed to be potentially applicable to other automobile manufacturers.

In line with the above, the analysis from the paper found that in its early days, Tesla had embraced Lean

manufacturing principles to enhance its manufacturing process and had successfully used JIT production to rapidly ramp up production and deliver high-quality cars efficiently. However, there have been several challenges associated with JIT which led Tesla to a new front altogether. Tesla's strategy focuses on technology, design, engineering, development, manufacturing, and distribution to increase market share and reduce vehicle costs. Elon Musk envisions highly automated manufacturing plants, but this vision contradicts the TPS principles. Tesla also tried implementing the Kaizen System for continuous improvement and developed a battery recycling program, but all these factors only led Tesla to realize that Lean manufacturing was not going to work out the way they wanted it to. While Tesla envisioned a Lean manufacturing system, they have been more 'agile' than 'lean'. The main point of the latter part of the text is that Tesla and Elon Musk initially aimed to disrupt the automotive industry with Lean manufacturing methodologies, but faced challenges with productivity and quality issues, after which Musk's background in software led him to apply an 'agile' approach to the car industry.

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