Toyota Production System

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Table of Contents

Introduction

The Toyota Production System (TPS) is a misnomer. It is not a production system as much as it is a complete business system. Lean is practiced throughout the business system. TPS is commonly thought of as a manufacturing system focused at the manufacturing part of the business. Thinking of TPS as a production system is similar to thinking of city streets as a transportation system. Yes, you drive on city streets but, to really get somewhere, you will take the freeway. TPS is a highly successful, integrated business system.

Toyota uses the practice of Lean Six Sigma throughout their organization. It starts with their database of customer information, dealerships, ordering, production, and finishes with delivery to the customer. Unlike American dealerships, with hundreds of cars on their lots, Toyota has about three weeks of inventory produced and most of those cars already have a buyer.

TPS contains an aggregate of tools but is not an aggregate of tools. If you look on the Internet for the Toyota Production System you will see a house with tools as its pillars. You do not bring in tools to build your version of the TPS. These TPS graphics are traditionally a house that shows things that are very important in manufacturing. If you ask somebody about TPS they will no doubt give you a list of tools such as:

- Takt time
- just in time
- pull
- andon
- problem solving
- standard operations

This is all on the side of the manufacturing part of the business. However, Lean starts with a customer and ends with a customer and includes all the internal business interactions between those contacts. This major point drives the effectiveness of the TPS. TPS is Lean from Customer order to well past customer's delivery.

The business part of the production system which I refer to as the Toyota Business System (TBS) includes:

- sales,
- customers,
- marketing,
- delivery to customers,
- integration with suppliers, and
- relationships with investors

Toyota did not collect some smart people in the room one day and devise the TPS. In fact, it took Toyota at least 30 years to develop an initial stage of the TPS and it is still working on improving it today. If Toyota builds a new factory it takes them 10 years to mature TPS within that factory. Toyota's focus is manufacturing and therefore it makes sense that there are improvements and innovations around manufacturing. But the innovations Toyota made within its factory walls mesh well with the innovations it's made outside its factory walls.

Toyota's innovations surpass mass production and bring to light the next phase, Lean Production. Companies that initially think of Lean Production often look at tools and stay within the boundaries of their company walls. Lean Production enhances mass production within company walls and builds value connections outside company walls.

TPS is not something that can be plopped down and analyzed. Many of Toyota's "innovations" were driven by conditions outside the control of the company. A good understanding of TPS requires at least a short look at the history that is the base rock of TPS.

Automobile History

TPS was not hatched on the manufacturing floor nor at any university. TPS is a result of the history of Toyota. TPS was forged on economic, competitive and people's push on the Toyota Company. I believe the best way to understand the TPS is to discuss it in the context of history.

Craft Manufacturing

So let's start with the very first manufacturers of automobiles. In the early 1900s due to the state of tools, materials, processes and so on, it was not possible to mass manufacture a car. Skilled craftsmen were needed to mate parts since no two parts arrived within tolerance to mate. You can imagine the onus this put on quick manufacturing, when each part needs to be hand modified in order to work. No two cars produced were ever the same. The production capability of this system throughout the world was very small.

Craft Manufacturing lasted until Ford came in with a better idea.

Mass Production is the primary accreditation that people give to Ford. However, Ford's real contribution was not mass production, but what he envisioned as the enabler to mass production.

I discussed how all cars during this time period were manufactured using Craft Manufacturing. This was because every part added to a car had to be custom modified to fit. When Ford first started to manufacture cars this is how he also did it. This is a situation where Ford and the TPS have similarities. The similarities are that everyone in the business had the same problem but one person looked at it differently. The effort that they engaged in had a risk of potentially ruining the company.

Ford recognized a few things, one of which is that in Craft Manufacturing every skilled craftsmen brought their own tools to perform work on a car. This meant that each skilled worker had their own gauge used for measurement. What Ford saw was that the process was missing standardization.

These were the challenges that Ford needed to address before he could ever think of mass production. Ford's greatest accomplishment involves parts standardization and this enabled what we all know Ford did in the area of mass production. Ford standardized the measurement system in his plant and also standardized the parts of the automobile. By doing this he no longer needed skilled workers and joining the parts of an automobile together became much simpler.

The key to mass production was not the assembly line, "*Rather, it was the complete and consistent interchangeability of parts and the simplicity of attaching them to each other.* These were the manufacturing innovations that made the assembly line possible." (Womack, Jones, & Roos, 1990)

A quick comment about the "simplicity of attaching them to each other". Though Ford had the concept of this need, the solution to in it was enabled due to the timely invention of hardened steel. With this innovation in steel, Ford had his standardized pieces to build his cars. He no longer needed highly skilled workers to mate pieces to a car.

Mass Production Introduction - Ford

Ford visited a meat processing plant and noticed that the meat was passed from one butcher to the next as each butcher removed his part of the animal. Ford now had the concept of an assembly line. He is best known for the implementation of the "assembly line" concept into manufacturing. Summarizing Ford's innovations:

- A need for standardized measurement
- The necessity of standard parts
- A need to move the car to the individual, instead of the individual to the car

Toyota Production System - Toyota Emerges

General Motors came into play because they out innovated Ford. GM saw a weakness in Ford. Ford did not produce cars in different colors. So GM took advantage of this weakness and started to produce cars in lots of different colors, displacing Ford in many markets. Innovation helps businesses move past competitors.

The Toyota Motor Company was founded in 1937. Toyota started by using Craft Manufacturing techniques to build its earliest cars. Unfortunately for Toyota this was right before the war and as the war was starting, Toyota was asked to build trucks to support the war effort. Toyota was getting off to a rocky start.

Toyota understood the advantages of innovation to gain a strong position for competing. Eight years before the company started, Kiichiro Toyoda visited Ford's Rouge plant in Detroit. In 1950 Kiichiro's nephew, Eiji visited the same plant for a duration of three months.

WW II & the Toyota Production System Start

Toyota made little advancement during the war. After the war the Americans knew that it was important for Japan to move itself out of its defeated state. America did many things to promote this and one of those things was to promote unionism for Japanese workers. The Toyota union turned out to be one of the major factors in the development of TPS.

In 1949, four years after the end of the war, Japan experienced an economic downturn which diminished Toyota's production requirements. This led Toyota to lay off a large portion of its workforce which resulted in significant union strikes. This was a seminal event for Toyota. Toyota negotiated with the union to end the strike, resulting in upper Toyota management, such as Kiichiro, to leave the company taking responsibility for failures at their level. Toyota laid off a large portion of their workforce.

The union and Toyota then negotiated a contract that guaranteed lifetime employment for the remaining union employees. Unknown at the time, this significant event has led to an alignment between the employees and management regarding improvement of the Toyota Motor Company. The advantages gained here are a major underpinning of the TMS. Today employees and management are all driving together to the same goals.

Mass Production and Toyota

Prior to and up to 1950 the total production volume of the Toyota Motor Company was 2685 automobiles. The most efficient automobile factory in the world, operated by Ford, produced 7000 in a single day. Eiji Toyoda and Taiichi Ohno's extensive research into Ford led them to believe that mass production would not work for Toyota.

Japan's situation in the world had changed. The Japanese automobile market was small. Japan faced an empowered workforce. The war depleted Japanese business capital and foreign-exchange. This is the environment that Toyota engineers found themselves in.

You maximize production in Mass Production by never shutting off the assembly line. This leads to two possible outcomes with respect to quality: 1) defective parts are pulled aside to avoid contaminating the population or 2) defects are overlooked therefore becoming buried in the product and difficult to discover later on in the process.

Toyota's engineers saw something else in this situation also. They saw that defects represented a waste that they could not afford. Mass Production would not work in Japan at that time.

Toyota's Production System is also famous for innovation. Taiichi Ohno discovered that it is less expensive to produce small batches than large lots. This is based on two phenomena. 1) Small batches result in much less inventory and, 2) If you run off a small amount of parts to assemble into your final product, defects show up right away.

Ford Mass Production Metrics

Fords manufacturing requirements were - yield and quality. The yield requirement means that falling below production yields is not acceptable. Workers pass on defects because they believe it will be fixed later in quality areas. The assembly line just passes the defects downstream. The automobile going down the assembly line with a misaligned part was the correct decision because it did not stop the assembly line or impact the yield. This led to Ford not aggressively chasing down the source of defects.

Taiichi Ohno

Ohno is credited with much of the advancement that the Japanese have seen with TPS. He worked closely with the President of Toyota which helped with executive buy-in. Ohno spent a lot of time in America looking for best practice ideas. For instance, his idea of kanban came from American supermarkets. He noticed that the shelves were always full. The idea of kanban is that a station signals the need of more supplies. This is key to a pull system where one process signals its need for material from the upstream process.

He noticed in American automobile plants that there was an excessive amount of waste. At that time "waste" was literal. Japanese companies did not have enough resources to waste any of them at this time.

When Ohno was looking at what the specialists were able to do he felt that assembly workers could probably do most of those functions. He began to experiment. Using the philosophy of who owns the process, Ohno gave the assembly workers the responsibilities to check the quality, perform minor tool repair, and housekeeping. He then let a little time go by before he asked them to suggest ways in which they thought their process could be improved. He asked them to do that as a group.

Ohno saw what he believed was a major flaw in mass production. That methodology passed errors on as opposed to addressing them where they stood. Errors could be hidden under work performed farther down the line. Also the methodology confused everybody about who was responsible for quality.

At this point Ohno came up with an ingenious idea of stationing a cord above every workstation and making it the responsibility of the worker to pull the cord if they detected a quality problem. This cord stopped the assembly line and signaled to everyone that had a capability of contributing to solving the problem to come and work on the team tasked to do exactly that. Mass Production defects or errors come from two different sources. Assignable Cause Variation or Random Cause Variation.

Random Cause Variation is the variation within a process that is just part of the normal process distribution. An error due to the Random Cause Variation is not fixable without changing the process itself. What Ohno was trying to drive out of his system was Assignable Cause Variation.

This could be the drift of a setting or the wear of a bore. These are the defects that Ohno was trying to eradicate from his system.

Ohno devised a methodology to eradicate Assignable Cause Variation. It's referred to as the "five whys." This is a system of continuous questions to allow you to dig down and determine the root cause of the variation. This leads to an eradication of defects. Ironically in Toyota plants today where every worker has the authority to stop the assembly line due to a defect, yields approach 100%. An important note to interject here is that this work was not painless. The initial assembly line, when this process was implemented, was continually stopping. This is an improvement process that is based on time and extreme willingness. Toyota has executed this process for decades to get where it is today.

Supply Chain Relationships

Toyota and the other automobile manufacturers are less a manufacturing company and more of an assembly company. The Toyota Production Line assembles vehicles. Some of the parts come from their own manufacturing facilities and other parts come from suppliers. For automobiles the final assembly accounts for about 15% of the value of the vehicle. The vehicle itself is comprised of 100,000 discrete parts assembled into 100 major sub-assemblies. The assembly of all of these discrete parts results in a vehicle whose performance is the responsibility of the manufacturer.

The question then becomes, how do you treat the companies that supply the components for your vehicles? This is an important area where TPS differs from Mass Production. The Mass Production companies look at suppliers as disassociated buffers of components. It is the responsibility of the supplier to alter their production schedule to accommodate the variation in the Mass Producers production schedule. Suppliers are looked at as interchangeable components that own their future. Suppliers jealously guard their processes knowing that this is a significant value add. The relationship between the supplier and the Mass Producer is antagonistic.

Ohno and others saw a problem with the system. When suppliers worked straight from Mass Producers blueprints, then they did not have an opportunity to add to the design process. Suppliers had improvement options taken away from them along with design responsibility. Suppliers were given practically no information about the rest of the vehicle.

The philosophical difference between Mass Production and TPS is the concept of the value add capability of the supplier and what type of operational relationship can optimize that value. TPS looks at the relationship with suppliers as long-term enabling ever increasing value.

TPS has a partnership relationship with suppliers. It shares technical information about the environment that the supplier's component will fit in to so the supplier has the opportunity of seeing the situation from a broader view. This allows the supplier, who is an expert on their component, to suggest improvement modifications that might impact their component and the environment that it goes into.

TPS also supports the assembler–supplier relationship. If this supplier is having problems and can benefit from the TPS, then it is not unusual for Toyota to send some of its employees to the

supplier to help solve the problem. It is not unusual for the Toyota to have an investment in their top-tier suppliers. Toyota then is able to ask more from the supplier. Such as building a major subsystem for them.

The Toyota supplier selection process is to request a prototype from the supplier for evaluation. If the prototype worked as expected, then the supplier got the contract. Toyota will encourage suppliers to talk to other suppliers in order to reduce production costs.

Customer Relationship

In Mass Production the customer is what is used to smooth the production system. This is done by varying the product price based on production. Lean Production starts with the customer and ends with the customer. Lean Production has the same problem as Mass Production in that it requires a smooth production environment. Both production techniques had the same problem but approach controlling it a different way.

Whereas mass production discount product price to stimulate sales in order to keep the production rate constant, TPS approaches this differently. TPS effectively increases the sales process. By combining their extensive customer database with increased sales personnel they are able to maintain their production rhythm.

Toyota and the other Japanese car manufacturers use a different sales process than elsewhere. They invest heavily in a database of customers. This gives them predictive information about who in a family may need a car and what car they may need. Customers in Japan are extremely loyal. Customers in America are not. Especially young people in America, they usually don't have a brand preference.

Conclusion

The Toyota Production System's capabilities are powerful and historic. It took people with the vision and ability to execute that vision. One of the beautiful things about TPS is that it is ever-changing. The changes are large and small. When you are adept like Toyota, and have everyone rowing the boat, you will constantly improve.

TPS is the best manufacturing system in the world. It propelled an auto manufacturer from a small company 50 years ago to the largest automobile manufacturer today. Toyota can change the model of car it is manufacturing on its manufacturing line every 42 seconds. Toyota is not only the best but it is also improving quickly. The TPS is an ever evolving system that should not be the same today as it was yesterday.

Toyota is where it is currently for a multitude of reasons. Some of those reasons are of happenstance and some of them are just because they did smart things. Here is a short list of reasons and impacts that drove Toyota to excellence today:

- Time

- The advantage of the union
- Lack of hubris
- Seeing things from a different point of view
- Union strike
- Lack of materials
- How projects are executed
- Going with an Innovation
- WW II
- What is just not good enough

These are just a few of the many differences between Toyota and its competitors. One of the most important considerations is that Toyota had the intestinal fortitude to take a tremendous risk. Lean Production was an untested methodology. Also time is a very important consideration because the TPS improves with time.

The good news for businesses today is that TPS is no longer an untested methodology. TPS belongs to Toyota. Because of the history, the business that they are in, and what they wanted to accomplish.

It is a Lean Businesses recommendation that no other business try to implement the TPS. Businesses should strive to analyze what Toyota did and build their own business system to solve their specific business problems. There are plenty of things that Toyota did and methodologies to accomplish it that every business can use. Toyota changed the thrust of their business 50 years ago and have stayed on that track. If you are the CEO of a company, can you change the direction of your business so significantly that it will affect your business 50 years from now?

Bibliography

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