

Tovota Production System: Beyond Large-Scale Production

by Taiichi Ohno

1978

Taiichi Ohno is credited with creating the just-in-time production system. He still feels today that the goal of Toyota is to shorten the time line, from the moment the customer places an order to the point where the cash is collected. He wants to further reduce that time line by removing non-value-added wastes.

The Toyota Production System was born out of need. At the end of W.W.II, Toyoda Kiichiro, president of Toyoda Motor Company, said "Catch up with America in three years. Otherwise, the automobile industry of Japan will not survive." (They knew that one American worker produced approximately nine times as much as a Japanese worker.) So the Japanese looked at American mass production methods.

What they found was a reliance on large lot production (optimal lot sizes) in order to create the greatest efficiencies, due to long set up times. Unfortunately, such methods would not work in Japan where demand was much smaller to begin with. So Ohno began looking at what to change.

The basis of the Toyota Production System is absolute elimination of waste. The two pillars that this is based on are just-in-time and autonomation. In just-in-time production, a later process goes to an earlier process in the operation flow and withdraws only the number of parts needed, when they are needed. Autonomation refers to automating a process to include inspection. Human attention is necessary only when a defect is detected (the machine will stop and not continue until the problem is solved).

Another primary principle to the Toyota Production System is in determining profit margins. Instead of selling price = actual. cost + profit, Toyota understands that the consumer, not the manufacturer sets price. Therefore they use the formula of selling price - cost = profit. The goal now is cost reduction, not increasing selling price.

In order to begin reducing costs, production leveling was instituted. For example, if a part is needed at a rate of 1000 per month, 40 parts a day should be made for 25 days. To go further, if there are 480 minuets per workday, one part should be made every 12 minutes, and to produce more would create an overstock. Ohno decided that establishing production flow and a way to maintain a constant supply of raw materials was the way Japanese production should be operated.

To improve process flow, Ohno decided that instead of putting the machines of one process together (i.e. all the lathes together, all the presses together, etc.) and having to carry parts back and forth between processes, he would lay out the plant according to the operation flow. He then assigned one worker to more than one machine (Japanese unions are not divided by function). Workers disliked being forced to become multi-skilled in the beginning, but again, necessity is the mother of invention and Japanese workers realized that they must adjust or lose the race against the Americans. Thus the theory of "one operator, many processes" was born. This system increases production efficiency 2-3 times over "one operator, one process" which mass production required.

The Toyota Production System evolved using a process called the "five whys." By asking why five times and answering each time, the real cause of a problem can be discovered. Often root causes are hidden under more obvious symptoms, and only by unpeeling the layers of the problem can the root be found. "Why can one person at Toyota Motors operate only one machine when one person can operate 40-45 looms at the Toyota textile plant?" The answer was found to be because machines at Toyota Motor didn't stop when machining was done. To this response came the birth of automation. Repeatedly asking why is the scientific basis of the Toyota system.

Evolution of the Toyota Production System

The Toyota Production System relies on elimination of waste as essential. The preliminary step of the Toyota Production System is to identify:

- waste of overproduction
- waste of time on hand (waiting)
- waste of transportation
- waste of processing itself
- waste of stock on hand (inventory) waste of movement
- waste of making defective products

Eliminating these wastes completely can improve operation efficiency by a wide margin. To do this Toyota only makes the quantity needed, thereby freeing up man-power. US unions are afraid that this will mean large layoffs, but this is not the idea. The Toyota Production System will clearly show excess manpower that can be put to use elsewhere, effectively. This will also help level manpower needs, so that massive hiring in times of high demand, and large layoffs in times of recession will also be unnecessary.

The second step is in creating standard work sheets. These list the standard methods for each procedure in the plant, and Ohno found they cannot be done from a desk, they must be done from the shop floor. They list cycle time to complete a process, work sequence (order in which the process is to be

completed), and standard inventory (minimum number of work-in-process pieces needed including those mounted in machines, in order for the operation to proceed). Creating these work sheets and refining them not only involves workers in the process, but helps detect areas where process improvements can be made. It is best for workers to create these sheets, because they know the processes best and have the best opportunities to see improvements.

The third area of concern is creating a mentality of teamwork. Ohno looked at team sports to find his analogy here, and the track relay is still referred to in explaining the Toyota Production System. Work flow is set up with "areas where the baton is passed." This simply refers to the idea that when one worker finishes processing a part, he passes it on to the next worker. If that worker is delayed for some reason in his/her process, the first worker (or other workers who may be available in the area) may help set up the second worker's machine for him. They concentrate on the idea that the better the "pass o.' of the "baton" the better the team does overall.

The next issue Ohno addressed was supply. This is when the just-in-time theory was developed based on American supermarkets. In a supermarket, a shopper can get what is needed, when it is needed, in the amount needed. Labor is not wasted, as in door to door sales where a seller may carry around products that do not sell. In manufacturing, just-in time means that a later process gets only what it needs from an earlier process. The earlier process immediately produces what was just taken.

The operating method of enforcing this in the Toyota Production System is called kanban. Kanban is merely a method used to control just-in-time processing. The most common form of kanban is a rectangular piece of paper in a vinyl envelope. The information listed on the paper includes pick up information, transfer information, and production information. It basically tells a worker how many of which parts to pick up or which parts to assemble.

All movements in the plant are systematized this way. Overproduction is prevented by kanban, because it starts in final assembly and works backward to create a "pull" of parts through the process. It control the flow of goods through the plant, but only works if practiced under strict rules.

Functions of Kanban

1. Provides pick-up or transport information.
2. Provides production information.
3. Prevents overproduction and excessive transport.

4. Serves as a work order attached to goods.
5. Prevents defective products by identifying the process making the defectives.
6. Reveals existing problems and maintains inventory control.

Rules for Use

1. Later process picks up the number of items indicated by the kanban at the earlier process.
2. Earlier process produces items in the quantity and sequence indicated by the kanban.
3. No items are made or transported without a kanban.
4. Always attach a kanban to the goods.
5. Defective products are not sent on to the subsequent process. The result is 100% defect-free goods.
6. Reducing the number of kanban increases their sensitivity.

It requires talent and courage to "rethink common sense" when implementing kanban. Top management must commit to reversing its way of thinking about the conventional flow of production, transfer and delivery. The process basically must be looked at backwards since later processes are picking up material from earlier ones.

This requires committing to no longer producing as much as possible, either. Production is now driven by demand, not by capacity. The multi-process system can now be used, because workers are not needed to tend one machine all day, making as much product as possible. Instead, they are required to make only as much as needed. The machine can be idle the rest of the time. But the worker should never be idle, therefore excess time can now be devoted to other machines nearby.

Making only the items needed also requires shorter set up times. Because only small lots of parts may be needed at a time, but must be replaced, workers are required to change set ups often. Therefore, the entire operation must be reengineered.

It should again be reiterated here that the Toyota Production System is the production method and kanban is the method by which it is managed. Kanban is a tool for realizing just-in-time. The goal of the Toyota Production System is continuous flow. For kanban to work, processes must flow as much possible.

Other conditions include leveling production and always working in accordance with standard work methods.

It wasn't until 1962 that Toyota was able to institute kanban on a company-wide basis. The process took 10 years to complete, but it took much perfecting to get it to work properly, and it had to begin at the end of the process and work backwards.

After kanban was instituted in the Toyota Production System, the next step was production leveling. If the process relied on taking what was needed when it was needed, and then replacing what was taken, the lots taken need to be small. If they are large, the earlier process now needs excess capacity to make the large amount. Ideally, leveling should result in zero fluctuation in the last process (final assembly). This requires small lot sizes and small set up times.

Leveling begins with setting a monthly production schedule. The total cars needed can be divided by the number of workdays, to determine the number of cars to make per day. Leveling is then fine tuned each day for how many of each car is to be made and in what order. In this way, needed materials meet in final assembly without delay.

It is also important to note rule 5 of the kanban system. Defective parts are not passed on to subsequent processes. This involves 100% inspection all along the production line, but excess capacity on each machine allows for meeting excess demand to make up for a defective part. The system of the five whys also forces teams to address what caused the defect and to make sure it doesn't occur again.

Further development

To continue to improve, Toyota needed an information system similar to the just-in-time method used in materials management. It is misconception to believe that Toyota does not use production schedules; the difference is in how they use them. For example, Toyota Motor Company has an annual plan that figures the total number of cars they will make in a year. They then make monthly production schedules about three months in advance, and which are fine tuned the month before production. This schedule includes data such as type and quantities of cars to be made. The daily plan is where the just-in-time mentality comes in to play. This daily production schedule includes leveling of production with actual demand and is distributed only to final assembly. All plans are sent to outside cooperating firms as they are developed, so that materials can all be coordinated effectively.

The daily schedule includes the sequence of production for the day. Kanban (working backwards from the end of the line) creates the production order for previous processes. Kanban gives the necessary information when and where

it is needed or just-in-time. Toyota firmly believes in this just-in-time of information because they feel providing unnecessary information in advance may only cause workers to become confused on which sequences they are currently supposed to perform or will encourage overproduction. With just-in-time information, changes in demand can also be adjusted each day, because production was not planned too far in advance.

The Toyota Production System forecasts demand based ONLY on required numbers. Required numbers are actual demand or sales (what the market requires). They cannot be increased or decreased arbitrarily. To determine actual demand, as opposed to speculated demand (the mass production method of forecasting), car dealers around Japan send daily reports to Toyota Automobile Sales Company. The resulting data serves as production requirements for plants.

Toyota feels too many businesses do not truly understand what is meant by economy. In the Toyota Production System, economy is thought of as manpower reduction and cost reduction. The purpose of manpower reduction is cost reduction. Manpower is thought of as needing fewer workers to complete a process. This frees up workers for other business. While most businesses think of using better machinery to increase economy, or running machines longer, the Toyota Production System stresses looking for simple changes, such as changing layout, which may reduce the manpower needed, but costs nothing for machinery.

Along those ideas, waste elimination is aimed at reducing manpower and inventory. It is considered waste for a worker to wait for a pallet to be filled. If he does line work while waiting, it essentially costs nothing. If a machine has excess capacity, an extra set up costs nothing, since the machine wouldn't have been doing anything anyway. These are simple examples of eliminating waste which don't require any extra expense.

All manufacturing is made up of two components: waste and work. Waste included needless repetitive movement (i.e. waiting for parts). The term work includes both value added work, which is processing, and non-value added work, such as walking to pick up parts. Non-value added work can also be classified as waste, but it is necessary for the current way business is done. The misconception to overcome here is that moving does not automatically mean working. Toyota still works toward the ideal, which is 100% value added work.

Another cost reduction focus of the Toyota Production System is on not operating machines at 100% capacity, unless demand dictates the need to do so. This is a place where traditional Western thinking has a problem. The Toyota Production System measures operable rate; the availability of a machine in operable condition when it is needed. Western manufacturers tend

to measure operating rate; the present production record of a machine based on full time capacity. In this way of thinking, when capacity of an old machine falls, Western manufacturers are quick to buy new, expensive machinery. In the Toyota Production System, they rethink the process of replacing old machines. Just because machines have been depreciated doesn't mean they can or should be thrown away. As long as the operable rate is sufficient to meet demand, the machine is kept. Some machines within the Toyota Production System have been there since the beginning of Toyota operations.

Many Western companies try to improve productivity through industrial engineering. Ohno feels I.E. is meaningless unless it involves cost reduction and increased profits. Improving the methods of manufacturing should not only include large-scale capital investment plans, but also work simplification to reduce the number of workers needed to complete a job, or changing the layout of an operation.

Genealogy of the Toyota Production System

Ohno began his work at Toyota Spinning and Weaving. This was a company founded by Toyoda Sakichi, who was essentially an inventor. Sakichi knew his firm was competing with English firms, and therefore was globally minded long before the concept of the global marketplace was developed. In studying ways to improve weaving processes, Sakichi developed looms that automatically stopped when a warp thread broke or weft thread ran out. The Toyota Production System understood this to be an essential concept; that machines must be stopped when the possibility of defects occurs and the machine must be fixed so that the possibility may never recur again. Sakichi learned that applying human intelligence to machines was the only way to make machines work for people. This is a concept still at work at Toyota today.

"Toyotism" was established by Toyoda Kiichiro, Sakichi's son. His dream was to provide cars for the general public. He wanted to perfect the passenger car industry and to make reasonably priced cars. He was the first to recognize the importance of sales in manufacturing. He understood the need to provide good equipment even if the factory was simple. Providing high quality products was the goal, not having the most sophisticated systems.

Kiichiro pursued his own Japanese-Style production technique. He knew he could not mass produce as in America. For starters, Japan did not have the market for autos like in America. Sakichi also believed Japanese industry would continue to lag behind that of America and Europe unless the natural creativity and original technology of the Japanese people was developed. He instilled this idea in his son, Kiichiro, and encouraged him in building their automobile plant without the aid of foreigners, either from Europe or America. Sakichi's patent for the auto-activated loom sold to Platt Brothers of England for

1 million yen. The profits from the sale were put into automobile research, all using Japanese scholars and manufacturers.

Surviving the Low Growth Period

It has been proven that almost anyone can improve efficiencies by increasing production. It is during low growth periods that superior management and superior workers can continue to improve. Toyota continues to focus on reducing waste, lower inventories, and improving techniques (i.e. having one worker able to handle more machines) that allow for survival in low growth periods.