

# **TOYOTrized: How the celebrated TOYOTA Production System is a TRIZ derivative**

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This paper is an attempt to showcase & link how one of the world's most celebrated techniques in manufacturing management and systems employed by TOYOTA are but a derivative of TRIZ.

## **1. The TRIZ principle of 'The other way round'**

### **Turn the event (or process) 'upside down'.**

Etymologically, Just-in-time means just enough time to complete a process. It is a philosophy that has shaped not just Toyota, but the way we look at the entire manufacturing process. It is about producing only what is required and then further transfer of only the specific requirements.

Instead of the old top-down "push" system, it represented a change to a "pull" system where the downstream workers go and fetch only what is needed by them. Tools, including the *kanban* (information card), *andon* (display board), and *poka yoke* (error prevention) were developed to implement the pull system.

In this form of production system, the type, number and other specifications are written on a 'tag-like' card called *Kanban*, put in a rectangular vinyl envelope. It is sent to the people of the preceding process from the subsequent process. The Toyota Production System mainly employs two kinds of *Kanbans*: -

- (a) The Withdrawal *Kanban* details the kind and quantity of product which the subsequent process should withdraw from the preceding process and
- (b) The Production-ordering *Kanban* specifies the kind and quantity of the product which the preceding process must produce.

These cards circulate within Toyota factories, between Toyota and co-op companies & ancillaries, and within the factories of these. As a result, the production processes are well connected allowing for better control of necessary quantities for various products.

## **2. The TRIZ Principle of Taking out**

**“Separate an interfering component or property from an event, or single out the only necessary component (or property) of an event.”**

The way to cut lead-time is to cut out all the bits that do not add value. The Toyota Production System is used to perform optimization by reducing/removing those parts of a production process which can be classified as non-necessary which can be based on the taking-out principle.

If you make it a rule to deal with defects only when they occur, the number of staff you need, will drop straight away. Things that are running smoothly should not be subject to any control. If you commit yourself to just finding and fixing problems, you will be able to carry out effective control on your lines with fewer personnel.

### 3. The TRIZ Principle of Preliminary action

**“Pre-arrange events such that they can come into action from the most convenient place and without losing time for their delivery.”**

Toyota changed their factory layout. Previously all machines of the same type, e.g. presses, were together in the same area of the factory. This meant that items had to be transported back and forth as they needed processing on different machines, implying that only a few processes that actually involve processing.

Most of the time, the work piece is just being transferred from place to place. Therefore, production processes were redesigned so that this lead time may be reduced. To eliminate this transportation, different machines were clustered together so items could move smoothly from one machine to another as they were processed.

The "Just-In-Time" production philosophy is the foundation of the Toyota process. This concept refers to the manufacturing and conveyance of only what is needed, when it is needed, and in the amount needed.

### 4. The TRIZ Principle of Self-service

**“Make an event serve itself by performing auxiliary helpful functions.”**

For the Just-in-time philosophy to work perfectly, all and only the high quality units must flow to the prior process, and this flow must be rhythmic without interruption. Therefore, quality control is so important that it must coexist with the Just-in-time operation throughout the *kanban* based production system.

Toyota also came out with another important principle of *autonomation*. This refers to building in a mechanism a method to prevent mass-production of defective work in machines or product lines. *Autonomation* is not automation, but the autonomous check of abnormality in the process.

The autonomous machine refers to a machine to which an automatic stopping device is attached. In Toyota factories, almost all the machines are autonomous, so that mass-production of defects can be prevented and machine breakdowns are automatically checked.

### 5. The TRIZ Principle of “Blessing in disguise” or “Turn Lemons into Lemonade”

**“Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.”**

After the Second World War, the domestic demand in Japan was considerably low and the domestic marketplace demanded production of small quantities of many different models, or high variety production. The mass production techniques that were developed by Henry Ford involving economically producing long runs of identical products were certainly not suitable in such a situation. This meant that the American method of Economic Order Quantity of making a "lot" or "batch" of an item before switching on to the other could not be applied. The American method of mass production without a focus on quality was unsuited for Japan as property prices have remained traditionally high and any method demanding wastage in resources was not suited in these conditions.

The Toyota Production System employed a lean implementation & produces what only you need approach in these circumstances.

Today, this philosophy has enabled Toyota to flood the automotive market with newer products developed from the same base model. For example, the Toyota Camry, Sienna Minivan have all been developed using a single development process.

The constraints leading to the Toyota Production System have eventually led to substantial cost savings; thereby proving to be a 'blessing in disguise' for Toyota.

## **6. The TRIZ Principle of Composite materials**

### **Change from uniform to composite (multiple) materials**

The Toyota Production System involved the clustering together of different machines and manufacturing equipments so that the produced items could move smoothly from one machine to another as they were processed. However, this meant that workers had to develop multi-dimensional skills as they had to work on a number of machines & adopt flexibility in their approach - previously workers were skilled at operating just one type of machine. Although this initially met resistance from the workforce it was eventually overcome.

## **7. The TRIZ Principle of Segmentation**

### **“Divide an event into independent persons”**

The production staff was reorganized into independent teams with the production system being divided into independent subsystems to be carried out by these teams. Within the newly rearranged factory floor worker teams were to pass the processed items between themselves. If one team worker was unable to perform his duties for a day, then the other workers of the team had to carry out the task so that the team output was unaffected.

## **8. The TRIZ Principle of Continuity of useful action**

### **“Carry on work continuously; make all persons/systems of an event work at full load, all the time.”**

To aid cost reduction, Toyota instituted production leveling - eliminating unevenness in the flow of items. So if a component which required assembly had an associated requirement of a thousand during a 25 day working month, then 40 components were to be assembled per day, 5 for each hour in an eight hour working day. This implied that the work was to be carried out at full capacity. Leveling was also applied to the flow of finished goods out of the factory and to the flow of raw materials into the factory.

The Toyota Production System also led to the substantial reduction in setup time. Machines and processes were to be re-engineered so as to reduce the setup time required before processing of a new item can start.

## **9. The TRIZ Principle of Dynamics**

### **“If an event (or process) is rigid or inflexible, make it movable or adaptive.”**

**&**

## **10. The TRIZ Principle of discarding and recovering**

**“Make portions of an event that have fulfilled their functions go away (discard by dissolving, evaporating, etc.) or modify these directly during operation.”**

The Toyota Production System also involves the production smoothing method to adapt to demand changes. Toyota relied on the principle of ‘Producing what is needed means producing the right quantity of what is needed’. This led to the development of a highly flexible system that allowed the system to produce what is necessary only when it is necessary. If, suppose it takes 10 workers to make a certain quantity of a required item and there is a drop in the quantity required, then the sub-system should be able to reduce the number of workers and allow a few to assist somewhere else. The workforce should be therefore highly adaptive to the situation and be able to provide support in different operations throughout the day. This system of flexible work force termed "*Shojinka*" in Japanese implies varying the number of workers to demand changes.

## **11. The TRIZ Principle of Inert atmosphere**

**“Replace a normal environment with an inert one.”**

### **Improvising the Toyota Production System:**

In 1997, Toyota’s operations were affected by a fire at a brake parts ancillary unit. This cost the company an estimated 195 million dollars and about 70,000 units of production. The fire was at a plant that was the sole supplier of brake parts for all but two Toyota models and forced the company to shut its 18 assembly plants in Japan for a number of days. As a result Toyota embarked on a review of components that were sourced from a single supplier.

Having a single supplier may be attractive in terms of the cost savings, but this may prove to be a very risky proposition.

## **12. The TRIZ Principle of Color changes**

**“Change the color of an event or its external environment”**

The idea of *Autonamation* is also expanded to the product lines of manual work. If something abnormal happens in a product line, the worker pushes stop button, thereby stopping his whole line. For the purpose of detecting troubles in each process, an electric light board, called Andon, indicating a line stop, is hung so high in a factory that it can easily be seen by everyone. The Andon in the Toyota system has an important role in helping this autonomous check, and is a typical example of Toyota's "Visual Control System."

## **13. The TRIZ Principle of Local quality**

**“Make each person/system of an event function in conditions most suitable for its operation.”**

It is the human worker who actually builds quality into a product. First, rules are formulated to identify the most suited condition for operation of a system. Specification files document all forms of work processes to include the content, sequence, timing and outcome of the system in consideration. Each

process at Toyota is specified with detailed instructions. This regime increases the linkage the way work is done and the results that follow. If work is carried out in a different manner rather than as specified, the links become obscure and may be therefore broken.

"It's important to create a climate in which people are trained to follow rules and standards as if they were second nature," Minoura says. "This kind of reflexive response is a hallmark of Toyota's *monozukuri*."

#### **14. The TRIZ Principle of “Nested doll”**

**“Place one event inside another; place each event, in turn, inside the other.”**

**&**

#### **The TRIZ Principle of Homogeneity**

**“Make events interacting with a given event of the same material (or material with identical properties)”**

Toyota put forward the philosophy of single, simple and direct flow path. Here, each piece of the finished equipment has been through the same process & machining systems. This improves consistency, makes error recognition easier and simplifies material handling and scheduling.

#### **15. The TRIZ Principle of Flexible shells and thin films**

**”Isolate the event from the external environment using flexible shells and thin films.”**

The Toyota philosophy tries to integrate each customer with supplier in the production process, without any external interference. Every operation involves the supplies to be directly sent to the customer unit using clear and precise methodology. This precludes separate warehouses and separate people or departments with only function being inventory control and management.

#### **16. The TRIZ Principle of Porous materials**

**“Make an event porous or add porous elements (inserts, coatings, etc.).”**

**&**

#### **17. The TRIZ Principle of Feedback**

**“Introduce feedback (referring back, cross-checking) to improve a process or action.”**

While the individual worker teams cannot vary the process, they are encouraged (read: required) to actively experiment, change, optimize and improve the process. Toyota has always emphasized the leading role people can and are playing in *monozukuri*. To keep coming up with revolutionary new production techniques, Toyota believes in the need to develop unique ideas by thinking about problems in terms of *genchi genbutsu*. This means becomes important to think about how to allow the system develop people who can come up with these ideas.

The Japanese principle of “*Soikufu*” relates to creative thinking or inventive ideas & implies capitalizing on workers suggestions to improvise the production process.

### **18. The TRIZ Principle of Strong Oxidants**

**“Replace common air with oxygen-enriched air.”**

For proper implementation of creative ideas, the workers are guided by a teacher, the *Sensei* for improvement of work processes. The teacher plays the role of motivator, guide and ensures that unfeasible ideas are not implemented.

### **19. The TRIZ Principle of another dimension**

**“To move an event in two- or three-dimensional space.”**

The Toyota Production System involves employee participation involving workers so as to gain from their knowledge and experience. Such participation is meant to ensure that workers feel involved with the system and make suggestions for improvements, cooperate in changes, etc. This provides a human face to the highly mechanized and standardized production system.

### **20. The TRIZ Principle of Copying**

**”Instead of an unavailable, expensive, or fragile event, use simpler and inexpensive copies.”**

Localization or *genchika* has always been seen by Toyota as integral to cost cutting. In the beginning of Toyota operations in any part of the world, the company had to keep some functions back in Japan. But, over a period of time, the local ingredient in any product has been considerably increased for minimizing transportation and allied costs and associated uncertainties.

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