

INTRODUCTION TO PRODUCTION SYSTEMS

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PRODUCTION SYSTEMS

Lean Manufacturing is based on the Toyota Production System (TPS). TPS is a method Toyota uses to make a product. Every manufacturer has its own way of making things, thus there are as many manufacturing methods as there are manufacturers.

A company's method of production reveals the philosophy of its administrators. And strictly speaking, even in the same company there are variations of method between plants.

The Features of Mass Production System – small variety, large lot

The basic manufacturing method in *mass production* is the assembly line conveyor system, also called the Ford System. Mass production systems seek to achieve the following goals:

- Increase in productivity
- Uniformity of product
- Reduction in costs
- Consistency of quality
- Shortening of production lead-time.

This means, in effect, that the production process is divided into simple work units, in which it is easy to learn the work and develop skills. This lessens disparities in skill between employees, promotes product uniformity, and makes mass production possible.

The work done by each work unit should require about the same amount of time to make overall work flow smoothly. This technique permits the workload to be evenly distributed among all the employees and improves the operational usage of equipment usage of equipment, enabling both men and machines to achieve 100% performance without stopping the lines. It also results in a certain measure of cost reduction.

In general, however, mass production systems must avoid design changes or model diversity as much as possible if they are to avoid changing the work content of each process, increasing the number of parts for every model and adjusting - as a result - the equipment for all necessary modifications.

If adjustment of work is required, there will always be an accompanying loss of time and quality. To avoid this loss, therefore, production is always done in large lots. For example, parts for the same types and models are made together. It is obviously a good idea to produce them in large lots with the fewest possible changes of press dies. The manufacture of common parts thus facilitates the whole mass production system. This is short is the practical concept behind the mass production work site.

It has generally been held that mass production, while possessing various market characteristics, makes the maximum effect on cost reduction by systematic production in large lots. The American automobile companies have indeed proven this in the past.

Mass production, as summarized by the phrase "conveyor system," certainly involves work that "flows" along assembly lines, but if one moves back up the production "stream" along the preceding processes, one will note that the flow is not everywhere constant.

An automobile plant uses an assembly line with a conveyor system, but those of its departments engaged in the rough processing of materials, such as stamping or casting and forging, cannot easily employ the conveyor system. Here large lot production - demanded by equipment limitations - becomes central.

We can see, in reviewing the characteristics of the mass production system, while the ability to obtain good results through large lot production is indeed an important factor, the current shift to large-variety, small-lot production presents serious problems for the older small-variety, large lot production technique.

The Features of Conventional Production System – large variety, small lot

The market is always changing through gradual expansion or contraction, and never remains static. As a market matures, the demands of its customers diversify and stimulate the development of large variety, small lot production. This variety includes types, models and options.

The ideal situation is to have the production department make products in accordance with sales. At the actual work site, however, there are many different restrictions on this ideal, so the production plan is often formulated with emphasis on the manufacturing side.

The sales and production planning departments can, in their interaction with the production department, cause problems at the plant, including poor forecast, uncertain production schedules and numerous design changes in the manufacture of products.

Given these conditions, the production department will try to produce goods strictly by the production schedule table in large lots, and without line stoppages, in order to increase production efficiency and prevent any decrease in the operational usage of the equipment. It will also increase stock as a hedge against breakdowns, defective products and absenteeism.

This type of factory employs many devices in each process, thus increasing extra work and making it difficult to properly assess production capacity. The various problems connected with employees and equipment all tend to blend into a murky fog. Under these circumstances, the plant will start to manufacture products independently of market needs and without the capacity to respond immediately to customer needs. The result of all this is that the amplitude of the increase and decrease in production quantities will be much larger than actual conditions warrant.

To counteract this at the actual work site, our hypothetical factory will increase equipment so it can accommodate maximum production increases and will start to automate its lines, both wasteful capital investments. Additionally, the work will become unbalanced and the working methods irregular, leading to problems in quality and labor relations.

A trend of this kind causes much waste and raises costs, and clearly influences business results negatively.

Conventional production systems all follow this pattern to a certain extent. Attempts to make improvements or introduce new equipment to develop the work site will, under such circumstances, have a negligible effect.

The Features of Lean Production System - TPS

The Toyota Production System symbolizes a management philosophy for addressing issues related to: quality, cost, productivity, and respect for people -- in conventional production systems.

To achieve this objective, Toyota aims at a synchronized, sequential production system that can deliver just enough stock, at just the right time (just-in time), to each line along the whole length of the production process.

In contrast to the conventional production system, in which systematic mass production with large lots is believed to have a maximum effect on cost reduction, the Toyota philosophy is the *"Make the smallest lot possible, and do so by setting up work stations in the shortest time possible."*

If each process in a large-variety, small-lot production system were to produce large rather than small lots, the stock needed would be enormous due to the large variety of parts and would lead to great waste. This in turn would invite an increase in cost and a decrease in quality.

At Toyota, measures have been taken to reduce almost to zero the various types of waste resulting from overproduction and overstocking. The key mechanism for this is the application of the "Pull System" rule, by which the parts needed for a succeeding process are picked up at the preceding process with Kanban as the prime means for conveying information.

The Pull System

In conventional production systems, parts produced at one process, as determined by the production schedule, are delivered to succeeding processes even if they are not yet needed there. This method may be good when parts can be produced on schedule throughout the whole process.

But if just one process has trouble and the line stops, the processes directly related to the troubled one will suffer from either a shortage or a backup of parts.

The pull system is designed to allow production of parts in response to sales: unless an employee from the following process goes to the preceding process to pick up the parts, the preceding process must not produce any more parts than required -- that is to say, the quantity indicated by the Kanban. The Kanban gives the preceding process information about production quantities and timing and thereby prevent production overruns.

For the preceding process to produce the necessary quantity of parts that the following process will pick up, all production processes must have personnel, equipment and materials that can manufacture the parts "just in time." If the succeeding process is irregular in its own quantity and time, the preceding process must proportionately increase (or decrease) its output to compensate for the irregularity. Costs, therefore, will rise.

Such irregularities must be minimized in large-variety, small-lot production. This is done, by keeping the lots small to hold down the flow of identical parts. The mechanism for this is "leveled production."

Since the concept of leveling is important in Lean Manufacturing, it will be discussed in detail in the following section.

Leveled Production

In the production work site generally, the bigger the fluctuations either in part flow or production quantity the greater the waste. A fluctuating production quantity or irregular manufacturing pace in any process will cause the production process as a whole to change in a disorderly fashion, resulting in confusion, work errors, line stoppages, quality defects and lowered efficiency. In this way, it has a serious effect on the preceding and succeeding processes.

To cope with production fluctuations, the company must always have in readiness the equipment, employees and other ancillary production items to meet the maximum possible workload. The more the workload falls below the maximum, the greater the delay among employees and equipment. And this has a serious effect on efficiency and cost.

For example, let us consider what effect the final assembly line will have on the preceding process if the former considers only its own process efficiency when planning to produce sedans today, hardtops tomorrow and vans the day-after-tomorrow.

The preceding process line that manufactures parts for Model A has work today but the lines that manufactures parts for Models B & C did not. Even if the latter two lines shift their schedules so they can work every day with the requisite stock, they will require three to four times more stock than they would normally use with an equilibrated, or leveled, daily production schedule.

Also, if the pull quantity of the following process fluctuates, the preceding process must reserve enough stock to meet the maximum possible part withdrawal to avoid part shortages. This situation worsens the farther back one goes along the preceding processes.

To avoid such situations, the final process assembly line must produce all the different models in a continuous sequence. So done, a great deal of the waste in the preceding processes can be eliminated. We call this "leveling" -- that is, to even out the many different factors controlling types and quantities.

The leveling of the production quantity means that a single part (or any one item) should be manufactured in a given number of minutes and seconds. This time is called the "Takt" time. Every process observes this Takt time in production. It is then easy to organize the equipment, man-hours and other factors necessary for effective production. If only one type of item is manufactured, smooth production is possible by leveling only the quantity. If multiple types are manufactured, however, the leveling of the types is necessary to avoid the waste that lead to lowered efficiency.

The leveling of the types means that the required production quantity ratio for all types is manufactured in a series. For example, if the production quantity ratio for Model types A, B and C is 2:1:1, respectively, the different types will be produced consecutively in the sequence A, B, A, C, A, B, A, C... and so on.

Production carried out in this fashion makes it possible to pull parts from a preceding process without causing any fluctuation in quantity and types. The preceding process also need not have additional stock, man-hours and equipment.

The ultimate purpose behind this leveling of production in all processes is to manufacture just in time vehicle types in quantities determined by sales, and to make an effective and

flexible organization which, by knitting the whole production process together as much as possible, eliminates time and money waste and places no excessive burden on employees.

Extending leveled production all the way to the last line also facilitates standardized work.

Continuous Flow Processing

In the marketplace, each Customer purchases a different model of our product, so the production site should manufacture these parts individually and in succession.

Furthermore, the same approach applies to those stages of manufacture where individual parts are produced. The ideal, ultimately, is to achieve leveled, sequential production without accumulation of part within a process or between processes.

Manufacturing comprises many processes, from the raw material processes of forging, casting, forming and pressing, to the intermediate processes of welding and on to the final processes of painting and assembly. The degree of leveling that can be achieved by integrating all these processes so they flow together equals the degree of improvement in overall plant efficiency.

Those places in the production process where a flow has not been established produce considerable amount of waste. And particularly in the case of parts that require many interim processes for completion, a failure to achieve flow before the end of the sub-production cycle will be critical.

The reason for this is that the intermediate set-up parts will accumulate before and after the various equipment and machines, and the order in which the parts enter the first process and the order in which they exit the last will bear no relationship to each other. Each time a part is completed, it will have to be loaded on a pallet or a tray and carried to the next process. This situation will require a kind of parts "traffic cop" every time a part must move to another process, and the total plant efficiency will suffer as a consequence.

The pressing or molding or forging processes, which must use lot production, should try to achieve production flow by keeping the lot size as small as possible. For this, it is important to set up dies in a short time.

To eliminate the congestion of parts within a process or between processes and to achieve sequential flow production is called "continuous flow processing". The following measures are necessary for continuous flow processing:

Products

- Successive production. Manufacture and assemble each single piece or unit in the process order so the product will flow one after the other between workstations or processes.
- Small lots. Shorten the die-change time or changeover process in lot production processes and keep the lots small.

Employees

- Multiple process responsibility (“multi process handling”). Arrange a system so employees perform several tasks that match the Takt time according to the work sequence.
- Multiple skill employees (“multi skilled employees”). Always provide several levels of training to the employees so they can operate various types of equipment, do various kinds of work and perform other work besides that for which they are directly responsible.

Equipment

- Process sequence layout. Lay out the equipment in the order of processes so sequential production and multi-process handling can be done.
- Equipment with simple set-up. Make a system to eliminate adjusting work or changing of associated equipment in order to shorten the set-up time.

It requires great effort, in the lot production processes, to keep the lots small and to create a production flow in the plant.

Sequential Information Flow Using Kanban

In a true Lean Operation it is necessary to link all processes into a single line to produce its goods in a smooth flow. However, when each process is physically separate from the others, transportation is required. An operator of the following process goes to the preceding process to pull parts as needed (Pull system).

The preceding process produces only the parts to be pulled by the succeeding process (fill-up production). The method used to exchange information between the pull and fill-up production sites is a ***Kanban***.

It is important for every employee at the production site to know what, how much and when parts are produced. This information interchange is the autonomic brain system of a very large production process and it keeps all processes operating without interruption.

Kanban plays a major role in leveling production or shortening production lead-time by maintaining a sequential flow of timely information to all processes. The number of Kanbans issued will increase or decrease depending on the current parts usage quantity. Raw materials and set-up part stock can, therefore, be held to the minimum.

One role of the Kanban is to serve as “a tool for improvement.” Since employees are permitted to determine for themselves the minimum stock necessary by evaluating stock conditions, they are able to use the Kanban information to make improvements (Kaizen) to reduce stock.

This also has the advantage of raising individual employees’ awareness concerning cost and personal participation.

Prevention of Quality Defects and Equipment Breakdown

If every process can obtain the necessary parts at the required time – Just-in-Time -- and in the proper quantities, there will be no need to maintain stocks of extra materials or parts. However, what are the appropriate countermeasures if equipment breaks down and the operational rate is lowered, with an accompanying decline in production, or if defects in quality occur frequently or parts cannot be obtained in a timely fashion?

There is a tendency, generally, to react by accumulating a reserve of stock based on an estimate of quality defects, equipment breakdown and employee absenteeism. Toyota, however, is opposed to using stock build-up to counter these problems. Keeping excess stock means that the various production problems are merely hidden or glossed over, and this makes it impossible to establish a work site with a strong constitution.

Recourse to stock build-up means that, even if production halts due to defects or machine and equipment breakdowns, stock is used to compensate. Thus the company does not perceive any strong need to prevent problems, to prevent their recurrence, or to improve the operational rate when defects or breakdowns occur.

Without an attempt to create a strong efficient work site, the period from receipt of an order to production and delivery of the product will lengthen and stock will increase. Therefore, it is crucial to prevent defects in quality and to “build quality into the process.”

On the other hand, maintenance is also important for deterring machine and equipment breakdown and for preventing their recurrence. The Toyota Production System also places importance on “kaizen of maintenance” and stresses training for such improvement.

The Toyota Production System can be summarized very briefly:

- Produce only the necessary parts
- When is necessary
- In the required quantity

To this end, Toyota strives to completely eliminate from its production activity all factors that only serve to raise costs. By long trial-and error, at the manufacturing work site, Toyota developed and implemented the best possible production method that we could devise -- not from theory but from hard experience. Since this is the technology of the actual work site, it is not permanently frozen, but will be improved and developed in the future.