JUST IN TIME (JIT), LEAN, AND TOYOTA PRODUCTION SYSTEM (TPS)

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1 History of Manufacturing Management

Manufacturing management has a long history goes back to Eli Whitney and the concept of interchangeable parts. In 1798, Eli Whitney invented a way to manufacture muskets by machine so that the parts were interchangeable.

Frederick W. Taylor began to look at individual workers and work methods. The result was Time Study and standardized work. He called his ideas Scientific Management. Taylor was a controversial figure. The concept of applying science to management was sound but Taylor simply ignored the behavioral sciences. In addition, he had a peculiar attitude towards factory workers.

Frank Gilbreth added Motion Study and invented Process Charting. Process charts focused attention on all work elements including those non-value added elements which normally occur between the "official" elements.

Starting about 1910, Ford and his right-hand-man, Charles E. Sorensen, fashioned the first comprehensive Manufacturing Strategy. They took all the elements of a manufacturing system (people, machines, tooling, and products) and arranged them in a continuous system for manufacturing the Model T automobile. Ford was so incredibly successful he quickly became one of the world's richest men and put the world on wheels.

The Allied victory and the massive quantities of material behind it caught the attention of Japanese industrialists. They studied American production methods with particular attention to Ford practices and the Statistical Quality Control practices of Ishikawa, Edwards Deming, and Joseph Juran. At Toyota Motor Company, Taichii Ohno and Shigeo Shingo began to incorporate Ford production and other techniques into an approach called Toyota Production System or Just In Time. They recognized the central role of inventory.

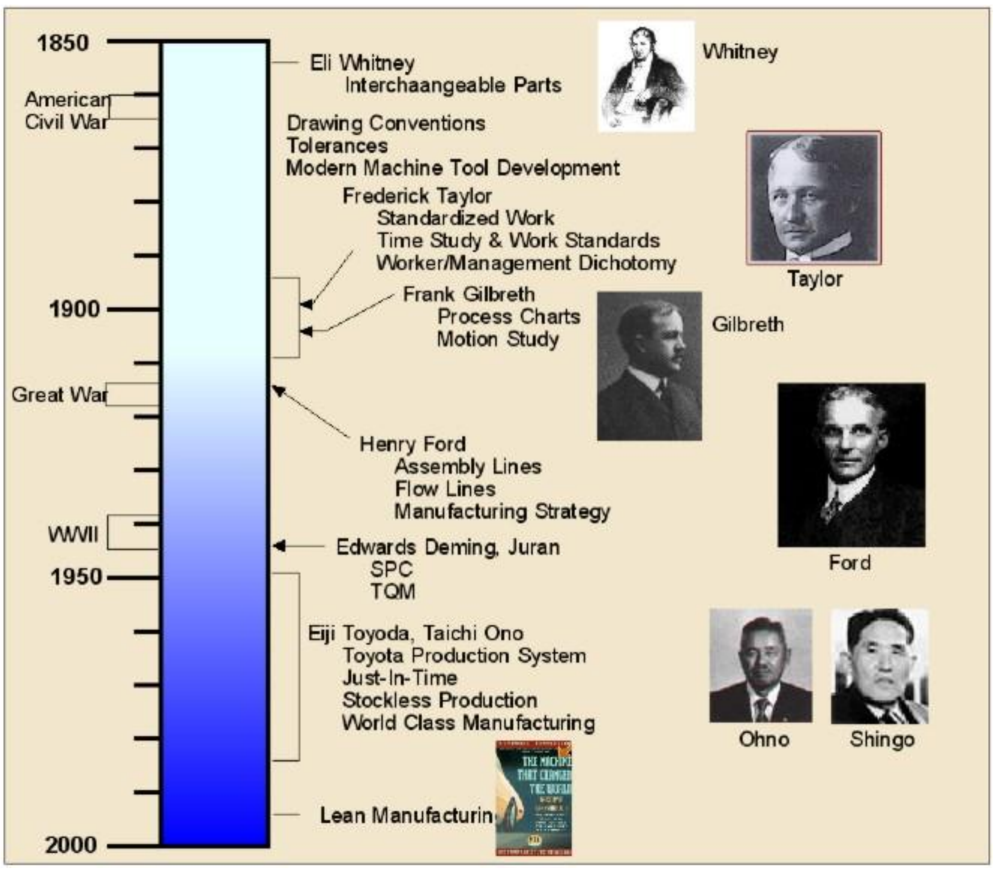

Figure (1) The high points of manufacturing management history.

In 1990 James Womack wrote a book called "The Machine That Changed The World". Womack's book was a straightforward account of the history of automobile manufacturing combined with a comparative study of Japanese, American, and European automotive assembly plants. What was new was a phrase-- "Lean Manufacturing." Lean Manufacturing caught the imagination of manufacturing people in many countries. Lean implementations are now commonplace. The knowledge and experience base is expanding rapidly.

2 Push and Pull systems

Push system

Is a manufacturing system in which production is based on production plan and where information flows from management to the market, the same direction in which the material flow.

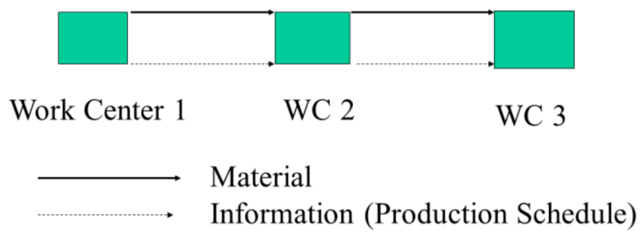

Figure (2) Push System

Pull system

Is a manufacturing system in which production is based on actual demand, and where information flows from market to management in a direction opposite to that in traditional (push) system.

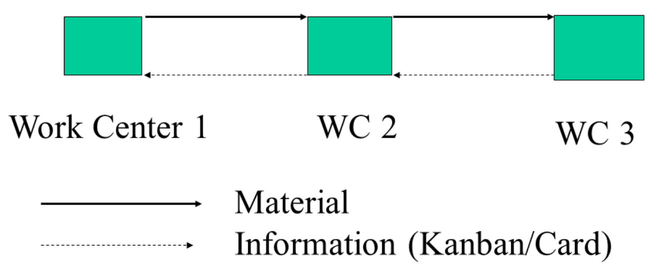

Figure (3) Pull System

3 Just in time (JIT)

Just-In-Time is a Japanese manufacturing management method developed in 1970s. It was first adopted by Toyota manufacturing plants by Taiichi Ohno. The main concern at that time was to meet consumer demands. Because of the success of JIT management, Taiichi Ohno was named the Father of JIT. The just in time manufacturing system considered as a pull system.

The principle of Just in time (JIT) is to eliminate sources of manufacturing waste by getting right quantity of raw materials and producing the right quantity of products in the right place at the right time.

4 The Goals of JIT

The ultimate goal of JIT is a balanced, smooth and rapid flow of materials through the system. This can be achieved by approaching the following supporting goals first;

1. Zero defects.
2. Zero inventories.
3. Zero set – up time.
4. Zero handling.
5. Zero break – down.

5 Planning for JIT

It is impossible to establish a new **JIT** system that can be used successfully without modification. Since each manufacturing process is different (e.g. in terms of Goals, Product requirements, Customer requirements etc.), it is up to the individual company to determine the degree of appropriateness and the final application of **JIT**. However, it is very important to define the plan and objectives before setting up a **JIT** manufacturing system.

6 Defining the Planning

Defining the planning process for a **JIT** manufacturing system requires an understanding of the objectives of **JIT**, and the goals and objectives of the JIT system. After the objectives are established for the manufacturing, the process of planning becomes one of determining what is required to meet those objectives.

The goal of a **JIT** approach is to develop a system that allows a manufacturer to have only the materials equipment and people on hand required to do the job. Achieving this goal requires six basic objectives:

1. Integrating and optimizing every step of the manufacturing process.
2. Producing quality product.
3. Reducing manufacturing cost.
4. Producing product on demand.
5. Developing manufacturing flexibility.
6. Keeping commitments and links made between Customers and Suppliers.

7 JIT and Kanaban System

The term *"Kanban"* has sometimes been used as equivalent to JIT, which certainly is not the truth. Kanban is a Japanese word for "card". They often use cards to signal the need for more material, hence the name kanban. The idea behind the kanban system is to authorize material for production only if there is a need for them. Through the use of this system, production is *"Pulled"* through the production system; instead of *"Pushed"* out before if is needed and then stored.

Part Description				Part Number	
Smoke-shifter, left handed.				14613	
Qty	20	Lead Time	1 week	Order Date	9/3
Supplier	Acme Smoke-Shifter, LLC			Due Date	9/10
Planner	John R.	Card **1** of **2**			
		Location		Rack 1B3	

Figure (4) Knaban Card

In general, kanban system works in the way that, two cards are used; a "withdrawal kanban" and a "production kanban". These cards are very simple, showing only the part number and name, the work centers involved, storage location, and the container capacity. The approach is illustrated in figure (5).

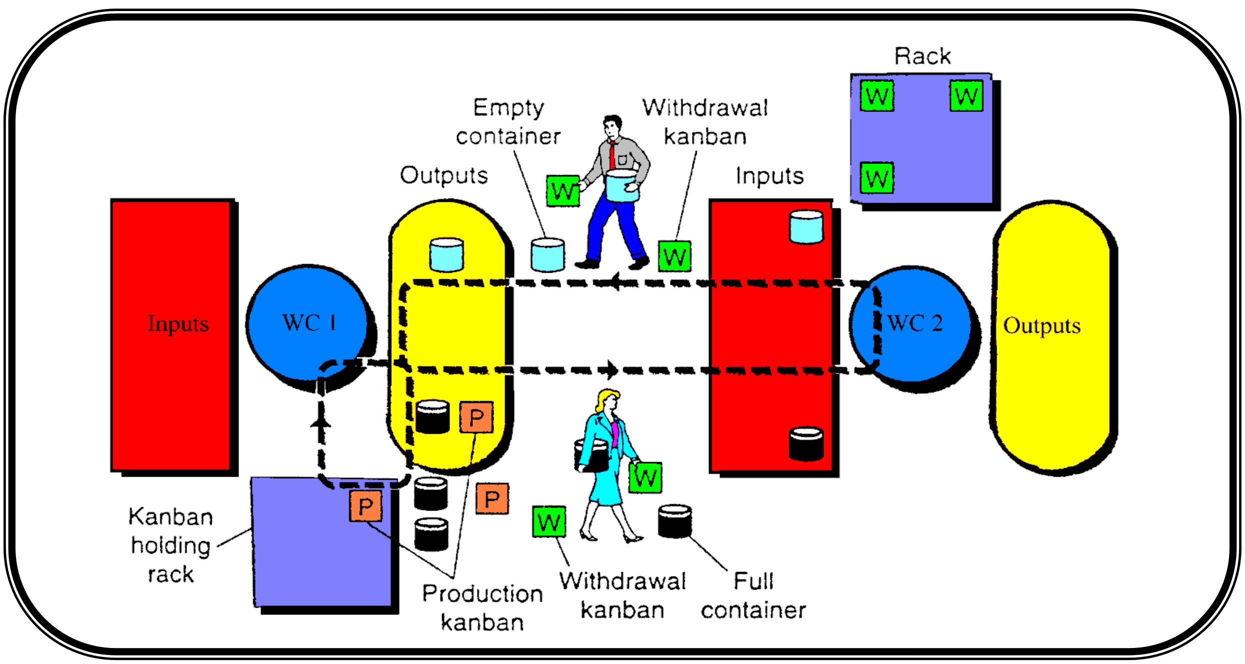

Figure (5) Kanban Process

For example, assuming that work floes from work center number one WC1 to WC2, and containers are used to transport the output from WC1 to WC2, where they are used as inputs. When WC2 sees that it will need more input parts, it takes an empty container and a withdrawal kanban back to WC1. There it leaves the empty container and locates a full one, which has a production kanban with it. WC2 replaces the production kanban with its withdrawal kanban, which authorized it to remove the full container and the withdrawal kanban. It puts the production kanban in a rack at WC1, thereby authorizing the production of another container of parts. Back at WC2, the withdrawal kanban is placed back in its rack. WC1 cannot initiate production and fill an empty container until it has a production kanban authorizing additional production. Thus, withdrawal kanban authorize the acquisition of additional material from a supplying work center and production kanban authorize a work center to make additional product.

Figure (6) illustrate the work of kanban system in manufacturing process:

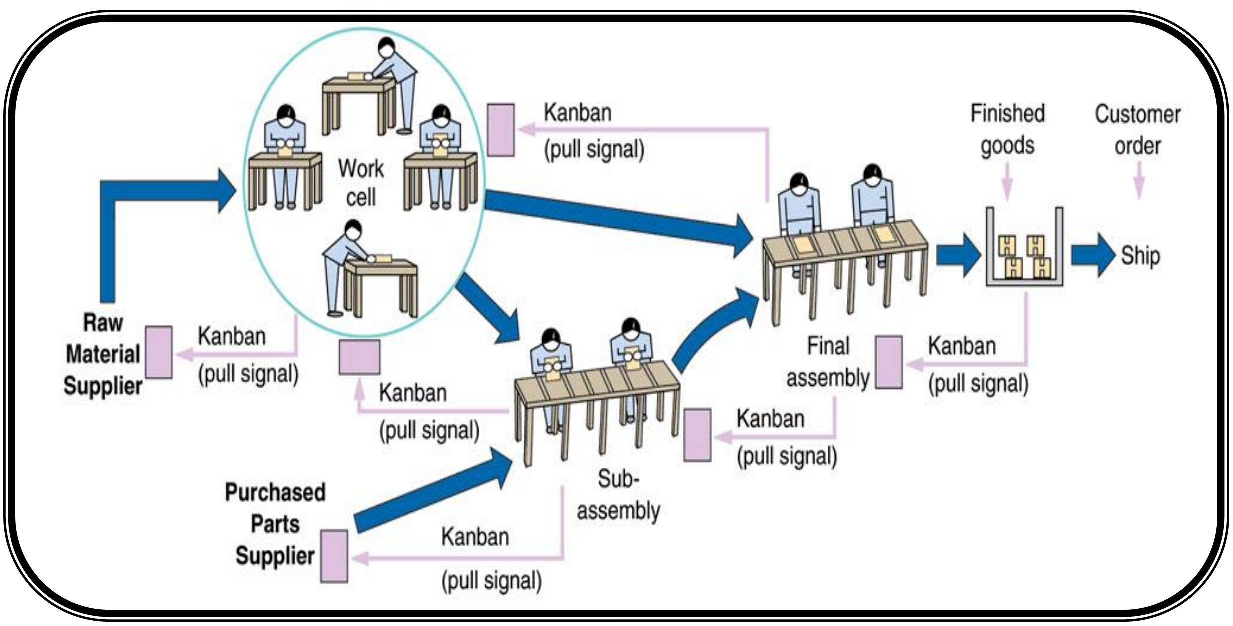

Figure (6) work of kanban system in manufacturing process

Although, the main advantage of kanban system is it's implicitly but, it is not appropriate in many manufacturing environments and cannot be applicable without preparing several requirements.

8 Objectives of JIT

The objectives of JIT can be mentioned as shown:

1. Produce with perfect quality.
2. Produce with minimum lead time.
3. Produce products with only those features the customer wants.
4. Produce with no waste of labor, material or equipment, every movement must have a purpose so that there is zero idle inventory.
5. Produce with methods that allow for the development of people.

9 Requirements for Successful Implementation of (JIT)

For JIT to be successful the following requirements must be met:

1. The environment has to support it.
2. The most appropriate way to implement JIT is to do it step by step.
3. A hybrid model (traditional + JIT) is the most appropriate. If JIT fails, the traditional model will be used as a fallback position.
4. A flexible management system is essential.
5. Key elements of the JIT system must be in place. They are:

(i) Close ties with few reliable suppliers.

(ii) Low inventories of raw materials, work-in-process inventories and finished goods.

(iii) Appropriate material handling system, so that there won't be work-in-process inventories.

(iv) Small lot sizes with shorter lead times.

(v) Low cost set-up times.

10 Advantages or Benefits of JIT

1. Continuous improvement in quality.
2. Cost is reduced.
3. Elimination of waste.
4. Manufacturing time is down.
5. Better productivity.
6. Lower Work in progress.
7. Better supplier relationships.
8. Cost efficient production.
9. Defect free output.

11 Drawbacks or Disadvantages of JIT

1. JIT system may not be able to manage sudden variations in demand.
2. Production is very reliant on suppliers and if stock is not delivered on time, the whole production schedule can be delayed.
3. There is no spare finished product available to meet unexpected orders, because all products are made to meet actual orders. However, JIT is a very responsive method of production.

12 Toyota Production System (TPS)

The Toyota Production System (TPS) is an integrated socio-technical system, developed by Toyota that comprises its management philosophy and practices. The TPS organizes manufacturing and logistics for the automobile manufacturer, including interaction with suppliers and customers. The system is developed between 1984 and 1975.

13 Principles of Toyota Production System

1. Continuous improvement.
2. Root cause analysis.
3. Visualization.
4. Proof mistake.
5. Standardize work.
6. Respect of employees.
7. Simplification.
8. Continuously solving root problems.

14 Lean Manufacturing System

Provide clients and customers of products or services they like when they want it and in the most effective and least loss in or missing.

15 The Relationship Among JIT, TPS & Lean Manufacturing Systems

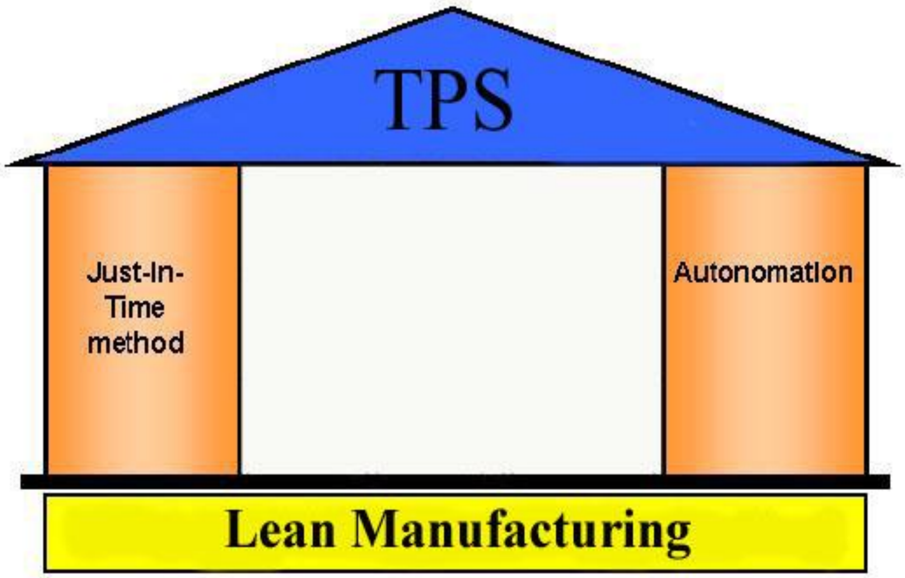

Figure (7) Lean Manufacturing, JIT and TPS

16 The Seven Deadly Wastes

We can identify seven types of losses in the traditional manufacturing system and the Lean manufacturing system must fight it and uprooting of the foundations:

1- Over-Production.
2- Waiting Time.
3- Transportation.
4- Over Processing.
5- Inventory.
6- Motion.
7- Defective Products.

Figure (8) The seven deadly wastes

17 The Principles of Lean Manufacturing System

1- Setup Time Reduction

2- Kanban system

3- Value Stream Mapping

4- Total Productive Maintenance

5- Cellular Manufacturing

6- Organization of the workplace (5S)

18 Total productive maintenance

Total productive maintenance (TPM) is 'the productive maintenance carried out by all employees through small group activities', where productive maintenance is 'maintenance management which recognizes the importance of reliability, maintenance and economic efficiency in plant design. In Japan, where TPM originated, it is seen as a natural extension in the evolution from run-to-breakdown to preventive maintenance. TPM adopts some of the team working and empowerment principles as well as a continuous improvement approach to failure prevention. It also sees maintenance as an organization-wide issue to which staff can contribute in some way.

19 The five goals of TPM

TPM aims to establish good maintenance practice in operations through the pursuit of the five goals of TPM;

1- *Improve equipment effectiveness* by examining all the losses which occur.
2- *Achieve autonomous maintenance* by allowing staff to take responsibility for some of the maintenance tasks and for the improvement of maintenance performance.
3- *Plan maintenance* with a fully worked out approach to all maintenance activities.
4- *Train all staff in relevant maintenance skills* so that both maintenance and operating staff have all the skills to carry out their roles.
5- *Achieve early equipment management* by 'maintenance prevention' (MP), which involves considering failure causes and the

maintainability of equipment during its design, manufacture, installation and commissioning.

20 Organization of the Workplace (5S)

The **5-S terminology** comes originally from Japan and although the translation into English is approximate - see Figure (9) - they are generally taken to represent the following:

1- Sort (*Seiri*). Eliminate what is not needed and keep what is needed.
2- Straighten (*Seiton*). Position things in such a way that they can be easily reached whenever they are needed.
3- Shine (*Seiso*). Keep things clean and tidy; no refuse or dirt in the work area.
4- Standardize (*Seiketsu*).Maintain cleanliness and order – perpetual neatness.
5- Sustain (*Shitsuke*). Develop a commitment and pride in keeping to standards.

The 5S's can be thought of as a simple housekeeping methodology to organize work areas that focuses on visual order, organization, cleanliness and standardization. It helps to eliminate all types of waste relating to uncertainty, waiting, searching for relevant information, creating variation and so on. By eliminating what is unnecessary and making everything clear and predictable, clutter is reduced, needed items are always in the same place and work is made easier and faster.

Figure (9) Organization of the workplace (5S)

21 Levelled Scheduling in JIT Environment

Heijunka is the Japanese word for **levelled scheduling** so that mix and volume are even over time. For example, instead of producing 500 parts in one batch, which would cover the needs for the next three months, levelled scheduling would require the operation to make only one piece per hour regularly. The principle of levelled scheduling is straightforward but the requirements to put it into practice are quite severe, although the benefits resulting from it can be substantial. The move from conventional to levelled scheduling is illustrated in Figure (10). Conventionally, if a mix of products was required in a time period (usually a month), a batch size would be calculated for each product and the batches produced in some sequence.

Figure 10(a) shows three products (A, B and C) which are produced in batch sizes of 600, 200 and 200, respectively. Starting at day 1, the unit commences producing product A. During day 3, the batch of 600 As is finished and dispatched to the next stage. The batch of Bs is started but is not finished until day 4. The remainder of day 4 is spent making the batch of Cs and both batches are dispatched at the end of that day. The cycle then repeats itself. The consequence of using large batches is, first, that relatively large amounts of inventory accumulate within and between the units, and second, that most days are different from one another in terms of what they are expected to produce (in more complex circumstances, no two days would be the same).

If the flexibility of the unit could be increased so the batch sizes were reduced to a quarter of their previous levels (see Figure 10 b), a batch of each product can now be completed in a single day. Smaller batches of inventory are moving between each stage, which will reduce the overall level of work-in-progress in the operation. Just as significant is the impact on the regularity and rhythm of the process. Now, every day, the activity in the process is the same. This makes planning and control much easier. So, if on day 1 the daily batch of A was finished by 11.00 am and all the batches were successfully completed in the day, then the following day, if the process again completes all As by 11.00 am it is on schedule. When every day is different, the simple question 'are we on schedule?' requires some investigation. When every day is the same, progress can be assessed simply by looking at the clock. Control becomes visible and transparent to all.

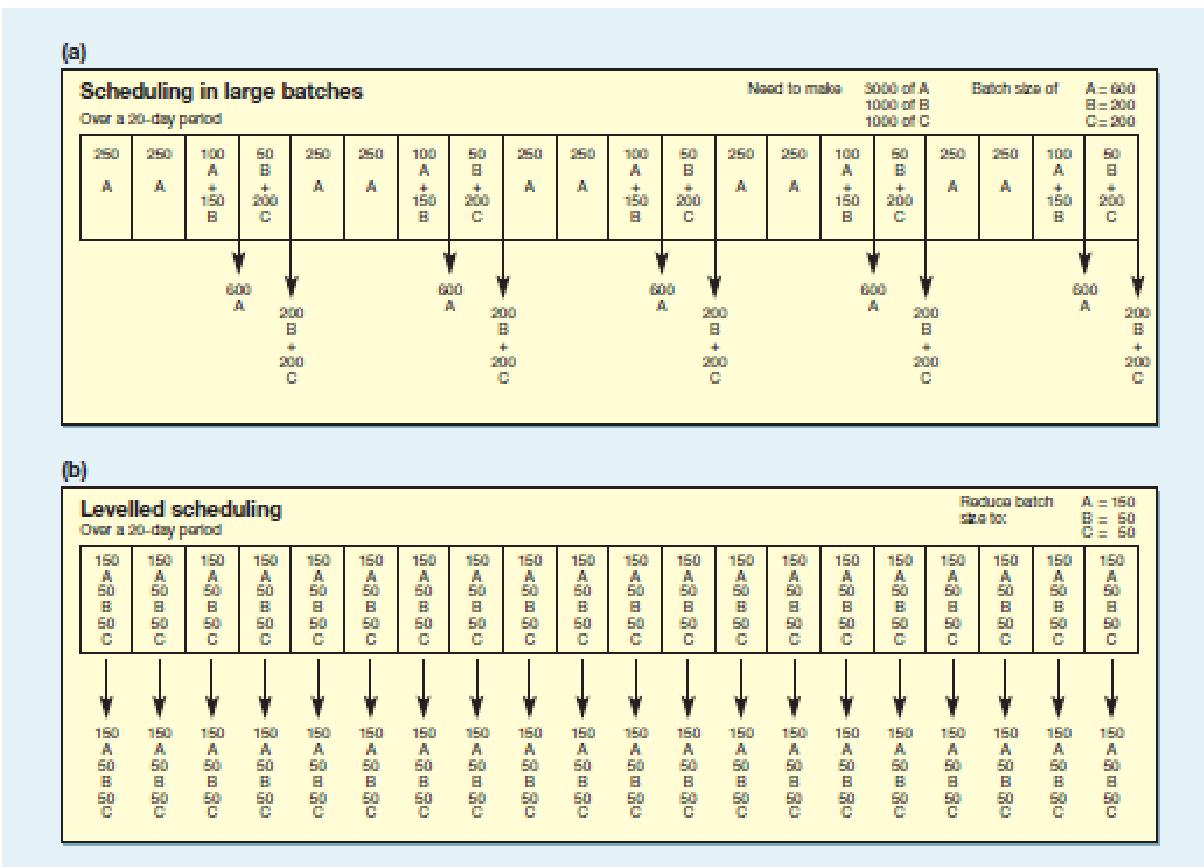

Figure (10) Levelled scheduling equalizes the mix of products made each day

22 Synchronization

Synchronization is very similar to levelled scheduling and means the pacing of output at each stage in the production process to ensure the same flow characteristics for each part or product as it progresses through each stage. To do this, parts need to be classified according to the frequency with which they are demanded. One method of doing this distinguishes between runners, repeaters and strangers:

- *Runners* are products or parts which are produced frequently, such as every week.
- *Repeaters* are products or parts which are produced regularly, but at longer time intervals.
- *Strangers* are products or parts which are produced at irregular and possibly unpredictable time intervals.

There are advantages in trying to reduce the variability of timing intervals. The aim for producing runners and repeaters is to synchronize processes so that production appears to take place on a 'drum beat' pulse. It might even be better to slow down faster operations than to have them produce more than can be handled in the same time by the next process. In this way, output is made regular and predictable.

23 Mixed Modelling

Also related to levelled scheduling is **mixed modelling** or the repeated mix of parts. It means that ultimately processes can be made so flexible that they achieve the JIT ideal of a 'batch size of one'. The sequence of individual items emerging from a process could be reduced progressively until it produced a steady stream of each item flowing continuously. So, for example, rather than produce 200 As, 120 Bs and 80 Cs, a steady mixed stream in the same ratio is produced (A A B A B C A B C A … etc.).

Illustration 1;

Suppose the number of products required in the 20 days period are:

Product A = 1920

Product B = 1200

Product C = 960

Assuming an eight-hour day, the cycle time for each product - that is, the interval between the production of each of the same type of product is as follows:

Product A, cycle time = (20) (8) (60)/1920 = 5 minutes

Product B, cycle time = (20) (8) (60)/ 1200 = 8 minutes

Product C, cycle time = (20) (8) (60)/960 = 10 minutes

So, the production unit must produce:

1 unit of A every 5 minutes

1 unit of B every 8 minutes

1 unit of C every 10 minutes

Put another way, by finding the common factor of 5, 8 and 10:

8 units of A every 40 minutes

5 units of B every 40 minutes

4 units of C every 40 minutes

This means that a sequence which mixes eight units of A, five of B and four of C, and repeats itself every 40 minutes, will produce the required output. There will be many different ways of sequencing the products to achieve this mix, for example:

BACABACABACABACAB . . . repeated . . . repeated

This sequence repeats itself every 40 minutes and produces the correct mix of products to satisfy the monthly requirements.

24 Calculation for Number of Kanbans

Kanban system attempts at continual reduction of inventory. The number of kanbans is calculated as follows:

$$N = (D)\ (L)\ (1+S)\ /\ C$$

Where;

N: Number of kanbans (or containers)

D: Demand units (average number over a given period of time)

L: Lead time (time to replenish an order, expressed in the same time unit as expressed in demand)

S: Safety stock (as a percentage of demand during lead time), based on service level and variance of demand during lead time

C: Container size

Container size should be kept much smaller (say 10 to 16%) than the average demand during the lead time, as this will force a continuous improvement process.

Illustration 2: A production manager is working in a cellular manufacturing system for an automobile parts. He has to process an average of 250 parts per hour in the cell. The capacity of each container is 30 parts and one kanban is attached to all the containers. The time to receive new parts from the previous work center is 25 minutes. Factory maintains a safety stock factor of 15%. Determine the kanbans needed for the plant.

Solution

Given:

D = 250 parts per hour

L = 25 minutes = 25/60 hours = 0.4167 hour

S = 0.15

C = 30 parts

Now, since number of Kanbans is

N = (D) (L) (1+ S) / C

= (250) (0.4167) (1+ 0.15) / 30 = 3.993 kanbans or container $\simeq$ 4 kanbans or containers

Thank You!

Assist. Prof. Dr. Mahmoud Abbas Mahmoud