A Level Product Design

Production Systems

Scale of Production

The selection of materials and components is determined by the manufacturing processes involved and the scale of production. However, in an attempt to reduce manufacturing costs and overall costs, products often have to be made in large quantities. The manufacture of any product will fall into one of three categories: one-off, batch or high volume.

One-off manufacture is seen in bespoke or commissioned work, such as jewellery, furniture or shop interiors. Despite their size, the Millennium Dome and a football stadium are both examples of one off design and manufacture. One-off items cost more since a premium has to be paid for the unique features and work involved in both the design and manufacturing elements.

Batch production involves the manufacture of identical components or products in specified, pre-determined 'batches' varying in size from tens up to thousands. If more products are needed after manufacture has stopped, it can be restarted and another batch produced. Tooling, machinery and the workforce are kept as flexible as possible, and careful tool and machinery management are essential. Complicated software programs are used to ensure that schedules and deadlines are adhered to.

High volume production (mass production) has long production runs. It requires high tooling and investment costs are expensive machinery. Mass production quite often runs non stop, 24 hours a day, seven days a week. Despite the high costs involved initially, unit costs are often very low, with very little input from skilled operators.

In both batch and high volume production, bulk buying allows materials, components and sub assemblies to be purchased more cheaply. This reduced the overall cost of the products. Greater use is also made of ICT in the planning of production. This will be used for the drawing up of schedules, quality control, and the making sure that materials and other components are ordered and delivered on time, JIT (just in time)

One-off: Custom - built kitchen	**Batch: Olympic medals**	**High volume: Garden table / chairs**
• Made to measure	• Same mould used, limited production	• Large market
• Choice of materials	• Identical quality	• Bulk buying
• Choice of finishes	• Reduced production costs	• Quality control
• Individual design	• Limited market	• Economies of scale
• Unique	• Increased production rates	• Rapid production levels
• High quality	• Same mould / different materials	• Standardised components
• High Cost - very skilled labour		• Cheaper to produce
• Time consuming		• Less skilled labour
• Slow production		• Greater level of production planning required
• Need to use standard components to reduce costs		• JIT stock control

Recent developments in production systems

Mass production companies are looking to develop more flexible systems based on batch production principle. Companies are under pressure to change production techniques to give a greater variety of products and the move to wards products that are 'customised' to meet the demands of particular market sector. Car manufacturers are under pressure to reduce the costs of cars but at the same time offer a greater range of options as 'standard' rather than 'optional extras'. Car manufacturers need flexible production systems to allow the car to be 'made to order'. Cars that are sitting in a stock compound waiting to be purchased are a costly overhead and a drain on the company's profits. **Flexible Manufacturing Systems (FMS)** are also employed when the scale of production cannot justify a fully automated production line or where there is a need to have a 'quick response' system.

Product Data management (PDM)

Product data management (PDM) is a complete (holistic) data management system that aims to integrate all aspects of manufacturing from product modeling to the management of the business processes. On line ordering tracking is an example of the potential power of PDM because of the advances in Information and communications technology (ICT), particularly in the area of **telematics**. This technology will allow a product to be managed electronically from receipt of the customer order. The product will be tracked from development into manufacturing, on through delivery to after sales support via real-time feedback from telematic reporting systems.

Production data from a manufacturing plant or a volume production line can be simultaneously merged with other data such as product demand and financial figures. This means that raw materials and components for the production line are bought in as required. As a result, financial efficiency improves as the size of the stock inventory and its storage space reduces. Reduced business overheads equals increased profitability. This type of approach is known as 'Just In Time' (JIT).

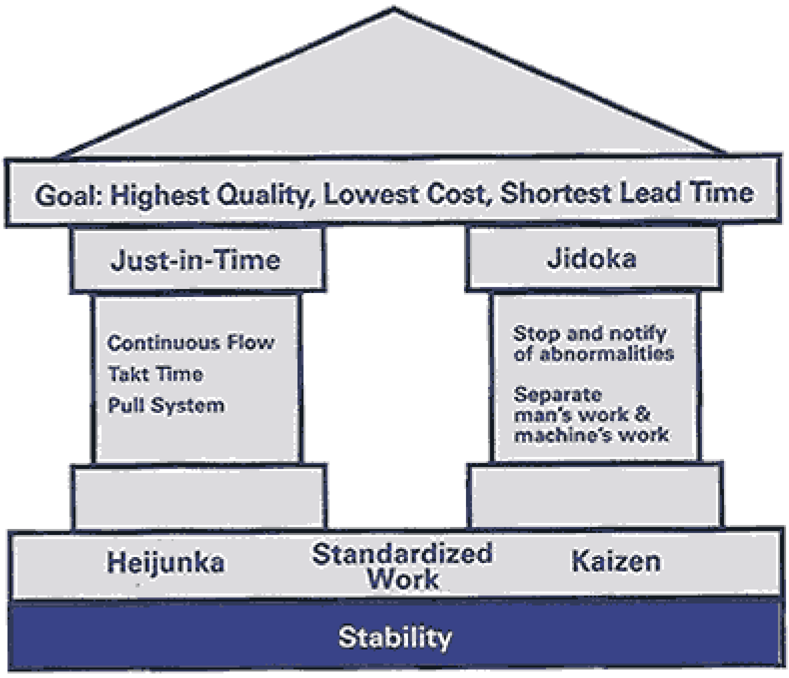
JUST-IN-TIME (JIT) PRODUCTION

Introduction

Just-in-time (JIT) is a management philosophy that strives to eliminate sources of manufacturing waste by producing the right part in the right place at the right time. Waste results from any activity that adds cost without adding value, such as moving and storing. JIT (also known as lean production or stockless production) should improve profits and return on investment by reducing inventory levels (increasing the inventory turnover rate), reducing variability, improving product quality, reducing production and delivery lead times, and reducing other costs (such as those associated with machine setup and equipment breakdown). In a JIT system, underutilized (excess) capacity is used instead of buffer inventories to hedge against problems that may arise.

JIT applies primarily to repetitive manufacturing processes in which the same products and components are produced over and over again. The general idea is to establish flow processes (even when the facility uses a jobbing or batch process layout) by linking work centers so that there is an even, balanced flow of materials throughout the entire production process, similar to that found in an assembly line. To accomplish this, an attempt is made to reach the goals of driving all queues toward zero and achieving the ideal lot size of one unit.

The basic elements of JIT were developed by Toyota in the 1950's, and became known as the Toyota Production System (TPS). JIT was firmly in place in numerous Japanese plants by the early 1970's. JIT began to be adopted in the U.S. in the 1980's.



Toyota Production System "House"

Some Key Elements of JIT

1. Stabilize and level the MPS with uniform plant loading (*heijunka* in Japanese): create a uniform load on all work centers through constant daily production (establish freeze windows to prevent changes in the production plan for some period of time) and mixed model assembly (produce roughly the same mix of products each day, using a repeating sequence if several products are produced on the same line). Meet demand fluctuations through end item inventory rather than through fluctuations in production level. Use of a stable production schedule also permits the use of backflushing to manage inventory: an end item's bill of materials is periodically exploded to calculate the usage quantities of the various components that were used to make the item, eliminating the need to collect detailed usage information on the shop floor.

2. Reduce or eliminate setup times: aim for single digit setup times (less than 10 minutes) or "one touch" setup. This can be done through better planning, process redesign, and product redesign

3. Reduce lot sizes (manufacturing and purchase): reducing setup times allows economical production of smaller lots; close cooperation with suppliers is necessary to achieve reductions in order lot sizes for purchased items, since this will require more frequent deliveries.

4. Reduce lead times (production and delivery): production lead times can be reduced by moving work stations closer together, applying group technology and cellular manufacturing concepts, reducing queue length (reducing the number of jobs waiting to be processed at a given machine), and improving the coordination and cooperation between successive processes; delivery lead times can be reduced through close cooperation with suppliers, possibly by inducing suppliers to locate closer to the factory, as Toyota has done in Japan and Honda has done in Ohio.

5. Preventive maintenance: use machine and worker idle time to maintain equipment and prevent breakdowns.

6. Flexible work force: workers should be trained to operate several machines, to perform maintenance tasks, and to perform quality inspections. In general, JIT requires teams of competent, empowered employees who have more responsibility for their own work. The Toyota Production System concept of “respect for people” contributes to a good relationship between workers and management.

7. Require supplier quality assurance and implement a zero defects quality program: errors leading to defective items must be eliminated, since there are no buffers of excess parts. A quality at the source (jidoka) program must be implemented to give workers the personal responsibility for the quality of the work they do, and the authority to stop production when something goes wrong. Techniques such as "JIT lights" (to indicate line slowdowns or stoppages) and "tally boards" (to record and analyze causes of production stoppages and slowdowns to facilitate correcting them later) may be used.

8. Small lot (single unit) conveyance: use a control system such as a kanban (card) system (or other signaling system) to convey parts between work stations in small quantities (ideally, one unit at a time). In its largest sense, JIT is not the same thing as a kanban system, and a kanban system is not required to implement JIT (some companies have instituted a JIT program along with a MRP system), although JIT is required to implement a kanban system and the two concepts are frequently equated with one another.

Kanban Production Control System

A kanban is a card that is attached to a storage and transport container. It identifies the part number and container capacity, along with other information. There are two main types of kanban (some other variations are also used):

1. ***Production Kanban (P-kanban):*** signals the need to produce more parts

2. ***Conveyance Kanban (C-kanban):*** signals the need to deliver more parts to the next work center (also called a "move kanban" or a "withdrawal kanban")

A kanban system is a pull system, in which the kanban is used to pull parts to the next production stage when they are needed; a MRP system (or any schedule based system) is a push system, in which a detailed production schedule for each part is used to push parts to the next production stage when scheduled. The weakness of a push system (MRP) is that customer demand must be forecast and production lead times must be estimated. Bad guesses (forecasts or estimates) result in excess inventory, and the longer the lead time, the more room for error. The weakness of a pull system (kanban) is that following the JIT production philosophy is essential, especially concerning the elements of short setup times and small lot sizes.

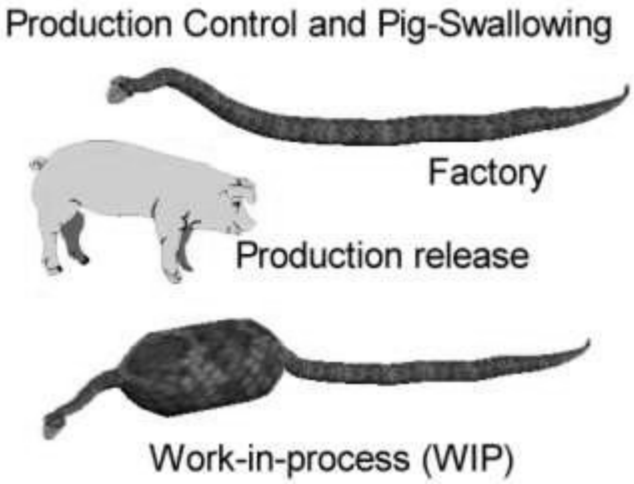
Productivity Improvement With Kanban:

1. deliberately remove buffer inventory (and/or workers) by removing kanban from the system

2. observe and record problems (accidents, machine breakdowns, defective products or materials, production process out of control)

3. take corrective action to eliminate the cause of the problems

OK, you've swallowed the pig; now what do you do with it?" This is a common problem in push production systems.
Constrictor snakes such as the one shown at the right are designed to process meals in the indicated manner, and they often sleep for several months while they digest their meals. This is not how we want a factory to operate; pig-swallowing should be left to systems that are designed to handle it.
Standard, Charles, and Davis, Dale. 1999. *Running Today's Factory: A Proven Strategy for Lean Manufacturing*. Cincinnati, OH, Hanser Gardner Publications (1999, 111-112) uses the phrase "pig in a python" to describe large inventory bubbles that move through a factory. "If smaller orders are released more often, the factory resources are loaded much more easily. …This is analogous to the python swallowing dozens of little piglets instead of one large pig. …Surprisingly, many factories prefer to 'stretch the python' so it can swallow an even larger hog!" The reference mentions an explorer who saw an anaconda swallow an adult hog in a Peruvian rain forest. (Dale Davis studied anthropology and specialized in Maya culture.)
However, Levinson (editor), *Leading the Way to Competitive Excellence* (1998, ASQ Quality Press) coined the phrase "pig-swallowing," and even included an actual photo of a recently-fed python from The Serpent's Den in Milford, PA.

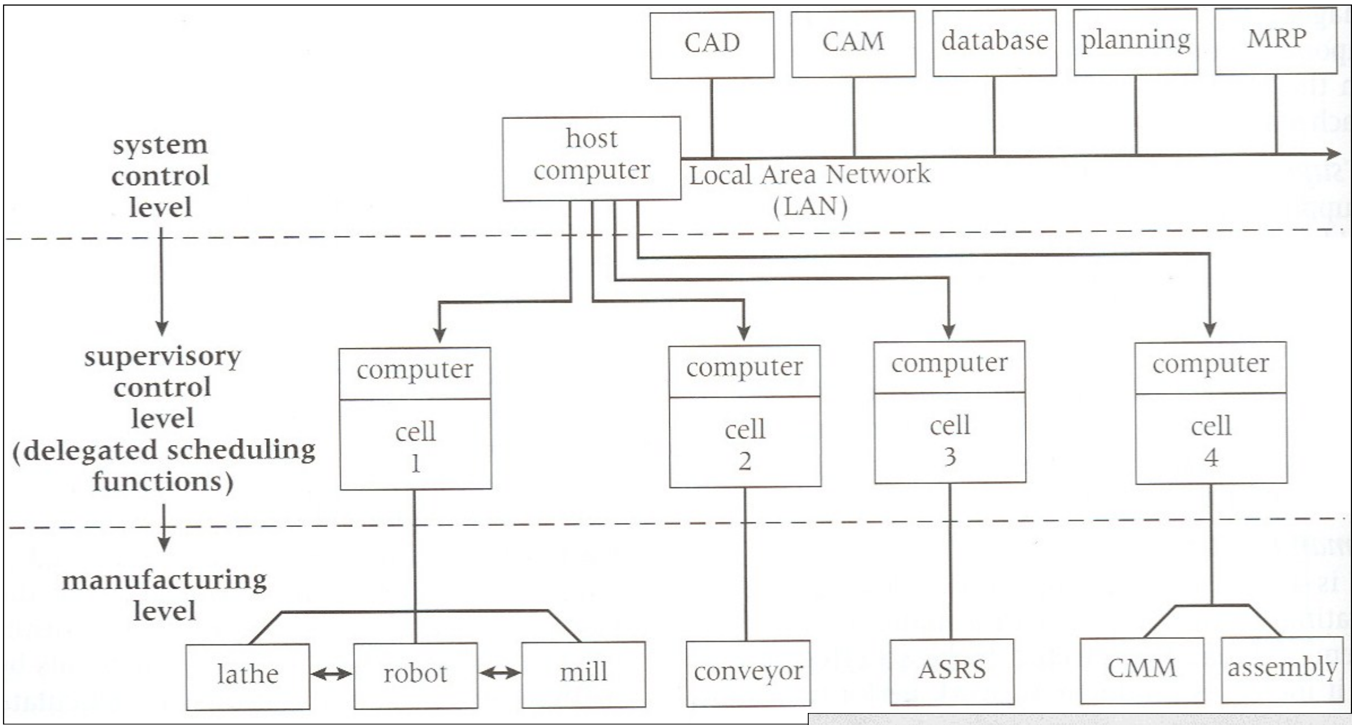


Computer Integrated Manufacturing (CIM)

To achieve full CIM all aspects of a company's operations must be integrated so that they can share the same information and communicate with one another. A CIM system uses computers to integrate the processing of production and business information with manufacturing operations in order to create cooperative and smoothly running production lines. The tasks performed within CIM will include:

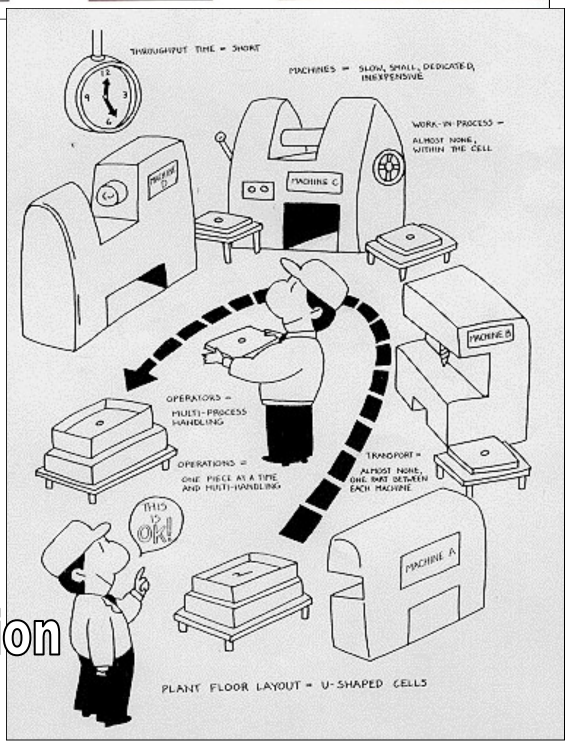
- The design of components
- Planning of the most effective production sequences and workflow
- Controlling the operation of machines
- Performing business functions such as ordering of stock and materials and customer invoicing.

On automated production lines computers will control the methods for transferring materials and components to the required points on the assembly lines, the numerically controlled machines (NC) or the robots used for fabricating or assembling components and inspection and quality systems. The various computers and microprocessors automate the processes of monitoring and provide information (feedback) to a 'host' computer that informs operators about the state of the system. The diagram below shows a typical



Process based or product based manufacturing cells

In all modular or cell manufacturing systems—sometimes referred to as group technology - machinery is organised so that related products can be manufactured or processed in a continuous flow. In modular layout, computers play an important role in controlling equipment, materials and work flow. The product flows smoothly from start to finish, parts do not sit waiting to be worked on and do not travel long distances from one part of the factory to the another. This can be contrasted to a typical production system, where machines are grouped by their function, for instance a 'bank' of milling machines or lathes, and products move from one end of a manufacturing facility to another and back again. This results in long waiting times between procedures.



Flow production