Elements of Lean Manufacturing

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- Once the ideas behind the Lean Manufacturing have been explained it is time to go through the practical elements:
    - Batch reduction (from EoQ to Batch=1)
    - Total quality control
    - JIT: pull system

- The guidelines given by another important author, **R.J. Schonberger** with his book **“Japanese Manufacturing techniques”** , issued in **1982** so much earlier than “The machine that changed the world” was published, will be used as reference for the matter.

Economic order quantity

- **Economic order quantity** is a metric that represents the ideal order size to minimize costs for the business. Economic order quantity is a useful formula for businesses of all sizes and types that order and hold inventory.
- The formula to optimize the ordering quantity and the **batch dimension after a setup is the same**

- It can be done per annual cost or per unit cost
- The annual cost of setup depend on the number of setup

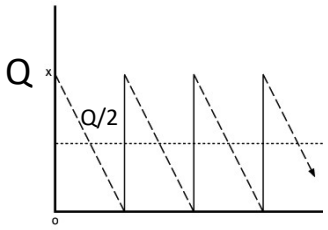
ACs= Cs*ns=AD/q

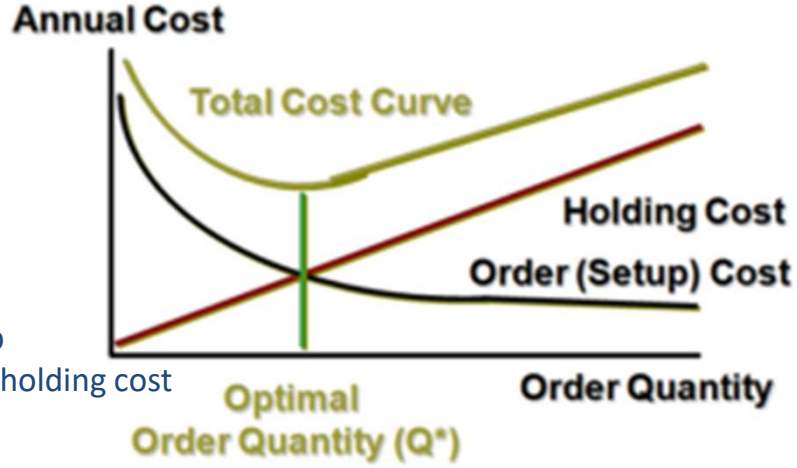
ACh= Ch*q/2 see aside

The optimal condition is where:

Cs *AD/Q= Ch*Q/2

$$Q=\sqrt{\frac{Cs*AD*2}{Ch}}$$





ACs= annual cost of setup
Cs= per unit cost of one setup
Ach, Ch= annual and per unit holding cost
Q= quantity of order or batch
AD= annual demand

Batch=1

- **Batch=1 is a way to say that the setup cost is not influent**.
    - For machining means that the necessary tools, fixtures and part program are always available.
    - For assembly that the necessary programs, tools and components are available line side.
    - For complex machines and stamping that: $\boldsymbol{Cs \leq Ch/(AD * 2)}$
- Batch=1 automatically means to produce according to the final mix target and consiquently with the minimum inter-operational stock.
- The biggest problem for European status is the assembly not so much for the tools or part programs **but for the materials at the line side.**
- Because of the high level of diversity, drawback of low level of standardization, limited volumes and the distance with the suppliers, the internal logistic problems is the major challenge at this moment for the Batch=1 especially for the European market. NA and SA have lower brand diversification and competition. An attempt has been done to create some logistic “consolidation centers” around the plant to minimize the dimension of packages but it is a cost. The future evolution is open to be assessed with the new electrified scenario of demand.

Total quality control – Responsibility and objectives

Responsibility

- The theory of Total Quality Control has a western origin and was developed by Edwards Deming and Joseph Juran, two American engineer and professors,.
- While in US and Europe only some aspects of the statistical control found full development, in Japan the full theory was used to support the rising needs I term of quality.
- The first essential concept is that the quality control is a **duty of the production itself** and cannot be delegated to some other organization as was happening in most of the post-war companies.
- Gradually, this has meant to delegate the responsibility of the quality control down to the worker level.

Objectives

- The objective that the Total quality propose is to reach **the perfection** through an inclination or better **a tension toward the continuous improvement**

Total quality control- Basic principles

- **Process control** for every single operation done by the workers
- **Quality easy-to-see** so the test results that show the production/quality progress must be easily understandable from big boards taken from the ones used in the basket matches >>Visual factory
- **Rigorous respect of specifications**
- **Stop of the line – This is fundamental –** the priority is to solve the quality issues to not repeat other scraps using sometimes automatic checks or “poka yoke” to detect it immediately.
- **Self repairing** – Again is more important the awareness and the cause analysis that the productivity so the worker who creates or detects a failure has to work to solve the issue and avoid the proliferation.
- **!00% control.** This seems a contradiction since the Deming’s theory is based on statistical control: the problem that the template require a control per batch and an accepted level of defect that are two bad words for the Japanese approach that require a modification of the SQC.
- **Improvement by project** so not individual activities but an organic and structured strategy

This principles **must be supported**, as we said, by **small batches**, **cleanness and order** on the work-place and in the machinery, planning for **less than full saturation, daily check of the machines.**

Push and pull systems

- The Supply chain systems, supported by a computer, were developed and applied universally starting from 1960 under the name of MRP (Material requirement planning).
- The MRP fulfil the following task:
    - The definition of requirement net of existing stock
    - The lead time to launch production order
    - The needs in term of components and raw parts based on production orders and Bill of material.
- The MRP's major defect was the planning at infinite capacity and not review in case of demand change. The MRP 2 included a capacity planning and a scheduling module to solve the first issue.
- They were called **Push system** since all the material supply was based on the plan.
- The stock was taken into account only at the end of the period. It could increase out of control in case of lower demand. This was considered a waste by Japanese industries that proposed a **Pull system,** since the production orders were launched on the base of the customer demand and not by a plan.

Just in Time

- It has been said that Total Quality Control (TQC) and Just in Time (JiT) are embedded methodologies since one cannot subsists without the other and now, we understand why.
- To create a Pull system, the first condition is to have a complete control on the production progress. This is ensured by small batches and low level of stock. In fact, per the Little's law:

$$\boldsymbol{Lead\ time = Work\ in\ progress * Throughput}$$

- So, in case of a high level of work in progress (e.g. great batches) the lead time becomes long and the delivery time cannot be ensured.
- How to arrange production orders without a plan?
- The legend tells that in the rising period, Japanese companies has not the resources to buy big computers and they found a simple system to build the supply chain system of a JiT organization.
- It was the Kanban system, based on two concepts:
    - For each line/department, the materials are joint with a card (Kanban) that is created in a limited number and is freed when the product is delivered to the customer, enabling a new supply from the supplier(s).
    - Every line/department creates a link with the suppliers to have a new material (batch) in a predefined time.