INTRODUCTION TO CAM

Definition

What is CAM?

The effective utilization of computers in manufacturing.

Direct application - device monitoring and control, NC, PLC, manufacturing cell.

Indirect applications - manufacturing support - planning, MRP, process planning, scheduling, inventory, shop floor control.

THE HISTORY OF CAM

1950's	NC hardwired relay control
	APT language for NC
1960's	Industrial robot
	Interactive computer graphics
1970's	CNC computer
	DNC/FMS
	CAD/CAM
	PLC device & cell control
	Computer vision
	3-D CAD
1980's	Solid modeling
	Factory networking
	MAP/TOP
	CIM
	Concurrent engineering
1990's	Intelligent Mfg System

THE HISTORY OF MANUFACTURING

Milestones	
skeleton	Hand tools - thousands of yrs. to several thousands of yrs.
muscle	Machine tools - industrial revolution , 18th century, custom made products
smartness	Gauges - late 19th century interchangeability
resource mgmt.	Mfg. Systems - early 20th century Modern mgmt. Transfer line
nerve	NC, robot - 50, 60, 70's, FMS
brain	Intelligent mfg.

INVENTIONS IN MANUFACTURING

1750	Screw-driven lathe
1751	Slide lathe - 1st metal lathe
1770	Screw-cutting lathe
1775	Boring mill
1813	Interchangeability of parts
	Simon North horse pistols
1817	Planing machine
1845	Turret lathe
1847	Milling machine - Brown & Sharpe
	making twist - drill helical grooves
1946	ENIAC - computer

THE TREND OF MANUFACTURING INDUSTRY

Facts:

1. Rapid changing market place
2. Fast development of new technologies

   Vacuum Tubes ->: Transistor -> IC -> VLSI

   Wiring -> thru-hole PCB -> Surface Mount Component

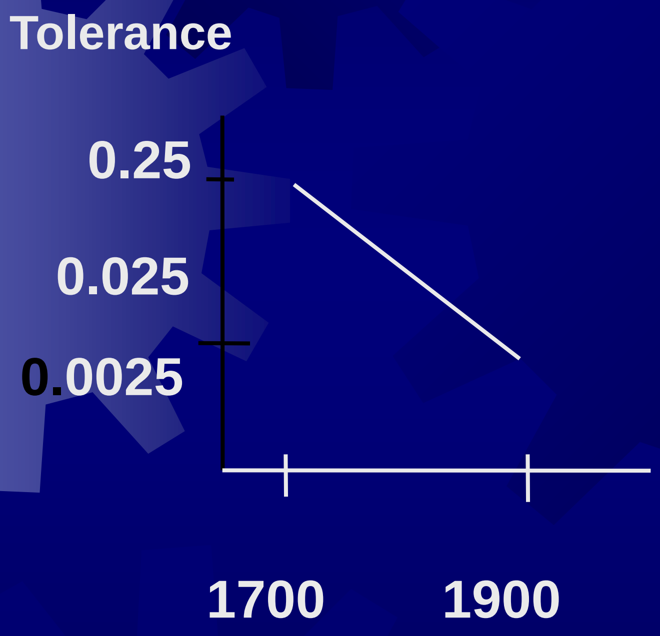
   Quality product -> precision engineering -> nano-engineering
3. Fierce competition

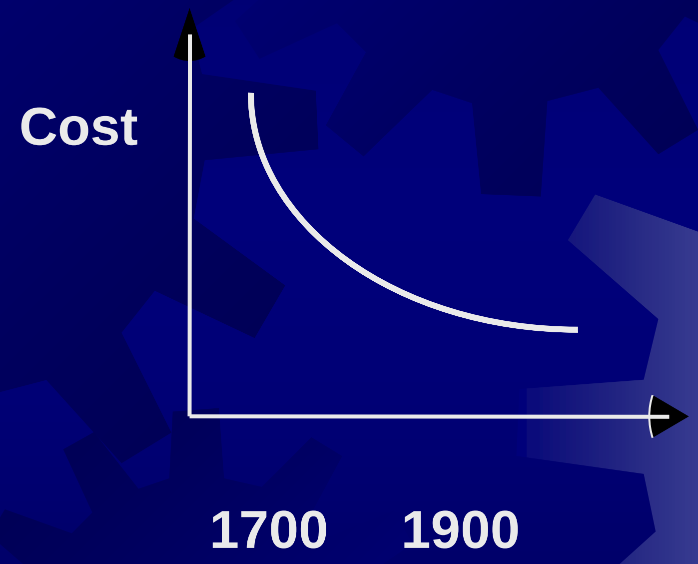
   Failing automotive industry, steel mills, Wang Lab, ...
4. A "use brain" generation, not willing to learn the trade which requires hand skill.

To survive:

1. Lower cost
2. Higher quality
3. Lower product development cycle

TOLERANCE AND COST REQUIREMENTS IN PRODUCTION





SOLUTIONS DEVELOPED

1. Small batch production 95% in lot size of 50 or less.
2. Just in time production, reduce inventory (union?)
3. Automation - quality, labor cost

   Automated lathe, screw machine (Swiss machine), transfer line
4. Flexible automation - further reduce lead time, automation of small batch

   (NC, FMS, FMC, Robotics, ...)
5. Integration - CAM, CIM, concurrent engineering, TQM, etc.

BENEFITS OF CAM

90% Inventory reduction

50% more efficient use of factory & warehouse space

75% reduction in machine setup time - item setup (re-measurement, repositioning, and replacement of cutting tools,..)

Does not change product specific set-up.

25% reduction in direct and indirect labor

90% reduction in lead time

PROBLEMS AND STATISTICS

According to a study by Kelley, M.R., Brooks, H., The State of Computerized Automation in US Manufacturing, J.F. Kennedy School of Government, Harvard University, Oct, 1988.

11% of machine tools are programmable type in US

40% (estimated) in Japan

50% (estimated) in Germany

More than half (53%) of the metal-working plants in US do not have even one computer-controlled machine.

Less than 5% use NC have FMS.

To implement, need not only technology but also organizational changes. Larger plants have better chance.

Too small a batch size is cited by 3/5 of all non-adopters as the reason of not implementing computerized automation.

ADDITIONAL COSTS OF USING CAM VS MANUAL OPERATION

- Programming
- Special tooling design and manufacturing
- Program proof out, 1st good part is a dream, not a reality.
- Maintenance - more sophisticated system.

CURRENT PROBLEMS

1. Manufacturing not emphasized enough
2. Designer tend to design for functionality alone
3. Manufacturing engineers lack overall concept in manufacturing
4. Systems are not integrated.

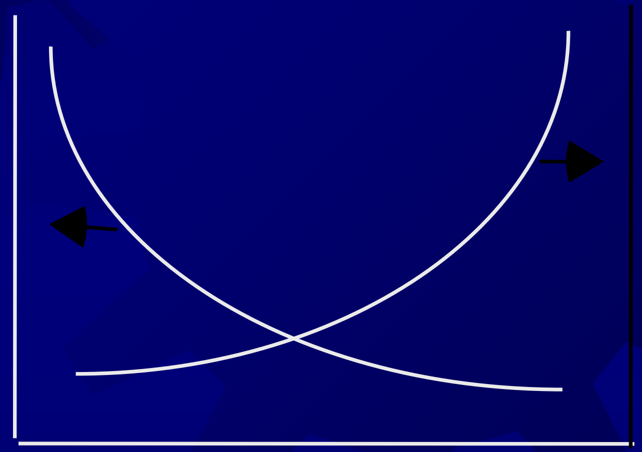
CONCURRENT ENGINEERING (SIMULTANEOUS ENGINEERING)

Design product and process simultaneously.

"Do not focus on only one aspect of the product realization process."

EFFECT OF TOLERANCE

Mfg cost



Quality opportunity cost

Tolerance value

FUTURE

Alvin Toffler, Power Shift, 1990

(two other books by him: The Future Shock, 1970

The Third Wave, 1980)

Sources of power:

Force

Money

Knowledge

From information to knowledge.

THREE LEVELS OF COMPUTERIZATION

- Data processing
- Information processing
- Knowledge processing

BASIC TAXONOMY OF MANUFACTURING

1. Discrete vs. Continuous Mfg

    Discrete - finite number of discrete steps

        parts & product separable entities

        TV, car,.....

    Continuous - continuous process

    We deal with discrete mfg. in this class.

DESIGN FOR MANUFACTURING

Designing products for the ease of manufacturing.

- **general guidlines** — **use std components (parts)**; **use work mtl. shape to design**

Some approaches:

- parameterized product model
  gear,......

- restrictive CAD system, force designers to use certain design features which are proven easy to mfg.

- mfg. evolution during the design stage

MATERIAL PROCESSING

Machining:

- Turning
- Drilling
- Reaming
- Boring
- Tapping
- Milling
- Grinding
- Broaching
- Planing
- Shaping
- Sawing
- EDM/ECM
- Laser

MATERIAL HANDLING

Mtl transportation - longer distance between cells

Mtl handling - short distance within cell

MATERIALS PLANNING

- mtl type
- mtl shape
- mtl preprocessing methods

eg. shape:
stock, casting,....

MATERIALS SELECTION COST MODEL

Other than the strength consideration the cost is another major one

$$NC_1 + N\sum_I C_I V_I = C_M + N\sum_I C_I V_I' + NC_1'$$

N: batch size

C_1: cost for preparing one workpiece from stock

C_i: cost of m/c a unit volume by process i

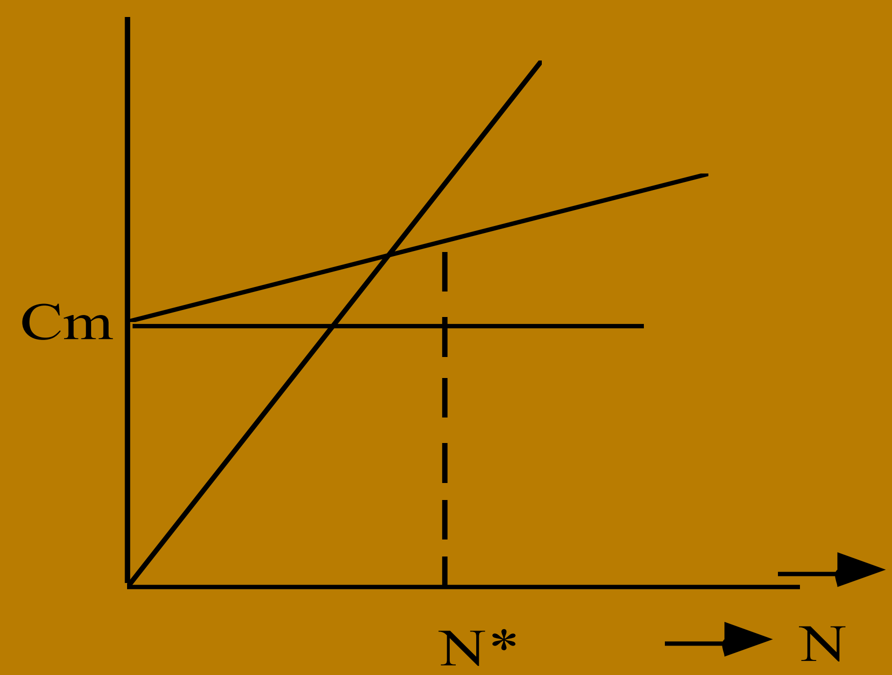
V_i: volume being machined by process i from the casting

C_m: cost of mold

V_i': volume being machined by process i from the casting

C_1': incremental cost of making one casting

BREAK-EVEN POINT



LAYOUT FOR DISCRETE PARTS PRODUCTION

Layout affects the production efficiency

Automation

1. Process layout - individual m/c, NC.....
2. Product layout - transfer line technology
3. Group layout - FMS, FMC

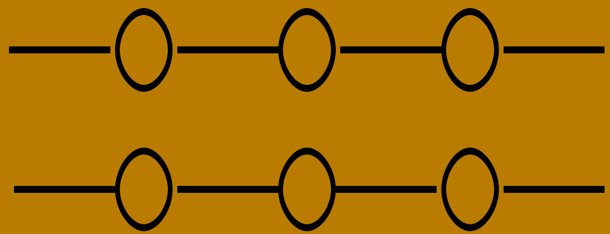
PROCESS LAYOUT (functional layout)

Job Shop

Milling	Lathe
Drilling	Grinding

- transportation problem
  random route
- scheduling problem
  complex flow
- most flexible, no new
  layout for new prod.
- for batch production

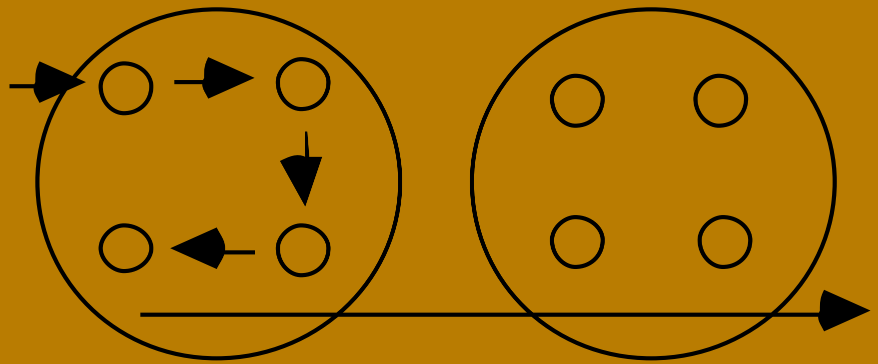
PRODUCT LAYOUT (flow layout)



Production Line

- may need redundant m/c's
- simple scheduling, easy to automate the mtl transportation function
- less flexible
- for mass production

GROUP LAYOUT (cellular layout)



- combination of 1 & 2
- trade-off interdepartment mtl handling w/ intra-department M.H.

Each cell produces one or a few families of parts.

MANUFACTURING SYSTEM CONTROL