Manufacturing

Transformation of materials and information into goods for the satisfaction of human needs

Big Picture?

History

1. Greek “manu factus”: made by hand
2. Early mode: piece by piece by skilled artisan
3. In 1750 - 1800: Industrial revolution
   - Early machine tool
   - Concept of factory
4. 1800’s Process specialization
   - Division of labor
   - Eli Whitney, etc., Interchangeable parts
5. Early 1900: Optimization (Manufacturing systems)
   - F.W. Taylor
   - Economy of scale
   - Cost reduction for high volume production
   - Henry Ford’s Model T
6. 1950’s: Numerical control (Information technology)
   - Automation
   - Lean manufacturing, JIT
   - 6 sigma, ppm

Post-Industrial-Revolution History of Manufacturing Technologies

- The Industrial Revolution (1770-1830): Introduction of steam power to replace waterpower and animal-muscle power.
- Decline in yearly hours worked per person: From 3000 hours to 1500 hours in Europe and to 1600 hours in North America.
- Increase in labor productivity.
- Increase in GDP per worker: 7 fold in U.S.A., 10 fold in Germany, and 20 fold in Japan.
Automotive Manufacturing Industry

- The Ford Motor Co. has been the most studied and documented car manufacturing enterprise.
- The 1909 Model T car was easy to operate and maintain.
- By 1920, Ford was building half the cars in the world (more than 500K per year).

Manufacturing Industry

- $4 Trillion, shipments, 1997
  - 1997 Economic Census, U.S. Census Bureau
  - Whole Sale $4 T, Retail $2.5 T
- 459 SIC industries (NAICS)
  
  http://libraries.mit.edu/subjects/course.html

US Gross State Product, 1992

Gross State Product

1992 Economic Census Coverage by Sector

Big Picture

- Information Technology (digital)
- Globalization
- New Manufacturing Technology
- New Materials
Key Issues

- Engineering disciplines
  - Materials
  - Manufacturing processes
  - Manufacturing equipment
  - Design for manufacturing (DFM)
- Management disciplines
  - Work force
  - Societal obligation
  - For-profit organization
  - 2.96
- Integration
  - Manufacturing systems

Processes of 2.008

- Metal components
  - Removal
  - Squeezing
  - Melting
- Plastic components
  - Injection molding
  - Thermo forming
- Joining processes
  - Welding
  - Soldering/brazing
  - Gluing
- Silicon
  - Deposition
  - Etching
  - CVD, PVD
  - Wet, dry

Manufacturing Attributes for Decision Making

- Cost
- Rate
- Quality
- Flexibility

Material removal – the oldest

- Cost:
  - Expensive $100 - $10,000
- Quality:
  - Very high
- Flexibility:
  - Any shape under the sun
- Rate:
  - Slow

Metal squeezing

- Cost:
  - Cheap, $0.1 - $100
- Quality:
  - reasonable
- Flexibility:
  - Shapes limited constant cross-section
- Rate:
  - Fast (cycle time in sec), high volume

Melting

- Cost:
  - Expensive $100 - $10,000
- Quality:
  - Requires post finishing
  - Die casting
- Flexibility:
  - Very flexible, good for large parts
- Rate:
  - Very slow
**Plastics processing**
- **Cost:** Expensive mold and die, over $10,000
- **Quality:** Very high
- **Flexibility:** Opening for ejection
- **Rate:** Very fast

**Joining**
- **Cost:** Cheap, but expensive labor
- **Quality:** Wide range
- **Flexibility:** Manual vs automated
- **Rate:** Slow in general

**Thinfilm fabrication**
- **Cost:** Very expensive $Millions
- **Quality:** Very high
- **Flexibility:** Any shape in 2-D
- **Rate:** Slow

**Typical Cost Breakdown**

**Performance Measures**
- Capital cost
- Production rate or capacity
- Cycle time
- Lead time
- Machine utilization
- Work-in-process
- On-time deliveries