ME477: Manufacturing Processes

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Introduction

• Manufacturing?
  – Making goods and articles
  – Shaping and treating materials to perform desirable functions
• Manufacturing Processes
  – Casting
  – Powder Processing
  – Forming
  – Machining
  – Surface processing
  – Joining
• To make goods and articles - A sequence of processes must be chosen, based on shape, material, tolerance and cost
• Before MFG, a Make or Buy decision
  – Process Design
  – Production Systems

Manufacturing as a set of processes

A set of Processes

Power Management Facility Machine Labor

Raw Materials Concurrent or Simultaneous Engineering Part Waste

Manufacturing

• Manufacturing: 20% of U.S. GNP
• Service sector: 70% of U.S. GNP (retail, transportation, banking, education, communication, insurance and government).
• Agriculture, Construction etc.: 10% of U.S. GNP
• Manufacture comes from the Latin words manus (hand) and factus (make).
• Definition: the application of physical and chemical processes to alter the geometries, properties and appearance of a starting material in order to make and assemble it into a product.

Manufacturing Processes

Casting Process
- Ingot Casting
- Crystal Growing
- Sand Casting
- Shell Molding
- Sucker Molding
- Investment Casting
- Evaporative Casting
- Die Casting
- Centrifugal Casting
- Squeeze Casting
- Rheocasting

Powder Processing
- Pressing
- Hot Isostatic Pressing
- Cold Isostatic Pressing
- Pressureless Sintering

Deformation Processing
- Open Die Forming
- Impression Die Forming
- Closed Die Forming
- Rolling
- Extrusion
- Deep Drawing
- Swaging
- Bending
- Stretch Forming
- Bulging
- Beading, Flanging
- Hammering & Snaping
- Explosive forming
- Electrohydraulic forming
- Magnetic pulse forming
- Superplastic forming

Machining
- Turning
- Boring
- Facing
- Forming
- Drilling
- Milling
- Threading
- Broaching
- Sawing, Filing
- Grinding
- Honing
- Lapping
- Ultrasonic Machining
- Buffing
- Polishing
- Chemical Machining
- Electrochemical Machining
- Laser Machining
- Plasma Arc Cutting
- Electron Beam Machining

More Manufacturing Processes

Polymer Processing
- Extrusion
- Blow Molding
- Injection Molding
- Reaction Injection Molding
- Transfer Molding
- Casting
- Thermforming
- Rotational Molding
- Solid State Molding

Composite Processing
- Polymer Matrix Composite
- Reinforced Polymer
- Ceramic Matrix Composite
- Metal Matrix Composite
- Graphite Matrix Composite
- Ceramicmatrix Composite
- Reinforced Metal Matrix Composite
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- Metal Matrix Composite
- Graphite Matrix Composite
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- Reinforced Metal Matrix Composite
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Microelectronic Processing
- Crystal Growth
- Czochralski growth
- Float Zone Crystal Growth
- Wafer Processing
- Silicing, Etching, Polishing
- Surface Processing
- Oxidation
- Lithography
- Wet Etching
- Dry Etching
- Packaging
Historical Note

- Powder processing (Clay) (4000BC)
- Casting - Lost Wax…Centrifugal casting (2500BC- 1850)
- The First Industrial Revolution (1760-1830)
  - Adam Smith (1723-1790) - division of labor
  - James Watt – Steam Engine
  - John Wilkinson – Machine tools
  - Eli Whitney (1797) – Interchangeable parts
- Henry Ford (1913) – Assembly line
- The Second Industrial Revolution (1950-)
  - Invention and Use of computers
  - Microchips

The importance of manufacturing

Underestimated in the development of civilization.
- Cultures with better manufacturing capabilities were more successful.
- Better tools, better crafts & weapons
  - Damascus and Samurai Swords
  - Shaving blade
  - Turbine blade
    - Making Superalloys
    - Cooled blade - Small holes to cool off
    - Directionally solidified
- To a significant degree, the history of civilization is the history of humans’ ability to make things

Manufacturing Industries

- Industry consists of enterprises and organizations that produce or supply goods and services
  - Primary – Agriculture, Forestry, Mining, Fishing
  - Secondary – Aerospace, Automotive, Electronics etc.
  - Tertiary – service sectors such as Banking, Education, Government
- Consumer goods and Capital goods
- Discrete vs. Continuous production
- Production quantity and variety

Materials in Manufacturing

- Metals
  - Ferrous – steels and cast iron (¾ of metals used)
  - Nonferrous – aluminum, titanium, nickel…
- Ceramics
  - A compounds of metallic (semi-metallic) and nonmetallic
- Polymers
  - Thermoplastic
  - Thermosetting
  - Elastomers
- Composites – Matrix & Second phases
- Thermomechanical Behavior
  - Elastic, plastic, fatigue, thermal
  - Electrical, Magnetic, Optical, Chemical

Production and Energy

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<th>Energy Consumption (MJ/kg)</th>
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Geometric Attributes (Shape)

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<th>1 Change at one end</th>
<th>2 Change at two ends</th>
<th>3 Spatial Curve</th>
<th>4 Change at center</th>
<th>5 Closed One End</th>
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Tolerance and Surface Roughness
Scope and Purpose

- Processing
  - Nature of process, Process variety
  - Physical Principal
- Standard
  - American National Standard Institute (ANSI)
  - American Society for Testing and Materials (ASTM)
  - American Society of Mechanical Engineers (ASME)
  - American Society of Precision Engineering (ASPE)
- Society
  - ASME, Society of Manufacturing Engineers (SME), ASPE
- Units – SI (and English Unit)

Solidification Processes

- Starting material is heated sufficiently to transform it into a liquid or highly plastic state
- Examples: Casting for metals, molding for plastics

Deformation Processing

- Starting workpart is shaped by application of forces that exceed the yield strength of the material
- Examples: (a) forging, (b) extrusion and etc.

Particulate Processing

- (1) Starting materials: powders of metals or ceramics
- (2) Pressing
- (3) Sintering,

Material Removal Processes

- Excess material removed from the starting workpiece so what remains is the desired geometry
- Examples: machining such as (a) turning, (b) drilling, and (c) milling; also grinding and nontraditional processes
Alternative Processes
Design: Geometry, Material, Surface finish, Tolerance

- Casting or PM
- Forging
- Extrusion
- Machining
- Joining

Other Processing Operation

- Property Enhancing Processes
  - Heat Treatment: Improve physical properties of the material without changing its shape
  - Alloying:
  - Composites
- Surface Processing – cleaning, surface treatment and coating deposition

Example (from Ashby & Jones)

- Turbine blade
  - High Temperature Alloy
  - Directional Solidification
  - Cooling – making holes on High Temperature Alloys

Manufacturing Capability

- Technical process capability
  - A capable set of manufacturing processes
- Physical product limitation
  - Size and weight limitation
- Production capacity
  - An important influence on the way its people, facilities, and procedures are organized

Production Systems

- Production facilities
  - Low-quantity Production (1~100 units/year) – job shop, prototyping
  - Medium-quantity Production (100~10,000 units/year)
    - Batch production and cellular manufacturing
  - High-quantity Production (10,000~millions of units/year) – mass production
  - Two categories of mass production:
    1. Quantity production - Mass production of single parts on single machine or small numbers of machines
    2. Flow line production - Multiple machines or workstations arranged in sequence, e.g., production line

Manufacturing Support Systems

- A company must organize itself
  - To design the processes and equipment,
  - To plan and control the production orders, and
  - To satisfy product quality requirements
- Manufacturing support systems to manages its production operations
  - Manufacturing Engineering – planning mfg processes
  - Production planning and control – logistics problems in manufacturing
  - Quality control