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VOLUME

7

Powder Metal Technologies and Applications

ASM INTERNATIONAL®

MECHANICAL ALLOYING FOR FABRICATION OF ADVANCED ENGINEERING MATERIALS

by

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MECHANICAL ALLOYING

NANOTECHNOLOGY, MATERIALS SCIENCE AND POWDER METALLURGY

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Introduction

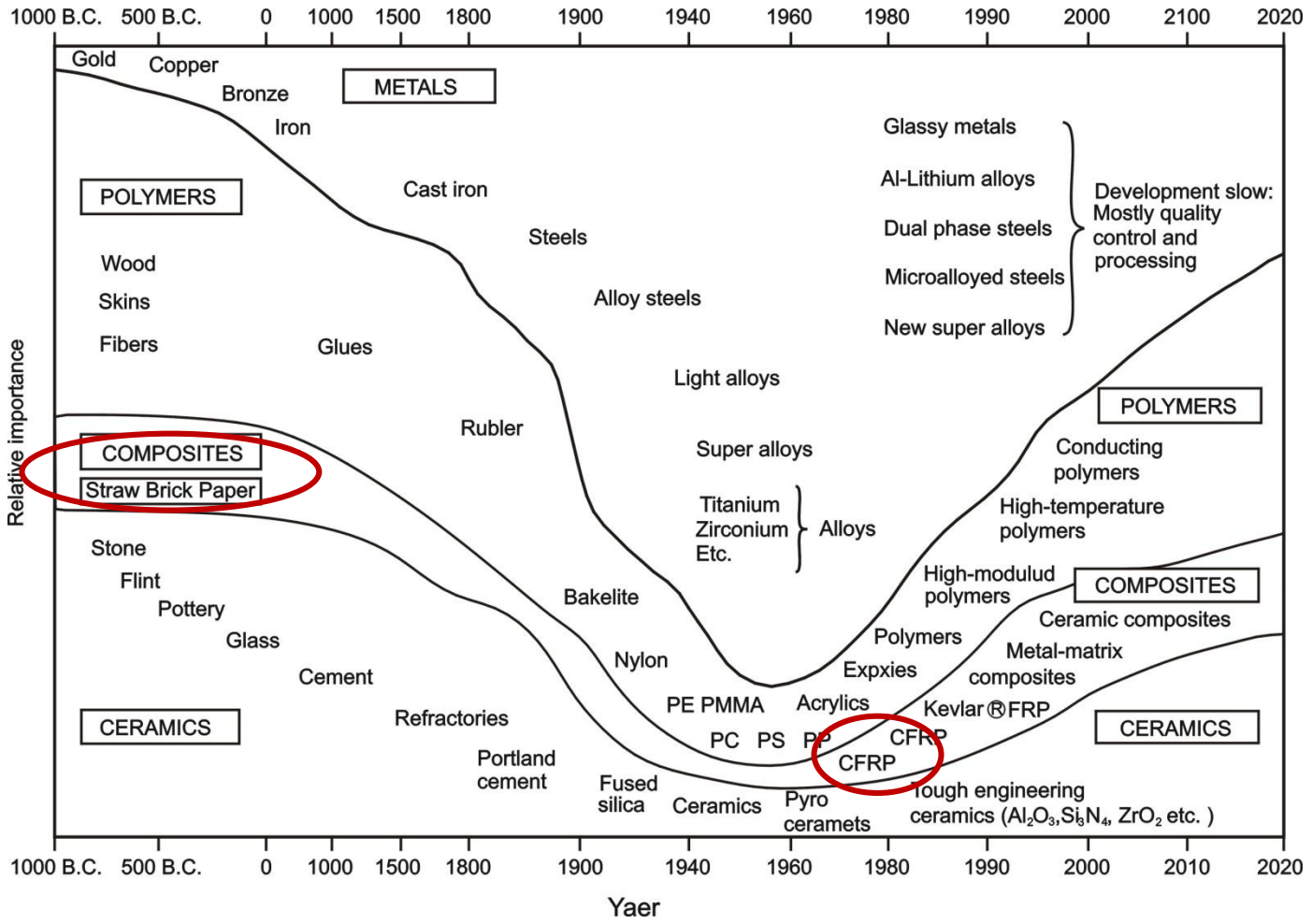


Fig.1. The relative importance of metals, polymers, composites and ceramics as a function of time.

Powder Metallurgy

- First used in 1900s to produce tungsten filaments for light bulbs.
- Net-Shape forming.
- Typical Products:
  - Gears, cams
  - Filters, Self-lubricant oil bearings

Table 1 Major historical developments in powder metallurgy

Date	Development	Origin
3000 B.C.	"Sponge iron" for making tools	Egypt, Africa, India
1200 A.D.	Cementing platinum grains	South America (Incas)
1781	Fusible platinum-arsenic alloy	France, Germany
1790	Production of platinum-arsenic chemical vessels commercially	France
1822	Platinum powder formed into solid ingot	France
1826	High-temperature sintering of platinum powder compacts on a commercial basis	Russia
1829	Wollaston method of producing compact platinum from platinum sponge (basis of modern P/M technique)	England
1830	Sintering compacts of various metals	Europe
1859	Platinum fusion process	
1870	Patent for bearing materials made from metal powders (forerunner of self-lubricating bearings)	United States
1878-1900	Incandescent lamp filaments	United States
1915-1930	Cemented carbides	Germany
Early 1900's	Composite metals	United States
	Porous metals and metallic filters	United States
1920's	Self-lubricating bearings (used commercially)	United States
1940's	Iron powder technology	Central Europe
1950's and 1960's	P/M wrought and dispersion-strengthened products, including P/M forgings	United States
1970's	Hot isostatic pressing, P/M tool steels, and superplastic superalloys	United States
1980's	Rapid solidification and injection molding technology	United States

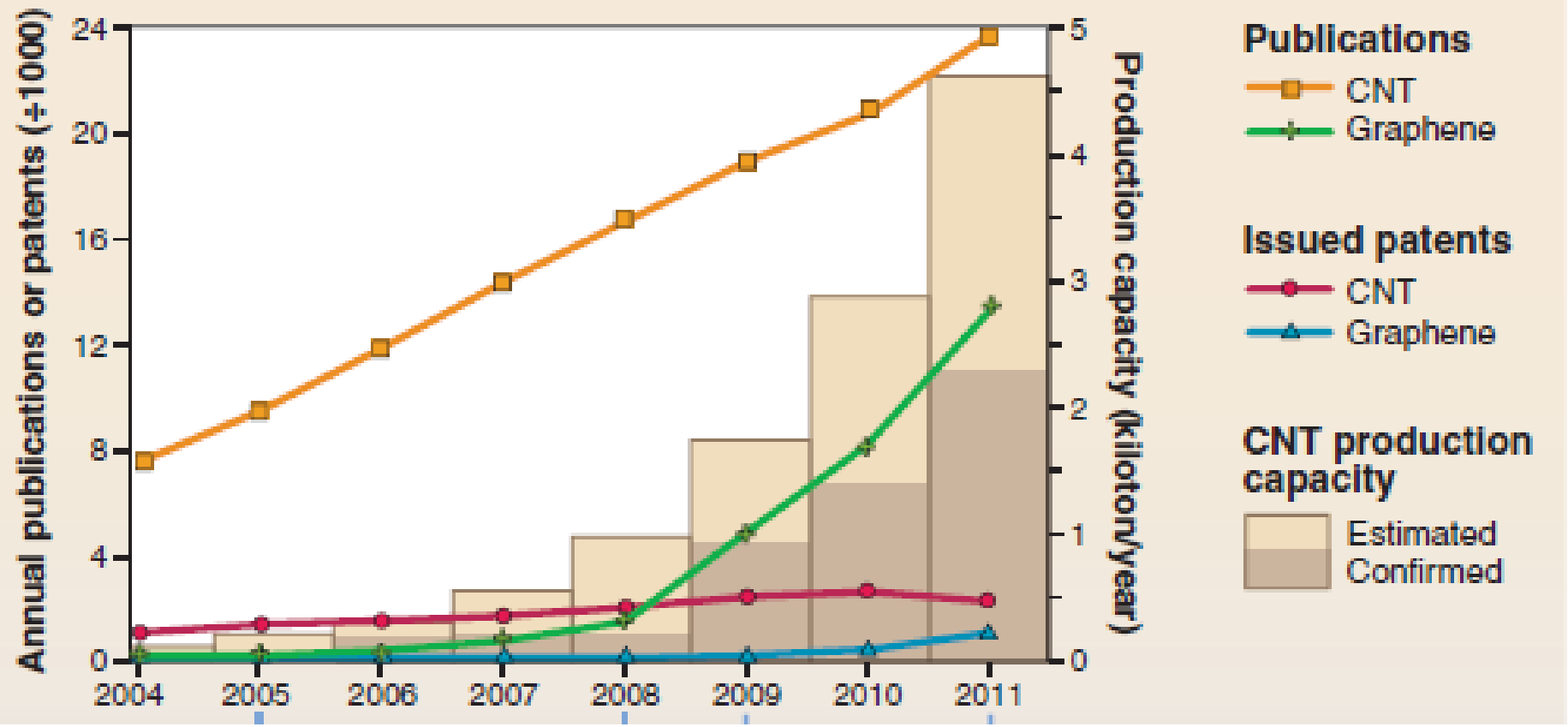
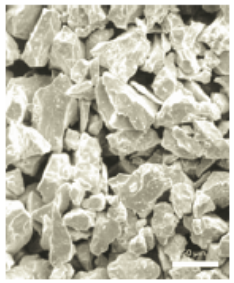
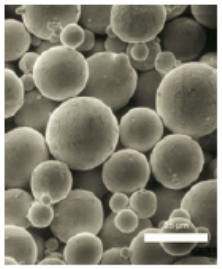
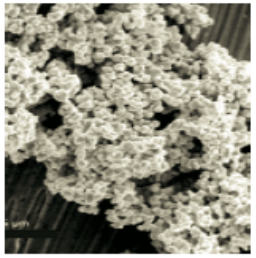


Fig. Number of publications on different metal matrix-CNT composites and production capacity

Powder Metallurgy Technology

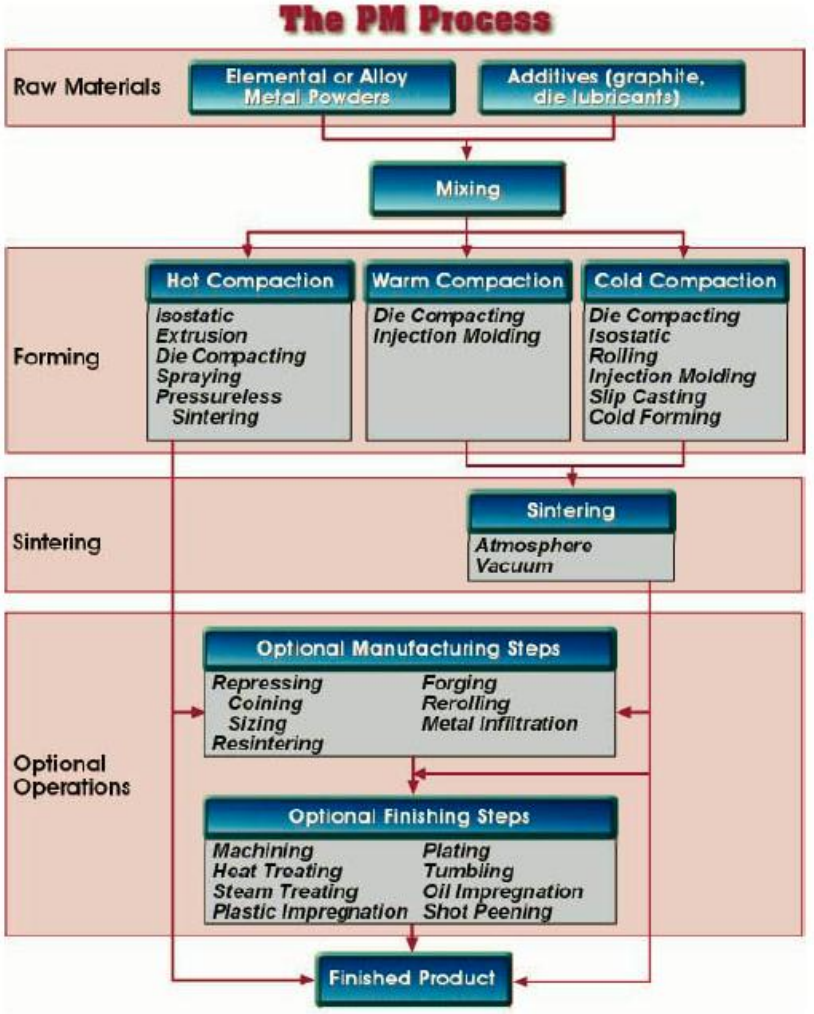
- General Classification
  - Powder Technology
  - Powder Processing
- Powder technology
  - It involves all processing operations to prepare the particles in the 100 μm range for subsequent shaping and consolidation processes.
    - Powder fabrication
      - Mechanical
      - Atomization
      - Electrolysis
      - Chemical synthesis
    - Particle classification
    - Particle handling, modification and mixing

  - Particle characterization and microstructure control are essential components of powder technology

Powder Metallurgy Technology (cont.)

- Powder Processing
  - It involves all operations to consolidate the particles to the final product
    - Shaping and compaction
    - Sintering
    - Densification
    - Finishing operations
      - Machining
      - Heat treatment
      - Joining
      - Coating
  - Selection of processing methods depends on desired properties of final product.



Why Powder metallurgy?

It the only near net-shape manufacturing technology capable of fabricating parts for all types of materials

- Metals and intermetallics
- Ceramics
- Engineered materials: Composites and porous materials

- Advantages
  - Achieves a wide variety of alloy systems
  - Facilitates manufacture of complex or unique shapes which would be impractical or impossible with other metalworking processes
  - Maintains close dimensional tolerances
  - Produces good surface finishes and eliminates or minimizes machining
  - Provides controlled porosity for self-lubrication or filtration applications
  - Suited to moderate-to-high volume component productions requirements

Powder Metallurgy (P/M)

- Competitive with processes such as casting, forging, and machining.
- Used when
  - **melting point is too high (W, Mo).**
  - **reaction occurs at melting (Zr).**
  - **too hard to machine.**
  - **very large quantity.**
- Near 70% of the P/M part production is for automotive applications.
- Good dimensional accuracy.
- Controllable porosity.
- Size range from tiny balls for ball-point pens to parts weighting 100 lb. Most are around 5 lb.

Application for Gear Boxes

source: Sinterstahl GmbH, Füssen

Fraunhofer Institut Produktionstechnologie

WZL RWTH AACHEN

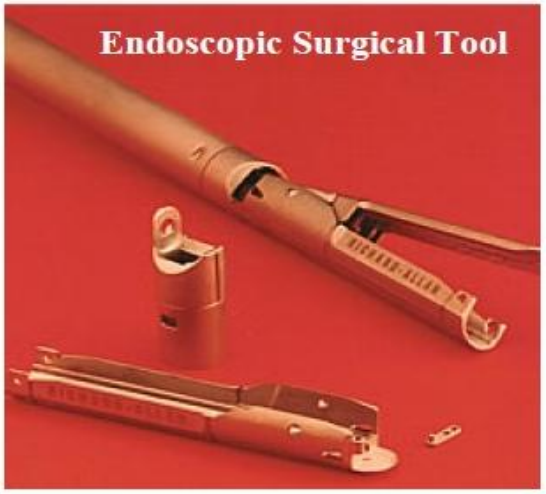
Applications in Automotive Engines

source: Sinterstahl GmbH, Füssen

Example Applications

➢ Automotive

➢ Biomedical components



PM Products

Basics of P/M

- Highly developed method of manufacturing precision metal parts
- Made by mixing elemental or alloy powders then compacting the mixture in a die. The resulting shape is sintered in an atmosphere controlled furnace to convert mechanical bonds into metallurgical bonds.
- Basically a ”chip-less” process, P/M uses roughly 97% of the starting material in the finished part.

Advantages of P/M

-Versatile in numerous industries.

-Eliminates or minimizes machining.

-Minimizes scrap.

-Maintain close dimensional tolerance.

-Permits a wide variety of alloy systems.

-Facilitates manufacturing of complex shapes.

-Provides excellent part to part repeatability.

-Cost effective.

-Energy and environmentally efficient.

- Limitations
  - Size and complexity limitations
  - High cost of powder metals compared to other raw materials
  - High cost of tooling and equipment for small production runs