



Powder Metallurgy Fact Sheet

A Growth Industry Vital to Many Products

Powder Metallurgy's Scientific and Industrial Importance:

- A cost-effective method of forming precision net-shape metal components that allows for more efficiently designed consumer and industrial products.
- The source of high performance and advanced particulate materials and alloys such as superalloys, tool steels, PM wrought aluminum alloys, dispersion strengthened metals, thermal spray materials, intermetallics and metal matrix composites.
- On the leading edge of new manufacturing processes for improved product quality and productivity.
- Saves valuable raw materials through recycling and elimination of costly secondary machining through net and near-net shape design.
- Improves industrial productivity by eliminating manufacturing steps and provides automation, precision and special properties such as self-lubrication and controlled filtration.
- Only way of forming vital metals such as tungsten carbide, dispersion-strengthened materials, high speed tool steels, superalloys and self-lubricating bearings.
- Saves natural resources through recycling and conservation of critical raw materials.
- Strategically important to products such as automobile engines and transmissions, aircraft turbine engines, riding lawn mowers, surgical instruments, power tools, oil/gas well drilling equipment and off-road tractors.

History:

Powder metallurgy was practiced long before ancient artisans learned to melt and cast iron. Egyptians made iron tools using PM techniques from at least 3000 B.C. Ancient Inca Indians made jewelry and artifacts from precious metal powders. The first modern PM product was the tungsten filament for electric light bulbs developed in the early 1900s. This was followed by tungsten carbide cutting tool materials in the 1930s, automobile parts in the '60s and '70s, aircraft turbine engine parts in the '80s and parts made by powder forging (P/F), metal injection molding (MIM), warm compacting in the '90s, and nanotechnology in the new decade.

Industry:

The PM parts and products industry in North America has estimated sales of \$5 billion. It is comprised of companies that make conventional PM parts and products from iron and copper-base-powders; and companies that make specialty PM

products such as superalloys, porous products, friction materials, strip for electronic applications, high strength permanent magnets, magnetic powder cores and ferrites, tungsten carbide cutting tools and wear parts, metal injection molded parts and tool steels. PM is international in scope with growing industries in all of the major industrialized countries. Annual worldwide metal powder production exceeds 700,000 tons.

Raw Materials:

The most common metals available in powder form are iron and steel, tin, nickel, copper, aluminum and titanium, as well as refractory metals such as tungsten, molybdenum and tantalum. Alloys such as bronze, brass, stainless steel and nickel cobalt superalloys are also available in powder form.

Powder particles are specific in shape and size ranging from 0.1 to 1,000 micrometers. Particles are similar in size to the diameter of a human hair (25 to 200 micrometers). They are not merely ground-chips or scraps of metal. Major methods for making metal powders are atomization of molten metal, reduction of oxides, electrolysis and chemical reduction.

North American Metal Powder Shipments

	2009	2010
Iron & Steel	244,839	353,121
Stainless Steel	4,500 (E)	6,700 (E)
Copper & Copper Base	13,239	18,000 (E)
Aluminum	55,000 (E)	55,000 (E)
Molybdenum	2,000 (E)	2,000 (E)
Tungsten	4,000 (E)	4,500 (E)
Tungsten Carbide	5,900 (E)	6,000 (E)
Nickel	4,500 (E)	5,000 (E)
Tin	543	700 (E)
(E) estimate	334,521	451,021
	short tons	short tons

Trends and New Developments:

- Improved manufacturing processes such as hot isostatic pressing (HIPing), PM forging, metal injection molding (MIM), and direct powder rolling through increased scientific investigation of PM technology by government, academic and industrial R&D programs.
- Fully dense PM products for improved strength properties and quality in automobiles, diesel and turbine engines, aircraft parts and industrial cutting and forming tools.
- Commercialization of technologies such as metal injection

molding (MIM), rapid solidification, PM forging, spray forming, high temperature vacuum sintering, warm compacting and both cold and hot isostatic pressing.

- The use of PM hot forged connecting rods in automobiles and a PM camshaft for automobile engines. The use of PM composite camshafts in auto engines and main bearing caps, and stainless steel ABS sensor rings and exhaust system flanges.
- New submicron and nanophase powders for cutting tools and other specialized applications.

Applications:

PM parts are used in a variety of end products such as lock hardware, garden tractors, snowmobiles, automobile engines and transmissions, auto brake and steering systems, washing machines, power tools and hardware, sporting arms, copiers and postage meters, off-road equipment, hunting knives, hydraulic assemblies, x-ray shielding, oil and gas drilling well-head components, fishing rods and wrist watches. Canadian nickels are made from strip rolled from pure nickel powder.

The typical U.S. passenger car contains about 41 pounds of PM parts. More than 650 million PM hot forged connecting rods have been made for cars produced in the U.S., Europe and Japan.

Commercial aircraft engines contain 1,500-4,400 pounds of PM superalloy extruded forgings per engine.

Iron powder is used as a carrier for toner in electrostatic copying machines. Americans consume more than two million pounds of iron powder annually in iron enriched cereals and bread. Iron powder is also used in hand warmers and water-proof cements.

Copper powder is used in anti-fouling paints for boat hulls and in metallic pigmented inks for packaging and printing.

Aluminum powder is used in solid fuels for rockets such as the booster rockets for the space shuttle program.

Process:

The basic PM process uses pressure and heat to form precision metal parts and shapes. Powder is squeezed (at room temperature) automatically in a rigid precision die at up to 50 tons per square inch into an engineered shape like a gear. Think of 50 compact cars stacked vertically and you have the pressure it takes to press the powder automatically in a mechanical or hydraulic compacting press. After the mass of powder is squeezed into a shape and ejected from the press, it is fed slowly through a special high-temperature controlled atmosphere furnace to bond the particles together. They are metallurgically fused without melting, a phenomenon called "sintering".

Other processes are also used to consolidate powders into finished shapes such as cold or hot isostatic pressing, direct powder rolling, forging, injection molding and gravity sintering.

In contrast to other metal forming techniques, PM parts are shaped directly from powders while castings are formed from metal that must be melted, and wrought parts are shaped by deformation of hot or cold metal, or by machining.



Metal Powder Industries Federation (MPIF):

Founded in 1944, MPIF is the trade association for the international metal powder producing and consuming industries. Members make metal powders, advanced particulate materials, process equipment and PM parts and products.

MPIF is comprised of the following PM trade associations:

- Powder Metallurgy Parts Association
- Metal Powder Producers Association
- Powder Metallurgy Equipment Association
- Metal Injection Molding Association
- Refractory Metals Association
- Isostatic Pressing Association



APMI International:

APMI International is a worldwide technical society for individuals working in, or interested in developments related to, PM technology.

Both are headquartered at 105 College Road East, Princeton, New Jersey 08540-6692; (609) 452-7700; Fax (609) 987-8523.

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