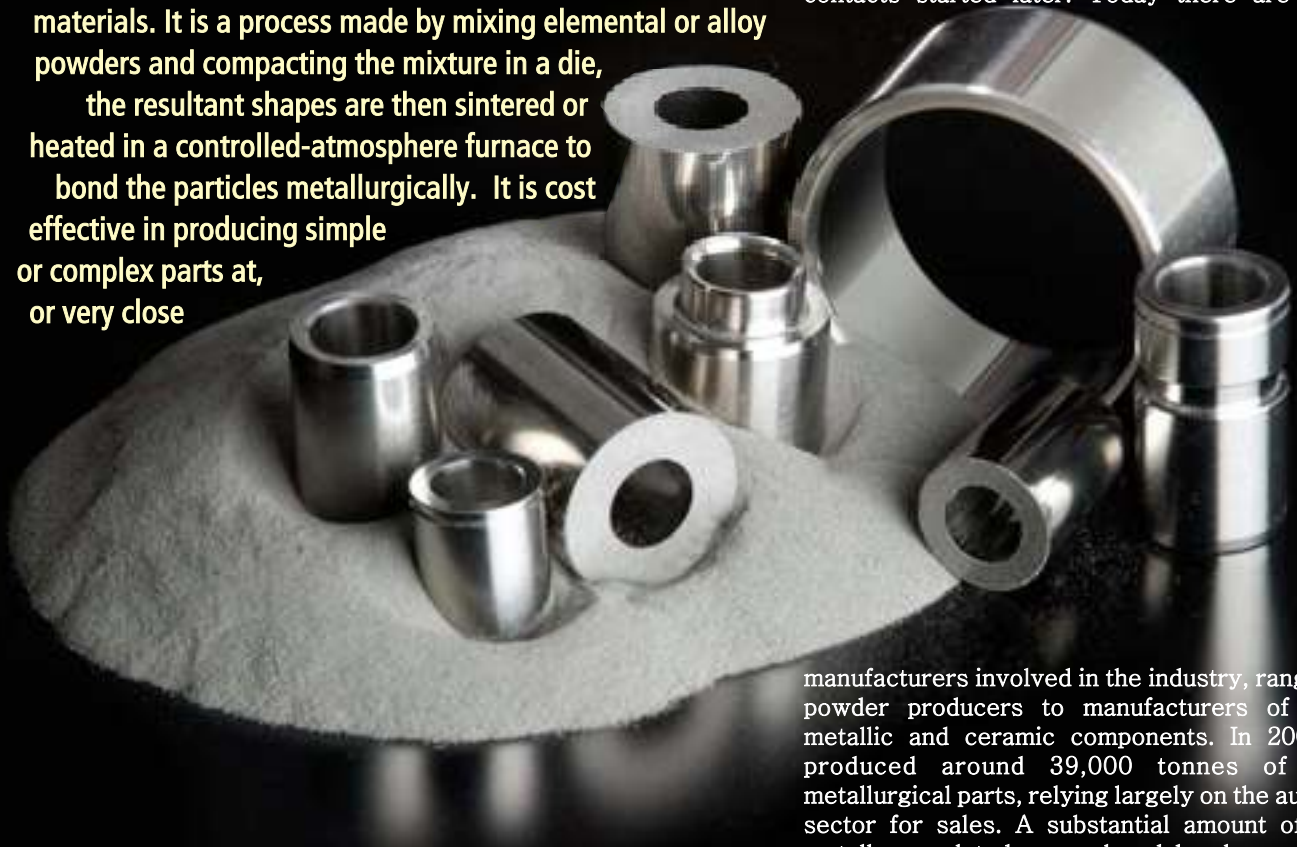
Powder Metallurgy

Growing in Tune with Consumer Demand

- Metalworld Research Team

Evolved in 1950, Powder Metallurgy (PM) is a highly developed method of manufacturing reliable ferrous and nonferrous parts which uses more than 97% of starting raw material in the finished part, thus, reducing the material wastage alongwith conservation of energy and raw materials. It is a process made by mixing elemental or alloy powders and compacting the mixture in a die, the resultant shapes are then sintered or heated in a controlled-atmosphere furnace to bond the particles metallurgically. It is cost effective in producing simple or complex parts at, or very close to, final dimensions in production rates which can range from a few hundred to several thousand parts per hour. As a result, only minor, if any, machining is required. PM parts also may be sized for closer dimensional control and /or coined for both higher density and strength. Most PM parts weigh less than 5 pounds (2.27 kg), although parts weighing as much as 35 pounds (15.89 kg) can be fabricated in conventional PM equipment. Many of the early PM parts , such as bushings and bearings, were very simple shapes, as contrasted with the complex contours and multiple levels which are often produced economically today.



Humble Beginning

The concept of PM began in 1950 with the production of porous component. Following the successful establishment of porous powder metallurgy components, the production of hardmetal and high speed steel tools coupled with electrical contacts started later. Today there are over 70 manufacturers involved in the industry, ranging from powder producers to manufacturers of sintered metallic and ceramic components. In 2009, India produced around 39,000 tonnes of powder metallurgical parts, relying largely on the automotive sector for sales. A substantial amount of powder metallurgy related research and development work is today carried out in more than 15 national institutes and laboratories. The production steadily grew to around around 48000 tonnes in 2012. The PM industry, whether it be structural PM parts, carbide tools, sintered magnets or self lubricating bearings, is heavily reliant on the automotive sector. Globally, around 80% of all structural PM parts manufactured are used in vehicle production and it is clear that the state of the automotive industry significantly affects the development of the PM industry.

The history of powder metallurgy and the art of metals and ceramics sintering are intimately related. Sintering involves the production of a hard solid metal or ceramic piece from a starting powder. While a crude form of iron PM existed in Egypt as early as

PM PARTS PRODUCTION IN INDIA (TONNES)*		
Year	Iron Base	Copper Base
2005	8000	2000
2006	21000	7000
2007	22000	9000
2008	26500	12000
2009	27000	12050
2010	28000	12500
2011	28500	13200
2012	30000	13800

** Approximate Tonnage*

MARKETS OF PM PARTS IN INDIA	
Sector	Share (%)
Automotive	77
Electrical machines	15
Industrial machines	6
Others	2

3000 B.C, and the ancient Incas made jewellery and other artifacts from precious metal powders, mass manufacturing of PM products did not begin until the mid-or late- 19th century. In these early manufacturing operations, iron was extracted by hand from metal sponge following reduction and was then reintroduced as a powder for final melting or sintering.

In PM or ceramics it is possible to fabricate components which otherwise would decompose or disintegrate. All considerations of solid-liquid phase changes can be ignored, so powder processes are more flexible than casting, extrusion, or forging techniques. Controllable characteristics of products prepared using various powder technologies include mechanical, magnetic, and other unconventional properties of such materials as porous solids, aggregates, and intermetallic compounds. Competitive characteristics of manufacturing processing (e.g., tool wear, complexity, or vendor options) also may be closely regulated.

PM products are today used in a wide range of industries, from automotive and aerospace applications to power tools and household appliances. Each year the international PM awards highlight the developing capabilities of the technology. According to data published by the Asian Powder Metallurgy Association (APMA), the Indian PM industry is no different, with around 77% of all structural parts destined for this sector. India is currently the seventh largest vehicle manufacturer in the world and is expected to rise to be the fourth largest by 2014. Annual domestic motor vehicle sales (Apr '09 – Mar '10) were 12.29 million, including passenger vehicles (1.95 million), commercial vehicles (0.53 million), two-wheelers (9.37 million) and three-wheelers (0.44 million). Currently, a four wheeler made in India uses 5- 6 kg of PM parts, while two and three wheelers use around 150g per vehicle. Despite the global recession, the Indian

automotive industry achieved growth of 12.88% in 2009, in strong contrast to North America and Europe where sales slumped. This, it can be suggested, reflects the shift in the importance of automotive markets towards China and India.

A wide range of PM parts are today produced in India, including the following automotive parts: bushes and bearings, engine mounting bearing caps, fuel injection components, rotors and gears for oil pumps, shock absorber components, sprockets, synchroniser hubs, thrust plates, timing pulleys and valve train components.

Steady Growth of the Industry

PM was grown in five stages in India. Stage one was the first use of PM technology for the production of low to medium strength parts by small presses for non-automotive applications. Stage two began when PM components found applications in the automotive sector, but with a low penetration of less than 1kg per car. Stage three was the participation of Suzuki and Isuzu in India, when usage of PM grew to around 5 kg of PM parts per vehicle, used in engine and transmission applications. This stage was concurrent with the start of Höganäs India in 1987 to support local developments. The introduction of light commercial vehicles by Tata and Hyundai constituted the fourth stage, with increasing use of PM parts. PM is now in the fifth stage of development in India.

There are two main factors for the inadequate spread of PM within India. First and foremost is the lack of awareness amongst OEM's regarding the capabilities of PM technology. The Indian PM trade association, Powder Metallurgical Association of India (PMAI), however is doing its best to rectify this with the organisation of conferences, seminars and courses aimed at potential end users. The second factor is that of the availability of some domestic raw materials and production equipment. There is, for example, no producer of tailor made powders for metal injection moulding (MIM) in India. There is also a need for powder forging capability to enable the production of high density high performance PM parts. It seems that part manufactures are reluctant to invest unless there is a demand, while OEM's require a ready to use product. Currently, there are a few gas and water atomisation plants producing stainless and alloy steels, for which there is limited local demand as they require higher sintering temperatures for processing. There is also production of spherical bronze and copper powders of sizes above 20 micrometers, however such powders are above the preferred size for MIM. A few manufacturers have, however, recently upgraded facilities and have started supplying stainless steel parts.

A rise to the next level of PM

technology, which would enable the production of around 12 kg of PM products per vehicle, requires a paradigm shift in technology possibly either through joint ventures or through participation of multinationals in Indian PM Industry. If this happens the market for PM components could soon be doubled to 45,000 tonnes per year.

Blending Process

PM is the process of blending fine powdered materials, pressing them into a desired shape (compacting), and then heating the compressed material in a controlled atmosphere to bond the material (sintering). The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending, compacting and sintering. Compacting is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducted at atmospheric pressure. Optional secondary processing often follows to obtain special properties or enhanced precision. Two main techniques used to form and consolidate the powder are sintering and metal injection molding. Recent developments have made it possible to use rapid manufacturing techniques which use the metal powder for the products. Because with this technique the powder is melted and not sintered, better mechanical strength can be accomplished.

Advantages of the P/M Process

- Eliminates or minimizes machining
- Eliminates or minimizes scrap losses
- Maintains close dimensional tolerances
- Permits a wide variety of alloy systems
- Produces good surface finishes
- Provides materials which may be heat-treated for increased strength or increased wear resistance
- Provides controlled porosity for self-lubrication or filtration
- Facilitates manufacture of complex or unique shapes which would be impractical or impossible with other metalworking processes
- Suited to moderate to high volume component production requirements
- Offers long-term performance reliability in critical applications
- Cost effectiveness

Growing Significance in Europe

PM is a continually and rapidly evolving technology embracing most metallic and alloy materials, and a wide variety of shapes. It is a highly developed method of manufacturing reliable ferrous and non ferrous parts. The European market alone has an annual turnover of over six billion Euros, with annual worldwide metal powder production exceeding one million tonnes. Created by mixing elemental or alloy powders and compacting the mixture in a die, the resultant shapes are then heated or "sintered" in a controlled atmosphere furnace to bond the particles metallurgically. The high precision forming capability of PM generates components with near net shape, intricate features and good dimensional precision pieces are often finished without the need of machining.

The PM process enables manufacturers to make products that are more consistent and predictable in their behaviour across a wide range of applications by producing parts with a homogeneous structure. In addition the PM process has a high degree of flexibility allowing the tailoring of the physical characteristics of a product to suit your specific property and performance requirements. The unique flexibility of the PM process enables products to be made from materials that are tailored to your specific needs. By using specially selected materials this capability enables refinements to be engineered into the mechanical properties of the part.

Conclusion

Adopted as the economical process of machine moulding and sintering, the PM has proved its economic viability over the last six decades. With attention being made to control costly material and energy wastage through technological advancement, PM is set to grow more rapidly than steadily in the future.

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