A Technology for Cost Effective & Non-porous Product Manufacturing

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A technology which involves spending considerable time and effort in converting the starting material to the required powder form and then even further time and effort in sticking the material back together again to produce a more or less solid object is known as powder metallurgy (PM). Now the question arises that if a solid metal is converted into powder for further processing it into the metallurgical component then, why use all these cumbersome technology when the same metallurgical components can be obtained directly. The question is valid for argument sake. But, its answer is not argumentative. While manufacturing metallurgical components, effort, cost and time make an integral part of the result. Any business makes sense only when that is appropriate for customers satisfaction, accuracy and profit making. PM is used only for the aforementioned three necessities. It (PM) is a term covering a wide range of ways in which materials or components are made from metal powders. PM processes can avoid, or greatly reduce, the need to use metal removal processes, thereby, drastically reducing yield losses in manufacture and often resulting in lower costs.

Evolving Technology

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 metals parts. 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 worldwide metal production is estimated at over one million tonnes of which India contributes 10-15 per cent. 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. These processes include: structural pieces with complex shapes, controlled porosity, controlled performance, good performance in stress and absorbing of vibrations, special properties such as hardness and wear resistance, great precision and good surface finish and last but not the least, large series of pieces with narrow tolerances. The unique flexibility of the PM process enables products to be made from materials that are tailored to your specific needs. This capability enables refinements to be engineered into the mechanical properties of the part by using specially selected materials.

Meanwhile, PM comprises a family of production technologies, which process a feedstock in powder form to manufacture components of various types. These production technologies generally involve a number of process steps.

Involvement of Processes

Powder Production

In this process, virtually all iron powders for PM structural part production are manufactured using either the sponge iron process or water atomisation. Non ferrous metal powders used for other PM applications can be produced via a number of methods.

Powders Mixing

Often mixing of powders can often involve the introduction of alloying additions in elemental powder form or the incorporation of a pressing lubricant.

Compact Mixed Powder

The dominant consolidation process of compact mixed powder involves pressing in a rigid toolset, comprising a die, punches and, possibly, mandrels or core rods. However, there are several other consolidation processes that are used in niche applications. Compact sintering to enhance integrity and strength : This process involves steps heating of the material, usually in a protective atmosphere, to a temperature that is below the melting point of the major constituent. In some cases, a minor constituent can form a liquid phase at sintering temperature; such cases are described as liquid phase sintering. The mechanisms involved in solid phase and liquid phase sintering are discussed briefly in a later section.

Secondary Operations

The application of finishing processes to the sintered part. In the PM industry, such processes are often referred to as secondary operations.

Preference of PM Route for Product Manufacturing

There are many good reasons why PM might be chosen as the preferred route for the manufacture of a product. Product cost effectiveness is by far the predominant reason for choosing Powder Metallurgy and is the main driver of the structural (or mechanical) parts sector. Powder Metallurgy wins the cost competition on the basis of its lower energy consumption, higher material utilisation and reduced numbers of process steps, in comparison with other production technologies. All of these factors, in turn, are dependent on Powder Metallurgy's ability to reduce, or even possibly eliminate entirely, the machining operations that would be applied in conventional manufacture. In order to eliminate machining operations, Powder Metallurgy relies on its abilities to form complex geometrical shapes directly and to hold close dimensional tolerance control in the sintered product. Powder Metallurgy's cost effectiveness generally also requires that the particular product be made in large production quantities. If production quantity requirements are too low, there would be no opportunity to amortise the costs of the (long-lasting) forming tooling over a sufficient numbers of parts or to avoid the loss of significant fractions of potential production time in tool changeover/setting operations. The production quantities at which Powder Metallurgy would be the process of choice is of course dependent on how difficult it would be to form the shape by a different route, but, in general, would be at least in the order of tens of thousands of parts per year.

Apart from cost effectiveness, product uniqueness is another issue why PM remained preferred. Product uniqueness can be delivered by PM in a number of different ways including processing combinations of materials that would otherwise be impossible to mix. PM allows the processing, in an intimate mixed form, of combinations of materials that would be conventionally regarded as immiscible. Well-established examples of this type of Powder Metallurgy application are: friction materials for brake linings and clutch facings in which a range of non-metallic materials, to impart wear resistance or to control friction levels, are embedded in a copper-based or iron-based matrix.

Hard metals or cemented carbides used for cutting tools, forming tools or wear parts. These comprise a hard phase bonded with a metallic phase, a microstructure that can only be generated through liquid phase sintering at a temperature above the melting point of the binder. Tungsten carbide bonded with cobalt is the predominant example of such a material, but other hard metals are available that include a range of other carbides, nitrides, carbonitrides or oxides and metals other than cobalt can be used as the binder (Ni, Ni-Cr, Ni-Co etc). Apart from that diamond cutting tool materials, in which fine diamond grit is uniformly dispersed in a metallic matrix. Again, liquid phase sintering is employed in the processing of these materials.

Enabling High Melting Point in Metal Processing

PM enables the processing of materials with very high melting points, including refractory metals such as tungsten, molybdenum and tantalum. Such metals are very difficult to produce by melting and casting and are often very brittle in the cast state. The production of tungsten billet, for subsequent drawing to wire for incandescent lamps, was one of its very early application areas. Also, PM enables the manufacture of products with controlled levels of porosity in their structure. Sintered filter elements are examples of such an application. The other prime example is the oil-retaining or self-lubricating bearing, one of PM's longest established applications, in which the interconnected porosity in the sintered structure is used to hold a reservoir of oil. In some specific applications, the generation of superior properties, often through superior control over microstructure, is possible by PM processing as opposed to conventional casting or wrought routes. Good examples in this category of application are: magnetic materials - Virtually all hard (permanent) magnets and around 30% of soft magnets are processed from powder feedstocks. High speed steels - The finer and more controlled microstructure from a Powder Metallurgy processed material provides superior toughness and cutting performance than wrought products. Nickel - or cobalt-based superalloys - Nickel- or cobalt-based superalloys are used for aero-engine applications, in which Powder Metallurgy processing can deliver compositional ranges and microstructural control not achievable conventionally and therefore an enhancement in operating temperature and performance.

Global market size

The global PM market is currently estimated at $3.37 billion with over 1 million tonnes of production. The market, however, is segmented and revenues are forecast on the basis of major regions, such as North America, Europe, Asia-Pacific, and the Rest of the World (RoW). The key countries are covered and their market sizes have been forecasted for each region. Further, the market is segmented and revenues are forecasted on the basis of application.

The metal powder industry is influenced by the increase in population, consumer awareness, changing consumer lifestyles & preferences, urbanization, and development in economy, which drive the demand for sustainable products. This has resulted in the rise in disposable income of consumers and the ability to purchase a range of new products from automobiles, personal technology, and packaged foods. These factors will drive the demand for metal powder from these regions. The increase in the demand for powder metallurgy processes would eventually drive the metal powder market. Advancement in technology and economies of scale process have enabled use of aluminum in a wide range of applications and lowered the production cost. Growing demand for metal powder in emerging economies such as China is expected to drive the metal powder market. Emerging countries such as China, India, Brazil, and countries in Southeast Asia are witnessing change in consumer preferences.

The market for metal powder is observed to be matured in developing economies such as Europe and North America. The reason behind this is the high disposable income. The Asia-Pacific region formed the fastest-growing market for metal powder and is projected to grow at the highest CAGR of 5.01% during the forecast period. North America accounted for the largest market, with a share of 40.4% in 2014. The global market for metal powder is projected to grow at a CAGR of 3.80% from 2015 to 2020, to reach $4.06 billion by 2020. The development of economies plays an essential role in increasing the demand for metal powder in the global market. The key parameter that determines the growth of the metal powder market in developing economies is the increase in consumption. The growing GDP (PPP) in emerging markets such as China, India, and Brazil is estimated to drive the demand for metal powder.