

## CHAPTER 16

### Powder Metallurgy

#### Review Questions

1. Powder metallurgy processes involve blending of powders, pressing of the powders to a desired shape and sintering.

Since powders are used, the composition of the part can be varied over a wide range and so a wide range of part properties can be produced.

By using a powder component that can be removed after the part is formed permeable parts can be made.

Since powders are compacted in relatively high precision tooling, accurate parts can be produced.

Compaction may require high pressure and in such a case compaction forces will be large and parts will be small.

Sintering enables part characteristics to be controlled by controlling the sintering process.

In general, small, high precision parts that need to have carefully controlled microstructure are candidates for production using powder metallurgy techniques.

2. Some of the earliest mass-produced powder metallurgy products included coins and medallions, platinum ingots, and tungsten wires. These were followed by carbide cutting tool tips, nonferrous bushings, self-lubricating bearings, and metallic filters.

3. Automotive applications currently account for nearly 75% of P/M production. Other

major markets include: household appliances, recreational equipment, hand tools, hardware items, business machines, industrial motors, and hydraulics.

4. Iron and low alloy steels are used in about 85% of powder metallurgy production. The large amount of this metal family previously (and currently) used and the workability and experience with working it led to the early and continued development of powder metallurgy processes using it.

5. The powder metallurgy process normally consists of four steps: powder manufacture, mixing or blending, compacting, and sintering .

6. Some important properties and characteristics of metal powders are: chemistry and purity, particle size, size distribution, particle shape, and the surface texture of the particles .

7. The most common means of producing metal powders is by melt atomization where molten metal is fragmented into small droplets and the droplets solidify into particles of metal. Any material that can be melted can be atomized and the resulting particles retain the chemistry of the parent material.

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8. Other techniques of powder manufacture include chemical reduction of particulate compounds, electrolytic deposition from solutions or fused salts, pulverization or grinding of brittle materials (comminution), thermal decomposition of hydrides or carbonyls, precipitation from solution, and condensation of metal vapors .

9. Powder production processes based on processes in which elemental forms of material are produced and exist will be practically useful (not overly complicated, time consuming, energy intensive, easily controllable) only for producing elemental powder. For example, as chemical reduction, thermal decomposition and condensation processes occur different elements are obtained at different stages (time, temperature or composition) and so elemental powders are the logical product to be produced using such processes.

10. The production of amorphous and rapidly solidified powders requires large energy density (energy per unit volume of material produced) and so with reasonable energy levels only small particles can be produced. That is, for fixed energy input the requirement of high energy density means that only small volume products can be produced. To make useful products these small particle, powder, raw materials have to be combined and powder metallurgy techniques accomplish this consolidation task effectively and efficiently.

11. To make a powder metal product powder is placed in a die, pressed and then sintered. To describe the ability of the powder to flow into the die and into various, small, sections of the die cavity and to be uniformly distributed in the die, quantitative measures of powder flow are useful. Flow rate tests provide such a powder behavior measure in flow rate.

12. Apparent density is the density of the loose powder to which there has been no

application of external pressure. Final density is measured after compaction and sintering

and is typically about twice the value of the apparent density.

13. Green strength refers to the strength of the powder metallurgy material after pressing, but before sintering. Good green strength is required to maintain smooth surfaces, sharp corners, and intricate details during ejection from the compacting die or tooling and subsequent transfer to the sintering operation .

14. Mixing or blending is performed to combine various grades or sizes of powders or powders of different compositions, or add lubricants or binders to the powder.

15. The addition of a lubricant improves the flow characteristics and compressibility of the powder at the expense of reduced green strength.

16. While lubricants such as wax or stearates can be removed by vaporization, the graphite remains to become an integral part of the final product. In the production of steel products, the amount of graphite lubricant is controlled so it will produce the desired carbon content in the final material when it is dissolved in the iron powder.