Aluminum Powder Metallurgy
Current Status, Recent Research and Future Directions

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The increasing interest in light weight materials coupled to the need for cost-effective processing have combined to create a significant opportunity for aluminum P/M, particularly in the automotive industry in order to reduce fuel emissions and improve fuel economy at affordable prices. Additional potential markets for Al P/M parts include hand tools, Where moving parts against gravity represents a challenge; and office machinery, where reciprocating forces are important.

Aluminum P/M adds light weight, high compressibility, low sintering temperatures, easy machinability and good corrosion resistance to all advantages of conventional iron based P/M. Current commercial alloys are pre-mixed of either the Al-Si-Mg or AL-Cu-Mg-Si type and contain 1.5% ethylene bis-stearamide as an internal lubricant. The powder is compacted in closed dies at pressure of 200~500Mpa and sintered in nitrogen at temperatures between 580~630℃ in continuous muffle furnace. For some applications no further processing is required, although most applications require one or more secondary operations such as sizing and finishing. These secondary operations improve the dimension, properties or appearance of the finished part.

Aluminum is often considered difficult to sinter because of the presence of a stable surface oxide film. Removal of the oxide in iron and copper based is usually achieved through the use of reducing atmospheres, such as hydrogen or dissociated ammonia. In aluminum, this occurs in the solid state through the partial reduction of the aluminum by magnesium to form spinel. This exposes the underlying metal and facilitates sintering. It has recently been shown that $< 0.2\%$ Mg is all that is required. It is noteworthy that most aluminum pre-mixes contain at least 0.5% Mg. The sintering of aluminum alloys can be further enhanced by selective microalloying. Just 100ppm of tin changes the liquid phase sintering kinetics of the 2xxx alloys to produce a tensile strength of 375Mpa, an increase of nearly 20% over the unmodified alloy. The ductility is unaffected. A similar but different effect occurs by the addition of 100 ppm of Pb to 7xxx alloys. The lead changes the wetting characteristics of the sintering liquid which serves to increase the tensile strength to 440 Mpa, a 40% increase over unmodified alloys.

Current research is predominantly aimed at the development of metal matrix composites, which have a high specific modulus, good wear resistance and a tailorable coefficient of thermal expansion. By controlling particle clustering and by engineering the ceramic/matrix interface in order to enhance sintering, very attractive properties can be achieved in the as-sintered state. At an as-sintered density approaching 99%, these new experimental alloys have a modulus of 130 Gpa and an ultimate tensile strength of 212 Mpa in the T4 temper. In contest, unreinforced aluminum has a modulus of just 70 Gpa.