Aluminum

AMAZING

Simply stated, aluminum is like no other material on earth. It is the most abundant metallic element in the earth's crust and, once converted to its metallic state, aluminum's combination of useful properties is nothing short of extraordinary.

Metal Powder Products Company, an international powder metallurgy company headquartered in Indianapolis, Indiana, is leading the way in the use of P/M aluminum for a variety of new and existing applications. MPP is the world's largest producer of structural aluminum P/M components.

MPP – WORLD LEADERS IN P/M ALUMINUM

Custom-Engineered Product Solutions

MPP uses the distinct P/M technologies and manufacturing capabilities of its specialized plants to provide custom-engineered product solutions to customers in a wide variety of industries. Long considered a leader in the P/M industry, MPP has developed a number of innovations in material formulation, sintering, densification, P/M joining techniques, and value-added secondary operations.

MPP has produced more than 45 million of these cam caps since1992. Pictured above are a dual front cap for a DOHC V6 (left) and a single front cap for a DOHC V8.

Amazing Aluminum

Simply stated, aluminum is like no other material on earth. While it can be difficult to extract from its host minerals, such as bauxite, it is nevertheless the most abundant metallic element in the earth's crust. Once converted to its metallic state, aluminum's combination of useful properties is extraordinary. Aluminum is:

- Light in weight – about a third as heavy as copper or steel.
- Highly resistant to corrosion
- An excellent conductor of heat and electricity
- Nonmagnetic – a valuable property around sensitive electronics
- Outstanding in cryogenic properties – strong, not brittle, in intense cold
- Highly machinable
- Very responsive to a variety of finishing processes, such as anodizing
- Completely recyclable and, therefore, energy-efficient

Aluminum has an excellent strength-to-weight ratio and it offers product forms and alloys that surpass any other material. It can compete successfully with less costly materials because of the advantages it brings in primary and secondary weight savings, structural performance and design flexibility. The design flexibility of aluminum is unparalleled, allowing designers to engineer optimum shape and performance for each specific application.

These P/M aluminum rollers are used in latches that secure a removable panel on a sports utility vehicle.

Aluminum Powder Metallurgy

P/M aluminum has been around since about 1960, but its use did not really accelerate until MPP's Washington Street Division began producing P/M aluminum camshaft bearing caps in late 1992. Since that time, the division has produced more than 45 million cam caps from P/M aluminum.

The P/M Aluminum Process

To understand the role that P/M aluminum plays, it is important to start with a basic understanding of powder metallurgy. P/M is a highly developed, cost-effective method of manufacturing complex ferrous and non-ferrous parts. Made by mixing elemental or alloy powders and compacting the mixture in a die, the resultant shapes are then sintered to bond the particles metallurgically. On average, P/M uses more than 97% of the starting raw material in the finished part. Typically, P/M parts are manufactured to net shape and require little, if any, secondary machining to achieve the desired part configuration. The processing fundamentals for P/M aluminum are similar to those employed for other P/M materials.

Material Selection – Several grades of P/M aluminum alloys are commercially available. Most contain additives of copper, magnesium, and/or silicon, as well as a small percentage of lubricant.

Pressing – Parts are pressed in conventional presses, using tools made with conventional tool steels or carbides. Because aluminum is soft, compaction and ejection pressures are far lower than those used for ferrous powders. P/M aluminum premixes can be compacted to 90% of theoretical density at only 12 tsi (165 MPa) and to 95% at 25 tsi (350 MPa). These lower pressures, combined with aluminum's ductility, reduce the possibility of tool breakage.

Sintering – As with conventional P/M materials, sintering is perhaps the most important of all the operations involved in the manufacture of P/M aluminum parts. Generally, sintering temperatures for P/M aluminum are lower than for other P/M materials, which saves energy.

DESIGNING WITH P/M ALUMINUM

A Winning Combination

When you link the usual advantages of powder metallurgy to the attributes of an exceptional material like aluminum, you have a winning combination. P/M aluminum offers a number of additional advantages related to the specific properties of basic aluminum.

This P/M aluminum hub guard for a circular saw was chosen over magnesium because aluminum, unlike magnesium, does not cause a galvanic reaction.

Light Weight

Lighter weight is a distinguishing characteristic of P/M aluminum. In fact, aluminum enjoys better than a 3 to 1 weight advantage over iron, nickel, and copper.

Mechanical and Performance Properties

P/M aluminum parts can be produced with a range of property levels. Mechanical properties (see Figure 1, next page) depend upon the composition and density of the alloy and are typically significant factors in the material selection process. For certain applications, dynamic and other performance properties are more critical and become the determinant criteria.

Conductivity

Excellent conductivity, both electrical and thermal, is also a hallmark of P/M aluminum. P/M aluminum parts are comparable to their wrought counterparts and can be utilized as heat sinks or electrical conductors. See Figure 2 (next page) for a comparison of the conductivity ratings of various materials.

These P/M aluminum parts act as heat sinks on electronic circuit board assemblies.

Corrosion Resistance

P/M aluminum alloys have excellent resistance to corrosion. In particular, the Al-Mg-Si alloys exhibit extremely high resistance to general corrosion, when compared to ferrous-based products. Parts may also be chromate conversion coated or anodized for increased resistance to corrosion. Hard type anodized finishes can be applied for water-resistant applications.

Appearance

The natural appearance of P/M aluminum parts is suitable for most applications where good appearance is a requirement. In addition, a wide range of decorative finishes is available. Many of the decorative and protective treatments currently employed for wrought and cast aluminum alloys can also be applied to P/M aluminum parts. These include mechanical finishing and etching to achieve textures, coloring for decorative or functional purposes, electroplating, and painting.

Machining

P/M aluminum parts also offer many of the important advantages of wrought aluminum in machining operations, including high cutting speeds, smooth surface finish and superior tool life.

Joining and Bonding

P/M aluminum lends itself to a variety of joining and bonding techniques. Sintered aluminum parts can be successfully fastened by adhesive bonding, although the use of threaded fasteners is a more conventional method of joining multiple parts. Excellent thread characteristics can be obtained in P/M aluminum parts above the 90% density level. The ductility of parts in the upper density range is also sufficient for self-tapping fasteners.

Powder Metallurgy Design Considerations

The P/M process in general, and P/M aluminum in particular, have their own sets of design guidelines for producing economical, soundly engineered parts. Designing for P/M necessitates close cooperation between the part user and the producer, especially in the initial design stages. Not infrequently, early designer-manufacturer interaction results in an expansion of the P/M concept that nets overall design production simplification and cost reductions.

Additional Applications

Because of its unique properties, P/M aluminum is being successfully applied in a variety of industries, including computers and other business machines, electrical and electronic equipment, small and major appliances, power tools, and automotive applications.

MECHANICAL AND PERFORMANCE PROPERTIES OF P/M ALUMINUM

MECHANICAL PROPERTIES OF SELECTED ALUMINUM P/M ALLOYS

Alloy	Composition %					Sintered Density	Temper	Yield Strength		Tensile Strength		Elongation
	Cu	Mg	Si	Al	Lub.	%		ksi	MPa	ksi	MPa	%
A	–	0.6	0.4	Bal	1.5	96	T1	9.0	62	19.0	130	9.0
							T4	9.5	65	19.5	134	10.0
							T6	25.0	171	27.0	185	3.0
B	0.25	1.0	0.6	Bal	1.5	96	T1	13.7	94	21.0	144	6.0
							T4	17.0	117	25.6	176	6.0
							T6	33.4	229	34.5	237	2.0
C	0.25	1.0	0.8	Bal	1.5	94	T4	17.1	117	26.3	180	3.8
D	0.2	1.0	0.5	Bal	1.5	93	T1	–	–	20.3	139	6.0
							T6	–	–	36.3	249	3.0
F	3.8	1.0	0.75	Bal	1.5	92	T4	29.1	200	38.6	265	2.5
G	4.4	0.5	0.6	Bal	1.5	97	T1	26.2	180	30.3	208	3.0
							T4	31.0	213	38.0	261	5.0
							T6	47.5	326	48.1	330	2.0

T-1 - As sintered:
T-4 - Heat treated, cold water quenched and aged (minimum of four days at room temperature)
T-6 - Heat treated, cold water quenched and artificially aged

Figure 1: This chart shows some of the selected mechanical properties of various P/M aluminum alloys.

P/M Design Seminars

Because of the importance of end-user understanding of the basics of powder metallurgy, MPP offers free P/M Design Seminars. Attendees learn P/M design fundamentals and receive copies of the MPIF P/M Design Solutions Guide, MPP's Design Ideas Kit, and other helpful materials, free of charge. Several public seminars are held each year and, for your convenience, MPP offers in-house seminars in your facilities.

To Learn More

For more information about how Metal Powder Products Company can help you determine if P/M aluminum is right for your application, or to sign up for a P/M Design Seminar, please call us at 1-800-783-2420 or contact us through our web site at www.metalpowder.com.

CONDUCTIVITY

Material	Temper	Electrical Conductivity (a) at 20°C, % IACS	Thermal Conductivity (b) at 20°C, CGS units
Alloy B (2.48 g/cm³)	T-4	38.0	0.36
	T-6	41.0	0.38
Alloy G (2.48 g/cm³)	T-4	32.0	0.30
	T-6	35.0	0.32
6061 wrought Al	T-4	40.0	0.37
	T-6	43.0	0.40
Brass (35% Zn)	Hard	27.0	0.28
	Annealed	27.0	0.28
Bronze (5% Sn)	Hard	15.0	0.17
	Annealed	15.0	0.17
Iron (wrought plate)	Hot Rolled	16.0	0.18
Copper	Hard	97.0	0.93
	Annealed	100	0.93

Figure 2: This chart shows the electrical and thermal conductivity ratings of P/M aluminum alloys in comparison to wrought aluminum, brass, bronze, iron, and copper.

Metal Powder Products Company
17005-A Westfield Park Road, Westfield, IN 46074
317-580-2420 • 800-783-2420 • Fax: 317-580-2444
www.metalpowder.com