AM-lite™ – a new light weight cost effective alloy for decorative applications

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Abstract

AM-lite™ is a new magnesium diecasting alloy for decorative applications that offers technical and economic advantages over zinc, aluminium and magnesium AZ91D alloys and also injection moulded plastics. In particular the alloy has high diecastability and can be readily electroplated to produce highly durable decorative coatings. These and other attributes are enabling the AM-lite™ to compete in markets that have previously been the domain of zinc, aluminium, magnesium AZ91D and plastics.

Introduction

The new magnesium alloy, AM-lite™, has been specifically developed by Advanced Magnesium Technologies to satisfy demand for a light weight diecastable alloy that is highly suitable for decorative surface finishing applications. The key technical attributes of AM-lite™ are its light weight, metallic feel, excellent diecastability, oxidation resistance and suitability for decorative surface finishing operations such as electroplating and painting. The alloy offers cost savings compared to zinc, aluminium, magnesium alloy AZ91D, and also injection moulded plastics, in the manufacture of surface finished articles. With these characteristics, AM-lite™ is highly suitable for a wide range of applications in areas such as building and sanitary hardware, consumer electronics and decorative automotive parts.

The electroplating process for AM-lite™ was developed by MacDermid Inc., a global supplier of chemicals and technology to the surface finishing industry. The process takes advantage of the alloy's favourable surface chemistry to greatly simplify pretreatment steps that are necessary before application of electroplated layers of copper, nickel and chromium. The pretreatment for AM-lite™ involves one step more than is necessary for electroplating of zinc diecastings but thereafter the process is the same as for the electroplating of zinc and surface finishes of equivalent high standard can be obtained.

AM-lite™ was first introduced to the market in June 2005. Since then there has been a high level of activity towards utilization of the alloy in commercial products. Diecasters have trialed the alloy, product developers have assessed which products are best suited for early introduction of the alloy, prototypes have been

developed, surface finishing processes have been adjusted to suit the alloy and extensive testing has been carried out on manufactured articles. The fruits of these efforts - the first products made from AM-lite™ – will soon be coming onto the market.

General features of AM-lite™

In comparison to other magnesium diecasting alloys, AM-lite™ is oxidation resistant at temperatures in the range of solidification and below. This results in less oxide on the surface of castings and their shelf life is considerably improved compared to castings of other magnesium alloys.

Figure 1. Electroplated diecast AM-lite™ auto parts

Molten AM-lite™ exhibits good fluidity and its diecastability is similar to that of zinc diecasting alloys. One of the consequences of the alloy's excellent diecastability is that it faithfully reproduces fine detail from the die and can produce castings with very thin section thicknesses. While production experience is limited, it seems likely that die life is considerably enhanced compared to aluminium and magnesium AZ91D. AM-lite™ is less prone to adhere to, or react with, dies (soldering). The usual polishing of dies after a set number of shots is significantly reduced with AM-lite™, thus reducing down-time and improving automation.

The electroplating process for AM-lite™

The as-cast surface of AM-lite™ provides an improved substrate for electroplating because of two main reasons. Firstly, the high as-cast surface definition reduces the amount of buffing, or polishing, that is necessary to produce a prepared polished surface for coating. Secondly, the surface chemistry of AM-lite™ is such that good adhesion of deposited layers is obtained.

Key differences in procedures for electroplating of different materials arise in the pretreatment sequences prior to electrodeposition of subsequent layers of copper, nickel and chrome (or what ever top coat is desired). For electroplating of zinc, pretreatment only involves cleaning and activation of the surface. However for aluminium and magnesium AZ91D steps of etching, deoxidation and zincating must also be added. Even then the quality of adhesion of electroplated layers on aluminium and AZ91D is significantly lower than for zinc. Pretreatment of plastics for electroplating is very different and even more costly.

Pretreatment of AM-lite™, with the process developed by MacDermid, eliminates the etching and deoxidation steps that are necessary for aluminium and AZ91D and utilizes a newly developed zincating chemistry called "Bondal® Mg". The process is simple and it is much less costly than processes for aluminium, AZ91D and plastics while providing better adhesion. The quality of electroplating is similar to that expected of electroplated zinc diecastings.

The Bondal® Mg pretreatment process for AM-lite™ allows the full range of possibilities for deposition of decorative electroplated layers and top coats that are available to other materials.

Electroplated AM-lite™ displays excellent coating performance in standard testing regimes. For example, no chipping or adhesion loss is experienced in standard saw cut tests. Accelerated CASS corrosion tests in accordance with ASTM and DIN standards have shown the absence of corrosion for up to 72 hours which is equivalent to more than 500 hours in standard neutral salt spray testing. This is far superior to what is normally obtained on AZ91D.

Figure 2. Electroplated AM-lite™ cell phone part

Comparison of AM-lite™ with other materials

Table 1 is a score card that has been drawn up to show the relative attributes of competing materials for diecast or moulded parts. The scores are in the range 1-5 with 5 being best and 1 being worst. While such a quick comparison does not allow a detailed comparison of the nuances of each material, it can easily be understood that, when considered over a range of properties, AM-lite™ is consistently better than its competitors for a broad range of applications.

Attribute	AM-lite™	Zn	Al	AZ91D	Plastics
Diecastability / mouldability	4	5	2	3	5
As-cast surface quality	4	5	2	3	5
Electroplating	4	5	2	1	2
Painting/Powder coating	4	3	5	3	3
Melt loss	4	4	4	1	5
Recycling	4	5	5	3	1
Productivity	4	4	3	2	5
Mechanical properties	4	3	5	4	1
Conductivity (metallic feel)	4	4	5	4	1
Density (lightness)	5	1	4	5	5
Cost of finished product (5 is lowest)	5	3	4	3	3
Average	4.2	3.8	3.7	2.9	3.3

Comparison with zinc

Zinc diecasting alloys are highly diecastable and their electroplating characteristics are excellent. The main disadvantages of zinc are its high density and the high current cost of the base metal. The density of AM-lite™ is less than 1/3 the density of zinc and therefore more than 3 times as many parts can be made with AM-lite™ for the same weight of material. Based on current prices, this results in the cost of metal per AM-lite™ part being only about 1/4 of the cost of zinc alloy for castings of the same volume.

The electroplating characteristics of AM-lite™ using MacDermid's Bondal® Mg technology allow the same standard of electroplated surfaces to be produced as can be formed on zinc diecastings with only a small increase in the cost of electroplating.

The high density of zinc makes zinc diecastings unfavourable in applications, such as automotive and personal electronics, where light weight is important. Painted and powder coated zinc parts are also vulnerable to the formation of surface blisters during baking due to the expansion of gases trapped in the metal during diecasting. AM-lite™ is resistant to the formation of blister defects because the alloy has an inherent creep resistance that stops the growth of gas bubbles. This much improved creep resistance of AM-lite™ also enables the design of thinner bosses for bolted joints compared to what is necessary for zinc.

Comparison with aluminium

Aluminium alloys are not as diecastable as zinc or magnesium alloys. Therefore they are not used for thin walled or intricate diecastings. Aluminium is more favoured for thick walled robust parts such as automotive transmission housings and other structural parts. Aluminium also has a 50% higher density than magnesium alloys so the latter have a distinct advantage when weight is at a premium. Current high prices for aluminium combined with the larger number of parts that can be made from the same weight of AM-lite™ mean that there is a cost saving of about 14% on the input metal for AM-lite™ castings of the same volume. In die casting, aluminium is significantly more aggressive on dies than AM-lite™ and therefore costs associated with die replacement are much higher for aluminium.

Aluminium is difficult to electroplate and the cost of pretreatment steps prior to electrodeposition of copper, nickel and chromium layers is very high compared to zinc and AM-lite™. For these reasons, AM-lite™ is being considered by a number of manufacturers for current aluminium applications where the advantages of light weight, improved diecastability, longer die life, ease of electroplating and lower costs make compelling arguments.

Comparison with magnesium alloy AZ91D

As can be seen in Table 1, AM-lite™ is superior to AZ91D in many respects. Most importantly, AM-lite™ is more diecastable, can be electroplated and saves substantial costs for surface finished components. The improved diecastability enables sections that are 10% thinner to be readily cast and also allows casting yields to be improved through the use of thinner runners and smaller overflows. The as-cast surface is improved and the oxidation resistance of AM-lite™ provides a longer shelf life for unfinished castings.

In melt handling, costly melt losses due to dross and sludge are reduced, from an industry average of 4% for AZ91D to about 1% for AM-lite™, through a virtual elimination of sludge and significantly less dross formation.

AM-lite™ has a higher design strength than AZ91D and this allows for the incorporation of even thinner sections and thinner bosses in bolted sections. The greater creep resistance of AM-lite™ also makes it an option for components, such as valve covers, that experience raised temperatures and require maintenance of tight bolted joints over long periods.

The most important advantage of AM-lite™ over AZ91D is however its excellent surface finishing characteristics and, in particular, its ability to be electroplated.

Comparison with plastics

Electroplated plastics might look like metals but, because the underlying plastic substrate is thermally non-conductive, they do not feel like metals. This simple matter of aesthetics often disappoints consumers when they touch an outwardly metallic looking item and realize it isn't what they thought it to be. Because it is a conductive metal, AM-lite™ does have a "metallic feel" and so is more attractive to customers.

AM-lite™ provides a much improved substrate for surface finishing than plastics and thus the cost of electroplating AM-lite™ is considerably less. This combined with current kilogram prices for engineering plastic feedstocks that are 2 to 8 times greater than AM-lite™ provides the opportunity for considerable cost savings in many circumstances.

AM-lite™ has a much higher stiffness, yield strength and creep strength than unreinforced plastics thus allowing improved thin section light weight designs. The alloy's electrical and thermal conductivity, and EMS shielding, is also important for the design of consumer electronics such as mobile phones and laptop computers.

Conclusions

1. AM-lite™ is a light weight diecasting alloy with excellent surface finishing characteristics.
2. AM-lite™ can be readily electroplated using MacDermid's Bondal® Mg pretreatment system.
3. AM-lite™ has a number of other technical attributes and cost advantages that make the alloy highly advantageous for use in many applications that currently use zinc, aluminium and magnesium AZ91D diecastings or injection moulded plastics.