SURFACE FINISHING FOR DIE CASTINGS

A guide to surface treatment systems for protection, decoration and improved performance of die cast product components

Prepared for OEM designers, specifiers and purchasers by the Diecasting Development Council

Bulletin No. 4

Many die cast products are put into use with no operations performed other than casting and trimming. A knowledge of recommended die casting surface finishing alternatives is important to the product engineer and specifier when a specific finish is required, however, to guide die casting alloy selection itself.

Surface treatment systems are generally applied to die castings for one or more of the following purposes:

- Provide a decorative finish
- Form a protective barrier against environmental or galvanic corrosion
- Achieve pressure tightness if interconnected subsurface porosity is present
- Improve resistance to wear

Even when a die casting requires no further surface treatment for decoration, protection or improved performance, a deburring operation is almost always recommended. This step removes any flash, burrs, sharp or ragged edges that might remain after trimming, to facilitate handling and any further finishing treatments. Mechanical, chemical and thermal deburring techniques are available, with vibratory deburring the most common.

Surface Treatment Systems

Final finishing systems that offer the highest performance levels and are specified most frequently for die castings are discussed here and summarized in the table on page 2.

Decorative Finishes

Three types of decorative surface treatments are used on die castings: painting, plating, and bright finishing other than by plating. Decorative finish quality largely depends on casting surface quality. Bright chrome and paint systems that produce high luster or gloss require a high-quality surface. Systems that produce a textured finish are much less sensitive to surface quality. Therefore the die caster must know the precise surface quality and finish requirements to apply appropriate process controls, perform required die maintenance, and introduce secondary operations.

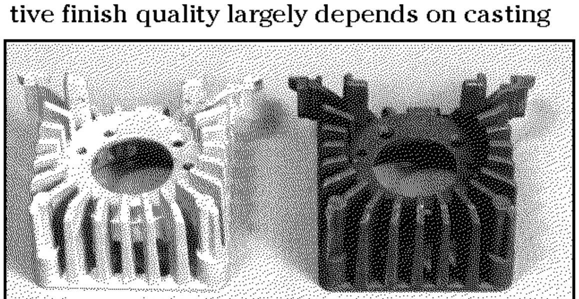


Fig. 1. The aluminum die casting for a computer printer heat sink, shown as-cast on left, was black anodized to provide corrosion protection and wear resistance.

Bright finishes, such as chrome-plated hardware, usually require a buffing operation to develop a mirror-like surface to receive the plating, and intermediate buffing during successive plating operations. Matte finishes, typically used for furniture and luggage, are achieved by sand blasting, grit blasting or scratch brushing followed by a clear lacquer. Scratch brushing develops smooth line textures or a satin finish. Textures such as stipples and grain can be cast into the surface (see illustrations on page 2), provided that the textured surface is generally oriented perpendicular to the direction of die draw.

Die castings that are to be electroplated must be designed to accommodate the electrical current density patterns that characterize the process. The complexity of the casting and the shape of features can affect current distribution and hence plate thickness. Good uniformity is achieved on gently curving convex surfaces. Corners, edges, fins, ribs and similar protruding features concentrate current flow and receive more than the average deposition of plated metal. Recessed features, such as grooves, serrations, holes, concavities and deep recesses, receive less than average (see illustrations on page 2).

Electroplating requires successive steps of immersion in plating solutions and rinsing. All casting features, particularly deep recesses, must be designed so that plating solutions will readily drain. The castings must also be designed so that they can be buffed and racked economically.

Process controls can help to equalize plate thickness. However, the most effective means of achieving good distribution at minimum cost is to follow recommended design procedures for configurations and orientation of features.

Die castings can be painted like ferrous and nonferrous wrought and sheet products. However, when exacting standards for a color-

Surface Treatment Systems for Die Cast Parts

PURPOSE	ALUMINUM	MAGNESIUM	ZINC	ZA
Decorative finish	Paint Polish/Epoxy Plate Powder coat	Paint Plate Chromate Phosphate	Paint Plate Chromate Phosphate	Paint Plate (ZA-8, ZA-12) Chromate Phosphate
Environmental or galvanic corrosion barrier	Paint Anodize Chromate Iridite	Paint Anodize Conversion coat	Paint Chromate Anodize Iridite	Paint Chromate Anodize Iridite
Fill and seal surface and subsurface	Impregnate	Impregnate	Impregnate	Impregnate
Improve wear resistance	Hard anodize	Hard anodize Hard chrome plate	Hard chrome plate	Hard chrome plate (ZA-8, ZA-12)

Die Casting Design for Improved Electroplating

Convex Surface

Poor Design

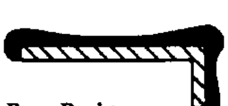
Improved Design. Easy to plate uniformly, especially where edges are rounded.

Flat Surface

Poor Design

Improved Design. Use 0.015 in./in. crown to hide undulations caused by uneven buffing.

Sharp Angled Edges



Poor Design

Improved Design. All edges should be rounded to avoid excessive edge build up.

match with adjacent dissimilar materials must be met, the paint may have to be specially formulated to achieve the desired result. Color match, surface preparation and priming vary depending on the alloy and application.

Protective Barriers

Die casting alloys are relatively active metals with a high potential to react chemically with the atmosphere, primarily water and airborne pollutants. The reaction forms a tight surface coating that seals the surface and retards further corrosion. The coating builds up at a progressively diminishing rate, developing an effective barrier that frequently requires no additional corrosion protection, even in moderately severe environments.

Factors that affect atmospheric corrosion can be managed through quality control and design specification, when designer and die caster interact in a simultaneous engineering program. Alloy purity is especially important to the corrosion resistance of magnesium, zinc and ZA die casting alloys.

Chromating is one system of surface treatment that is often applied to aluminum, magnesium, zinc and ZA die castings as a corrosion protection system or a base for paint or dyes. The film presents a physical barrier, and the hexavalent chromium content inhibits corrosion. When the film is disrupted, the hexavalent chromium in contact with water slowly leaches and effectively self-heals. The degree of protection increases with film thickness, progressing from the thin clear films, to the intermediate light iridescent films, to the heavy olive drab and brown coatings. Applications range from humidity protection during storage to marine atmosphere exposure.

Chromate coatings are normally soft and easily damaged while wet, and become reasonably hard when dried. They will accept dyes when soft, providing an economical means of color coding. When hard, they will withstand considerable handling, but not continued abrasion or scratching. Mechanical fastening usually causes local damage; the corrosion protection will then depend on the self-healing capability of the film. Prolonged exposure to temperatures in excess of 150°F (66°C) can substantially decrease the protective value of conversion coatings on aluminum and zinc. However, normal paint-curing cycles do not appear to affect chromate coatings.

Phosphate conversion coatings are applied to aluminum, magnesium, zinc and ZA die castings to improve corrosion resistance and increase paint adhesion.

To determine the level of corrosion protection required, first determine the type and severity of corrosive agents expected and then define the condition that must be maintained. For example, if a component remains serviceable as long as its function is not impaired by corrosion, discoloration and dullness can be tolerated.

Wear Resistant Finishes

Die castings may be employed in applications subject to severe abrasion and wear by applying an abrasion-resistant surface. Protection is often applied locally when only a localized area is subject to abrasion. Aluminum and magnesium alloys are hard-coat anodized; magnesium, zinc and ZA-8,12 alloys may be hard-chrome (copper-nickel-chrome) plated.

Sealant Impregnation

Impregnation can be used to develop pressure tightness and seal surface pits in die castings. The preferred method, where possible, is to prevent the formation of porosity which causes the condition. The second method is to avoid removing surface metal, exposing porosity in critical areas. When machining operations remove 0.020 in. (0.8 mm) or more of metal, subsurface pores may be exposed, leaving the surface pitted.

Impregnation is more common with aluminum die castings manufactured by the cold-chamber process than with zinc, ZA-8 and some magnesium die castings manufactured by the hot-chamber process. Porosity can be minimized in both processes by careful control of die casting parameters; it may be virtually eliminated by employing one of several available proprietary systems.

Systems employing anaerobics and methacrylates are currently employed when impregnation is specified to achieve 100% pressure tightness. These systems produce sealed castings ready for pressure testing in 40 minutes at a yield of 90%, assuming average porosity.

1. Aluminum Alloys

Aluminum die castings exhibit good to excellent corrosion resistance, depending on alloy copper content. Alloys with restricted copper content exhibit improved corrosion resistance in atmospheric exposure. When corrosion protection is required beyond that afforded by the protective surface film, aluminum die castings can be chromated, painted or anodized. Electroplating is less frequently used to produce a decorative surface.

Painting

Painting systems for aluminum die castings encounter few production problems. When they do occur, they are generally traced to processing factors which are readily corrected. When exacting standards for color match with adjacent sheet steel must be met, paint formulation should be adjusted.

Available paint formulations for aluminum die castings penetrate the normally thin oxide coat and develop adhesion. When aluminum die castings have been stored for an extended period prior to painting, particularly in conditions of high humidity, the oxide layer accumulates, making it necessary to remove it by vibrating the casting in an abrasive medium or surface blasting it. In conditions where the component is subject to impacts, such as stone damage that can chip the paint, or in very corrosive atmospheres, paint adhesion can be improved by applying a conversion coating, such as chromating or phosphating, as a paint base.

Anodizing

Anodizing is used to improve the natural corrosion resistance of aluminum die castings. Aluminum anodizing is an electrochemical process that converts aluminum into aluminum oxide at the surface of the casting.

The thickness of the anodized surface can be increased to develop a wear-resisting hard coat. As silicon content increases, aluminum alloys become more difficult to anodize. Anodizing is not generally used as a decorative coating on aluminum die castings.

2. Magnesium Alloys

During prolonged environmental exposure, the natural pattern of corrosion on magnesium is formation of a surface film of hydroxide on exposure to water, and formation of a surface coating of hydroxide-carbonate on exposure to the atmosphere. The coating thus formed offers some protection against further corrosion, and is partially self-healing.

The atmospheric corrosion resistance of high-purity magnesium alloy is vastly superior to unmodified mild steel, somewhat superior to copper-modified mild steel, better than die cast 380 aluminum, and inferior to zinc and ZA alloys.

A wide variety of surface treatment systems has been developed for magnesium.

Short-term protection

A thin film of oil or wax is often applied to bare magnesium surfaces to provide protection during storage in dry environments and in shipping. The films are low in cost and applied by brush, spray, or dip. Oil coatings can be readily removed prior to machining or painting by vapor degreasing, alkaline cleaning, or solvent dipping followed by a final rinse in clean, unused solvent.

A number of chemical treatments (conversion coatings), both chemical and electrochemical, are used for short-term surface protection. The coatings replace the naturally alkaline hydroxide-carbonate film with a surface which is more corrosion inhibiting and less alkaline to slightly acid.

Painting

Paint systems that perform well on aluminum or zinc are generally satisfactory on magnesium die castings. Proper surface preparation and choice of priming materials are important, particularly under severe conditions, to ensure good contact between the primer and the metal surface. Surface preparation is often accomplished by applying one of several available chemical treatments that prevent oxidation in storage and shipment, form a good paint base, and retard the natural alkali which forms at any point of damage on a painted magnesium alloy surface.

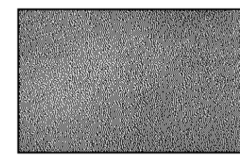
Chemical or electrochemical treatments improve adhesion and durability, but are not necessary in less severe applications.

Bright finishes

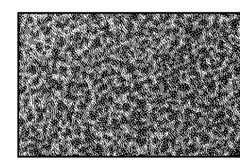
Polishing and buffing produce a bright metallic luster on magnesium die castings. Mechanical finishes acquire a gray film on atmospher-

Cast-in Decorative Surface Textures

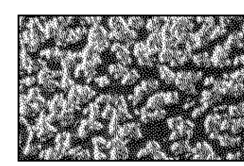
Using photoengraving techniques in the making of the die casting die, virtually any desired pattern, depth and graining can be integrally die cast into the surface of a part. Samples are shown here, enlarged many times. Acrylic-type finishes are used as the final finishing step. Product enhancement through the use of detailed cast-in patterns should be weighed against reduced die life and required die maintenance.



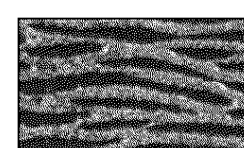
Finely Stippled



Sand (No. 3)



Spanish Stucco (No. 6)



Bark (No. 7)

Lattice (No. 8)

ic exposure; the luster must therefore be protected with a clear baked lacquer. This treatment is used for furniture and luggage. A ferric nitrate bright pickle chemical treatment is used to develop a semi-bright to bright silvery surface on magnesium die castings suitable for interior and mild exterior service. Typical uses include business machines, furniture, luggage trim, and tools. A more durable bright finish is obtained by a mild etch followed with a clear anodize.

Magnesium die castings can also be bright chrome-plated to produce a high-luster, durable surface. Service testing is recommended to determine the proper plating cycle for the conditions anticipated. Where increased wear resistance is required, heavy chrome plates may be applied.

Anodizing

Anodizing of magnesium alloys essentially follows the same procedure used on other metals: surface cleaning, deoxidation, and anodize. Both alkaline and acid anodizes are available. However, anodic coatings on magnesium alloys do not lend themselves to dyeing. Color effects are achieved by bright pickles in combination with tinted or dip-dyed clear lacquers. Alkaline anodize must be post-treated for paint adhesion, but is harder and more wear- and abrasion-resistant than acid anodizes. Acid anodizes are more flexible, less subject to spalling or chipping, and make excellent paint bases on magnesium die castings even under most severe conditions.

Other available processes include hard anodize, for improved resistance to wear, and an impregnation anodize process, which is applied where impregnation plus a protective or paint-base coating is required.

3. Zinc and ZA Alloys

Electroplating

The plating characteristics of the zinc (Zamak) alloys have made them the prevailing choice for hardware applications, particularly where moderate to high strength is required. Zinc alloys readily accept a decorative bright chrome finish or a wear-resistant hard chrome finish. Chrome plating also improves corrosion resistance. High-quality polished surfaces can be maintained on zinc die cavities to impart cast surfaces which do not require buffing prior to bright chrome plating.

ZA-8 can be plated using the same processes as the zinc alloys. ZA-8 is being used as an alternative to zinc in applications where bright chrome plating combined with higher strength or improved creep resistance is required. ZA-12, with higher aluminum content, requires some plating process modifications. ZA-27 is not chrome plated.

Painting

The zinc alloys are readily and economically painted. Color-match with sheet steel is excellent. Zinc die castings painted in the same operation as contiguous sheet steel members meet the exacting standards for adhesion and color match of the automotive and home appliance industries. Primers and chromates are specified to improve adhesion and durability in severe conditions.

ZA alloys are also readily painted. There is, however, less experience with these alloys, particularly color-match with steel.

Chromate treatments

Chromate treatments are applied to the zinc alloys to develop a decorative finish, a base for paint, and corrosion protection. Chromate treatments combined with chemical polishing solutions have replaced more expensive finishing operations for zinc die castings.

ZA-8 and ZA-12 accept chromate finishes. Chromating ZA-27 requires some process modification. Zinc plating prior to chromating produces a decorative, economical finish.

Anodizing

Aside from the name, zinc anodizing bears no resemblance to aluminum and magnesium anodizing. Zinc alloys, ZA-8 and ZA-12 can be anodized using one basic process; ZA-27 requires some process modification. Although proven in severe operating environments, the cost of anodizing is high relative to other processes, and it is not currently in wide use.

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