

Engine Coatings

An updated look at various coatings applicable for engine builds.

BY MIKE MAVRIGIAN

A variety of “coatings” are available for both internal and external engine components, with applications varying from power enhancement, engine efficiency and durability/longevity to corrosion protection and external appearance. Here we’ll touch on all of these applications.

PERFORMANCE ENHANCEMENT COATINGS

Once viewed as unnecessary “add ons” and initially thought of by some builders as “gimmicks,” specialized internal engine coatings have proven their worth in terms of both power increases, friction reducers and benefits in terms of engine longevity. Today’s coatings include those designed to reduce friction and enhance lubricity, thermal barrier coatings for increased engine efficiency and protection of components exposed to extreme heat levels, and drainback coatings that speed-up oil return to the sump. Today’s available coatings offer distinct advantages with regard to thermal control, increased lubricity and resulting reduction of friction, as well as oil shedding properties that serve to free-up horsepower by reducing parasitic oil drag on rotating assemblies. In a nutshell, four distinct types of coatings are available for performance engine applications: thermal barrier coatings, heat-emitter coatings, low-friction coatings and oil-shedding coatings.

THERMAL BARRIER COATINGS

Thermal barrier coatings (which can be referred to as a heat shield) feature a ceramic formulation, designed to prevent excess heat from passing into and being absorbed into a component. Applications include piston domes, turbocharger housings, cylinder head combustion chambers, exhaust ports, exhaust valve throats and exhaust manifolds and tubular headers.

The specific formulas will differ depending on the application. Specialized thermal barrier coatings applied to piston tops aid in reflecting heat, reducing the amount of piston expansion (allowing the builder to maintain more consistent wall clearance) and protecting the piston from extreme temperatures encountered in forced induction systems. For forced induction and nitrous applications, highly specialized thermal barrier coatings are available to not only enhance combustion efficiency but to protect the piston from potential heat-related damage. By applying a ceramic heat shield coating to areas exposed to the combustion process (chambers, valve faces,

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exhaust valve throats, exhaust ports, piston tops and the exhaust path), combustion efficiency can be enhanced, which aids in producing additional power. Essentially, thermal barrier coatings applied to the combustion and exhaust path serve to contain combustion heat energy, greatly reducing heat soak and resulting wasted thermal energy.

Bear in mind that the quality of application of a ceramic coating (especially for internal engine components) is extremely critical. The last thing you want is for hard and potentially damaging ceramic to break loose and contaminate the engine. That's why you need to use established coating services such as those listed in this article. When properly applied, the coating not only adheres to the applied surfaces, but permanently bonds to the material, essentially becoming part of the base material. If substandard application practices are used, the coating may not be fully bonded and

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MAHLE Clevite, as an example, uses a polymer-based moly-graphite coating on their performance bearings. Specific formulas may vary but the goal is the same: to promote oil retention and to provide a protective lubricity surface in the event of inadequate or temporary reduction of oil delivery, such as during a cold start or temporary starvation.

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could flake off. In other words, don't try this at home. In the course of building engines for 24-hour endurance racing, I've had many dozens of engine build components ceramic coated (heads, pistons, valves, exhaust) with absolute success, but I've seen a few devastating issues with components that were "coated" by inexperienced mom 'n pop shops that caused serious damage. Don't be afraid of ceramic internal coatings....the top shops do an outstanding job, and they know what they're doing. Their specific processes are kept highly confidential (they could tell you how it's done, but then they'd have to kill you). Don't be tempted to cheap-out and go for bargain basement services. If surface prep, temperature and application isn't right, you're asking for problems. While I admit that I haven't used all of the shops listed in this article, but I have used the services of Swain and Polydyn, and have never had a problem. After

(continued)



Specialized wrist pin coatings such as the Casidium treatment shown here increases pin lubricity.

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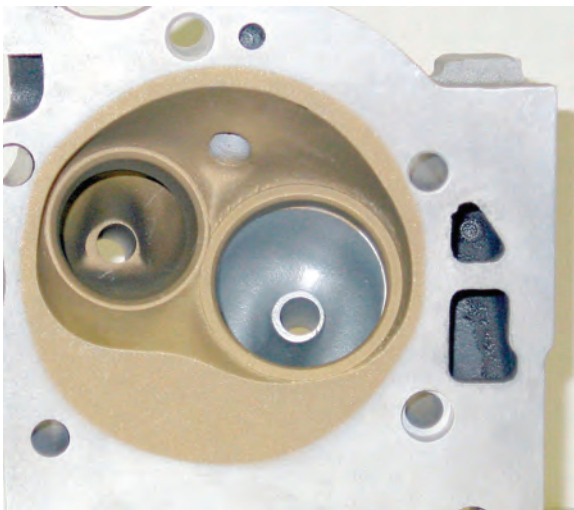
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Ceramic top coatings on pistons serve as a thermal barrier, reducing heat soak and protecting the piston from extremes of heat. Anti-friction (usually moly) skirt coatings provide superior oil retention and provide a slick surface to reduce skirt-to-wall contact wear.



In addition to piston dome coating, the same high-temperature heat barrier coating can be applied to the combustion chamber, all valve faces, exhaust valve throats and exhaust valve ports, which completely encapsulates the combustion stream path (courtesy Dart).

experiencing my initial results years ago with two endurance engines where I took advantage of thermal barrier, anti-friction and oil shedding coatings, I became an avid fan of the processes, as our engines produced measurable increases in power and significant resistance to wear.

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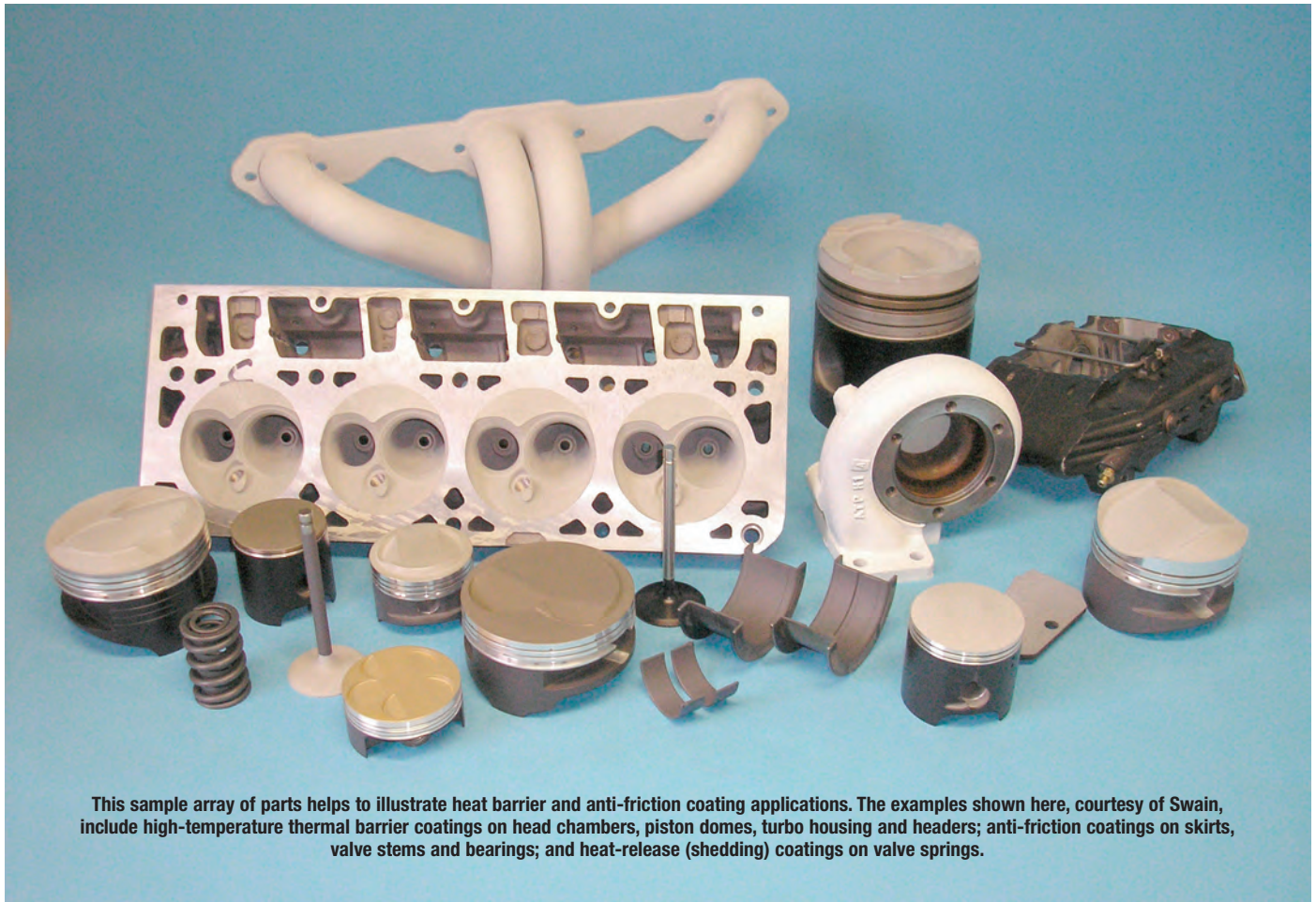
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ENGINE COATINGS

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This sample array of parts helps to illustrate heat barrier and anti-friction coating applications. The examples shown here, courtesy of Swain, include high-temperature thermal barrier coatings on head chambers, piston domes, turbo housing and headers; anti-friction coatings on skirts, valve stems and bearings; and heat-release (shedding) coatings on valve springs.

ANTI-FRICTION, OIL MANAGEMENT AND HEAT-RELEASE COATINGS

Anti-friction coatings are applicable to surfaces that make, or potentially make contact, such as (but not exclusive to) main bearings, rod bearing, cam bearings and piston skirts. Anti-friction coatings, also called lubricity coatings, provide a temporary lubricity when/if the surface is starved for oil, upon cold-starts, etc., but also serve to retain oil on the surface. While specific anti-friction coating formulas vary among the coating services, the materials are generally composed of moly, graphite or Teflon based materials. The intent is to provide better oil retention and to provide a super-slippery surface. Piston skirt coatings are generally applied at an average thickness of about .0005" per side, which might provide about a .001" increase in piston overall skirt diameter. Since the moly is applied in such a thin layer, no additional bore dimension changes are required to run "moly-coated" pistons. Unless otherwise instructed by the

piston maker, DO NOT compensate for the added moly coating when finishing your bores.

In addition to anti-friction coatings, specialized materials called "oil shedding" coatings treat metal surfaces to repel oil, in order to reduce parasitic energy losses that would normally be caused by oil cling. Applications include crankshaft counterweights, connecting rods. In addition to reducing parasitic drag, these coatings (also referred to as "oil drainback" coatings) can be applied to specific surfaces to prevent oil cling and to speed-up oil return to the sump, such as the inside of valve covers, oil pan walls, windage trays and even oil pumps. Applying an oil-shedding coating to the flow areas of the pump (gears and passages) allows the pump to more efficiently move oil, reducing the amount of oil that clings to the passage surface areas. Think of it as an aerodynamic body effects approach that reduces the drag coefficient for the oil pump.....an oil

shedding coating lets oil move through the pump faster while reducing the amount of oil that "hangs around" by sticking to passage walls.

Valve covers represent a unique opportunity to help control temperatures that would otherwise encase the valvetrain, in addition to promoting quicker oil drainback inside the covers. A thermal barrier coating can be applied to the cover exterior, while an oil shedding coating can be applied to the interior. This dual coating combination helps to reduce radiated cover temperature, while preventing oil from clinging to the cover roof and walls, allowing oil to scoot back to the moving parts where it's needed.

Heat emitter coatings represent yet another specially-formulated application that, unlike a ceramic barrier coating that prevents heat transfer, serve to promote the release of heat. This type of coating can provide a distinct longevity advantage to components such as valve springs, which serves to prolong spring life.



Camshaft bearings are readily available already coated with moly from several bearing makers. Or, you can send your bearings out for coating.



Ceramic coating of exhaust manifolds or tubular headers act as a heat barrier, reducing exterior surface temperature (and heat radiation inside the engine bay) and promote a more efficient exhaust flow, in addition to the obvious corrosion prevention (courtesy Cerakote).

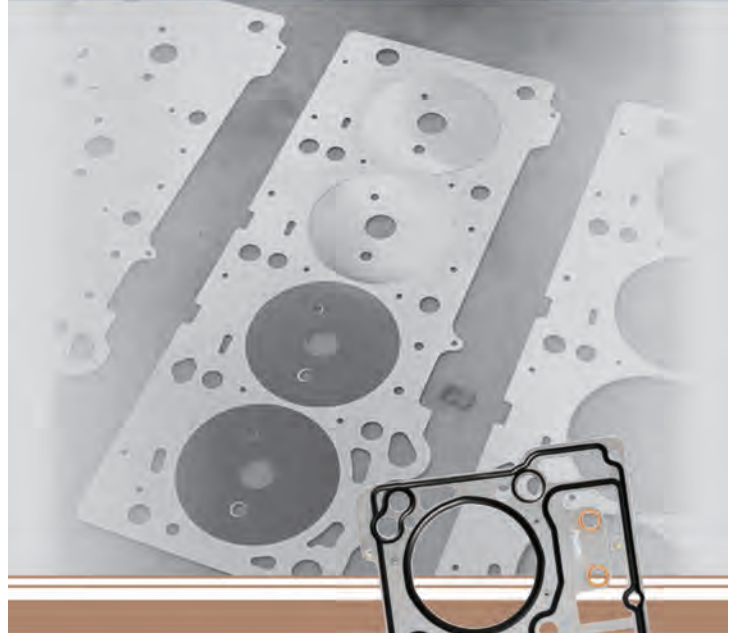
DIAMETER / CLEARANCE INCREASES

In addition to providing power enhancement and lubricity improvements, specialized coatings (or other specialized processes) are sometimes available to increase the surface diameter of a part, or to restore a worn part. Using an appropriate process, a skilled coater may be able to build up piston skirt diameters, restore cam journal dimensions, etc. Services and specific applications vary, so check with the coating shop of your choice. Keep this in mind as a potential answer to a specific dimensional or clearance issue.

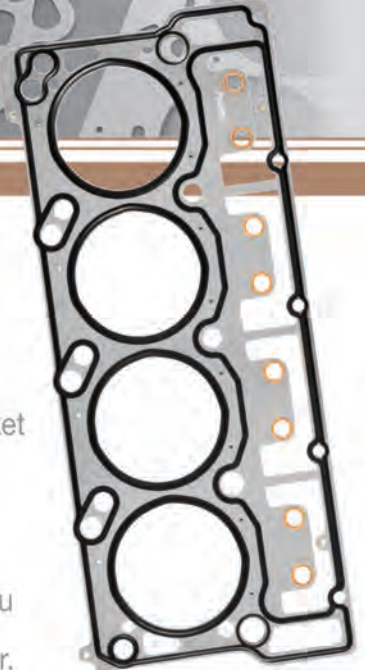
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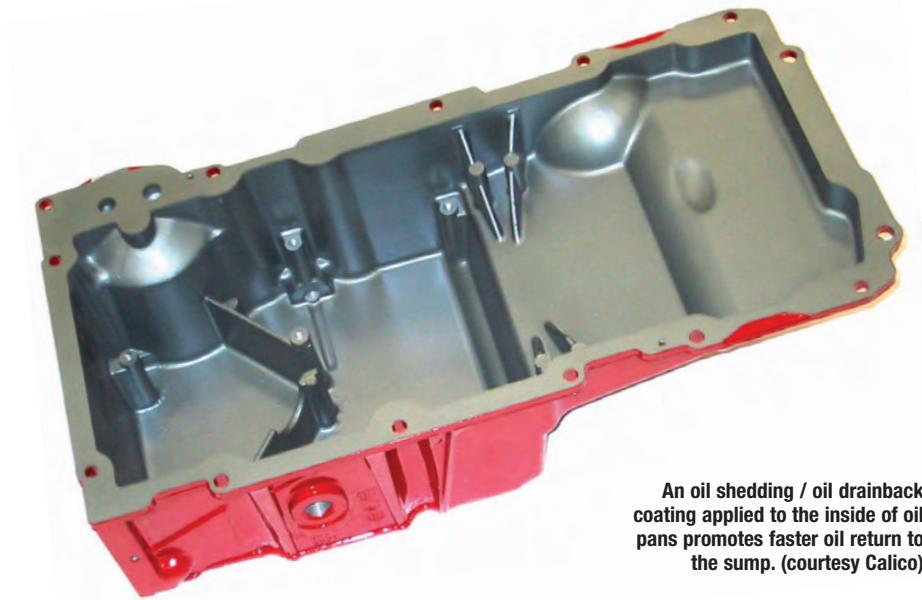
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POWDER COATING, ANODIZING AND HYDROGRAPHICS

POWDER COATING

The process of powder coating is much more simple than most folks realize. This simply involves applying dry “thermoset” or “thermoplastic” paint powder, followed by oven-curing, which melts and flows the dry powder, resulting in a tough, protective finish.

Typical powder coat application involves spraying the powder in a state of electrostatic charge. The coated part is then heated to approximately 320 - 410 degrees F (typically around 395 degrees F), which causes the powder to melt and flow, creating a continuous film coating. Once cured, powder coating provides a very durable protective finish that is highly resistant to chipping, peeling or cracking and weather/road condition exposure. Types of powder vary in terms of resistance to heat, but powders are



An oil shedding / oil drainback coating applied to the inside of oil pans promotes faster oil return to the sump. (courtesy Calico)

offered that will withstand as much as 100 degrees F without discoloring. For automotive use, a thermoset type powder is used to better withstand heat environments.

The application is fairly straightforward. The part to be coated

must be clean and must provide a decent “tooth” for paint adhesion. Typically this will involve blasting the surface with aluminum oxide or other media (but avoid silicon glass bead, as this can contaminate the surface). The part is then washed and dried.

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Anodizing alloy parts involves an oxidation process as opposed to a coating process. For the sake of appearance, color dyes are added to provide the color(s) of choice. Anodizing protects the surfaces from further oxidation. Hard anodizing (depending on the application) is also available to provide a harder, more dense surface.

Powder spraying is done with an electrostatic spray gun (or in a powder-emitting tunnel), while the part to be sprayed is grounded. Because the powder particles are electrostatically charged, the powder wraps around the part, covering all surfaces. The powder will remain on the surface as long as the electrostatic charge is present (if the part is bumped during transport into the curing oven, the powder can fall off). Once the powder paint has been applied, the part is carefully moved into a curing oven, where it's baked at 360-400 degrees F to as high as 550 degrees F (depending on the specific application and type of powder). Note: It is preferable to pre-heat the part prior to paint, which serves to cook off any surface oils, fingerprints, etc. When the part is pre-warmed in this manner, the powder paint adheres better, especially to small nooks and crannies.

While some powder coating shops may offer only a limited color selection, powders are actually available in an incredible array of colors and finishes, including flat matte, semigloss, satin, high gloss, pebble finish, "hammered" textures, wrinkle finish and more. Even metallic chrome-like, neon and

(continued)



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Custom color anodizing is available from a select number of shops. These exhaust port plates were custom anodized in a violet color. Since anodizing, especially for a part that was previously anodized in a different color, results in a dull, matte finish. If gloss is desired, the part must be polished after stripping, or “bright dipped” by the shop after color anodizing.

translucent finishes are available. You may need to search a bit for a shop beyond your immediate locale for certain colors and/or textures, but it’s all available.

Regarding powder-coat resistance to glycol brake fluid, brake fluid won’t blister or remove the powder coat, but if left exposed for a long enough period of time, exposure to brake fluid can create a stain or dull sheen, or at worse, the powder coat can turn “muddy” and pliable. So, even though a piece has been powder coated, you need to continue to be careful to avoid glycol brake fluid exposure.

ANODIZING

It’s important to understand that anodizing is not a coating, and has nothing in common with coatings such as paint, powdercoat or plating. Anodizing involves an electrolytic oxidation process that alters the surface of an alloy

component, with the primary benefit involving surface protection, and a degree of wear-resistant surface hardening. The addition of a dye provides the desired color, which is absorbed into the oxidized surface. Aluminum materials may be anodized clear or in any of a variety of colors. Aluminum material may be anodized in a variety of colors, including “clear.”

During the process, aluminum oxide is generated during anodizing at/near the surface, creating aluminum hydrate, which provides the additional surface hardness. Since the anodized surface is also fairly porous, it readily accepts a color dye. In terms of increasing surface hardness, varying levels of hardness are possible, depending on the component’s application.

The treatment is referred to as anodizing because the part being treated forms the anode of an electrical circuit. The process alters the microscopic texture

of the alloy surface and the crystalline structure of the aluminum surface.

The anodizing process applies to alloys only. Anodizing steel or iron materials will result in unappealing oxidation. While the process can be applied to aluminum castings, results may be sketchy due to irregularities or impurities in cast materials, as a dull gray or non-uniformity color may result. The best choices for anodizing are aluminum billet/machined/forged materials.

The appeal of the anodizing process involves avoiding surface corrosion, to apply a color to the surface, and depending on the level of anodizing, to increase surface hardness. The final anodized part’s surface will readily allow the surface finish to be revealed. By this, I mean that you can consider clear or color anodizing as an almost translucent finish. If you want high gloss, the part must be polished prior to anodizing, or a “bright dip” treatment following anodizing. If

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you want a satin or semigloss finish, the part can be buffed with a light abrasive (such as Scotchbrite) prior to anodizing. If you want a matte finish, don't perform any polishing or buffing.

Common applications for color-dyed anodizing include aluminum pulleys, carburetor spacers, brackets, -AN hose and fittings, spark plug wire dividers, miscellaneous spacers, boost pressure regulators and wastegates, etc. As long as the component is made of a machined or formed aluminum alloy, it can be anodized. As noted earlier, castings may be anodized, but appearance results will vary depending on the make-up of the casting.

Another potential issue to be aware of is material uniformity. If you plan to have pieces color anodized, all components must be made from the same material stock. Variances in the alloy mix can (and usually do) result in color variances. For example, if you fabricate a handful of items from a variety of aluminum stock (sheet, round or square tubing, etc.),



Anodizing protects the alloy surface from oxidation and corrosion. The color dye is added simply for the sake of appearance.

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differences in the alloy formula can easily result in varying shades of the desired color. If you opt to fabricate items from aluminum stock, all pieces should be made from the same stock (preferably with all pieces cut/machined from a single piece of stock). If you grab miscellaneous pieces of aluminum from your inventory or from a local scrap metal supplier without paying attention to the alloy content and/or grade of aluminum, even when the batch of items is anodized at the same time using the same color dye, you may very well end up with mismatched colors. For instance, if all pieces are to be anodized in a blue color, if the grades of aluminum differ, some pieces may be darker or lighter than others. Be aware of this potential concern. If dissimilar alloy materials will be in close proximity to each other when installed, be aware that the colors may not perfectly match!

You may have noticed when buying color-anodized -AN hardware that even from the same manufacturer, blues or





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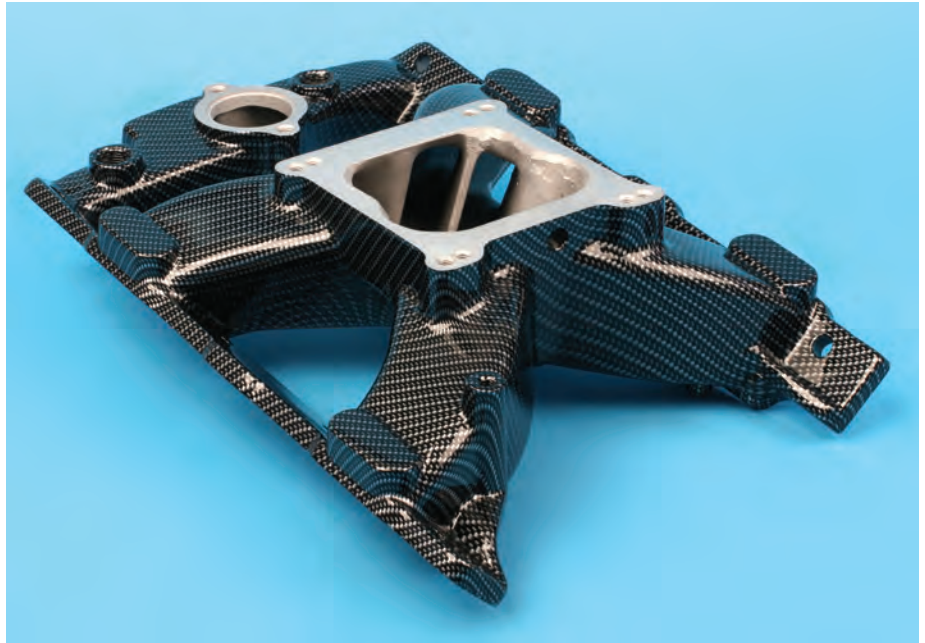
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reds may not be consistent. This is likely because the pieces may have been machined from a variety of billet stock. While integrity and durability isn't compromised, the final color hues may vary.

HYDROGRAPHICS

This process is strictly cosmetic and serves no mechanical or thermal function. Also referred to as "wet-dip," "ink film transfer," or "ink transfer printing," this process involves the application of a graphic ink film that "wraps" onto a surface to provide a desired appearance. Relative to engine builds, applications can include valve covers, timing covers, oil pans, intake manifolds and various brackets. Literally thousands of film graphics are available, including those that provide the appearance of camouflage (in various colors/designs), blue backgrounds with water droplets, skulls, barbed wire, carbon fiber, machine turnings, diamondplate metal, various woodgrains, and more. If you can



Hydrographic films are available in a dizzying array of designs. The intake manifold shown here was treated with a "carbon fiber" film. Hydrographics, or "wet film printing" provides only an appearance benefit. A high-temperature clearcoat protects and seals the ink film.

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Imagine it, the graphic film probably exists.

In basic terms, the graphic is applied as follows: the part to be treated is cleaned and primed, then painted with an appropriate base color (since most films are somewhat translucent, the base color will influence the final appearance). For example, if you want a pair of valve covers done in "orange" carbon fiber, an orange basecoat is applied. If you want a traditional carbon fiber look, a black basecoat is applied. The graphic ink film is then laid on a water surface (in a temperature-regulated tank designed for the process). Water begins to break down the binders in the film, and an activator is then sprayed onto the floating film to fully break down the binders, to leave a floating "oil slick" of the graphic. The part is then carefully dipped through the film, with the film clinging to the part's surfaces. Any film that has nowhere to attach floats loosely and is shaken off. There is a skill involved here...it's not as simple as dipping an Easter egg. Once the part is removed from the water, it is dried and then clearcoated to protect the film. For parts that will experience heat, such as intake manifolds, valve covers, etc., a special high-temp urethane clearcoat is applied.

Again, a wet dip treatment is strictly for the sake of looks, where you desire a certain custom graphic appearance. ■



Mike Mavrigian has written thousands of technical articles over the past 30 years for a variety of automotive publications. In addition, Mike has written many books for HP Books. Contact him at Birchwood Automotive Group, Creston, OH. Call (330) 435-6347 or e-mail: mike@birchwoodautomotive.com. Website: www.birchwoodautomotive.com

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(Examples)

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*NOTE: MAHLE Clevite and Federal-Mogul offer specific parts with coatings already applied, but do not offer general coating services to the public.

ALSO NOTE: Some crankshaft and connecting rod makers now offer optional oil-shedding coatings for their respective products.

EXAMPLES OF ANODIZING SOURCES

(Refer to your local phone directory, or perform a Google-search for anodizing shops in your region. Listed below are three sample anodizing shops that I've used in the past with great results.)

McNICHOLS POLISHING & ANODIZING

12139 Woodbine
Redford, MI 48239
313-538-3470

METFIN

4th St. at Railroad
North Wales, PA 19454
215-699-3505

FORT WAYNE ANODIZING

2535 Wayne Trace
Fort Wayne, IN 46803
260-424-1030

POWDER COATING AND HYDROGRAPHICS

These services are available nationwide, usually with shops in close proximity to all cities and towns. Check your local directories or Google to find a shop in your area. You shouldn't have any trouble finding a good powder coater nearby, but finding a good hydrographic (wet dip/ink transfer) shop may present more of a challenge. If you have trouble finding a wet dip shop, check with your local gun and/or archery stores, since wet dip camouflage treatments are common for applications such as shotguns, bows, etc. A competent wet dip shop should have access to a wide variety of ink films, such as carbon fiber, diamondplate, etc.