BY TECHNICAL EDITOR LARRY CARLEY
LCARLEY@BABCOX.COM

Surface Coatings and Treatments

When it comes to preserving performance parts, it's the 'Icing on the Cake'

Various kinds of coatings and surface treatments can be applied to engine parts like icing on the cake to improve durability, enhance scuff resistance and lubrication, control heat, boost thermal efficiency and reduce friction.

No single coating or surface treatment can do it all because different parts applications require different treatments. But knowing which kinds of coatings and surface treatments will work best for you can give your engines a significant advantage over your competitors. And the best place to get this kind of advice is directly from the companies who make and apply the various types of coatings.

If you are one of those who still believes coatings and surface treatments are more of a gimmick than a necessity, or that coatings or surface treatments don't provide that much benefit for what they cost to apply, you might want to reconsider your position after reading this article.

There are a lot of myths and misinformation about coatings and surface treatments.

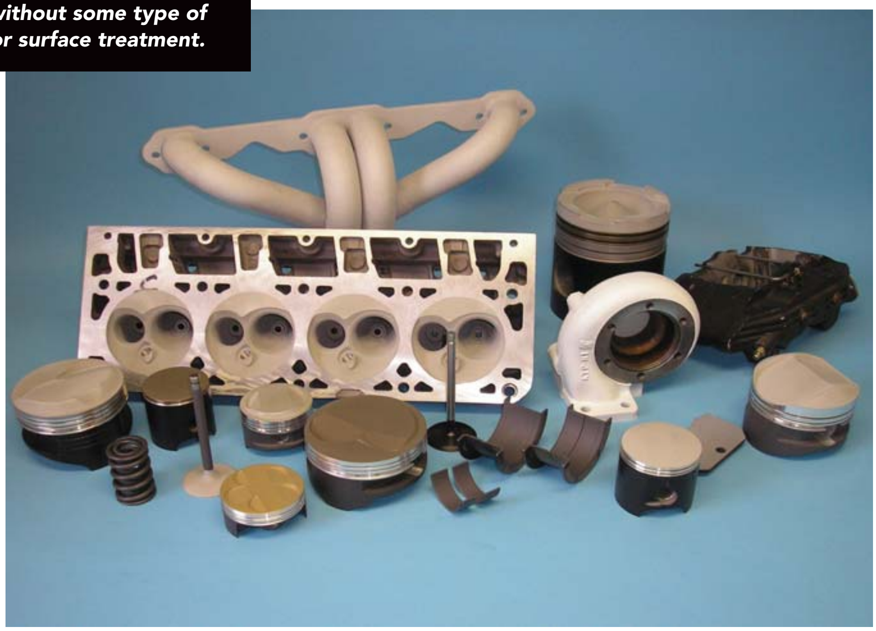
Some coatings will reduce friction and parasitic horsepower loses while others help valve springs and other parts run cooler and last longer. Some coatings can insulate against heat and reduce operating temperatures while others help cool by radiating and dispersing heat. Some coatings will last as long as the parts they are applied to while others are temporary and will sacrifice themselves to protect those parts.

The physical properties, performance and surface adhesion of any given coating or surface treatment will vary depending on the makeup of the product, what it is intended for, how it is applied and what it is exposed to. The biggest fear expressed by non-believers is that a coating may flake or peel off and end up causing more problems than it prevents. But when properly applied and used, that is seldom an issue.

Reasons for Coating

Many engine parts would not survive without some type of coating or surface treatment.

Aluminum pistons in an engine



Many engine parts would not survive without some type of coating or surface treatment.

Three Most Common Issues Coatings Address

1. Friction
2. Heat
3. Corrosion

with aluminum cylinder bores require a thin coating of iron on their skirts to resist scuffing. The ring lands and even the entire piston in some engines may be hard anodized to improve surface hardness and wear resistance.

New methods of anodizing can also incorporate molybdenum disulfide into the micropores of the surface to add much needed lubricity and friction reduction.

Anodizing also increases corrosion resistance for aluminum parts, and is often used in marine engines to protect aluminum heads and blocks. Anodizing also allows aluminum parts to be colored with dye to enhance their appearance and to provide a longer lasting and more durable finish than most paints.

Uncoated aluminum cylinder bores are relatively soft and have little wear resistance, so the cylinders in some aluminum block engines and electroplated with Nikasil or a similar blend of nickel and silicon carbide to form a hard, wear-resistant surface layer.

(***Note:*** *Nikasil is a trademarked process by Mahle, while "nicasil" is the generic name for these types of coatings.*)

Uncoated aluminum cylinder bores are relatively soft and have little wear resistance, so the cylinders in some aluminum block engines and electroplated with a nickel and silicon carbide to form a hard, wear-resistant surface layer.

The only substance harder than silicon carbide is diamond. The resulting surface layer, which is only about .0025″ to .005″ thick, has a hardness rating of 600 on the Vickers scale and a sliding hardness of 58 to 60 Rockwell C, which multiplies wear resistance 3X to 10X over an untreated cylinder.

The surface treatment also attracts and retains oil to improve ring and piston lubrication. The same process can also be used in conventional cast iron blocks and aluminum blocks with iron liners, but is not used in blocks made of **Compacted Graphics Iron** (CGI) because it doesn't stick well to CGI and because the graphite in CGI provides natural lubricity for the rings.

Wrist pins are another engine component that can benefit from a special coating. Wrist pins are highly loaded, lightly splash lubricated and forced to run with very tight clearances.

A process called **Physical Vapor Deposition** (PVD) can be used to apply an extremely thin (only a few microns thick!) coating of chromium nitride, titanium nitride or other metal oxides to the surface of the wrist pin. The coating is applied by placing the wrist pin inside a vacuum chamber, negatively charging the part with electricity and vaporizing the material that is being applied as the coating.

The vaporized atoms are attracted to the negatively charged surface and form a long-lasting bond. The resulting coating is very hard (2,400 to 3,800 Vickers) and extremely heat and wear resistant, reducing the risk of wrist pin failure in a highly loaded performance engine. A similar coating process called **Chemical Vapor Deposition** (CVD) can apply vaporized non-metallic materials to electrically charged parts.

COAT SIZE

Piston skirt coatings are usually about .001" thick or less, but most piston manufacturers say the added thickness of the protective coating can be ignored when fitting pistons to cylinders even though the coating does reduce actual clearances slightly.
A thinner coating is usually applied to engine bearings, typically .0002" to .0003" thick. The coating is thin enough that it won't affect installed normal bearing clearances.

Another process that uses PVD and/or CVD with a charged plasma beam can apply a thin layer of amorphous carbon to the surface of a part, forming a hard (3,200 Vickers), wear-resistant, low friction coating of **Diamond-Like Carbon** (DLC). DLC coatings are used on wrist pins in many high end racing engines to prevent wrist pin failure. It is also being used on intake and exhaust valves, and lifters to improve durability.

Various types of DLC coatings are available and are engineered for specific types of parts. Gears, for example, require a variation of DLC that is more resistant to sliding wear.

Coatings to Reduce Friction

This category includes the PVD and DLC coatings previously mentioned, plus a whole range of dry film lubricants such as molybdenum disulfide, tungsten disulfide and/or PTFE (Teflon) mixed with some type of polymer surface coating. Anti-friction coatings are often viewed as "insurance" coatings to protect the engine and reduce the risk of galling or seizure if the engine loses oil pressure during a race.

The coating creates a sacrificial layer that can provide temporarily lubrication in critical situations that would otherwise result in metal-to-metal contact and catastrophic parts failures. These types of coatings are typically applied to piston skirts and engine bearings, but may be used on other engine parts too such as camshaft lobes and valvetrain components.

An added benefit with anti-friction coatings is usually cooler oil temperatures, as much as 20 to 30 degrees F cooler.

Are these anti-friction coatings worth the extra cost? A lot of racers say it's the best insurance policy they ever bought. A set of coated pistons and bearings only adds a couple hundred bucks to the cost of the engine. If something goes wrong during a race and the engine overheats or loses oil pressure, a coating that sacrifices itself to save an expensive racing crank or the engine itself will have been money well spent.

Thermal Barriers

Thermal coatings include both the spray-and-bake metallic/ceramic compounds and plasma sprayed compounds that are often applied to exhaust headers, the tops of pistons, combustion chambers in aluminum heads, and intake and exhaust valves to reflect heat. This keeps parts cooler and improves thermal efficiency. Thermal barrier coatings are usually only about .001″ to .003″ thick, and require careful surface preparation for good adhesion.

When a thermal coating is applied to the top of a piston, more heat stays in the combustion chamber and less heat goes into the piston. This can make a big difference in high-heat applications such as blown or turbocharged engines or

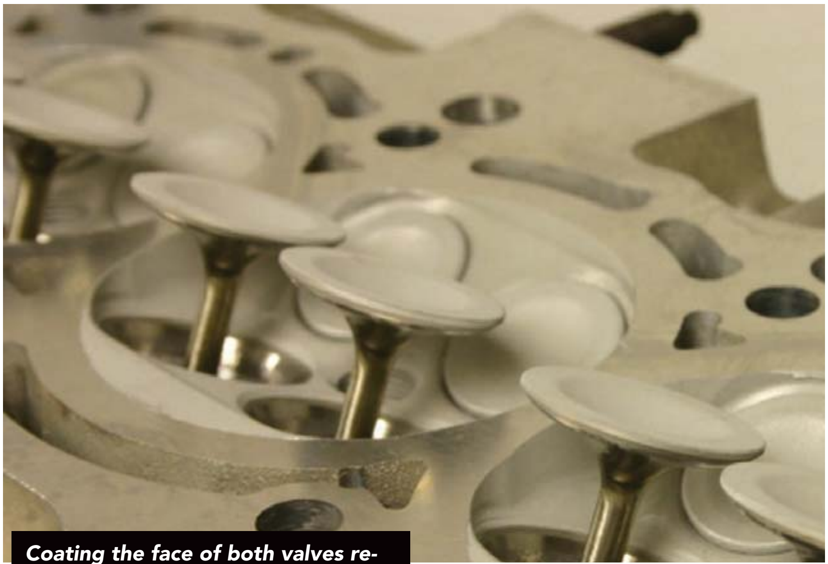
Coating experts say that customers for coated engine parts are coming from all over the automotive spectrum with one thing in common – the need for protection against wear and a gain in performance.

those using nitrous oxide. Coated pistons are also used in many diesel engines. Coating suppliers tell us that in gasoline engines, top coated pistons are usually good for an extra 10 or more horsepower, and up to 30 or more horsepower in a diesel application.

When applied to exhaust headers, thermal coatings also deliver a lot of bang for the buck by retaining heat and energy in the exhaust. The coating insulates the pipes and increases exhaust velocity, which in turn improves combustion scavenging and power (7 to 10 hp typically). If the coating costs $200 to have it applied, that's roughly $20 to $30 per horsepower gained – which is a relatively cheap power gain.

Exhaust thermal coatings provide additional benefits, too. By keeping more heat within the exhaust system, underhood temperatures are also reduced as much as 40 to 50 degrees depending on the application. Everything runs cooler and better.

On a street vehicle with catalytic converters, a thermal barrier coating on the exhaust manifolds or headers allows the cats to reach light-off temperature sooner to reduce cold start emissions. The coating will also



Coating the face of both valves reflects heat back into the combustion chamber and helps the valves run cooler (especially exhaust valves).

help keep the converter lit at idle and low speed for more efficient operation and cleaner exhaust.

Thermal barriers coatings on exhaust components protects the pipes against rust and corrosion, and is far more durable and long-lasting than high temperature paint.

Thermal coatings can also be applied to combustion chambers in aluminum cylinder heads. Aluminum absorbs a lot of heat from the combustion chamber. Heat dissipation reduces combustion temperatures somewhat and lowers the risk of pre-ignition and detonation. It also allows the use of high compression ratios, but it also robs some of the heat energy from the combustion process that would otherwise generate more pressure on the pistons. With a high-octane racing fuel, pre-ignition and detonation are less of an issue, so coating the inside of the combustion chamber with a heat insulating coating does the same thing as coating the tops of the pistons. It keeps the heat in the chamber and squeezes more power out of the engine.

Thermal barrier coatings can also be applied to the underside and flange surfaces of intake manifolds, and the carburetor or throttle body flange to keep heat away from the incoming air charge. On a normally aspirated engine, every 10 degree

Ceramic thermal barrier coatings used on the top of a piston allows the piston to reflect heat back into the combustion chamber for better combustion and more power.

reduction in inlet air temperature can increase engine power almost one percent (cooler, denser air equals more power). On a turbocharged or supercharged engine, a 10 degree reduction in inlet temperature is good for up to two percent more horsepower.

Another type of thermal coating is the "thermal dispersant" that absorbs and dissipates heat rather than reflects heat. This type of coating can be applied to oil pans, valve covers, radiators and heat exchangers to help radiate heat away from these parts more efficiently. It also works well on valve springs by helping the springs run cooler. Many racers say coated valve springs last 2X to 3X longer than uncoated valve springs.

Coatings that Shed

A coating that is both a thermal dispersant and sheds oil is also a good choice for crankshaft counterweights. These types of coatings help pull heat away from the journals while reducing crankshaft drag and windage by flinging oil off the spinning crank. Oil shedding coatings can also be used on the undersides of pistons to reduce high rpm oil windage drag.

Oil-shedding coatings often contain PTFE (Teflon) or similar fluoropolymers, and may be applied to any internal engine part (connecting rods, cranks, the inside surface of valve covers, timing covers, oil pans, intake manifolds, etc.) to improve oil return to the crankcase.

Such coatings also help reduce the buildup of varnish and sludge deposits inside an engine, and protect bare metal surfaces from rust and corrosion. Added benefits include reduced oil foaming and oil temperature.

Protective Powder

Though many engine builders leave the final assembly and finishing work to their customers, a completed engine has to look good especially if it is going into a street rod, classic muscle car or show car. Powder coatings are often used as an alternative to paint for finishing the external surfaces of engine blocks, heads, valve covers, oil pans, timing covers and intake manifolds. Unlike paint, which is sprayed on wet and uses a solvent to hold the paint in suspension until it dried, powder coatings are sprayed on dry with an electrostatic sprayer and is heat-cured to form a tough, long lasting protective coating.

As with painting, proper surface

preparation is essential for a high quality and long lasting finish. All surfaces must be clean, dry and oil-free. The surface of the part is then chemically etched or sandblasted to promote good adhesion of the powder coating. If a powder coated surface needs to be redone, the original powder coating can be removed chemically (acetone or methylene chloride) or by sandblasting.

Plain Ol' Paint

High temperature engine paints and epoxies are coatings that can be applied to engine parts for cosmetic purposes and corrosion protection. Aluminum blocks, heads, timing covers and intake manifolds are often left "as is" because fresh aluminum has a nice bright finish and doesn't rust like iron or steel.

Aluminum forms a protective layer of oxide on the surface that protects the metal underneath. But aluminum can stain over time and take on a grungy appearance if it is exposed to dirt, grease, oil and road splash.

Coating aluminum with clear paint or aluminum-colored paint helps the metal retain its like-new appearance longer. Aluminum can also be polished to a chrome-like finish, too – which can also benefit from a top coat of clear paint or some type of protective sealer.

As with powder coating, proper surface preparation is essential for a long lasting finish that won't peel or flake.

Chrome Finishes

Chrome used to be the "it" finish for glamorizing and dressing up valve covers, oil pans and various engine accessories. The more chrome, the better. Today, it's more about powder coating and anodizing. Chrome plating is usually applied electrochemically by dipping steel parts in an acid tank, but it can also be applied to metal or plastic parts electrostatically in a vacuum chamber.

The quality of a chrome finish depends on surface preparation (cleaning, degreasing and polishing the part), whether or not a base plating used (nickel prevents corrosion), the thickness of the plating and the number of layers (more is better).

Chrome plating cleans up easily and has a nice shiny appearance, but if it is applied without a base coating it provides minimal corrosion resistance. Cheaply plated parts typically start to rust rather quickly, and the plating may flake or peel off over time. Chrome-plated exhaust headers usually blue and discolor rather quickly, too, and don't offer the same kind of durability or heat retention that ceramic/metallic coatings offer.

A process called hard chrome plating can be applied to crankshaft journals to improve hardness and durability. It can also be used to build up badly worn journals so they can be remachined back to their original dimensions. ■