Anodized titanium banjo bolts. Photo: Sandwell

Surface engineering

John Stowe considers means to enhance the properties of component surfaces

Readers of RET have been exposed to a number of reports in the areas of both coatings and materials in recent years, culminating with a couple of 'omnibus' articles that reviewed a broad range of material types and options - Focus: Advanced Metals (RET 034) and Focus: Coatings (RET 031). In between the world of base materials, and of top coatings, lies the realm of surface treatments, and RET has run a few feature articles in this sphere as well (including REM in RET 026 and RF85 in RET 038). This is a rapidly growing field, and it now seems appropriate to look at a broader spectrum of these processes as well.

Generally speaking, most of these technologies fall under the classification of 'surface engineering'. Surface engineering has become its own discrete branch of materials science, one which deals with how the surface of a solid reacts with, and responds to, the environment in which it resides through the use of a separate surface material or treatment. The goal of surface engineering is to provide improved characteristics that would not be obtainable from either the base material or the secondary treatment individually. While the term 'surface engineering' is comparatively recent, many traditional techniques fall within its scope. Almost any material can be made to respond to surface engineering technology, which is used in power generation, aerospace, biomedical, machine tool, electronic, and powertrain applications.

In the performance powertrain world, surface treatments are used for a variety of material improvements, including hardness and durability, lubricity, corrosion resistance, to serve as a substrate for subsequent coatings, and to prevent component failure caused by cracks propagating from surface stress risers. They can also be used to either increase or reduce thermal and electrical conductivity. In many cases, these processes overlap with, or are used in conjunction with, coating technologies, and the dividing line between the two classifications is as thin as the molecular films that frequently characterize them. In this article, we will apply the term 'surface treatment' broadly, and look at case hardening, peening, and superfinishing, as well as some ion-bonded and/or passivation/conversion treatments. Some of the processes being discussed here will fall into more than one of these categories, and are increasingly being combined. Additionally, there are many different trade names for these treatments; frequently, these are for essentially the same processes.

CASE HARDENING

Dating from ancient times, case hardening was one of the first surface engineering techniques to be employed for metal improvement, although the chemistry was, of course, completely unknown at the time. Carburizing must have first occurred when an intelligent metalsmith noticed the improvement in the hardness of his ferrous products when he removed his chunk of wrought iron from the glowing charcoal bed and then subsequently chilled it in water to cool it down quickly. Once the connection had been made, that it took both the charcoal and the quench to achieve this, the obvious next step would be to pack the iron or steel with as much charcoal, or even better, ground up animal horns and hooves, and/or other carbonaceous material and then to heat it for a sustained period of time in a sealed container (this is the 'solid pack' method). Case (surface) hardening was born, and it is reasonable to believe that this method was 'rediscovered' in many times and places in the ancient world. The methods have improved since then, and in addition to the original 'pack' hardening process, carburizing can be achieved by immersion in liquids or gases.

One of the advantages of carburizing is the progressive infusion of carbon into the base material. Because of this, the change in characteristics from the ductile core, and the hard, more brittle, surface is progressive. As a result, there is no discrete 'layer' to flake off or fracture. Carburizing results in the growth of the component being treated, with roughly one-half of the infused material growing outward, and the second half absorbed inward. Hence, the part growth is a good 'seat of the pants' indicator of the case depth.

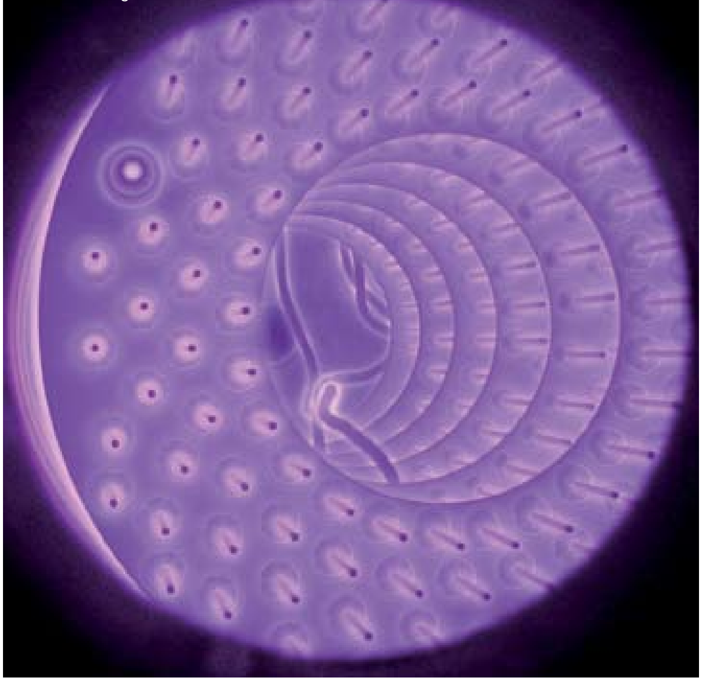
Carburizing is still an important process; easily machined, inexpensive, ductile low alloy steels frequently have a carburized case applied for use as shafts, precision locating pins, positioning components, and the like. The normally un-hardenable austenitic stainless steels can also be carburized, greatly expanding their utility. When used for shafting, the hardened surface normally receives a subsequent ground finish, and the finished case depth is commonly developed to about 1 mm deep. In the shop, quickly made cutting tools and parts can be machined from mild steel which is then heated with an oxy-acetylene torch and plunged into one of the several commercially available case hardening compounds, which usually come in powder form. These can then be re-heated, quenched, and then tempered back to the desired hardness.

NITROGEN-CARBON

Apparently, some of those ancient metalsmiths discovered that it all worked even better when the material was quenched in urine instead of water. This would have been the first example of something like today's carbon nitriding, with the necessary nitrogen being absorbed from the ammonia present in the urine. A common carbon-nitrogen treatment for camshafts and crankshafts goes under the name of 'tuftriding', which was particularly popular with performance parts in the UK. It seems as though this is now a name used generically for a number of carbon-nitrogen infusion processes. In the course of preparing this article, the author has come across other articles that have refered to nitriding and tuftriding as the same process.

Tuftriding was originally developed by Degussa as a cyanide salt bath process, one that produces a very hard surface that is also somewhat open and porous. The surface can be polished to a smooth finish after the treatment, but the pores will still remain. This has been considered to be highly beneficial for lubricant retention and after polishing the resulting surface has a low coefficient of friction as well. Part straightening is sometimes required after treatment. Glock uses a similar process, topped with a Parkerized surface for the slides on its pistols. This treatment is referred to as 'Tenifer', and we have seen at least one company at the PRI show promoting this combination as an extraordinarily good cam-to-tappet surface treatment system. Some specialists will still apply tuftriding, in addition to the full range of carbonitriding treatments discussed below.

Plasma nitriding of valves. Photo: Eltro



NOMENCLATURE

Some other trade names in the carbon-nitrogen family include 'Lindure', 'Corr-I-dure', 'Melonite', 'Sursulf', 'Arcor', and 'Koline'. Sometimes trade names come from the chemical or equipment manufacturer of the treatment process, and others are created by the contracting company that provides the treatment service. Each of these has a definite attachment to a specific variation by a particular company or supplier. 'Carbonitriding' is the designation normally applied to gaseous carbon-nitrogen surface infusion, but this has been used to describe other hardening systems. A few sources define carbonitriding as a variation of the nitriding process, as when nitriding is applied to a high carbon steel. These distinctions have been made even more confusing by the transition from salt bath to gas and ion-based systems.

Nitrocarburizing is yet another name given to nitrogen-carbon infusion systems. In some applications, this process also introduces small amounts of hydrogen, oxygen, and sulfur into the chemistry. It can be applied to both carbon and austenitic steels, by both liquid and gaseous methods. The processing benefits include particularly low distortion and predictable, low order growth. As with other carbon-nitrogen systems, the upshot is improved fatigue properties and hardness, combined with excellent seizure and scuffing resistance.

When sealed or oiled, all of these carbon-nitrogen and nitrogen-carbon processes provide excellent corrosion resistance, which is one reason why they have largely replaced one-step passivated finishes (such as bluing) on firearms, and critical machine tool parts. Currently, there are gas, liquid, and solid pack methods available for all of the ▶

nitrogen-carbon infusion methods, and, as with carburizing, these can all be 'tuned' to produce an assortment of different case depths, hardness, and surface characteristics using temperature, time, and chemistry variations.

Once dominant, solid pack infusion is now used less frequently with carburizing and carbon-nitriding as it offers the least control of all of the methods described, and it is virtually impossible to quench material directly from the 'pack' vessel. Liquid salt bath methods are very fast, but entail serious environmental difficulties, and bath cleanliness and maintenance require constant monitoring. As a result, gas, and most recently, plasma methods are becoming increasingly popular.

The nitrogen infusion process is called nitriding and this is one of the most common applications for crankshafts, where it has largely replaced tuftriding. It has a number of advantages in that it is a relatively low temperature, quench-free process that does not introduce detrimental stress into the affected component, or create undue growth or distortion. Accordingly, it is normally applied after all other machining and finishing operations have been carried out, which not only improves hardness but fatigue resistance as well. The base steel alloy must contain nitride-forming elements such as aluminum, chromium, vanadium, and molybdenum for the process to be effective. Nitriding produces among the highest hardness of the infusion processes, depending on alloy and treatment. Some steels contain alloys that act as inhibitors to the nitriding process, but recently 'selective passivation' techniques have been developed to remove these inhibitors from the surface of the steel so that a nitrided case can be developed. Hardenable steels require hardening and tempering to process temperature before nitriding, which produces a hard depth of about .01" on most crankshafts.

PLASMA AND ION SYSTEMS

All of the carbon, carbon-nitrogen, and nitrogen technologies can be implemented by ion infusion, hence, for example, the term, 'plasma nitriding'. A plasma is formed in a vacuum with high voltage electrical energy, and nitrogen ions then accelerate through the plasma to impinge on the workpiece. The base material receives the active nitrogen or carbon from this action, which also cleans the surface at an elevated temperature. (Sometimes a separate hydrogen cleaning step precedes the nitrogen infusion for this purpose.) The various processes for all of these ionic plasma technologies are very versatile, and allow complete control of the thickness of the treated zone, and with nitriding, the brittle, top 'white layer' is greatly reduced. As a result, the hard layer ductility, fatigue resistance, and wear resistance are improved over traditional techniques.

Plasma application systems can be engineered to control the process locally in the treated part with completely automated set-ups. Gas consumption and pollution are reduced to negligible quantities. The cycle time is usually faster than gas infusion though not as fast as salt bath techniques. The one downside is that plasma methods entail much higher equipment costs, as well as precise fixturing requirements when applied locally. Plasma-ion processes are not as new as the name suggests - initial work was done as far back as the 1920s- but it was the introduction of microprocessor controls to the equipment that really made it a fully controllable, commercially viable method.


Isotropic superfinished gears. Photo: Rösler

Frequently one will see a reference to 'sputtering' with plasma/ion systems. Sputtering is the result of the collision of an infusing ion with an existing atom on the base material surface. As a result of these collisions, base material atoms are released, creating an opportunity for the new ions to occupy the resulting spaces in the surface energy field. At least one specialist in this field offers a fully programmable and reproducible technology that allows complete control of the discreet layers created during the process.

Ion beam technology is the most recent method used to modify surfaces. Often referred to as 'ion implantation', this method uses a directed high-energy beam to literally drive the ions into the surface of the base material. While many ionized materials can be used, nitrogen is the most common with ferrous materials. Case depth is as much a product of impact velocity as ionic concentration, and because this is a directed process, it is strictly a local, line-of-sight operation; either the beam or the affected part must be moved to increase the area being treated.

It should not be inferred that one process is necessarily more 'advanced' than another, ie, that ion is superior to gas. In fact, one longtime ion-nitriding specialist has just announced the introduction of a new vacuum gas process for shallow-case work that produces exceptional hardness.

NEW APPLICATIONS AND COMBINATIONS

One of the advantages of ion beam technology is that it can be combined with PVD and CVD coatings to change the surface of the material. The accelerated nitrogen ions drive elements of the vapor deposited coating into the surface of the base material, creating a new, composite, engineered surface. This increases the wear resistance, and durability of the coating. This process is called either 'ion assisted coating' (IAC), or 'ion beam assisted deposition' (IBAD).

As noted, plasma carburizing can be applied to austenitic stainless steels, and the particular value of this is that it can harden these surfaces without reducing their corrosion resistance. The carburized layer retains high carbon saturation, but unfortunately develops an equally high ▶


WPC-treated crankshaft. Photo: WPC Treatment

coefficient of friction (cof) at about .55. In one experiment, when 304 stainless steel was first pre-treated by peening, and then carburized at low temperature by the plasma method, it achieved a stable cof of .2, after having been DLC coated. 'Plain' DLC-coated 304 started off in its testing at a .2 cof as well, but quickly rose to .43 during friction tests. The combination of carburizing with a DLC coating was necessary to achieve both a low coefficient of friction and performance stability in that condition. The peening step allowed the application of the DLC coating without the normal interlayer, eliminating one deposition step. This is another case of surface engineering, where separate surface technologies are intelligently combined.

Boronizing, or boriding, is another ion infusion process used to produce the same kinds of results as carbon-nitriding. Exceptionally high hardness can be developed, and the treated surface has high resistance to elevated temperatures, as well as acids. Nickel and titanium can be boronized as well as virtually any ferrous material; the treated surface can be polished to a very high finish, and heat treatable materials can be heat treated after boronizing is applied.

Flame hardening and induction hardening have limited application in the high-performance environment. Both of these are used as local heating and quenching methods; for example, an induction coil can be placed right around a camshaft bearing, which is then quickly heated and quenched immediately, producing a typical case penetration of .06″-.08″. This is just fine for high speed, low-cost surface hardening of production parts. The problem is that significant local stresses are created within the component from the localized heating and quenching. This is exacerbated by the different cross sections encountered in the part's geometry, rendering it dimensionally unstable when it becomes exposed to stresses approaching material limits. Only small, uniform-section parts, with the most favorable geometry, are likely to lend themselves to this type of heat-treating for a high performance application.

PASSIVATION

Passivation is the term used to describe the variety of processes by which metal surfaces are made nonreactive with their surrounding environment. In some cases, this means the removal of surface elements or impurities that will attract oxidation reactions. In others, this may mean the addition of new elements or compounds to form a protective layer. Often times, passivation treatments are referred to as 'conversion coatings', or simply, 'conversions'.

The original steel passivation process was black oxide, often referred to as 'bluing' or 'blacking'. Today, this is mainly used where the blue-black surface appearance is considered to be beneficial. 'Cold' black oxide is still used as a quick convenience method on small parts by individual operators, but it has been replaced by far more effective methods for general commercial use.

'Parkerizing' is now a generic term that has actually been used for a variety of steel surface treatments. Originally it was a manganese phosphate conversion but the need to develop non-strategic materials during the second world war led to the creation of the modern zinc phosphate treatment. Further improvements allowed a reduction of the immersion bath temperature to 115-130 degrees Fahrenheit, making this one of the most economical passivation systems available. There is also an iron phosphate passivation technique, which is distinct, but it, too, is now frequently referred to as Parkerizing. 'Kitchen stove' recipes for Parkerizing can be found in various gun magazines from time to time, and major gun parts distributors also sell kits for the purpose. Interesting updated variations on the blacking and phosphating technologies are offered by a UK motorsports specialist, which also provides a full range of surface treating services. These two processes are referred to respectively as 'Chemi Blacking', and 'Kephos'.

Parkerizing is increasingly coming under attack as an environmentally unsound method. A byproduct of the process is that phosphates are inevitably introduced into local surface water, and accordingly, replacement technologies are being developed. The most popular of these new conversion coatings ('Vanadate') uses vanadium as a transition metal and is fluorozirconium-based.

There is some disagreement about how passivation works with corrosion resistant stainless steels, but there is no dispute about its efficacy. One group holds that it works by leaving a transparent 'thin film' after the passivation process is completed; others believe that the process succeeds entirely by removing impurities from the surface of the base metal. Whatever the reason, repeated environmental tests such as water immersion, salt spray, and elevated temperatures with humidity verify the value of passivation on stainless steels, and the process has been a standard specification for a long time, particularly in aerospace and high tech industries.

Passivation of stainless steels is usually accomplished by immersion in an acidic bath such as nitric acid, and although there are other types used such as citric acid, nitric acid at various concentration levels still has the highest degree of commercial acceptance. It is expected that more environmentally acceptable fluids will replace it over time.

Before the passivation immersion is performed, thorough cleaning and decreasing of the components is completed by any of a number of common industrial methods. Immersion is a low temperature operation, often performed at less than 160 degrees Fahrenheit. Once the immersion is completed, a rinse cycle is performed, often with sodium dichromate, which is added so as to leave a chromic oxide film on the part surface. Sometimes, this is added to the passivation immersion bath instead. As with all immersion processes, the water used in all operations must be completely free of contaminants, and baths must maintain chemical purity.

Passivation of titanium is generally similar, but done strictly to remove surface impurities, with no film to be left.

NON-FERROUS

Pure aluminium forms its own oxide skin that protects it reasonably well from environmental corrosion, but aluminium alloys require a passivation process to produce a protective layer, which is referred to as a 'conversion coating'. The familiar anodizing process is normally conducted in an electrolyte bath of sulfuric acid, with an electric current passed through; the part being treated functions as the anode. This produces a somewhat porous aluminium oxide surface that is much harder than the base material. The thickness of this coating can be altered by immersion time in the bath, and when the oxide skin exceeds .001", it is generally referred to as hardcoating. A typical general-purpose anodized thickness is usually about .0002", with half the oxide layer 'growing outside' of the original part boundary, and the other half inside.

Besides corrosion resistance, anodizing is used to improve appearance, and the porous aluminium oxide layer can be dyed in a variety of colours, and then subsequently sealed. Aluminium has very low natural emissivity, and a black anodized exterior improves this many times over, which is why it is so prevalent on motorcycle cylinders and other similar applications. Hardcoat anodizing can be used to protect piston ring lands, and to improve wear and scuffing resistance on piston skirts. The porous surface can be impregnated with fluorocarbon polymers to enhance wear resistance and lubricity. Some companies that specialize in anodizing offer an advanced electrolytic conversion coating that is harder and tougher than hardcoat anodizing, with the ability to be applied around sharp corners without breaking down in use. Additionally, this coating is sufficiently tough to resist cracking caused by the different coefficient of expansion between aluminium oxide and aluminium. This is a micro-arc process (not a form of anodizing), which can be applied to magnesium as well. Toughened conversion coating processes have even been used to replace nickel silicon carbide on piston bores. It should be noted here that anodizing, especially hardcoat, functions as an electrical and thermal barrier.

Not all anodizing is done in sulfuric acid baths; boric-sulfuric acid anodizing is a new process that is an environmentally friendly replacement for chromic acid anodizing, which is used for very thin film applications. As with case hardening, there is now a broad variety of proprietary anodizing and related processes. Accordingly, trend in military and industrial standards is to classify by coating properties rather than by process chemistry.

Non-electrolytic passivation of aluminium and magnesium is known generically as 'chem film'. While the terms 'Alodine' and 'Iridite' are often used generically to denote this process, they are actually proprietary process names. As with anodizing, the process consists of an initial cleaning, etching, neutralizing wash, colour dip, and final wash. The chromate-based colourizing step replaces the electrolytic bath step in anodizing. 'Chromate conversion' is often used interchangeably with 'chem film', but not all passivation films are chromate based; in fact, chromates are being phased out because of their native environmental impact.

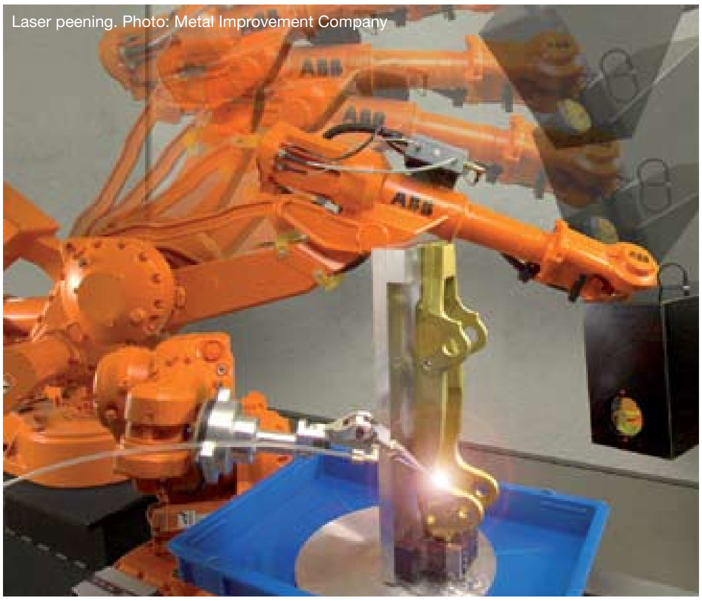
Chem film treatments are an excellent adhesive substrate for subsequent painting and coating, and also are very effective in controlling corrosion. Unlike anodized surfaces, chem film treated surfaces are very good electrical and thermal conductors, which is one reason why they are used so extensively for electronic applications - the characteristic gold-yellow colour is ubiquitous on the heat sinks, housings and chassis used in this industry. Applying a chem film wash over an anodized surface doubles its salt spray corrosion resistance, and chem film finishes are a very good idea for competition rally, marine, and aircraft engines.

BLASTING, CLEANING, AND POLISHING

For many years, exquisite polishing of highly stressed engine components was the rule. Remember those beautiful built-up Hirth crankshaft and rod assemblies used in the Mercedes-Benz W196 engine? The belief was that progressive polishing with ever finer media would eventually remove potential stress risers from the material, and while that was often the case, it was equally true that it was possible to introduce stress risers in this process if not very carefully done. That Mercedes dated from the mid-1950s, but in the 1930s, Buick had already proven the value of shot peening as a superior surface treatment preventative for stress crack-induced failures.

Peening media varies in size and material composition (usually metal, ceramic, or glass), and in some cases more than one type is mixed together, but the principal is the same: the bombardment of the material surface by thousands of little balls, which is like thousands of little ball peen hammer strikes, producing a dense, hard, compressive layer that closes up micro surface cracks through plastic deformation of that surface. Today, shot peening is the dominant procedure for preventing stress risers and crack failures; virtually every high quality con rod and crankshaft receives this treatment. These components are characterized visually by a uniform, moderately reflective, 'pebbly' appearance. Occasionally shot media, and abrasive media are combined; more commonly abrasive sandblasting and/or vapour blasting will follow the peening stage to improve the adhesion of subsequent coating, plating, or conversion processes.

Critical, high-stressed turbine components can be treated by laser peening. In this technology, parts are coated with an energy-absorbing layer such as black paint. Short energy pulses focused on this coating cause it to explode, creating a shockwave against the parent material. This process is repeated over and over again as the laser beam is moved along ▶


Laser peening. Photo: Metal Improvement Company

the material's surface, creating a compressive layer up to ten times deeper than a standard shot-peening operation depending on the material. This would appear to be an excellent application for components like piston rods, particularly stock rods used in 'spec' classes.

Recently, micro-peening methods have been developed; this offers much smoother surfaces, in some cases smooth enough to be serviceable for use as bearing journals. Fine details, such as threads can be retained with the correct velocity and pressure during application. An extreme example of this kind of peening is the 'WPC Treatment' process, which uses extremely fine media accelerated to extremely high velocity, which is said to create a "micro thermal reaction" at the point of impact. Claimed advantages include superior surface compaction and extraordinary smoothness with a surface that in some ways resembles a fine isotropic texture. At the same time, the ultrafine particulates are driven in to the surface of the parent material, altering its chemistry. The process can be applied to already hardened parts. This makes this technology somewhat difficult to classify: is it a shot peening methodology, a surface infusion technology, or a surface polishing technique?

Speaking of polishing, polishing is not dead; it has just become reinvented. A number of advanced polishing techniques have been developed in the postwar era, and these have gained acceptance within both the aerospace and the performance powertrain community.

Abrasive flow machining was developed in the 1960s as a method of polishing and de-burring surfaces that are difficult to reach. This method uses a fluid abrasive media that is forced through passageways in the component being processed. Twin opposing cylinders drive the fluid back and forth until the desired level of finish is achieved. In some applications, this method has even been used to port cylinder heads, and before scrutineers caught onto it, a significant number of Formula Vee intake manifolds were surreptitiously enlarged in the US by this method!

Of course, this does not strictly meet the definition of surface engineering but the developer of this service also makes equipment and media for a microsized version of the above technology. This is used to deburr and condition the surfaces of the inside passageways and tiny holes found in components like ultrahigh pressure fuel injector nozzles, which have to stand up to repeated opening and closing cycles. The resulting finish is used to improve high cycle fatigue strength, and eliminate crack propagation.

Of course, superfinishing is a form of polishing. Originally developed at Chrysler in the 1930s for smoothing valve stems, today's superfinishing systems can produce surfaces of less than 1 micro-inch. Traditional superfinishing, such as very fine cylindrical and straight-line lapping produce a distinctive, unidirectional scratch pattern, but orbital, rotated lapping processes produce a multidirectional, random, pattern. This second configuration is an 'isotropic' surface, which eliminates 'micro-valleys'. Polishing need not be an abrasive process; readers of RET will be familiar with the REM chemical finishing system (RET 026), which produces a very fine, mirror-like surface, while at the same time removing those tiny cracks and valleys where oxidation and stress corrosion cracking can start. The surface is not actually flat; it is composed of evenly distributed rounded mounds about one micro-inch high, that allow the surface to retain a lubricant without penetrating its molecular boundary.

Suppliers have combined surface engineering in different ways: one specialist offers a combined isotropic surface finishing and cryogenic service dedicated specifically to racing components, which can be combined with a dry-film lubricant. Micro-polished surfaces also lend themselves to 'nano' thin-film surfaces, and readers of the previous issue of RET (038) will recall the article on RF85, a very high durability, ultra-low coefficient-of-friction thin film that is ionically bonded to the material surface. This is applied as an immersion wash coating at low-temperature, and can be applied directly over previously nitrided or carburized surfaces without altering their beneficial characteristics.

Another example of a highly developed, combined set of surface engineering technologies is the so-called 'SnakeSkin' valve stem treatment. Originally developed to create a low-cost, low-friction, valve stem surface, this is a two-step superfinishing process. The first step is the creation of a grooved pattern on the valve stem. This pattern is reminiscent of the flaking seen on machine tool ways, and serves the same purpose: the retention of the lubricant. The second stage is the deposition of a special polymer, done with "a dedicated polymer lapping device", which creates "an organic, oil-retaining nanolayer". The combination of the two processes is said to create a coefficient of friction and wear performance that rivals the more expensive DLC and PVD surfaces applied to other valves. The supplier also reports that the process can be performed directly over an existing PVD-coated valve, resulting in an even greater improvement.

Traditional honing and superfinishing techniques still have plenty of applications in the high-performance regime. One firm specializing in gun drilling operations, which involves extreme diameter-to-depth ratios, has customers throughout the competition world, all the way up to Formula One. It finds that its superfinishing and honing processes are the ideal complement to this specialty, and lists impressive tolerance figures for these deep-hole applications.

On the other extreme, many companies are offering a broad spectrum of finishing and surface modification services: abrasive and shot blasting, several forms of vibratory and tumble polishing options, automated systems, and even CNC de-burring systems.

CONCLUSION

With all of the excellent processes and choices now available, there are some hazards. Virtually every engine builder or engineer in the business has a story about how an expensive piece got ruined by an improper heat treatment or surface application. Part of the problem is identification. The casual and frequently interchangeable use of trade names, process names, and technical specifications, even by technical journals, but especially, web sites and chat forums, contributes to errors, particularly when one is using a new process or vendor for the first time. To make things even more confusing, in response to the increasing complexity and variety of industrial processes, the US military started changing specifications from the once-reliable MIL-spec to DTL (Detail) or PRF (Performance) spec. This move will eventually eliminate military specs altogether as industry and ISO specifications become fully developed. For the time being, DTL specs will continue to provide exact instructions and requirements; PRF specs give a performance minimum and let the vendor/supplier/user figure out how to get there, e.g. “paint must be blue, and provide 5000 hours salt fog protection” or the like.

Which brings us to vendors. Often times, the lowest cost source for these services is a small ‘mom-and-pop’ outfit. Typically, these have a single specialty that they perform quite well over and over again for a group of long-term customers. It is advisable to stay within this prime expertise when obtaining services from these vendors. On occasion, these firms will not have sufficient technical depth for them to recognize their own limitations, so when visiting these places, make sure you see work similar to your own being processed.

As an example, some years ago the author brought a set of complex aluminium microwave-guide castings (these could have just as easily been a gearbox casing) to a ‘shop specializing in ‘Alodine’. The technical call out for the components was the common “MIL spec 5541c type 3”. This sounds very specific, but in fact, it allows for a fair amount of process variation. The ‘shop that these expensive parts were brought to never mentioned that they worked almost exclusively with wrought aluminium such as 6061 and had almost no experience with cast materials like A356. Wrought aluminium alloys are generally very tolerant of wide timing variations in the etching bath. Silicon-aluminium casting alloys are not; the parts came back severely over-etched, looking like micro-porous sponges, and their small tapped holes had their threads almost completely removed. With cast aluminium, either a caustic etch, or a short, controlled, acid etch is required, along with subsequent ‘de-smutting’; the owner of that little ‘shop was himself unaware of this, and pointed out that the parts had been processed “within specification”.

The point here is that the engineer or mechanic must thoroughly understand in detail the treatment that is going to be applied to their parts, make sure the material is appropriate for the process they have selected, and that post-treatment operations are recognized and accounted for. If the work is new or unusual, it is best to go to a well-established “top shelf” firm that has a full staff and laboratory, and the kind of personnel that can give knowledgeable advice about the work being contemplated. Contact them early in the process: it does not do one much good to bring a shaft to the nitriding house if it is machined from one of those alloys that will not accept nitrogen infusion. Most of the time, surface treatments come at the end of the manufacturing cycle for a given component, which means that a mistake here costs many times more than the finishing service itself. The financial loss is painful enough, but even worse is that the build schedule for that engine or gearbox is now at risk, which is especially difficult to explain to a customer during racing season. Trying to save the last bit of expense at this point is usually a false economy.

SURFACE TREATMENT SUPPLIERS

GERMANY
Rösler
+49 9533 924 802 — www.rosler.com

ISRAEL
Sinus
+972 97655217 — www.sinusvalves.com

UK
Bodycote
+44 1625 505300 — www.bodycote.com
Eltro
+44 1252 523000 — www.eltro.co.uk
Keronite
+44 1223 893222 — www.keronite.com
Metal Improvement Company
+44 1635 279621 — www.metalimprovement.com
PDJ Vibro
+44 1908 648757 — www.vibratoryfinishing.co.uk
Poeton
+44 1452 300500 — www.poeton.co.uk
Sandwell
+44 1327 350205 — www.sandwell-uk.com
Subcon Drilling
+44 1442 205960 — www.subcondrilling.co.uk
Tecvac
+44 1954 233 700 — www.tecvac.co.uk
TTI Group
+44 1952 671010 — www.ttigroup.org.uk

USA
Evans Performance Products
+1 770 888 8818 — www.evansperformance.com
Kennametal (Extrude Hone)
+1 724 863 5900 — www.extrudehone.com
Finishing Associates
+1 215 953 1340 — www.finishingassociates.com
REM
+1 860 621 6755 — www.remchem.com
RF85
- — www.rf85.com
Solar Atmospheres
+1 800 347 3236 — www.solaratm.com
Superior Shot Peening
+1 281 449-6559 — www.superiorshotpeening.com
WPC Treatment
+1 310 782 8647 — www.wpctreatment.com