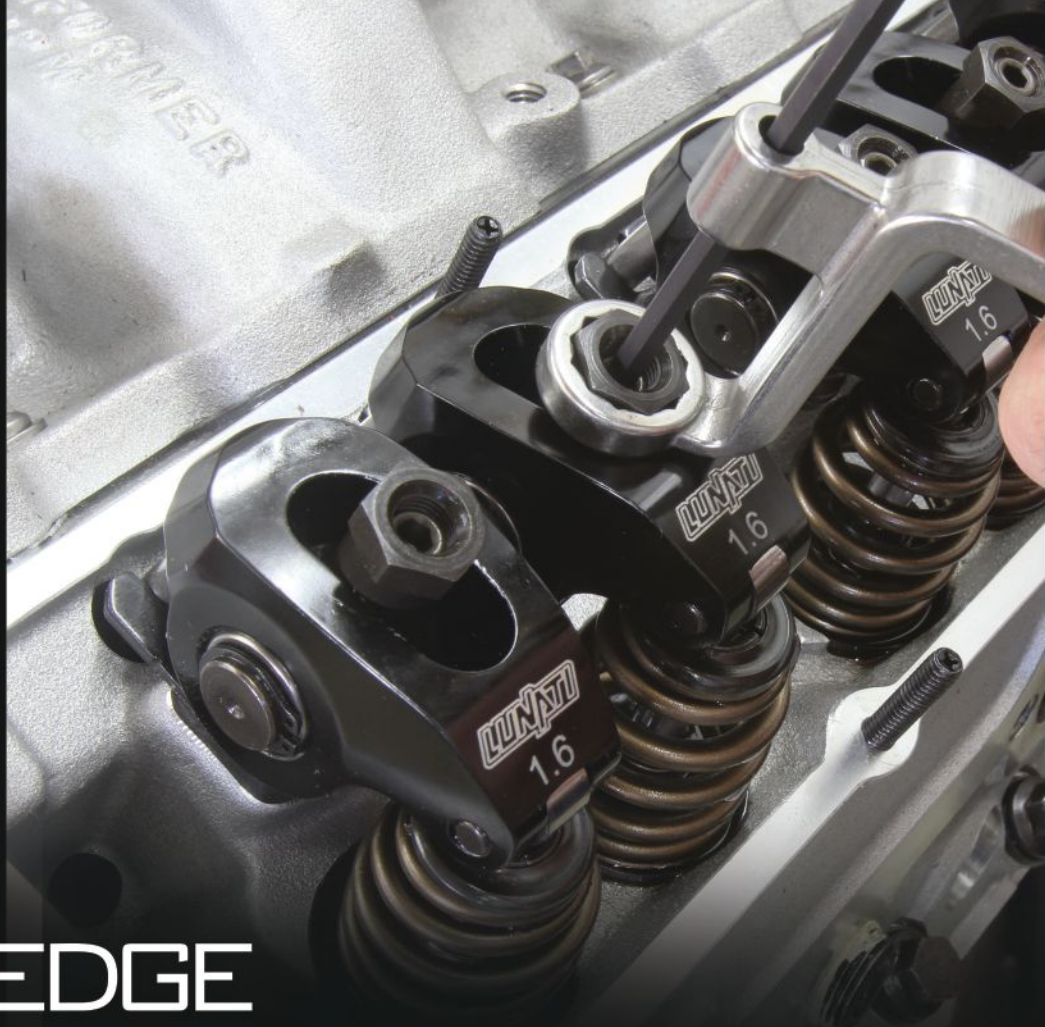


CUTTING-EDGE VALVE SPRINGS &

With added stress placed on today's race engines, manufacturers of valvetrain components utilize superior designs, materials and processing techniques to enhance the quality of valve springs and rocker arms.

ROCKER arms rock against the tips of valves, and valve springs push back—it is a dance that's as old as internal combustion. But what separates the pros from the amateurs are those star performers from the masses of the merely adequate.

As with all things racing these days, the apex is a moving target, and staying on it requires agility. "The introduction of several new aftermarket cylinder heads, and of short-travel lifters, have challenged the manufacturers of rocker arms," noted Roger Vinci of Yella Terra Performance Products, Moorabbin, Victoria, Australia. "This industry is always evolving, and as premium manufacturers, we must always stay ahead of the curve."

"Since racers and engine builders continue to push for bigger heads, bigger valves, and bigger engine CIDs—with stronger valve springs—the demand grows for rocker arms with less flex and less weight," added Phil R. Elliott of T&D Machine Products, Carson City, Nevada. "This is a difficult compromise, as the rocker tries to pry open the valve against the resistance of a 1000-pound spring."

As for the valve springs themselves, "The stresses on them will continue to increase," observed Bob Kamp of K-Motion Valve Springs, Lafayette, Indiana, "making the chemistry of the wire absolutely critical."

LS Rocks

Before we separate the triumphant from the toys, however, let's examine some of the new product developments in these areas. As we've found elsewhere, the GM LS market continues to heat up.

"Performance enthusiasts have been enamored with Yella Terra's new Pro Street and Pro Street Lite rocker arms for the LS3 and LS7," said Vinci. "Our stronger, lighter, and adjustable rocker arm series filled a void. Our Pro Street Lite rockers are bolt-on and nonadjustable; while the Pro Street version is equipped with a pushrod cup adjuster. Both are offered for a variety of new aftermarket cylinder head applications." New for 2015 are shaft-mount roller rockers for Trick Flow's LS3 and LS7 heads, covering the 215cc, 225cc and 235cc port volumes.

"Higher-end engine builds that require short-travel hydraulic roller lifters, or solid roller cams, which require stronger springs and adjustability, now have affordable super duty shaft mount rockers arms to use," Vinci continued. "These rocker arms require little or no machine work for a simple bolt-on installation, and are furnished in 8-mm, 10-mm or 7/16-inch bolt styles."

Lunati of Olive Branch, Mississippi, has enjoyed sales success with the LS applications recently added to its Voodoo line of aluminum roller rockers. "We offer these rockers in a kit with all the hardware," said David Chamberlain, "including studs, poly locks, and guide plates." Applications include "the standard LS1-, LS2- and LS6-style heads that don't require an offset rocker. We also carry offset rockers for the popular LS3/L92 rectangle-port heads."

Lunati also continues to offer factory-style LS rockers retro-fitted with a captured bearing roller trunnion.

BY JOHN F. KATZ

CHE Precision of Newbury Park, California, offers a conversion for GM LS and LT1 rocker arms that replaces the factory needle bearings with a bronze bushing and trunnion. "Sales have picked up dramatically in the last year for these LS rocker arms," reported Ed Doyle. "They work particularly well in off-road applications where dirt and debris can be a problem. The LS market in general is getting bigger every year, and so the demand for converted rocker arms has grown with the increased interest in these engines."

For the past two years, Crower Cams of San Diego, California, has been replacing the needle bearings in its rocker arm roller tips with the same bushing material used in the company's roller lifters. "We're also testing that material on the rocker shafts," said Kerry Novak. "We are trying to get needle bearings out of engines entirely."

The Strength of Steel

Another continuing trend has been the growth of steel-billet rockers. Crower machines custom rocker arms from 4340. "Racers running, say, Brodix SR20 cylinder heads want steel billet exhaust rockers," Novak explained, "because with all the boost they have on their motors, they are breaking aluminum rocker arms." Steel billet also provides far more dimensional freedom than die-cast stainless. "And on some of the newer cylinder heads, we're machining offsets of up to .750 inch."

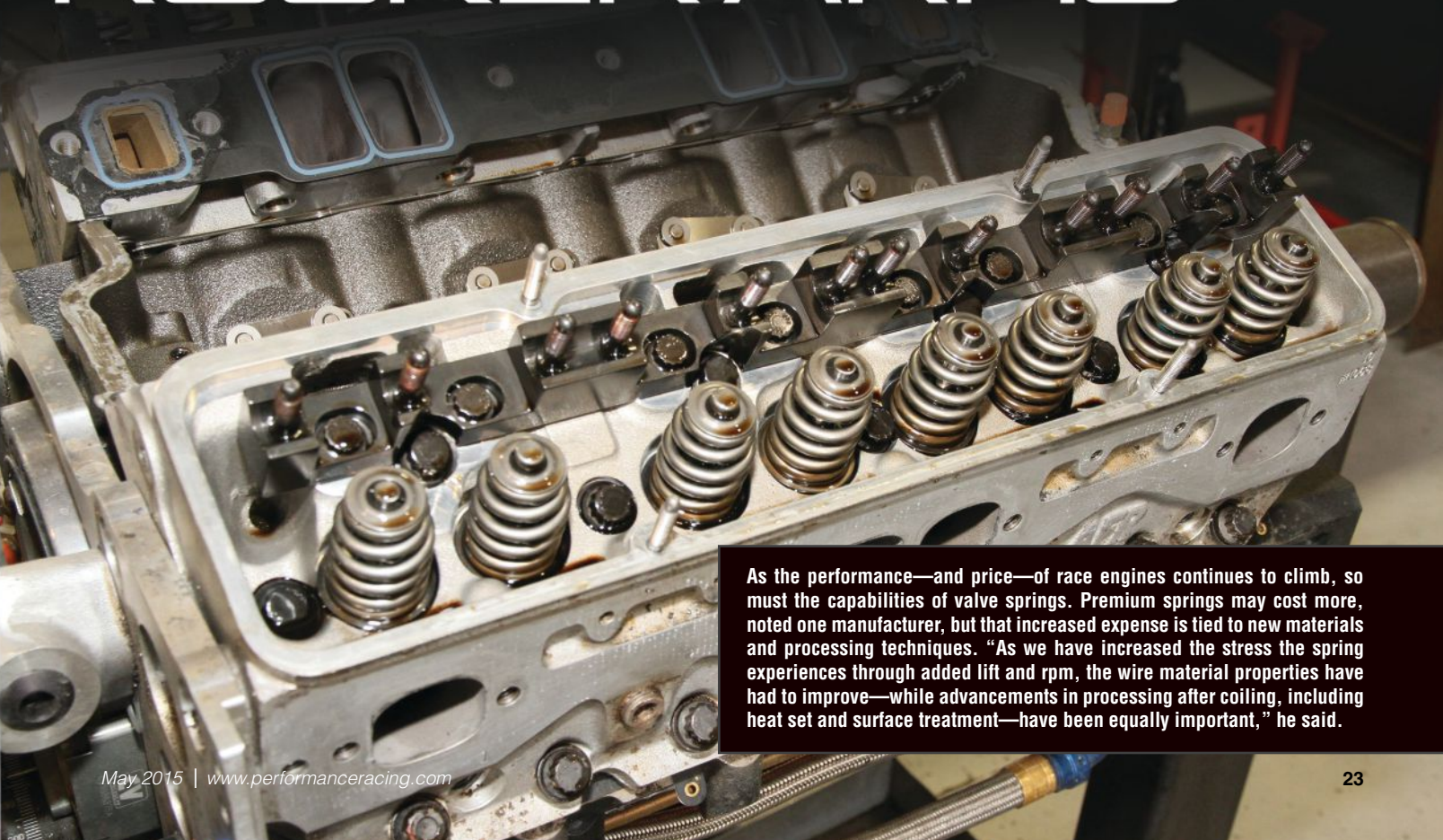
"It's very expensive to make them," noted Randy Becker Jr. of Harland Sharp, Strongsville, Ohio, "but with open spring pressures of over 1000 pounds, they are needed to keep the valvetrain together. And with improvements in the manufacturing process, the cost should come down, making them more affordable for sportsman racers. We can see more applications being developed as a result of lower production costs."

Rob Remesi of Jesel in Lakewood, New Jersey, cited "an increase in requests for steel rocker arms. Unfortunately, due to design constraints, we cannot always supply a steel equivalent to an aluminum-body rocker, and in most instances, you wouldn't want us to. If you were to make an intake rocker for a spread-port, big block Chevy head out of steel instead of aluminum, the weight of the rocker would destroy the valvetrain harmonics.

"In most cases, to make a steel rocker replacement, we would have to completely redesign the kit and rotate the rocker to take the offset out of the body," Remesi continued. "This is exactly what we did for the steel rocker kits we supply, with great success, for 410 sprint cars. By rotating the intake rocker, we replaced a 1.600-inch-wide aluminum body with .750 offset with a .625-inch-wide steel rocker, greatly decreasing the moment of inertia."

Mike Schropp of Livernois Motorsports in Dearborn Heights, Michigan, noted some movement toward lighter-weight alloy steel, "with reduced mass over the nose and increased stiffness in relation to their aluminum-body counterparts."

ROCKER ARMS



As the performance—and price—of race engines continues to climb, so must the capabilities of valve springs. Premium springs may cost more, noted one manufacturer, but that increased expense is tied to new materials and processing techniques. "As we have increased the stress the spring experiences through added lift and rpm, the wire material properties have had to improve—while advancements in processing after coiling, including heat set and surface treatment—have been equally important," he said.

Several valve spring makers are reportedly expanding their product lines to accommodate a wider range of racing applications. In addition to the use of new materials, today's processes ensure tight tolerances and include heat-treatment, stress relieving, and multistage shot peening for extended life and durability, reported one manufacturer. Photo courtesy of Ferrea.

Comp Cams of Memphis, Tennessee, has been "working with NHRA racers on half-inch stud versions of our Ultra HD investment-cast steel rockers," said Billy Godbold. "These large-diameter studs provide almost the same stiffness as a stud girdle, in applications where stud girdles are not allowed."

Quality, Controlled

Material, it turns out, accounts for much of the difference between an entry-level rocker arm and a premium professional piece. "As performance demands increase," said Godbold, "so must the stiffness and durability of rocker arms"—while their moment of inertia decreases. "Material and cost options range from die cast aluminum and extruded aluminum to investment-cast high-alloy steel."

"Materials play the biggest part," said Becker. "Cheaper materials are unable to achieve the appropriate structures and hardness required for a high-end rocker application. Processing is also important, since rocker arm bodies and their components need heat-treatment,

plating, and precision grinding and finishing in order to build a durable, long-lasting product." And, of course, "these procedures and services all add to the final cost."

Ferrea Racing Components of Fort Lauderdale, Florida, machines rocker arms from domestic 70-series aluminum-magnesium alloy supplied by Alcoa or Kaiser. "With our latest CNC machines and tooling practices," said Daniel Urrutia Jr., "we can achieve very fine surface finishes, which in turn provide long life by reducing stress concentrations. And lastly, all of our rocker arms go through an anodizing coating bath to eliminate the possibility of aluminum oxidation, and to provide a wear-resistant boundary layer."

An ongoing rocker arm project at Ferrea, according to Urrutia, is an aluminum roller rocker for the Lotus Elise/Exige 1.8, which uses a Toyota 2ZZ-GE engine platform. "The mass of the factory steel rocker arm from Toyota becomes counterproductive when engine speeds exceed the stock limits," he explained.

Chase Knight of Crane Cams, Daytona Beach, Florida, noted how stamped steel rockers—often needed to meet rule requirements in limited classes—can use premium and/or heavier-gauge material for improved durability, in addition to "upgraded heat-treating and surface finishing. Pivot balls should have a premium surface finish, hardness, and proper shape for maximum contact with the rocker, and oiling grooves should be provided where required.

"Ductile iron rockers should be made with modern tooling to provide a good surface finish, and the particular alloy being used should be compatible with the stresses and loads that the rockers are subjected to," he added. "Surface finishing and hardening of the critical areas (especially where the rocker contacts the pad) must be properly controlled to produce a quality part."

With aluminum rockers, Knight continued, "a variety of factors affect the quality of the assembled piece. The bodies should be produced from an alloy that maintains its strength at

actual operating temperatures, and will not be subject to premature fatigue. The machining centers that produce the bodies must hold close tolerances to maintain the ratio and geometry, and the press fits for each of the components. The body's surface finish should be free of imperfections that could cause a stress failure, with tumbling, polishing, or peening operations performed prior to assembly. The roller tip, front axle, fulcrum, bearings, pushrod seat, and the adjusting nuts each must use the proper materials, surface finishes, and hardening steps for a long life. Premium materials make all the difference in a better product."

Other factors figure into material selection. In addition to its steel billet products, Crower manufactures rocker arms from extruded aluminum and die-cast stainless steel. Aluminum provides an economical entry into shaft rockers, but "with high temperature, pressure, and rpm, aluminum is stretching and moving," said Novak. "So if you want a more stable valvetrain, you want a stainless steel rocker arm. And you can rebuild a stainless steel rocker arm, so they will last a lot longer." The downsides of stainless consist mainly of the dimensional limitations imposed by the die-casting process. Which brings us back to steel billet.

"Controlling the weight of the rocker—and where that weight ends up—is usually one of the most important aspects of the design," said Schropp, "along with stiffness and durability. And with more widespread use of computer-aided modeling and testing, we're seeing a quickening in the pace of new product development and release—with new designs having much shorter windows to release in."

Rocker Specialists

Last year, we described the "300-H" high-ratio rockers from Titan Speed Engineering in Ojai, California, for Chrysler Hemi 354 and 392 applications. This year, Bob Sanders reported that these "are running and working very well in the Nostalgia Junior Fuel Dragster classes." With intake and exhaust ratios of 1.85 and 1.7, respectively, Titan 300-H rockers are engineered specifically for the stock valve angle and position, but for valves where the lash cap is .350 to .365 inch longer than stock. Titan Speed Engineering manufactures various rocker arms from both billet aluminum and cast stainless steel, specializing in pushrod hemis, including the Toyota 2TC/3TC and early Chrysler Hemi and its derivatives.

T&D specializes in custom-engineered rocker arms: "Approximately 75 percent of all our rockers are custom," reported Elliott. "Racers and engine builders are the source of many of our best ideas—a little more ratio here, a little more offset there. Every engine builder and race team has a different agenda. But when an engine builder provides feedback on these specially machined pieces, those ideas go into the next set of rockers we produce for that same application."

A growing demand for rocker arms with less flex and weight can be traced to racers and engine builders who continue to push for bigger heads, bigger valves, and bigger engine CIDs—all requiring stronger valve springs, reported one valvetrain component supplier.

And even after 50 years of production, Harland Sharp continues to "improve the materials, manufacturing, and outside processing" of its original-series roller rockers. Harland Sharp's Diamond series benefit from additional machining, which reduces weight and also provides additional clearance when using a factory-style valve cover with a stud-girdle setup. "We developed the Diamond series for engines with lower spring pressures and that need to turn higher rpm," Becker added.

Specializing in shaft-rocker conversions, Jesel offers these products

in entry-level Sportsman, mid-range Pro Series Aluminum and high-end Pro Series Steel. "Our Sportsman kits, manufactured from 2024 aluminum, are basic, no-nonsense rocker systems that offer greater stability, less valve-guide wear and improved rpm compared to stud-type rockers," Remesi said. "Our Pro Series Aluminum systems, which feature a proprietary blend 7000 series aluminum, represent the majority of our sales. The 7000 alloy has a higher tensile strength than 2024, and can withstand higher temperatures before it begins to lose that strength. Our Pro Series Steel rockers are available for a limited number of applications, and are machined from a 4340 forging. They are used in endurance applications such as oval track and road racing, and in extreme-cylinder-pressure applications such as nitrous/turbo engines."

"One of the most important parts of engine building is obtaining correct valvetrain geometry," explained Scott Stutler from PRW, Perris, California. "The correct geometry is critical to not only making horsepower, but also the durability and service life of the engine as a whole. The most common root cause of valvetrain failure is related to incorrect valvetrain geometry. In short, if you are breaking rocker arms, there is probably something amiss with your setup and a stronger rocker arm is not likely going to fix the problem."

"Valvetrain geometry encompasses many facets, not just the location of the rocker arm nose roller over the tip," added Shaun Snow from PRW. "The pushrod angle changes dramatically when using roller lifters. If the lifter seat is higher, the pushrod angle is altered. If the pushrod bore hole doesn't match that of the pushrod operating within the confines of that hole, bad things can happen."

PRW designs rocker arms based on performance levels for individual needs. "Sportsman rockers are the most moderately priced, with Pro Series aluminum or alloy steel stud mount rocker arms designed to meet the needs of higher performance and racing," Stutler said.

PRW's Bill McGloghlon said. "Sportsman rocker arms share the same CR-40 alloy steel roller tips with other PRW Pro Series rockers, assuring that these will perform well under the most extreme conditions."

Spring News

The LS/LT engine platforms have provided fertile ground for new valve spring products as well. Last year Livernois Motorsports released a new LT1 spring package that included a drop-in spring, retainer and lock.

Godbold reported that the single-conical valve springs introduced last year by Comp Cams are now used in "several circle track applications," as well as for street performance. For 2015, Comp Cams has released dual-conical springs for racing applications with up to .800-inch lift.

Ferrea continues to expand its line of Ferrea-PAC sport compact valve springs with new Pro-PAC springs for the 2.3-liter Ford EcoBoost, "capable of a .394 inch lift, given its constraint on spring pocket size," said Urrutia. Ferrea is also expanding applications for its PAC-alloy Beehive Ovate springs for "aggressive endurance requirements, as well as our traditional single, dual and triple cylindrical springs."

Higher engine speeds continue to push valvetrain components to be smaller, lighter and higher stressed, noted Jeff Villemure of Performance Springs Inc. (PSI), New Hudson, Michigan. "PSI has released several new designs with smaller diameters, higher rates, and higher natural frequencies to control surge. And the benefits of these smaller diameter springs are magnified because they allow the use of a smaller, lighter retainer," he said.

As with rocker arms, materials and processing contribute to performance, reliability and durability. "Through the use of the latest developments in melt technology, composition control and casting practices," Villemure continued, "the chrome-silicon alloys used in PSI valve spring wire are held to the strict standards of cleanliness, which, of

course, reduces inclusions."

"As the cost and performance of engines increase," said Godbold, "so must the performance of valve springs." Premium springs "are not inexpensive, but 99 percent of the increased cost pays for new materials and processing techniques. As we have increased the stress the spring experiences through added lift and rpm, the wire material properties have had to improve—while advancements in processing after coiling, including heat set and surface treatment—have been equally important."

"A big factor is material, and the equipment the manufacturing company is using," agreed Jason Youd of PAC Racing Springs, Southfield, Michigan. "For example, whether or not they are made on dedicated, 'racing-only' CNC equipment." PAC Racing has recently launched a new alloy, and a new series of springs "that is near inclusion-free and ultra-processed for professional circle track racers," said Youd. "This alloy has taken years to develop and should revolutionize the circle track market. A new blueprint service was also launched that allows the customer to define the specs they are looking for on a specific set of valve springs."

Some manufacturers report that custom-engineered rocker arms account for a majority of their business. And, many of their best ideas come from racers and engine builders, such as providing greater ratio in one area or more offset in another, said one of our sources.

"The alloy makeup and the amount of processing is what separates our entry-level springs from our higher-end Signature series," reported Chamberlain. "All of Lunati's valve springs are made from high-cleanliness alloys and are carefully wound to ensure there are no unwanted twists, etc. Then comes the heat-treatment to further strengthen the spring and prevent fatigue and load loss. Then, for our Signature Series springs, there are extra measures taken for stress relief. Processes such as chamfering the sharp ends, polishing, and nano-shot peening all to reduce high stress points and load loss over time."

"Processing, in addition to material, is very important in distinguishing a high-end spring from an entry-level product," commented Marty Zimmermann of CV Products/X2 Valvetrain, Thomasville, North Carolina. "Then post-processing operations such as surface impingement, tip conditioning, select fitting, nitriding and quality assurance operations all lead to a superior spring as well." Valve springs in general "have evolved into a better product because of the inspection levels required and quality of materials, which have reduced failure modes."

Listing the processes that impact quality, Knight cited "eddy current testing, checking for visible defects, and Magnaflux inspection prior to winding. Then the winding process (not necessarily by the same group that created the wire) should include its own quality control steps to verify the wire, and the ability to react quickly to any changes required for a correct finished product. Care must be taken to avoid scarring the wire throughout the process. The end coils must be precision ground, and may be chamfered to prevent stress areas. The wire ends can receive additional processing to avoid too thin a cross-section, while finishing steps such as tumbling, heat setting (achieved by compressing the spring to a designated height, then passing an electric current through it, sometimes followed by a quenching process), and then additional surface treatments such as shot peening and polishing are utilized. It's helpful to observe how springs are manufactured, as they are not wound around a spindle or fixture; instead, the wire is pushed against a form tool to create each coil."

The cost of the wire increases with more extreme designs, noted Kamp.

"Manufacturing, processing and assembly require large amounts of time, and many engineering hours are required to develop new applications." He added, "Installation is also very important. Installed height, coil bind and oiling are essential. And make sure the engine is warmed to 160 degrees F, minimum, before any revving."

"New custom alloys will arrive in the future," Knight predicted. "Costs are prohibitive currently, but a few years down the road we should see some upgrades. It won't be earth-shattering, just refinement."

Retainers & Locks

No survey of the valve spring market would be complete without a look at retainers and locks. Godbold rates the migration toward tool steel as the most significant trend in retainers in recent years. "When we first made and tested tool steel retainers, our Spintron team refused to go back to titanium because it had failed so often during durability testing. Now a large number of our customers have followed their lead, with great results. For most circle track and endurance applications, the one or two-gram penalty in mass is more than offset by increased strength and durability."

Urrutia noted how Ferrea has been "investing in our tool steel retainer line. With new advancements in CNC machine tooling, we have been able to machine pre-hardened H13 material with greater precision, accuracy, and super fine surface finishes."

Zimmermann also noted the trend toward lightweight steel retainers, and away from "softer materials that can deteriorate over time in an unstable valvetrain. Titanium is still the standard for locks," he said. "However, radius groove and top lock designs are still the most prevalent."

Chamberlain pointed out how "certain areas of the retainer can be reduced in size to reduce weight without compromising the strength of the part. Profiling, with radiuses and tapering in the necessary areas, can actually add strength and reduce weight." PRI