➤BY BILL KENNEDY, CONTRIBUTING EDITOR

Automotive, *à la carte*

By diversifying its customer base, an automotive machine shop found new markets for its services.

What do you picture when you hear the phrase "machining automotive parts?" Long production runs? A handful of vehicle-development prototypes? Reverse-engineered vintage parts? A small batch of racecar components?

One shop does all that and more. Part factory, part prototype shop, part big-boy toy store, Roush Machining Services offers a wide-ranging à la carte menu of automotive engineering and machining services.

All images: B. Kennedy

In addition to outside work, Roush Machining Services machines a variety of parts to support Roush Racing's NASCAR effort, like this aluminum brake pedal mounting bracket.

A Diversified Response

The Roush name is often associated with Roush Racing's successful efforts in NASCAR. Roush Racing is, in fact, only one unit of Roush, an engineering company founded in 1976 by Jack Roush, a mathematician and hot rodder who previously worked in the engineering departments of Ford and Chrysler. Other Roush business units include its global engineering and vehicle development group, which provides design, prototyping, testing and manufacturing services to OEMs worldwide, and Roush Performance Products (RPP), which makes and markets performance vehicles, Crate (high-performance replacement) engines and aftermarket parts. Roush has racing, engineering and manufacturing centers located throughout North America and in Europe and Asia.

Early on, Roush established its machining services facility in Livonia, Mich., to provide internal support to the company's racing efforts and engineering and development programs. As the machining operation grew and added capabilities, it began taking in outside work, including development of Chevrolet engines for the Indy Racing League and design and manufacture contracts for Toyota, Chrysler and Honda.

The machine shop built Roush Racing's NASCAR engines until 2004, when Roush merged its NASCAR engine activities with those of rival Robert Yates Racing. Roush headquartered the operation in Mooresville, N.C., adjacent to Roush Racing's motorsports center.

Moving the racecar engine building activities to North Carolina gave the Livonia shop an opportunity to expand its work for customers outside Roush. Don Trefney, Roush Machining Services operations manager, said, "We welcomed the challenge of diversifying our customer base and finding new markets for our production services."

Jim Ryder, an R&D engineer in the NASCAR engine program, became the Livonia operation's engineering manager. Ryder and Trefney's first order of business was adding the expertise required to handle longer-run manufacturing by hiring a quality system expert and adding engineering and design staff. With its broader focus, Ryder said the shop is "a different business, requiring a different set of people."

Equipment in the 20,000-sq.-ft. facility now includes 14 machining centers, four turning centers and 25 manual mills and lathes, as well as specialized automotive machine tools such as block and head milling machines, cylinder hones and line boring machines.

Job coordinator Bob Gadigian at Roush Machining Services' whiteboard, which employs color-coded cards to indicate the urgency and status of each job in the production schedule.

Prototypes and Production

Today, Roush Machining Services performs a range of prototype and production jobs for Roush businesses and external customers. It still supports the Roush NASCAR effort with parts such as billet valve covers, brake pedal supports and shift knobs. "We make a lot of chassis components for them, too," Ryder said. A typical internally generated, production-level job consists of machining lots of 50 to 100 intake manifolds for RPP.

Typical of production work for external customers is machining 429 Super Cobra Jet aftermarket engine heads in 250-piece lots for Ford Racing Technology. The contract includes "complete machining and assembly, and putting each head in a box ready to go," Ryder said.

Spicing the job mix is short-notice prototype and limited-run work from both external and internal customers. An aftermarket supplier might come to the shop with a sample head and ask for a small run of copies. "We'll go back to the [coordinate measuring machine] and completely reverse engineer it," Ryder said. Or an RPP staffer might present a print of a prototype part. "They say, 'I need two of these tomorrow or next week,' because they've got a $5 million project and they need an engine mount," he said.

Efficiently combining production and prototype runs in the same shop isn't easy. "We have to be able to do prototypes and keep the repetitive stuff, 100 of this part and 200 of that part, going at the same time," Ryder said. Scheduling is complex and extemporaneous. "No software is going to do it for you," he added.

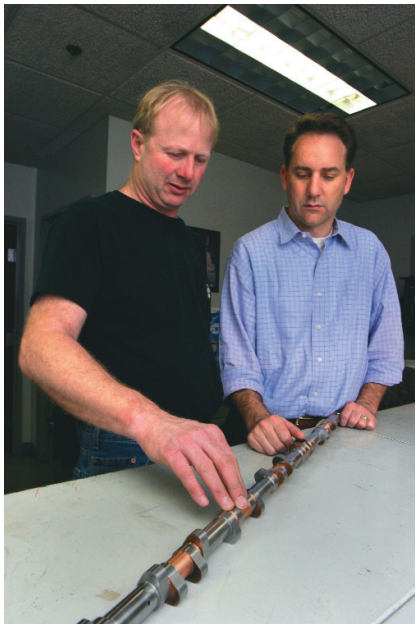
As a result, at 8 a.m. each Monday, Trefney and job coordinator Bob Gadigian determine a tentative shop schedule. Tentative, because it "sometimes changes every 10 minutes," Gadigian said. "The minute the phone rings, we juggle," Trefney added.

Schedule management revolves around a wall-mounted tracking board that has rows and columns of slots holding color-coded index cards keyed to individual jobs. A blue card represents repetitive work, yellow a prototype and red a critical job. The shop's CNC machines are listed across the top of the board. The card at the top of the column under each machine represents the job in process on that machine, and the next card down the column is the job on deck.

"Red cards are in need of delivery. You move them to the top and, hopefully, you're far enough ahead on your repetitive jobs that you can move the blue cards down," Ryder said. "When prototype work is slow, we do more inventory parts."

In-Process Improvement

As jobs make the transition from prototype to production, Roush Machining Services looks for ways to improve manufacturability. A good example involved an RPP request to design and machine an air-cleaner cover based on the classic design from the Cobra sports car engines of the 1960s. Working with sketches and photos of the original, project engineer Steve Grosick created a solid model in Pro



Technical specialist Randy Vsetula, left, and engineering manager Jim Ryder inspect a recently machined camshaft.

Engineer software in about a day. After RPP approved the basic design, the shop machined a prototype. After getting approval for that, the shop machined 10 prototypes to be used to gauge potential customer reaction.

While machining the prototypes, the shop found ways to speed up the process. "When we made our first couple of pieces, we were running 55 minutes to an hour apiece," said Trefney. The shop worked with RPP to reduce machining time. In the initial design, for example, the raised letters spelling "Roush" on the cover were so close together it was difficult to fit even a 1/32"-dia. endmill between them. Shop personnel suggested moving the letters apart so a 1/16"-dia. endmill could be applied, permitting use of more aggressive machining parameters. That change, and others made during the prototype stage, enabled Roush Machining Services to reduce machining time to 10 minutes per cover when the initial production run of 250 covers began.

Another case of in-process productivity improvement involved spark-plug wire holders developed for RPP Crate engines. The original holders were made of black plastic, which "didn't look good with all the polished parts," Ryder said. In addition, because of their proximity to the exhaust headers, the plastic parts could actually melt in some high-output applications. RPP proposed making the holders from aluminum, which would also permit them to be anodized in stylish, more marketable colors.

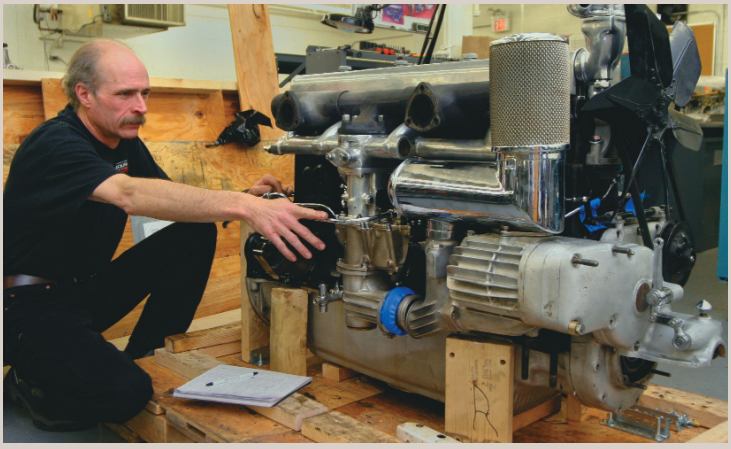
To test the idea, Roush Machining Services machined 10 sets of prototype holders from billet aluminum stock. One curved surface had to be formed via an electrical discharge machine, which required additional setup and process time. "Once we had the fixtures and the part program, we made a set of holders in about 45 minutes," Ryder said. Machining the 10 sets took

Roush Machining Services worked with Roush Performance Products to design and manufacture this air-cleaner cover that recalls the classic style seen on Cobra sports car engines of the 1960s.

Vintage revival

In many respects, old or new, an engine is an engine. In addition to applying its skilled machinists and comprehensive selection of machine tools to make parts for engines of the present and future, Roush Machining Services also does work on iconic power plants of the past. Recently, vintage engines in the shop included a 1931 Daimler Double Six, a 1916 Cole and a straight-eight from a 1937 Mercedes 540K.

The vintage business comes from a variety of sources, including vehicles being restored in the Roush special vehicles department, word of mouth from the vintage show circuit, and auction companies that restore and auction vintage vehicles. Jim Ryder, Roush Machining Services engineering manager, said the work ranges from basic cleanup of engine components to complete rebuilds, which may include fabricating and machining parts no longer available. Engines are dynamometer tested and inspected before final installation. Typically there are six to 10 engines being tended to in the shop, and the number is growing, Ryder said.



Vintage engine builder Fred Burkhart displays a straight-eight engine from a 1937 Mercedes 540K.

Vintage engine builder Fred Burkhart, working on the Mercedes engine, displayed a binder of recorded measurements and digital photos he took as he disassembled the engine. "Whether all the measurements make a difference or not, I don't know, but I want to know what it was when I took it apart." He said the engine ran when it was taken out of the car for shipment to Roush, "but not real well." After it's brought to normal running condition, Burkhart said, the shop plans to explore the owner's request for performance enhancements.

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7 to 8 hours.

Positive reaction to the prototype holders prompted RPP to go into limited production. To reduce machining costs, Ryder suggested the parts be made from extruded bar stock shaped to eliminate the need for EDM setup and machining. Machining time dropped to 10 minutes per set.

Ryder said some of the holders will go in RPP vehicles, and some will be sold retail through RPP. "Any time you can design and make your own products, you're controlling your own destiny," he added.

Head Games

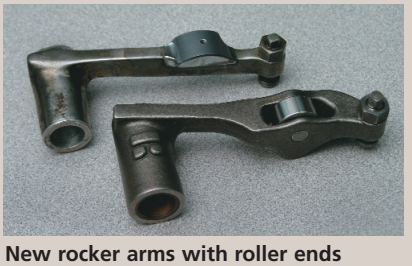
To reinforce its ability to handle production machining of engine blocks and heads, Roush Machining Services recently added a pair of A81 Makino horizontal milling centers with a 14-pallet automated workhandling system. The machines perform production-level work, but not on the level of OEM setups dedicated to long runs of a single product. Therefore, quick changeover between jobs is important. To speed transitions, for each job, the shop employs a series of bolt-on plates engineered to hold the parts at an angle that facilitates machining of certain features. "For cylinder heads, you need about seven different plates to do all the compound angles," Trefney said.

Two 460 in.^{3} engine blocks bolted to angled plates on a pallet for machining on an A81 Makino horizontal milling center.

On a wing

Roush Machining Services has been a licensed FAA repair station for more than a decade. The aircraft work reflects Jack Roush's, chairman of Roush, interests. A pilot with multi-engine, instrument, commercial and airline transport pilot ratings, he owns and flies two World War II P-51 fighter planes, as well as other less-entertaining aircraft.

To help grow its aircraft business, the shop brought in 30-year aircraft industry veteran Jim Gardini as aircraft manager in September 2003. The objective was obtaining PMA certificates (Parts Manufacturing Authority, issued by the FAA on a part-by-part basis) for aircraft parts.



New rocker arms with roller ends (foreground) designed to replace arms with sliders for the V-12 Merlin engine.

At the same time Gardini was brought in, the FAA released new requirements for PMA parts and repair stations. Gardini wrote and implemented the new FIS manual (Fabrication and Inspection System for making PMA parts) and the new repair station manual to meet the new regulations. The repair station and PMA parts are completely separate from each other and operate under different quality manuals, different FAA guidelines and a different group of inspectors from the FAA. The shop presently is certified to produce about a dozen different parts.

A major activity in the shop is maintenance, repair and overhaul of the huge 1,650 in.^{3} displacement, two-stage supercharged, 1,600-hp, 12-cylinder Merlin engines that power the P-51 planes.

The first new parts the shop designed and manufactured for the Merlin were rocker arms that move the engine's valves. The original arms had followers tipped with chromed sliders that rode the engine's camshaft. Sixty years past the engine's heyday, the slider surfaces now tend to wear and crack. The shop's response was to design new rocker arms with roller ends instead of sliders. Project engineer Paul Draper said the shop is certified by the FAA to make the new arms to replace the sliders. He estimates there are 200 to 220 aircraft still flying with the Merlin engines, each with 48 rocker arms.

Jim Igrisan, supervisor of the aircraft engine build department, thinks the shop can partner with the half-dozen or so facilities around the country that work on these engines. "With the resources we've got, we can do component work for them." Already, the shop is repairing castings and cylinder heads and line-boring blocks for oversized main bearings. Igrisan pointed out, "This is a passion for [Jack Roush]. He's pretty involved in what goes on here."

Technician Karl Bausman works with the water-jacket plumbing on part of a V-12 Merlin engine.

Ryder said it's ironic that an automotive shop is involved in machining aircraft parts because, "you go talk to the aircraft guys and they're trying to get into the automotive business!" He added that the Merlin remains a milestone in power plant engineering. "It was really nicely designed in the late '20s or early '30s," he said. "When I need new ideas, I come back and see how they did it on this engine so I can figure out how to do it on a new one."

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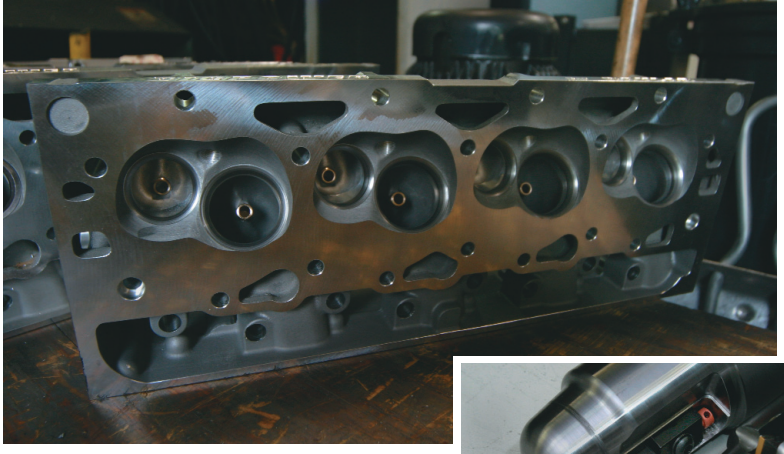
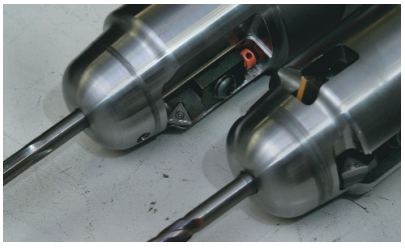
Tooling the machines to enable rapid response to customer demands requires speed, ingenuity and efficient use of resources. One case involved a contract to machine lots of 100 heads for 8.1-liter GM V-8 marine engines. When the customer brought the job to the shop, he wanted production to begin within weeks.

According to technical specialist Randy Vsetula, providers of the custom multifunction tools needed to machine the valve areas on the heads "wanted 10 weeks and $20,000 to do the tools. I had 3 weeks to do it, and Roush didn't want to spend that kind of money if it didn't have to." Vsetula created drawings for roughing and finishing cutters for both intake and exhaust valve locations and fabricated the tools within 3 weeks.

The tools employ standard V-flange shanks and screw-on heads, and machine a number of features in a single pass. The rougher, for example, features four different cutters: it roughs out the valve guide, cuts a 45° seat diameter and then cuts 30° and 75° angles that direct gas flow. The finisher, with two different cutters, then reams the valve guide and finishes the 45° angle on the valve seat.

Part of the tools' versatility results from running them at varying speeds.





Roush Machining Services designed its own multifunction tools (inset) to machine valve areas of the heads for 8.1-liter V-8 marine engines.

In the case of finishing, reaming the valve guide takes place at 600 rpm and a 10-ipm feed. Then, for finishing the valve seat, the parameters are reduced to 300 rpm and ½ ipm. The part program also employs a dwell sequence. "To make sure the seat is round, the tool sits there and dwells for a second," Vsetula said. He acknowledged that a special carbide form cutter could probably be used to create multiple features, but "you get a lot of tool pressure with all the cutting being done by one insert," he said. "In this case, there is a tool for each surface."

By using its resources, Roush Machining Services handles everything automotive, and more (see sidebars). Ryder said Jack Roush has compared the shop's ability to satisfy a range of customer needs to that of the Cold Stone Creamery stores, which are famous for blending ice cream and toppings to match unique customer desires. "They mix it up for you right there," Ryder said. "You get to pick what you want." Production, prototype, old, new, even nonautomotive ... the Roush shop mixes it up right there to meet its customers' needs. △

For more information on Roush Machining Services, visit www.roushind.com or call (734) 779-7006.