BY BILL KENNEDY, CONTRIBUTING EDITOR

Reinventing the WHEEL

Customization is changing the aluminum-wheel market.

Performance demands and fashion trends are driving sales of aluminum wheels for light vehicles. From a performance perspective, reasonably sized versions of the light, strong wheels help boost fuel economy and aid vehicle handling. Fashion comes into play as compact hot rodders, good ol' boys, urban rappers and soccer moms seek custom wheels to give their "ride" a unique look.

The Specialty Equipment Market Association says 55 percent of all light vehicles in the U.S. feature alloy wheels, and since 1996, sales of custom wheels have increased more than 70 percent, to about $1.1 billion annually. As with any popular product, a multitude of competitors has appeared, including a wave from overseas. U.S. wheel makers are examining all aspects of their businesses to reduce costs, increase responsiveness and satisfy their customers' need for bling bling.

According to Keith Miller, program launch manager for the Forged Specialty Wheels Division of Alcoa Inc., Cleveland, there are two distinct markets for light-vehicle aluminum wheels: OEM and aftermarket. Miller's division serves both.

He said: "Look at the total size of the aftermarket in terms of all the retrofitting and upgrading people do on their vehicles. It is big and growing rapidly. OEMs realize people want to customize their cars, and are offering an alternative where people can do customization at the dealership instead of having to run around and do it on their own."

Production volumes are quite different for the two markets. "In the OEM world," Miller said, "they frequently talk about program volumes of 200,000 to 400,000 wheels a year for a high-volume automobile, and 10,000 to 20,000 a year for a specialty platform. In the aftermarket, most of it tends to be low volume. They are making 1,000 or maybe 2,000 a year of a particular style."

Cast or Forge

The methods by which wheels are manufactured vary greatly. The most basic distinction is whether they are cast or forged. Cast wheels are generally less expensive than forged ones, but pound-for-pound they are usually not as strong.

"Forgings cost more than castings, so you tend to find castings on family cars," Miller said. "Pickups, SUVs, off-road vehicles and performance vehicles like Corvettes and Mustangs have more forged applications. [Because of] the structure of the marketplace and OEM focus on pricing, the forging market globally is a little more specialized and smaller than the cast-wheel market."

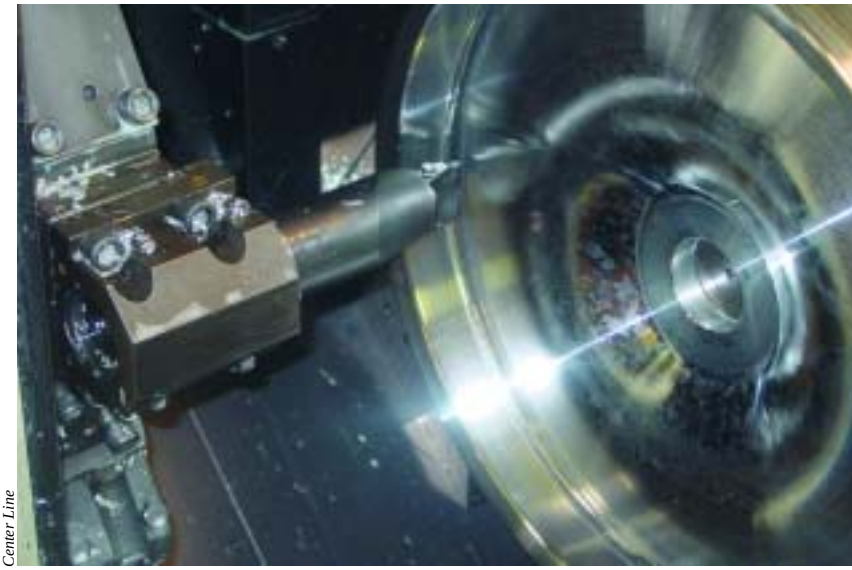
Alcoa/Forged Specialty Wheels

This 17"-dia., 8.5"-wide forged wheel with machined features is manufactured for the popular Hummer H2 SUV.

In general, most of the styling of a cast wheel is produced by the shape of the mold. Once out of the mold, the casting is turned on a lathe and the bolt pattern and finishing details are completed on a mill.

Forging usually produces a relatively simple wheel blank. Greg Smith, marketing director for aftermarket supplier Weld Wheel Industries, Kansas City, Mo., said, "Our initial forging is done in an 8 million-lb. forging press that produces a wheel blank with no holes. After the blank is turned, all styling is added in a mill."

Alcoa's Forged Specialty Wheels Division makes forged wheels two ways. For machine-feature wheels, styling is milled into a wheel blank after forging. For forged-feature wheels, some styling features are produced with custom dies at the time the wheel is forged. The complexity of the wheel design and its production volume determine which approach is used.



Center Line

After heat treating and aging, a 20"-dia, 8"-wide wheel blank with a spun rim is turned in a horizontal lathe.

The following companies contributed to this report:

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Forged Specialty Wheels Division
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Iscar Metals Inc.
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www.iscarmetals.com

Kitagawa Division/NorthTech Workholding Inc.
(800) 222-4138
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Okuma America Corp.
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Specialty Equipment Market Assn.
(909) 396-0289
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Superior Industries Intl. Inc.
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Weld Wheel Industries
(800) 669-9353
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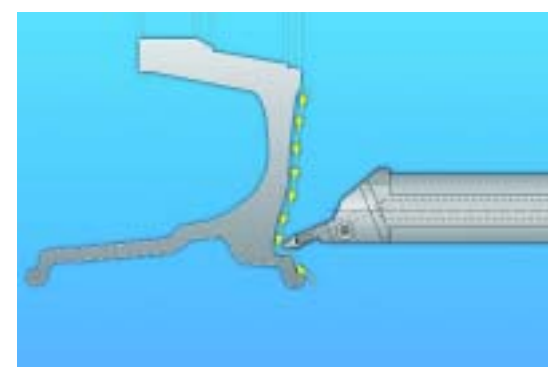
Tooling Solutions

Wheel makers work with suppliers to take advantage of advanced automation and tooling technology to reduce the cost per wheel. Stuart Maynard, mid-south lathe tooling manager for Iscar Metals Inc., Arlington, Texas, said, "For example, when you automate, chip control becomes a very high priority." An operator can knock stringy chips off a tool, but in an automated situation, chips will build up. Uncontrolled chips can scratch the surface of the wheel and can also damage the tool or machine. In response, Maynard said, Iscar developed its YZ chipformer geometry for carbide inserts and its CB chipformer for PCD tools.

Increased automation also heightens the need for reliable control of burrs. Maynard said one solution is to employ a light DOC, 0.1mm to 0.2mm, on finishing passes. "That's when a very sharp insert would be a help, too," he said.

Beyond the effects of chips and burrs, surface finish is largely dictated by the relationship of insert nose radius to the feed rate. The larger the nose radius of an insert, the faster it can feed and still produce a good finish. Wheel geometry, however, may dictate the maximum insert size that can be applied. This is because wheel makers prefer to machine the surface of a wheel from the lip edge to the center in one pass, avoiding blend lines that occur when tools are changed in midcut.

Maynard pointed out, "Especially in the OEM wheels, the lip edge is a small radius, about 2mm or 2.5mm, and a 4mm- or 5mm-wide insert is used to machine it. Roughing a 2.5mm radius with an approximately 5mm insert, we're feeding at 1.5mm/rev., and, when finishing, we're down to 0.5mm/rev. The smallest radius on the face of the



Iscar

To avoid blend lines, wheel makers prefer to machine the surface of a wheel from the lip edge to the center with one tool. The smallest radius on the face of the wheel determines the size of the insert and the feed rate.

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Steve Vanderink, Iscar's Ohio Valley lathe product manager, said PCD inserts can impart excellent surface finish and extend tool life when machining aluminum. However, he cautioned, the cutting speeds must be high to be effective. "If you can generate the rpm you need to run with PCD, you'll get good finishes," he said. In some situations, the machine tool's clamping mechanism or its capability won't permit the necessary speed to run PCD effectively.

With this CB chipformer insert, a chip-control groove is molded into the insert body and the PCD edge is brazed on around the chipformer.

To reduce cycle times, manufacturers also employ custom, multifunctional toolholders that hold two or more insert geometries, enabling two or more operations to be completed without indexing the turret or even returning to the home position. Such tooling is more prevalent in plants with longer part runs, which usually have been optimized to maximize efficiency. To simplify tooling inventories, Vanderink said, "we try to stay with standard inserts in the special tools."

As more wheel-making operations are automated or run by less-skilled operators, Maynard said, "you need to engineer solutions to be able to manage the tooling. Everything should have a preset gage line. Even on our standard tools, we will drill and put in a location pin, so when the operator puts the tool in the turret, it stops against the pin and is in the same location every time."

Bernie O'Neil, director of corporate manufacturing for OEM wheel maker Superior Industries International Inc., Van Nuys, Calif., said, "It sounds simple to throw a wheel up there and turn it round, but it's not so." A machined wheel still chucked in the lathe may appear round when checked with an indicator, but "when you release the chuck, the stresses you've released in the casting when you machined the skin off take effect and the wheel may not be round after all," he said.

Such results are highly specific to each wheel and different wheels require different feeds, speeds and cutters. "A wheel with seven spokes doesn't machine the same way as the same size wheel with five spokes," O'Neil said.

Machine Tool Strategies

Different wheel configurations require different machine tool technologies. Richard Turner, wheel business project manager at Okuma America Corp., Charlotte, N.C., said Okuma has determined that horizontal turning centers are suitable for wheels under 20" in diameter, but recommends vertical machines for diameters of 20" and above. The reason is that the larger wheels are heavier, he said, and with the vertical machines "you have gravity working with you" because the weight of the wheel fixes it to the reference surface. Loading and unloading time is also reduced, because a wheel-changing robot can simply place the wheel on the vertical spindle without waiting for the chuck to clamp it, as would be the case in a horizontal machine.

Turner noted that many aftermarket wheel makers feel that because they produce smaller batches than OEMs, they should use stand-alone machine tools instead of more expensive automated cells. In reality, changeover techniques have been developed that permit switching wheel styles in 45 minutes or less. "Even with the additional expense and the shorter runs, you're still going to recover the money you invest in the automation, because you get more wheels out the door," he said.

Much of the increase in changeover speed results from improved workholding technology. When changing between wheel diameters, Turner said, "most of the time is spent in replacing the workholding so you can clamp up the new wheel properly." Okuma worked with Logansport (Ind.) Matsumoto Co. to develop a chuck that can handle 14"- to 24"-dia. wheels by changing the top tooling alone.

In addition to changeover speed, other considerations in chuck design include reliability, uniformity and overall quality of the wheel, said Shawn Luschei, automotive products

Basics of making wheels

Wheels are cast by a variety of techniques, from simple gravity flow to a number of pressure-assisted methods. One-piece, forged wheels are formed in a massive press from a billet of aluminum. The forging forces change the grain structure of the aluminum and boost its strength.

A typical cast alloy is A-356, which contains approximately 7 percent silicon. Forged wheels, on the other hand, are most often made from 6061, a strong, corrosion-resistant composition that typically contains about 0.6 percent silicon and 1 percent magnesium, as well as other elements. The machining characteristics of the two alloys differ as well. An A-356 alloy machines relatively easily. Because it is formulated to be malleable, 6061 can present chip-control problems, especially when light finishing cuts are being made.

Wheel construction methods include 1-piece casting or forging, as well as 2- and 3-piece assembly. Two-piece aluminum wheels are fabricated much like steel wheels. A hoop or rim is formed from an aluminum sheet, and a cast or forged center is welded to it. Three-piece wheels consist of a center bolted or welded to a 2-piece rim. Wheel hoops for 2-piece wheels generally are made from a 5000 series, workhardening, manganese-alloy aluminum. The stock is coiled into a hoop, the seam is butt-welded and the rim is workhardened by spin forming.

Variations exist for each process, such as forging methods that involve spinning the billet as it is pressed, or 1-piece cast wheels on which the rims are spun to shape.

—B. Kennedy

manager for Kitagawa Division/ NorthTech Workholding Inc., Schaumburg, Ill. As automation increases, reliable chucking becomes crucial in preventing crashes and interrupted production. Luschei said a standard feature on his company's chucks is seating and clamping confirmation. When the wheel is clamped firmly into the chuck, three air plungers close an air circuit, which tells the machine control that the wheel has been properly seated and clamped against its locators.

In pursuit of higher wheel quality, Luschei said NorthTech is completing work on a chuck for wheel finishing. The chuck will be about half the weight and diameter of a standard chuck, and will cost 15 to 20 percent less than a typical fully tooled wheel chuck. NorthTech expects the chuck to improve overall final quality of the wheel considerably, with the capability to consistently provide TIR of 150µm between the mounting bore of the wheel and the inboard and outboard bead seats.

Fashion Sense

Wheel quality and performance are paramount, but fashion has a large influence on wheel making. "One of the reasons that people demand aluminum wheels is cosmetic," O'Neil said. He pointed out that even Superior's OEM customers are producing customized vehicles.

For General Motor Corp.'s full-size 1500 series, "the wheels for all of their pickup trucks and sport utilities used to be two part numbers," he said. "Now they are up to eight or nine, for basically the same volume of vehicles."

OEMs are trying to turn their product lines over more quickly because consumers want more choices. Alcoa's Miller said: "Car and light-truck platforms previously were produced from 5 to as long as 8 years before they were refreshed. A wheel manufacturer would book a wheel and make it for 5 years. Now, it's very common for OEMs to turn them around in 2 years. We've seen the benefit, or the extra work, of having to add those to our launches. It is a fair statement to say we've probably tripled the volume of work that we do in terms of new product development."

Jim Blandford, cost accountant at aftermarket supplier Center Line Wheel Corp., Santa Fe Springs, Calif., said: "We are constantly having to come up with new ideas and get them out on the market and see if they are accepted. You do look and see what's popular out there, but you have to remember that you have to put a tire on it. You've got to have that in mind whenever you design something, and, believe me, some people don't get that."

Asian Invasion

Like many other manufacturers, wheel makers are witnessing a flood of products from China and elsewhere in Asia. The aftermarket business has been hit especially hard. Blandford said: "Business has changed so much in the last year. I know how the furniture industry feels now. I wouldn't have believed it. There are a lot of companies out there that are holding on by importing the wheels and selling them under private label."

Weld Wheel's Smith said, "There is only a handful of manufacturers, maybe five, that actually still manufacture wheels in the U.S. that are considered aftermarket wheels." Smith sees some competition from high-end European wheels, "but the rank and file are primarily selling Chinese wheels now. They've flooded the market and the prices have dropped. Luckily, the

Bigger is not better

Bernie O'Neil, director of corporate manufacturing for Superior Industries International Inc., said the market isn't all that's growing—the wheels are, too. Up from the 17"- and 18"-dia. options of recent years, a common option is now 20"-dia., he said, "and there are two major players that are looking at 22s."

A recent issue of "Dub" ("The Original Automotive Lifestyles Magazine") featured Hummer H2 SUVs "hooked up" with giant 28"-dia. rims.

Center Line Wheel Corp.'s cost accountant, Jim Blandford, noted that as wheels grow larger, the strength vs. weight difference between cast and forged wheels takes on greater significance. "A 20"-dia. cast-wheel and tire package can get up over 100 lbs., with the cast wheel itself in the 40-lb. range. Center Line's forging in a 20"-dia., 8"-wide wheel is around 24 lbs."

The larger the diameter of cast wheel, the more the disparity grows. "You put that heavy rotating mass on the vehicle, and you're wearing your brakes out. It takes more to push it, more to stop it," Blandford said. "The OEMs are putting their foot down, because the weight of these things is getting beyond what their warranties will allow."

In fact, "The Detroit News" recently quoted GM engineers cautioning consumers that some plus-size wheels available on the aftermarket might compromise their comfort, if not their safety. The engineers said wheels can create balance problems or affect the performance of safety devices such as antilock braking and stability control systems.

Keith Miller, program launch manager for the Forged Specialty Wheels Division of Alcoa Inc., said the Tire and Rim Association Inc. issues a set of standards for wheel performance and the design criteria that must be followed so the wheels interface properly with the tire.

In addition, the Society of Automotive Engineers, with assistance from the Specialty Equipment Manufacturers Association's Wheel Industry Council, has recently completed a new aftermarket wheel specification (SAE J2530) that provides minimum performance requirements for cornering fatigue and radial fatigue of aftermarket wheels intended for normal highway use.

Miller said those guidelines are primarily related to the aftermarket, and many OEM specifications are more rigorous. "Since we supply all the markets, we find the toughest specification for each one of the criteria and build to that so that we meet them all."

—B. Kennedy

wheels they bring into the market are cast. They are not on the high-end range and haven't affected us as much."

Blandford said, "We can't buy our raw materials for what they are selling their wheels for in some cases. Luckily, we've got our own niche in forging." Blandford and Smith agreed that over the last 5 years, the quality of the imported wheels has improved significantly.

Miller said Alcoa's product launch teams focus on quick response to beat the competition. "We are very disciplined about it, so when we have a request for a new wheel, the team is like a pit crew. Everyone knows what their job is, they go off and do it, and a lot of the design work is done in parallel."

The OEM customer plays a role, too. "They have to respond very quickly to get the design finalized," Miller said. "At some point, you have to decide what the thing is going to look like and start doing the real engineering work."

Miller said the Alcoa Business System, basically a lean-manufacturing process, is another example of a way to increase competitiveness. "Every person looks at his or her job every day and tries to figure out a way to make it better," he said. Miller cited a case where a CNC machine operator in an automotive wheel plant examined the steps required to changeover his machine from one wheel to another and suggested that the forging designs be altered to add common centering locaters on every wheel. "We followed his recommendation and completely eliminated a changeover on the turning cell," Miller said.

The best way to compete with overseas suppliers, said Superior's O'Neil, is "to get leaner and more efficient." He said the overwhelming cost of manufacturing wheels is in the casting process and that Superior is working on several different proprietary ideas in casting to reduce scrap and changeover and cycle times. "There's nobody out there doing anything spectacular right now," he said. "You're not going to reinvent the wheel, you just work on it. It's a constant battle.

"You work really hard to get something accomplished, to scratch out a 20-cent savings on a wheel. Someone will catch onto it sooner or later, but hopefully by then you'll have the next 20 cents," O'Neil said.