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MELTING POINT

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CASTINGS FUEL OUR SOCIETY

p.18

Inside This Issue:

Why Metalcasting?... Metalcasting produces engineered metal components for use in all facets of our world, including what you drive, where you live, what you eat and how you work. The metalcasting industry maintains its traditions while embracing advanced manufacturing techniques. But the key to metalcasting is what is illustrated in ***Melting Point*** magazine—the diverse ways metalcasting helps propel society forward. If you are interested in joining this forward-thinking industry, look to the sections of the magazine dedicated to Metalcasting Universities & Scholarships and Career Opportunities on p. 20-23.

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LIGHTS. CAMERA. CASTING

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to view these videos and more.

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Wonder what the inside of a metalcasting facility is like? Check out the aluminum casting operations of Busche Performance Group in Fruitport, Michigan.

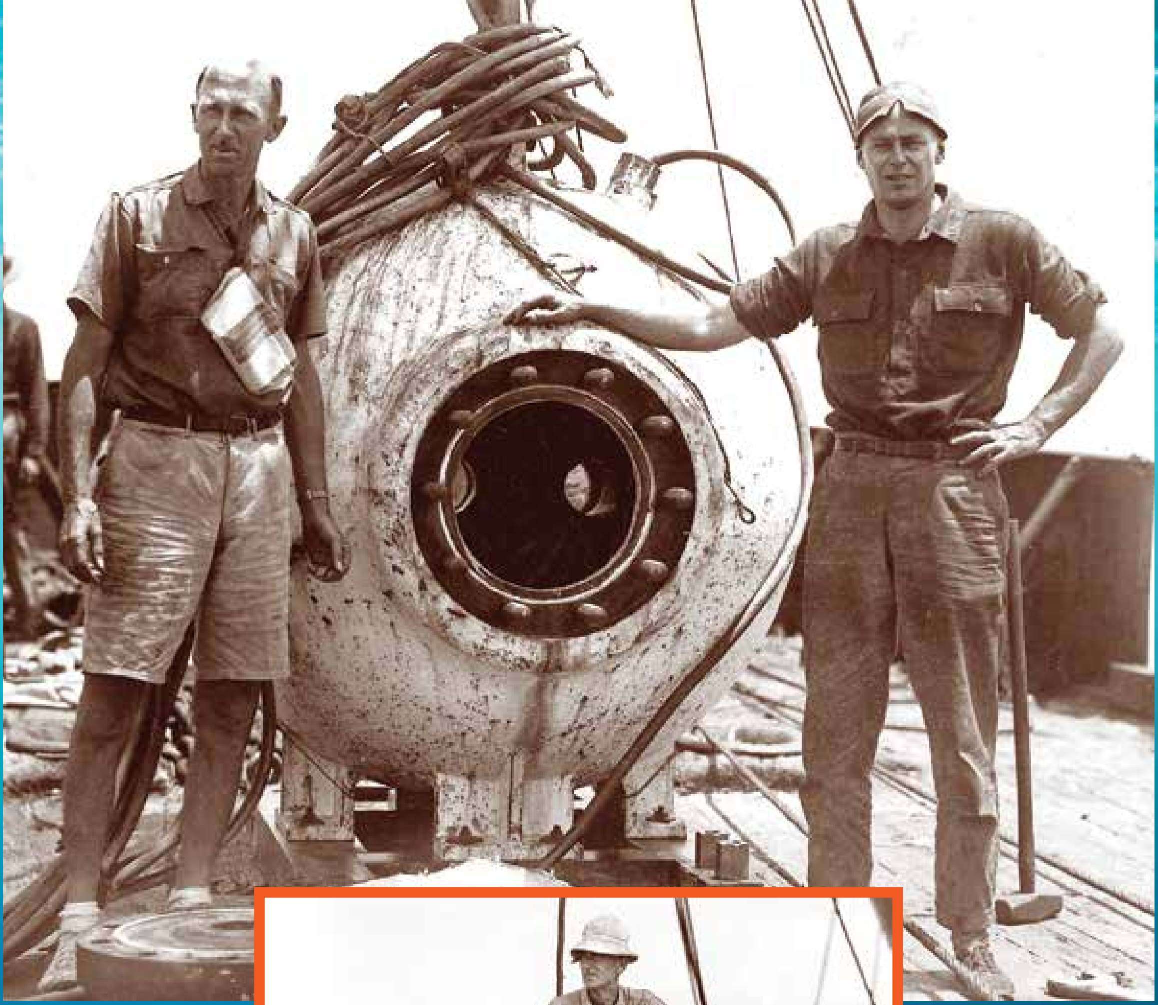
In college, you can jump start a career in metalcasting through involvement with FEF-the Foundry Educational Foundation. It's mission is to encourage students to pursue the metalcasting industry, and it offers scholarships, chapters, and other resources as a bridge from class to career.

BEEBE AND BARTON DIVE TO THE OCEAN'S DEPTHS

When naturalist William Beebe and engineer Otis Barton began a collaboration to explore the ocean in the 1920s, humans had ventured only 500 ft. below the surface. By 1930, the two settled on a spherical design for a vessel called the bathysphere (from the Greek words for “deep” and “sphere”) that would be raised and lowered by a cable.

The Watson Stillman Hydraulic Machinery Co. (Roselle, New Jersey) initially cast 3-in. thick steel walls for the sphere in June 1929. The first iteration was too heavy to be lifted and placed in the ocean, so a modified design with 1-in. walls was cast. The initial craft measured approximately 4.75 ft. (1.5m) in diameter and weighed 2.25 tons.

The two conducted a number of dives in the summer of 1930, reaching a depth of 803 ft. Over the next four years, Beebe and Barton continued to descend deeper into the ocean and eventually reached a depth of 3,028 ft. (928m) in 1934, a world record that stood for 15 years. MP



Photos courtesy the Wildlife Conservation Society (www.wcs.org).

KNOW THE LINGO

Sound smart to your friends and teachers by using the right words to describe what goes on in the metalcasting industry.

Alloy A material composed of two or more elements, at least one of which is metal, created to improve the properties or lower its cost.

As-cast A casting condition without subsequent finishing, including heat treatment.

Base metal The principal metallic material used in an alloy.

Bath The molten metal in the hearth of a furnace, in a crucible or in the ladle.

Binder The bonding agent added to mold or core sand to keep the mold sand together with a strength and rigidity.

Blast cleaning The removal of sand or other material from castings by blasting it with metal shot or grit.

Brinell hardness A test for determining the hardness of a material.

Captive foundry A division of a larger manufacturing establishment that produces cast parts for the parent company.

Castability A combination of liquid metal properties and solidification characteristics that promotes accurate and sound casting manufacture; the ease with which a metal flows through a mold or die.

Charge A given weight of metal introduced into the furnace.

Chill A metal insert placed in a sand mold to induce local rapid heat loss and equalize the rate of solidification throughout the casting.

Cleaning Removal of runners, risers, flash, surplus metal and sand from a casting.

Coldbox process A form of sand molding that relies on a two-part organic resin binder system to create the mold.

Cope The top half of a horizontally parted mold.

Core A sand or metal insert in a mold to shape the interior of the casting or that part of the casting that cannot be shaped by the pattern.

Core assembly A substructure made from a number of cores.

Corebox The wooden, metal or plastic tool used to produce cores.

Crucible A receptacle made of refractory materials used for melting and holding molten metal.

Cure To harden, as in a sand mold or core.

Die A metal form used as a permanent mold for diecasting or for a wax pattern in investment casting.

Draft Tapering on the vertical sides of a pattern or corebox to permit the core or sand mold to be removed without distorting or tearing the sand.

Drag The bottom half of a horizontally parted mold.

Elongation The amount of permanent extension near the fractures in a tensile test, expressed as a percentage of original gage length.

Expendable pattern A pattern that is destroyed in the making of a casting, usually made of wax or foam.

Fatigue The tendency of a material to break under conditions of repeated cyclic stress.

Feeder Part of the gating system that forms the reservoir of molten metal necessary to compensate for losses due to shrinkage as the metal solidifies; a riser.

Fillet A concave piece of material used to replace sharp corners on patterns or coreboxes; may be part of the mold (struck) or made separately (planted).

Fin A thin projection of metal on a casting resulting from imperfect mold or core joints.

Flash A thin section of metal formed at the mold, core or die joint or parting in a casting.

Flask A rigid metal or wood frame used to hold the sand of which a metalcasting mold is formed and usually consisting of two parts, a cope and drag.

Floor molding Used when pattern sizes prohibit the use of a molding machine; the pattern is bolted to the floor, and the assembled mold is moved by crane.

Foundry returns Metal in the form of gates, sprues, runners, risers and scrapped castings returned to the furnace for remelting.

Gate (ingate) The portion of the runner where the molten metal enters the mold cavity (Fig. 6).

Green sand Moist, clay-bonded molding sand.

Heat treatment A combination of heating and cooling operations timed and applied to a metal or alloy in the solid state to produce desired mechanical properties.

Holding furnace A furnace for maintaining molten metal supplied from a larger melting furnace at the proper pouring temperature.

Inclusions Particles of slag, refractory materials, sand or deoxidation products trapped in the casting during pouring solidification.

Ingot A mass of metal cast to a convenient size and shape for remelting or hot working.

Investment casting A pattern casting process in which a wax or thermoplastic pattern is used. The pattern is invested (surrounded) by a refractory slurry. After the mold is dry, the pattern is melted or burned out and molten metal is poured into the resulting cavity.

Jobbing foundry A metalcasting facility that manufactures castings not intended for use in its own product.

Ladle A container used to transfer molten metal from the furnace to the mold.

Lost foam A casting process in which a foam pattern is placed in a flask filled with loose sand, and molten metal is poured onto the pattern, replacing its shape and forming a casting.

Machinability The index or rate of removal by machining methods, usually expressed as cutting speed in surface ft./minute or depth of cut.

Mechanical properties Those properties of a material that reveal the elastic and inelastic properties when force is applied. This term should not be used interchangeably with "physical properties."

Melting range Pure metals melt at one definite temperature, but the constituents of alloys melt at different temperatures; the variation from the lowest to the highest is called the melting range.

Mold Normally consists of a top and bottom form, made of sand, metal or any other investment material. It contains the cavity into which molten metal is poured to produce a casting of definite shape.

Nobake process Molds/cores produced with a resin-bonded, air-setting sand. Also known as the airset process because molds are left to harden under atmospheric conditions.

Orientation The position of a part or tool in a production operation.

Parting line The line showing the separation of the two halves of the mold.

Pattern The wood, metal, foam or plastic shape used to form the cavity in the sand. A pattern may consist of one or many impressions and would normally be mounted on a board or plate complete with a runner system.

Physical properties Properties of matter such as density, electrical and thermal conductivity, expansion and specific heat. This term should not be used interchangeably with "mechanical properties."

Plaster molding Molding method where gypsum or plaster is mixed with talc and water to form a slurry that is poured around a pattern. After the slurry hardens, the pattern is removed and the mold is baked at an elevated temperature to remove all moisture prior to use.

Porosity Holes in the casting due to gases trapped in the mold, the reaction of molten metal with moisture in the molding sand or the imperfect fusion of chaplets with molten metal.

Refractory Heat-resistant ceramic material.

Riser See feeder.

Runner system or gating The set of channels in a mold through which molten metal is poured to fill the mold cavity. The system normally consists of a vertical section (downgate or sprue) to the point where it joins the mold cavity (gate) and leads from the mold cavity through vertical channels (risers or feeders).

Sand inclusions Cavities or surface imperfections on a casting caused by sand washing into the mold.

Scrap **a)** Any scrap metal melted (usually with suitable additions of pig iron or ingots) to produce castings. **b)** Reject castings.

Semi-permanent mold A permanent mold in which sand, plastic or graphite cores are used.

Shakeout The process of separating the solidified casting from the mold material.

Shrinkage Contraction of metal in the mold during solidification.

Slag A fused nonmetallic material that protects molten metal from the air and extracts certain impurities from the melt.

Sprue (downsprue-downgate) The channel, usually vertical, through which molten metal enters the mold.

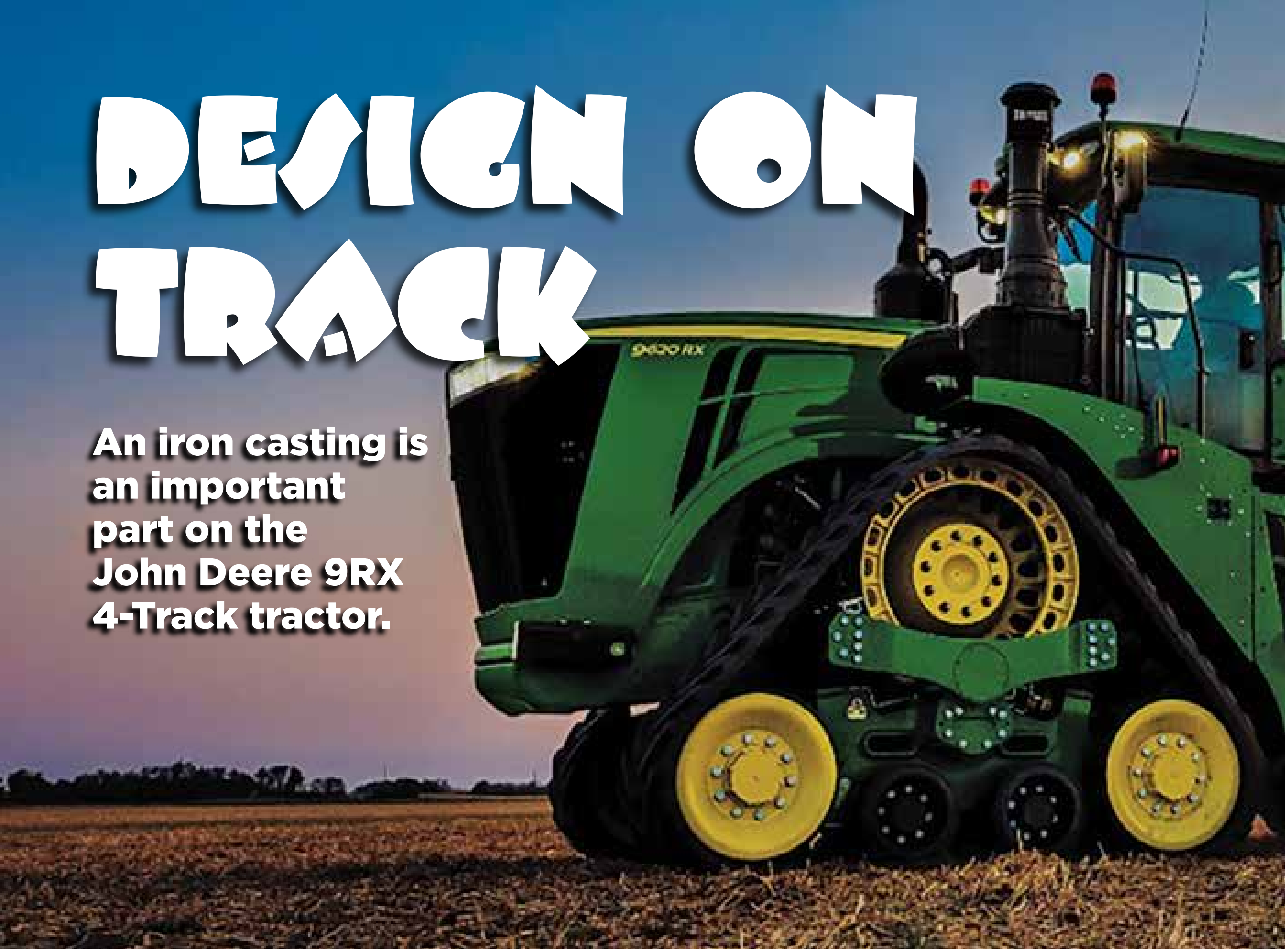
Superalloy An alloy developed for very high temperatures where relatively high stresses are encountered and where oxidation resistance is needed.

Tilt-pouring In permanent molding, when the mold is moved from a low angle to a vertical position during pouring.

Vent An opening or passage in a mold or core to facilitate escape of gases when the mold is poured.

Yield or casting yield The percentage of quality degated castings produced in relation to the amount of molten metal poured.

DESIGN ON TRACK



An iron casting is an important part on the John Deere 9RX 4-Track tractor.

When a complicated casting for a major company is designed, it's not a one-person job. Multiple teams, crews and departments are involved. Each has specific roles they need to fill with their respective areas of expertise, which helps even more when challenges and hiccups arise.

What happened when John Deere Waterloo Works built the drive housing casting for the 9RX 4-Track shows the importance of that teamwork.

The engineering and casting sides of the company communicated frequently, exchanged ideas and worked together to create a component that helped John Deere jump into a new market segment—four-track tractors.

"In order for this to be a success, it took a lot of collaboration between a lot of different groups within Deere," said staff engineer Jeff Lubben. "Machining people, our foundry, our analysis group, design. In order to make this a success on the assembly line and for our customers, it took a lot of work from a lot of different folks."

Four track tractors maneuver fields using a track system similar to what you might see on a construction vehicle. This is a deviation from Deere's line of wheeled tractors. The drive

housing carries the gear train and supports the whole tractor and undercarriage for the track system.

Engineers at Deere determined a single large casting would help the different gears, one of which is over 27 in. in diameter, to line up better.

The designers also wanted to incorporate a lubrication system for the axle within the cast housing to avoid external routing oil lines. The oil was designed to route through the housing via a patented system.

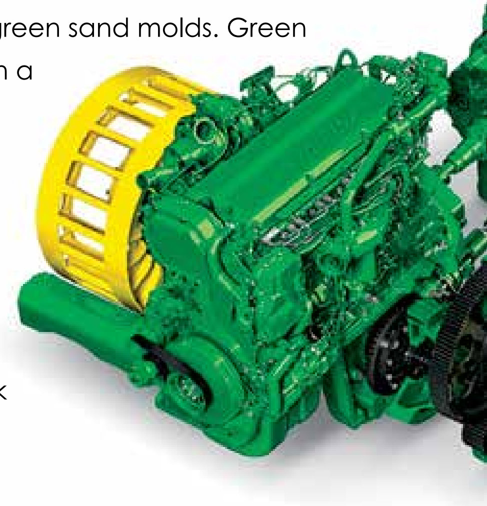
Each tractor has four of these castings—one in the left front, right rear, right front and left rear.

Some ways to manufacture parts include stamping—in which a flat sheet of metal is formed into a shape with a stamping press—and welding, where metal parts are joined together using heat to create a final shape.

But Deere decided metalcasting—in which liquid metal is poured into a mold to make the desired shape was the best way to make the drive housing.

"Obviously, you could make a stamped and welded part look nice but there's only so much you can do with a cut and fold piece of steel," said Pete Murfey, senior engineer. "Weight savings was a big goal, so we were able to manage where we put the weight in the part, focusing on just adding iron where we needed it and taking it out where we could. The casting gave us the ability to put all the features exactly where we wanted them."

The component was eventually cast in ductile iron using green sand molds. Green sand molds are molds made of sand that keep its shape with a water-based solution—similar to making a sand castle.



Starting From Sketch

In September 2010, Lubben went to work on a simple piece of paper, sketching concepts that were startlingly similar to what eventually was produced.

One of the goals of the casting was for it to be relatively low mass. Deere also wanted to minimize the number of leak paths and share common geometry with its wheel tractors.

Before the work could bear fruit, teamwork was needed.

A lot of teamwork.

"It was from, literally, a sketch on an 8 1/2 x 11-in. sheet of paper when we started collaborating," said Anthony Childers, foundry pattern development engineer, John Deere. "That's about the right time to get a foundry involved. We're very proud of that collaboration."

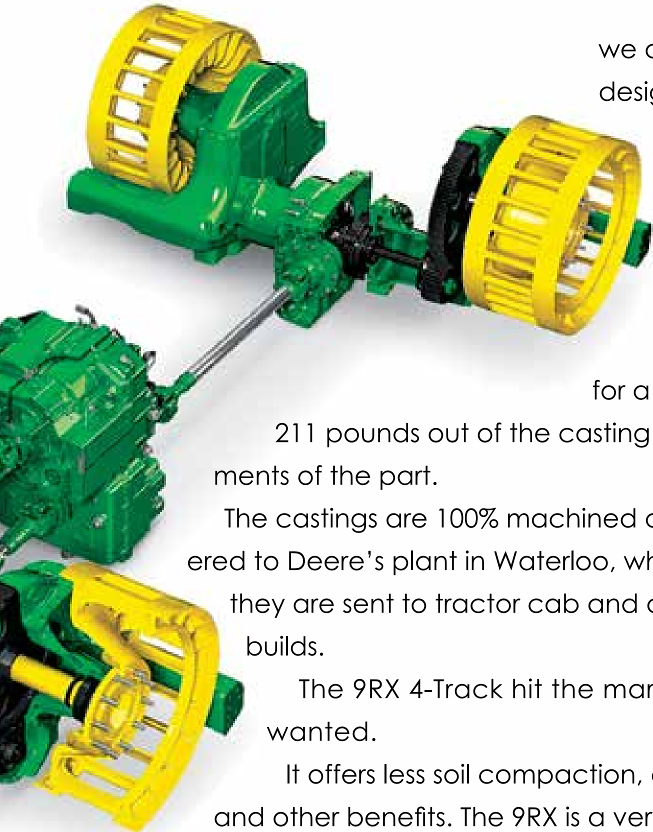
That collaboration was an important one for John Deere. One of the market leaders in farming machinery, Deere was looking to break into a new market segment with a four-track tractor.

"The four-track capability is something that's growing in popularity on the market, and Deere decided it was high time we got in the market," Murfey said. "Being able to spread out the load across four large track footprints rather than tires or two tracks is a big improvement in the field. The biggest advantage I think it offers is the ability to turn a tight corner without pushing up a large berm of dirt that you get with a two-track tractor."

To deliver what was needed, Deere needed to design and implement a large casting.

The casting was designed to fit Deere's new green sand molding line at its Waterloo, Iowa, casting facility. Deere was also able to cut eight weeks from the product development time of each build via 3-D sand printing.

"We worked on a once- or twice-weekly basis with engineering as the design was being developed because we had a core manufacturing strategy that we were pursuing and



we asked for a myriad of changes in the casting design to accommodate that," Childers said. "Plus we asked them to make changes in the casting design for directional solidification and for the flow of stresses through the casting. We made some design suggestions that made the casting stronger and stiffer."

After the first durability build, Deere asked for a reduction in mass. Ultimately, Deere trimmed 211 pounds out of the casting while still meeting all of the functional requirements of the part.

The castings are 100% machined at GMT Corporation (Waverly, Iowa) and delivered to Deere's plant in Waterloo, where internal components are assembled. Then they are sent to tractor cab and assembly operations in Waterloo for the tractor builds.

The 9RX 4-Track hit the market last year and has brought what Deere wanted.

It offers less soil compaction, a better turning radius, skid-free movement and other benefits. The 9RX is a very effective puller, with its four large axles and undercarriages transferring power from the engine to the ground. MP

With its recent additions, Waupaca altered its operations.

WAUPACA FOUNDRY BUILDS FOR ITS FUTURE

Foundry construction can be a difficult challenge. Whether it's building a completely new plant or adding onto an existing facility, obstacles come up that are both expected and surprising, even to the most seasoned professional. Challenges can stem from the distance between the company and the project, weather, construction delays or other issues that threaten to turn an idea haywire.

But the successful completion of projects is not impossible. Far from it, actually.

One example is how AFS Corporate Member Waupaca Foundry (Waupaca, Wisconsin), a Hitachi Metals company, expanded production of cores (inserts placed in a mold to shape the interior or a part of a casting that cannot be shaped by the pattern) at two of its Waupaca-based gray iron foundries. The project is now complete, as one robotic cell is running at Plant 1 and six robotic cells are running at Plant 2/3.

Getting there, however, was a process.

At Plant 1, the first phase saw 11,500 sq. ft. of storage space added for storage of sand cores, and the second phase was the construction of a 25,000 sq. ft. core production facility. Meanwhile, at Plant 2/3, the first phase included the addition of a core production facility with three coremaking cells. The plant also developed new robotic work cells, a sand conditioning system, a new way to distribute material, a new additive system and a new core-drying oven. In the next phase at Plant 2/3, one new and two coremaking cells were moved to the facility. A pair of robotic cells were moved and a robotic cell was added.

In doing this, Waupaca took a legacy foundry process and redesigned it from the ground up. Waupaca reviewed its production process and improved it before designing the space. That allowed it to automate features to achieve repeatable quality results, improve ergonomics for worker comfort, and leave room to expand to meet future customer requirements. At Plant 2/3, Waupaca completed two phases of design, engineering, construction and implementation within a condensed 26-month timeline while decommissioning existing equipment in order to commission the new cells. This was all done while maintaining production capacity to meet customer orders.

According to the company, the project has clearly had an impact on Waupaca's operations. The workspace improved for workers, and the customers are happy with the product. The material and process flow is better thanks to efficient and accurate equipment locations and the new technology reduces variation throughout the coremaking process. The employees have workstations with better ergonomics, improved lighting and improved process controls.

"It shows what you can accomplish when you bring the best foundry team together, truly listen to concerns and

The core room at Waupaca Plant 1 underwent an extensive upgrade.

suggestions, and seek out sound solutions." said Dale Hardel, engineering manager, Waupaca. "Collectively we have demonstrated that safety and ergonomic improvements, energy efficiency, environmental awareness, and equipment innovation can be applied in a state of the art fashion to a classic foundry process."

The project required strong collaboration with all involved. Waupaca engaged its vendors and suppliers early in the process by sharing design models and equipment requirements to provide for the most efficient construction process. Waupaca was able to engage team members across functions and departments to design an optimal workspace through Kaizen and benchmarking best practices.

Waupaca also had to battle a tight timeline, one that went right through the typically harsh Wisconsin winter. And it also had to figure out when to draw a line between what they wanted and needed to keep the project within budget. MP

This is the core room from Waupaca Plant 2/3, where the facility dramatically altered its operations.

During its expansion, Waupaca had to be mindful of a budget.

CASTINGS HELP BUSES PUT ON THE BRAKES

So much needs to happen for children to arrive safely to school. Many of them take school buses twice a day so they can get the education to grow their brains and become adults.

They depend on many cast components for a smooth ride, and one of them is under the bus driver's feet.

In many buses, the operator pedal system is cast via the permanent mold process, using nickel-aluminum bronze. The pedal system is made up of the brake subsystem and the accelerator subsystem, and both must be dependable.

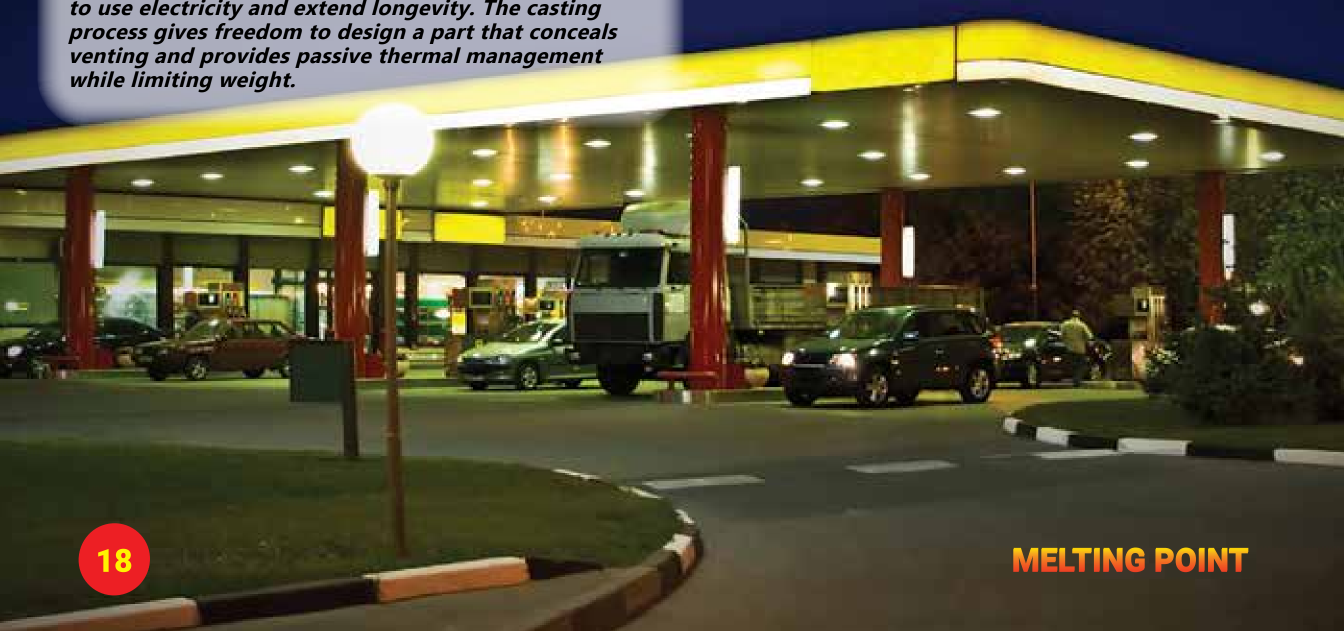
Thanks to casting, they are. MP

A nickel-aluminum bronze operator pedal system in school buses is cast via the permanent mold process.

FUELING OUR SOCIETY

Cast parts are a crucial part of our society. They help us get from place to place and do the jobs that keep our lives and economy moving along. Perhaps no place better represents this than a gas station. Beyond the obvious applications, cast components are everywhere when we refuel. MP

Outdoor lighting of all types uses cast components in a variety of forms. Aluminum aids LED lighting systems to use electricity and extend longevity. The casting process gives freedom to design a part that conceals venting and provides passive thermal management while limiting weight.



Though not all gas stations have mechanics and garages, many do. And those mechanics rely heavily on cast tools to get your car back on the road. One such example are cast iron wrenches.

It might not look like it, but gas pumps include cast components. Under the coating, the handle and nozzle are frequently die cast.

Buckling up is a key part of getting anywhere safe, and as soon as people are ready to leave they fasten their seat belts. They do that with cast seat belt buckles.

Find a College to Study Metalcasting

Ready to launch your metalcasting career? Want to know where to get started? These colleges are optimal institutions to consider if you are interested in metalcasting as a career.

California Polytechnic State University
Pomona, CA

California State Polytechnic University
San Luis Obispo, CA

California State University—Chico
Chico, CA

Central Washington University
Ellensburg, WA

Eastern Michigan University
Ypsilanti, Michigan

Instituto Technologico De Saltillo
Saltillo, Coah, Mexico

Kent State University
Kent, OH

Michigan Technological University
Houghton, MI

Milwaukee School of Engineering
Milwaukee

Missouri University of Science & Tech
Rolla, MO

Mohawk College
Hamilton, ON, Canada

Penn State Erie—The Behrend College
Erie, PA

Pennsylvania State University
University Park, PA

Pittsburg State University
Pittsburg, KS

Purdue University
West Lafayette, IN

Saginaw Valley State University
University Center, MI

Tennessee Tech University
Cookeville, TN

Texas State University—San Marcos
San Marcos, TX

The Ohio State University
Columbus, OH

Trine University
Angola, IN

University of Alabama—Birmingham
Birmingham, AL

University of Alabama—Tuscaloosa
Tuscaloosa, AL

University of Michigan
Ann Arbor, MI

University of Northern Iowa
Cedar Falls, IA

University of Wisconsin—Madison
Madison, WI

University of Wisconsin—Milwaukee
Milwaukee, WI

University of Wisconsin—Platteville
Platteville, WI

College Scholarships Available... YES!

Visit
American Foundry Society Chapters at:
www.afsinc.org/chapters

Visit the Foundry Educational Foundation at:
www.fefinc.org

Virginia Tech
Blacksburg, VA

Western Michigan University
Kalamazoo, MI

Youngstown State
Youngstown, OH

CAREER OPPORTUNITIES

Do You Like:

- Science?
- Building things?
- Designing things?
- Being creative?
- Working with People?
- Solving Problems?

Consider Metalcasting. We Need:

- Business Managers
- Chemical Engineers
- Computer Engineers
- Electrical Engineers
- Human Resources
- Safety Managers
- Accountants
- Quality Control Technicians
- Marketing & Salespeople
- Mechanical Engineers
- Metallurgists
- Skilled Trade

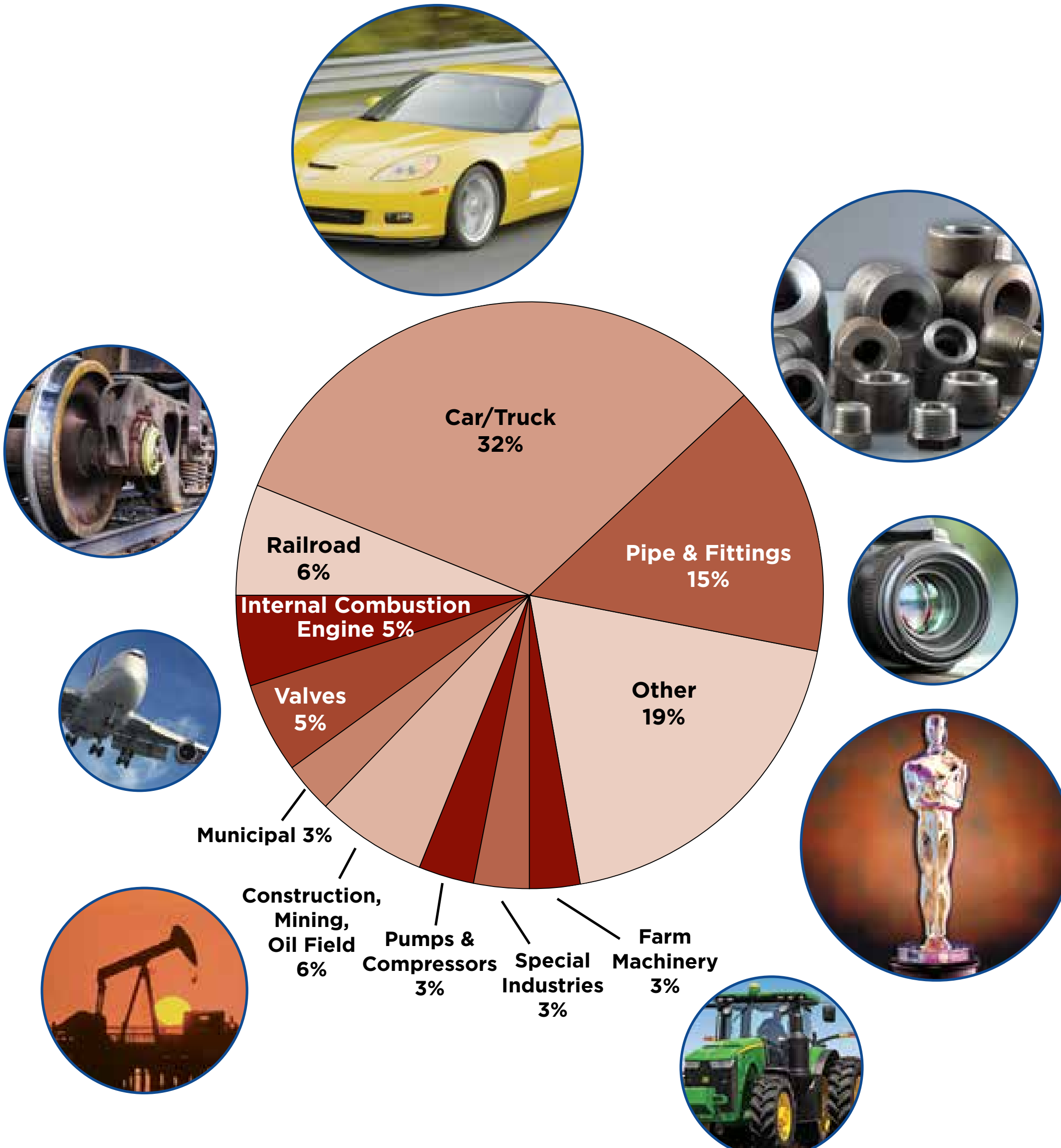
Careers: Post High School

- Molder, Melter & Welder: $16+/hr
- Patternmaker, Crane Operator: $17+/hr
- Maintenance & Electrician: $20+/hr

Careers: Post College

- Supervisors-Plant Floor: $50,000+/yr
- Production, Quality, Safety Manager: $60,000+/yr
- Top Manufacturing, Human Resources, Engineering Executives: $90,000+/yr

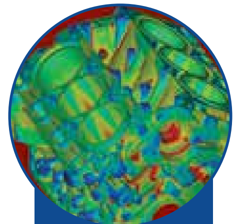
WHERE DO CASTINGS GO?



Metalcasters Everywhere!

- 1,900+ Metalcasters
- 700 Ferrous; 1,300 Nonferrous
- Employ 200,000

METAL CASTING SUPPLY CHAIN



Engineering

Raw Materials & Equipment

Pattern & Tooling

Metalcasting Facility

Did you know?

Ninety percent of all manufactured goods rely on metal castings.

Did you know?

In the middle of an average city you are never more than 10 ft. from a metal casting.

Value Added

- Machining
- Heat Treatment
- Parts Assembly

End Users of Castings

- 80% Are Small Businesses With Less Than 100 Employees
- 2016: $30.3 Billion in Sales; 11.5 Million Tons Shipped

ADVOCATE. EDUCATE. INNOVATE.

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