



CASE STUDY

Global Foundry Group Grows Business with Sand 3D Printing Innovation

With nine decades of experience in sandcasting innovation, Kimura Foundry America places sand binder jetting at the core of its business to deliver top-quality rapid prototypes.



Fully embracing additive manufacturing as the cornerstone of the next industrial revolution, the company today has six ExOne sand 3D printers in Japan for core and mold production and three at the Kimura Foundry America.

INDUSTRIES SERVED Automotive, Construction Machinery, Pumps, Industrial Equipment
LOCATION Shelbyville, IN
CHALLENGE Delivering the highest quality prototype metalcastings with fast turnaround times, even of the most complex designs or for high-temperature pours

SOLUTION
3D PRINTERS Two ExOne S-Max® and One ExOne S-Print®
MATERIAL Patented ceramic sand
BINDER Furan and Cold-Hardening Phenol (CHP)
ALLOYS CAST A range of ferrous materials, including precision iron, steel, specialty alloys, and compacted graphite iron



CUSTOMER
Kimura Foundry America

WEBSITE
www.kimurafoundry.com



Kimura Foundry America delivers quality prototypes and low-volume production castings

Dr. Yoya Fukuda, President, Kimura Foundry America



*“We researched 3D printers from around the world and chose ExOne printers for their **high-end technology that delivered top-quality prints.**”*

Dr. Yoya Fukuda, President of Kimura Foundry America



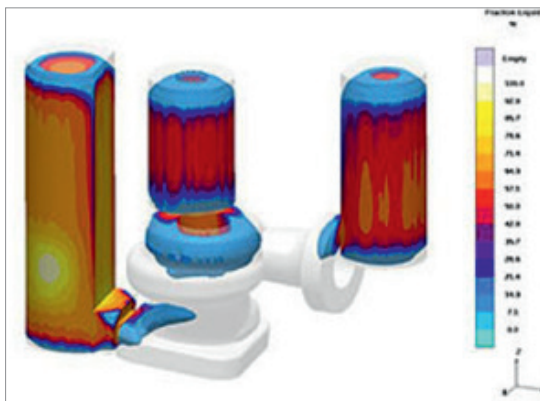
Kimura Foundry America

Kimura Foundry America provides added value for all castings with the shortest delivery times and a high value of service to meet the specific production requirements of any application. On a mission to be the number one foundry in the USA for rapid prototyping and small-lot production castings, Kimura utilizes the most up-to-date technology and integrated operations to ensure the delivery of quality castings. With a goal to serve as a role model in foundries, they realize zero defects with their production systems and continue to push industry boundaries.

Headquartered in Shimizu-cho, Japan, Kimura Foundry Group is one of the largest independent full-service manufacturers of iron, steel, and specialty alloy castings. Founded in 1927, the company has been owned and operated by four successive generations of the Kimura family. Today, Kimura employs more than 900 people at over ten facilities in Japan and the United States.

ExOne

ExOne is the pioneer and global leader in binder jet 3D printing technology. Since 1995, we've been on a mission to deliver powerful 3D printers that solve the toughest problems and enable world-changing innovations. Our 3D printing systems quickly transform powder materials — including metals, ceramics, composites, and sand — into precision parts, metalcasting molds and cores, and innovative tooling solutions. Industrial customers use our technology to save time and money, reduce waste, improve their manufacturing flexibility, and deliver designs and products that were once impossible.



The entire facility was built around the ExOne binder jetting process and the company offers A-to-Z production including simulation, mold and core design, 3D printing, finishing, and quality control.

Building on a Foundation of Binder Jetting

ExOne binder jetting is so central to Kimura Foundry America that the company built a brand-new facility in Shelbyville, Indiana, around the technology in 2018. Today, the 46,000-square-foot facility features two S-Max® and one S-Print® industrial 3D printers that churn out sand molds and cores for a complete end-to-end casting process managed entirely in-house with an eye on delivering the best quality prototypes and low-volume production in the shortest time frame.

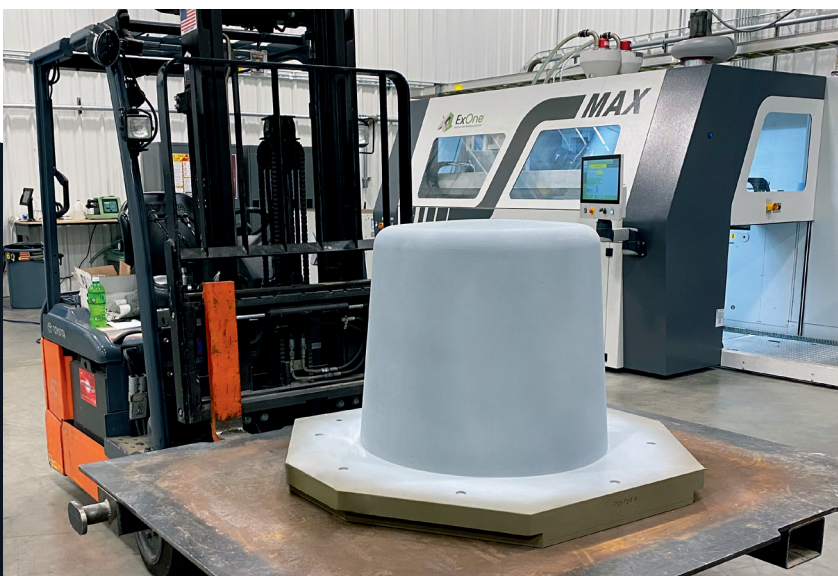
Kimura Foundry America President Dr. Yoya Fukuda has been with the Kimura Group for 25 years and leads the first international expansion for the company. He emphasizes a clear mission to utilize binder jetting to deliver quality to customers and helped develop a patented method of using ceramic sand in that eliminates cracks, veins, and burrs, even on steel and iron castings, and without the use of adhesives. Within the factory, the company has built a high-efficiency system for recycling and reusing the material, enabling them to deliver high quality at lower costs, while also establishing a sustainable manufacturing process.

Kimura's journey into 3D printed sand castings started almost a decade ago in Japan, where the company's parent company has a rich history of foundry leadership. The Kimura Foundry Group continues to build on nine decades of metalcasting experience that saw it innovate from wood patterns to full-mold castings to the adoption of additive manufacturing. Fully embracing additive manufacturing as the cornerstone of the next industrial revolution, the company today has six ExOne sand 3D printers in Japan for core and mold production and three at the Kimura Foundry America, which began operations in late 2018 at their greenfield foundry designed entirely around the sand binder jetting process.

A Centuries-Old Process Re-Imagined

Kimura Foundry America recognizes the benefits additive manufacturing brings to the centuries-old sandcasting process, allowing them to stay agile to the needs of their customers. The fast turnaround times of their binder jetting machines required the company to expand its offerings around the complete prototype development process to better serve customers. "Our focus is on quality, and if we want to guarantee quality and fast delivery, we need all the facilities in one area, in one location. We're a one-stop service," Dr. Fukuda said in explaining the A-to-Z production approach of the foundry to offer all the process steps in-house.

When planning their new foundry, Kimura focused on housing engineering, mold design, simulation, 3D printing, cleaning, inspection, assembly, metal pours, finishing, and quality control all under one roof. It was strategically important to offer all aspects of production near the epicenter of the automotive, construction



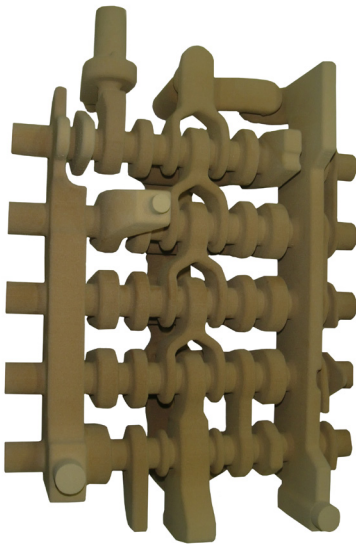
2012 lb (913 kg) mold, one of the largest prints Kimura has made on their S-Max

*“With the ExOne printers, we can do undercuts and cores that we would not be able to create with traditional foundry practices. There’s a lot of detail we can make that **wouldn’t be possible without the binder jetting technology.**”*

Lead design engineer responsible for S-Max production and quality, Kimura Foundry America



machinery, pump, and industrial equipment industries they serve. Their newly built facility in Shelbyville, Indiana was designed with ExOne binder jetting machines at the heart of operations. By focusing exclusively on 3D printing to produce sand molds and cores, Kimura does away with the need to use patterns to create tooling and drastically reduces the lead times for functional prototypes with production quality. “When we started with this technology, we researched 3D printers from around the world and chose ExOne printers for their high-end technology that delivered top-quality prints,” Dr. Fukuda stated.



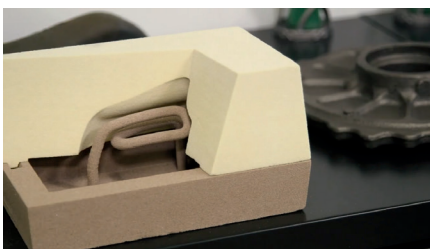
Delivering in One-Eighth the Time

Embracing the digital metalcasting workflow, Kimura has significantly reduced lead times for customer jobs. In their experience, conventional manufacturing processes take about 40 days to produce a finished cast prototype, with the bulk of that time needed to build a wood pattern. Using additive manufacturing technology to their advantage, they are able to produce sand molds and cores directly from digital CAD data that can go from print file to cast product in their facility within 5 days.

Being a one-stop shop is not only beneficial for production speed, but also quality. “Because we do everything at Kimura we have a good line of communication between all the process steps,” Dr. Fukuda explained. He described the crucial lines of feedback between their design, casting, and quality departments to ensure customer requirements are met for each piece. Engineers evaluate the casting and can analyze the design very quickly without delays caused by outsourcing to external vendors. The in-house lab allows for constant feedback with the ability to carry out Brinell, tensile, metallography, surface scan, leak, ultrasonic, and penetration testing. With a CT inspection system in-house for precise internal evaluations, they also assess parts with non-destructive methods to guarantee a quality casting. Having this ability also means Kimura can provide direct feedback to the engineering team on how accurate their pre-casting simulations are while reducing material waste without the need to section cast parts for testing.

The four furnaces at their facility, ranging from 300 lb up to a 2,000 lb electric induction furnace, allow Kimura Foundry America to do select melts for low-volume jobs without having to wait to fill a large furnace, but also support poured castings as large as 1,700 lbs (771 kg). The heat treatment capabilities being located at the foundry also ensures the customer receives quick deliveries.

Delivering prototypes in less than one week is a gamechanger for metalcasting, opening the door to quicker product development and new freedom of design. By concentrating their sandcasting capabilities under one roof, Kimura can iterate designs quickly based on casting results and customer feedback. “It’s easy to communicate with our customers and to give them feedback that supports their needs for unique



runner and riser designs or other difficult requirements because we have the engineers in-house,” Dr. Fukuda explained. Using MAGMASOFT® solidification modeling, the engineering team tailors vents and risers to the part while running flow and solidification analysis to confirm the pour capabilities in advance to ensure they produce good castings. “With the ExOne printers we can do undercuts and cores that we would not be able to create with traditional foundry practices,” the lead design engineer responsible for S-Max production and quality emphasized. “There’s a lot of detail we can make that wouldn’t be possible without the binder jetting technology.”

Innovative Spirit Leads to Material Optimization

Quality is the main pillar of the Kimura business model, and the company’s dedication to delivering this to customers drives their additive manufacturing strategy as well. Dr. Fukuda worked to optimize the material used in Kimura’s binder jetting process that has been an integral part of the company’s success with sand 3D printing.

In 2010 he began to investigate sand materials optimized for high-quality castings. Silica sand is the most common material because of its low cost; however, his team identified the phase transition around 1058°F (570°C) caused it to expand. The large thermal expansion of the silica sand leads to a network of cracks in the mold that fill with metal to form veins and burrs on the surface of the casting, especially with steel and iron pours. Because of the high-quality of the ceramic media used in all of Kimura’s prints, anti-veining additives are not required.

After almost two years of research showing that high-temperature performance was determined by the material’s thermal volume stability, the decision was made to switch to a more stable, 100% artificial ceramic sand to avoid the temperature limitations of silica sand. By suppressing the expansion of the material, even at melting temperatures exceeding 2,552°F (1,400°C), Kimura is able to prevent deformations in the shape of the sand molds and cores. While it was traditionally expected that an iron or steel pour with natural sand would exhibit veining defects, the team was able to eliminate its presence as well as sand burn-in in their process. Today, Kimura Foundry America binder jets with a patented formula ceramic sand material with a low thermal expansion to prevent veining and other defects without the need of special additives.

While using ceramic sand was the right choice for casting quality, the cost of the material presented a unique challenge to the Kimura team. The increased quality of the material also meant it came at a higher price than common silica sand. And as a clean foundry



Kimura developed a patented artificial ceramic sand for increased casting quality. The samples to the right show a silica sandcasting with veining defects (left) and a defect-free casting (right) using Kimura’s ceramic sand.

“We want to establish success in the United States so we can support all prototype casting made by 3D printing technology around the world.”

Dr. Yoya Fukuda, President of Kimura Foundry America



dedicated to the local community and creating a safe work environment, an effective way to reuse material was necessary.

Thus, Dr. Fukuda and the Kimura team turned their attention to creating an efficient, sustainable process through material recycling. In 2012 they partnered with other industry companies, including the material supplier and a furnace producer, to engineer their own in-house sand recycling system in Japan. When designing the Shelbyville facility, a second material recycling system was developed to maximize material recovery while also keeping the foundry facility clean of excess sand. Air pipes throughout the facility deliver sand to the fleet of ExOne binder jetting machines for production and return it to the recycling system for processing and sieving before the next use. “There are only two points in the entire process you can actually touch activated sand in our facility – once in the 3D printer job box and once in the shake out machine. Everywhere else the sand is contained in a closed pipeline to keep the foundry very clean and very efficient,” Dr. Fukuda stated.

Through their system they are able to reuse 99% of their material, refreshing only to maintain a defined grain fineness as material is sieved to ensure a quality surface finish. This allows Kimura to provide high-quality castings at lower production costs to their customers while also establishing a sustainable manufacturing process.

Options to Meet Every Quality Requirement

To ensure the company can meet the needs of a variety of customers, Kimura pours gray and ductile iron as well as producing heat-resistant Ni-resistant castings, stainless steel castings, and compact graphite iron. A choice in binder systems allows cores and molds to be tailored for various applications. Furan binder, the industry standard because of its ease of use and production speed, is available on two machines. Since it does not require thermal curing, solvent-based furan binder systems create molds that can be used directly after printing and depowdering and are easy to disassemble after casting.

For applications with increased melting temperatures, phenolic binder is available to produce cores with high-temperature strength. Not only does phenolic binder have a green strength double that of furan, making it the strongest material for complex core assembly, it also keeps its strength over a longer period of time. For complicated cores with thick metal sections or special high-temperature melting requirements, Kimura can achieve very high sand mold and core strength using phenolic binder.

In conjunction with binder tailored to higher melting temperature castings, Kimura also pre-heats the sand mold as another step to ensure quality. Pre-heating before the pour maximizes the mold’s strength while also ensuring that it’s dry to prevent moisture

As the entire industry rebounds from the pandemic, Kimura Foundry America is prepared to continue growing after watching its parent company in Japan experience revenue increase more than 500% in the five years after investing in ExOne sand binder jetting.

WATCH THE
VIDEO
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from creating gas defects in the part. Increasing the mold's temperature also aids in filling, allowing Kimura to pour more thin-walled parts because of the improved metal flow.

With their combination of binder jetting options and metalcasting expertise, Kimura Foundry America can produce complex-shaped castings with internal geometries and wall thicknesses as low as 4 mm and with dimensional accuracy controlled within ± 0.5 mm.

Poised for Growth

Preparing to celebrate its 100 year anniversary later this decade, the foundry is looking to the future of the industry to continue offering the latest advancements to customers. Already pouring a range of ferrous materials, Kimura continually expands its specialty alloy offering, for example with compacted graphite iron (CGI) for parts required to withstand vibrations. "Landing between gray and ductile iron, CGI can better absorb vibrations at higher strength than gray iron, so we can reduce the wall thickness, and thus the weight of an engine block, for example," Dr. Fukuda noted. The combination of specialty alloys and the freedom of design afforded by additive manufacturing will continue to push sandcasting innovations forward.

The two production S-Max machines run every day, each printing two job boxes of sand molds and cores daily. But Dr. Fukuda stressed the future-forward investments of the company. "Here we have more space so in the future we want to install more 3D printers in this room," he said gesturing around the current ExOne binder jetting machines. The facility was also built to be easily capable of expanding its size for future expansion, where the foundry plans to install more equipment to further expand capacity with the increased adoption of rapid casting and the unique benefits of binder jetting.

As the entire industry rebounds from the COVID-19 pandemic, Kimura Foundry America is prepared to continue growing. After watching its parent company in Japan experience revenue increase more than 500% in the five years after investing in ExOne sand binder jetting machines, the company's first international manufacturing facility has global ambitions. "We want to establish success in the United States so we can support all prototype castings made by 3D printing technology around the world." Dr. Fukuda concluded.

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X1_Kimura_CaseStudy_EN_2021-05

