BETTER PARTS, FASTER

LINCOLN ELECTRIC'S ADDITIVE MANUFACTURING TECHNOLOGY KEEPS REFINERY RESTART ON SCHEDULE

CASE STUDY

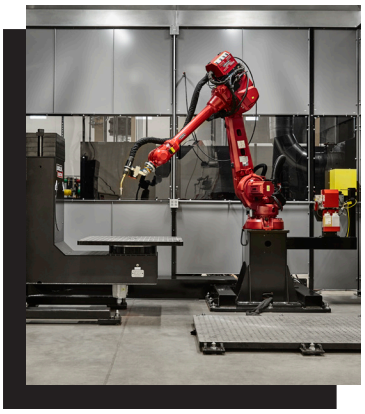
Oil and gas refinery

When it comes to maintenance at large-scale industrial operations, there are times when traditionally manufactured replacement parts can't be produced fast enough. When a major oil and gas refinery needed parts to restart its Mississippi refinery on time after a scheduled maintenance shutdown, Lincoln Electric offered the company a faster solution utilizing additive manufacturing.

Lincoln Electric's 3D metal printing solution – also known as additive manufacturing – is ideal for high-mix, low-volume applications, and is capable of printing parts more than 8 feet in length and in excess of 10,000 lbs. Our additive technology significantly reduces manufacturing lead times, shortens supply chains, and enables design enhancements that may not be possible with traditional manufacturing methods.

Lincoln Electric was able to put this technology to work to keep the refinery's operation on schedule.

The additive alternative



A Lincoln Electric Additive Solutions 3D metal printing cell

The company approached the Lincoln Electric Additive Solutions business unit in January 2022, after maintenance engineers discovered eight large piping components – four header tees and four reducers – needed to be replaced during a routine scheduled maintenance shutdown before the end of the parts' anticipated useful life. Traditionally manufactured parts would not be available for three months, which would have significantly delayed the refinery's restart schedule.

LINCOLN ELECTRIC'S ADDITIVE MANUFACTURING TECHNOLOGY KEEPS REFINERY RESTART ON SCHEDULE

Based on conversations with Lincoln Electric Additive Solutions engineers prior to the shutdown, the company chose to explore the possibility of leveraging Lincoln Electric's additive manufacturing technology to get the parts they needed in a more timely fashion. Leading the Lincoln Electric team was Mark Douglass, Business Development Manager, Additive Solutions.

"We had a series of virtual meetings between the engineers at Lincoln Electric and the refinery personnel," says Douglass. "We discussed material considerations, what their needs were for these particular components, what weld wires we should use, how our process works, and what the parts would look like after printing."

The result was a deeper understanding among the refinery's engineering team about options that were available with 3D printed parts that weren't available via traditional manufacturing.

"When they agreed to use our additive process, they also took the opportunity to redesign their parts," says Douglass, "which not only facilitated our ability to 3D print them, but also actually improved the function of the parts in their respective application."

Prior to 3D printing of the parts, it was necessary for Lincoln Electric to optimize and then qualify the 3D printing process procedures. Given the critical nature of the application, the company and Lincoln Electric agreed the procedures should be qualified to Code Case 3020 within ASME Boiler and Pressure Vessel Code (BPVC) Section IX (Welding). Code Case 3020 describes how to qualify procedures for Gas Metal Arc Additive Manufacturing (GMAAM). ASME has since adopted the procedure qualification into the full BPVC under QW-600.

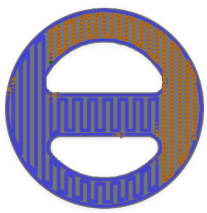
Test run

Once the refinery's production needs, time constraints, and redesign opportunities had been clearly identified and the procedures qualified, 3D printing of a first article test part got under way.

"The company's engineers spent a night implementing a redesign and ran a finite element analysis to confirm that it would work in the application," says Douglass. "They communicated that design to us the following morning, and we were printing later that day. The part was on a truck four days later."

The 3D printed parts were made from Lincoln Electric's Techalloy® 617 nickel wire. Compared to the original 800H alloy parts in need of replacement, 617 maintains increased strength and longer life at elevated temperatures. In addition, 617 is already field proven for this application, in that it is the consumable that's typically used for welding the header tees and reducers.

An unexpected benefit during the design and printing of the initial part was the opportunity for part consolidation, thanks to the versatility of Lincoln Electric's additive manufacturing process.



Proprietary SculptPrint™ software slices CAD models, determines the ideal path for material deposition and incorporates optimized processparameters for each layer

"The refinery's engineers looked at the overall component and realized that other smaller parts had to get welded to this large part," says Douglass. "They asked us if it would be possible to 3D print the smaller parts onto the larger part. They delivered an updated CAD design that was added into our SculptPrint™ OS software, and the software reprogrammed the robots to add these additional small parts on

top of the large part while it was in production. Our 3D printing process and software enables us to make changes like that on the fly."

After the part was 3D printed it was subjected to a series of qualification tests per the American Petroleum Institute (API) 20S standard for additive manufacturing and ASME code case 3020. This included hydro testing, elevated temperature tensile testing, and other destructive tests. "We had to prove the material and process used to make the part met the required oil and gas industry codes and standards," says Douglass.

Lincoln Electric drum packaging

Full capacity production

Once the first article part passed all the necessary qualification procedures, full production of the eight replacement parts got under way using nearly 6,000 pounds of 617 wire, which Douglass describes as "an extremely large amount" of that particular material for a single project.

"If one would have looked across the United States and tried to gather all of the 617 weld wire in stock, they would have been hard pressed to come up with anywhere close to 6,000 pounds from a single source," says Douglass. "But we're vertically integrated at Lincoln Electric, and we make our own wire. We had several thousand pounds of raw material already in stock, and we were able to fast-track the production of the remaining wire that was still needed to complete the project."

In addition, Lincoln Electric was able to package the 617 wire in large drums, which is preferable for the 3D printing process. Using eight of the eighteen arc additive systems at Lincoln Electric Additive Solutions, they were able to print the eight parts for the refinery in short order.

"There are other companies in the world that offer wire arc additive manufacturing services," Douglass concedes. "Not many, but there are some. However, no one has the capacity that we have with eighteen systems. So as soon as we had the wire, we could print them simultaneously in order to get them out the door as fast as possible. Our Additive Solutions manufacturing center was the only facility in the world that could have done that for them."

Parts now, parts for the future

Only thirty days passed from the time of the company's initial call to Lincoln Electric to the shipment of the last of the eight replacement parts. Using traditional manufacturing methods for the eight parts would have taken three times as long, and would have caused a delay in the restart of refinery operations following the scheduled maintenance shutdown.

Since then, Douglass and his team have visited other facilities operated by the same company to educate their engineers about their additive manufacturing technology and services. This education process has included a review of the company's

LINCOLN ELECTRIC'S ADDITIVE MANUFACTURING TECHNOLOGY KEEPS REFINERY RESTART ON SCHEDULE

various other components to determine which ones might be candidates for additive manufacturing when further maintenance and replacement are necessary.

"That way, they can have this information on hand so that if there is an emergency need – or even if they just want printed parts ahead of a shutdown – we can be ready to do it without the need for a fire drill," says Douglass. "Maintaining a digital inventory is an important part of the additive manufacturing model. Instead of storing parts on a warehouse shelf, you can keep them on a digital shelf, because 3D printing is so fast. You can tell Printer A to print a part, and the customer can have that part in a matter of weeks."

Educating customers about the advantages, and dispelling some of the misperceptions, continues to be an important step in the development of Lincoln Electric's additive manufacturing business.

"There's still a perceived risk with additive manufacturing," says Douglass, "but this project shows that it can be done, and it can be done to a high level of quality and efficiency, and we have the capability to do it. It's a capability that would be hard to find elsewhere."

MC24-16 | 02/24 | LincolnElectric.com |