



ThermoLift

CASE HISTORY



HIGH PRECISION WELDING HELPS AN INNOVATIVE HVAC SYSTEM BECOME A REALITY

As design engineers create more complex and innovative products, high precision welding solutions need to follow suit to meet the challenges to weld exotic and dissimilar materials, with complex weld joint geometry, all on time and within budget. After all, if you can't join the pieces, you have no end product.

One market that relies heavily on advanced welding capabilities is the HVAC industry. As OEMs pursue cleaner energy and higher heating/cooling efficiencies, HVAC technology is becoming more and more intricate, requiring high-quality precision welds in their fabrication.

ThermoLift, an emerging leader in clean energy HVAC systems, recognized the importance of high precision welding when creating an innovative new air-source heat pump. Cutting down carbon dioxide emissions and energy costs by as much as half compared to typical HVAC systems, ThermoLift's patented Thermal Compression Climate Control (TC3) unit required a significant level of precision welding for proper fabrication to bring it to market.

Welding and production challenges for the TC3 included:

- A significant number of precision welds in a small space
- Welding at difficult angles
- Subpar parts and extensive re-machining
- Material issues
- Delayed timelines

By partnering with EB Industries, an industry-leading high precision welding services provider, ThermoLift overcame these challenges to combine advanced engineering and high precision welding in ways that brought the TC3 to successful commercialization.

BACKGROUND: MARKET FORCES LED TO THE TC3'S CREATION

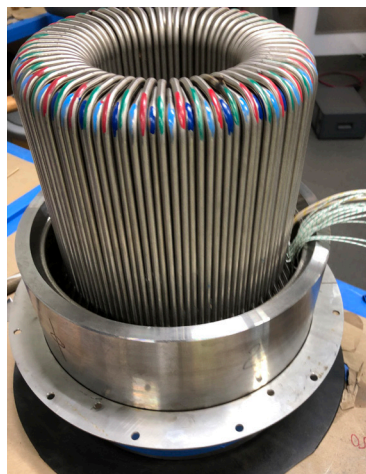
There are several issues that introduce inefficiencies into typical heating and cooling systems. For one, there is often a need for multiple systems in the same unit to provide adequate temperature regulation. Having separate devices for heating and cooling, as well as water heating, leads to increased maintenance needs and higher costs. Sometimes even multiple different cooling devices are required when dealing with extreme temperatures.

Many HVAC systems are also electrically driven, which aren't as efficient or environmentally sustainable as thermally driven systems. Rather than using available heat, electricity must be created from other methods such as a nuclear reactor or a coal-fired power plant. At most, these direct fire systems can only reach about a 90-95 percent efficiency rating.

Instead of sticking within these constraints, ThermoLift's TC3 provides a high-efficiency, refrigerant-free HVAC, hot water, and refrigeration system—all in one device. With concurrent heating and cooling from a single thermal energy source, this specialty air-source heat pump utilizes patented Hofbauer Cycle technology. Rather than relying solely on electricity, the TC3 transfers heat from outside to the inside of a building in winter and vice versa in summer. Since electricity is not the primary fuel source, the TC3 can capture and utilize ambient heat, delivering up to three times more heat energy than the electrical energy it consumes.

"We're developing a thermally driven heat pump so that when we burn one unit of fuel, we can get more than 100 percent efficiency," said Paul Schwartz, director, and co-founder at ThermoLift. "Even when it is cold outside, we can capture heat from the outside and bring it into the house so that there are two streams of heat to make your house warm."

With its ability to utilize the natural heat in the atmosphere, the TC3 can achieve efficiencies of more than 100 percent. It can also meet very specific refrigeration requirements. Without the need for a secondary unit, the TC3 can maintain high performance and energy efficiency in large commercial applications at extremely cold temperatures — as low as minus 25 degrees Celsius.



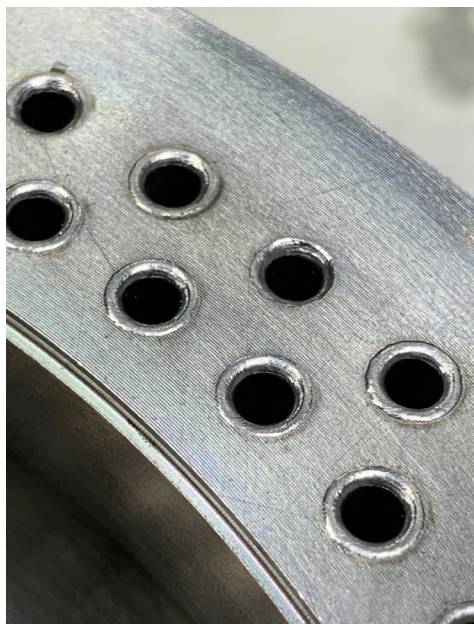
Key benefits of the TC3 include:

- Reduced annual energy consumption for heating, cooling, and water heating
- Significant operational-costs savings
- Cutting carbon dioxide emissions and energy costs by as much as half across residential and commercial applications
- No need for harmful refrigerants

To achieve these benefits, the TC3 involved a much more complex design than typical HVAC systems. The design of the TC3 utilized 120 tubes, each about the thickness of a pen or pencil, which needed to be welded into place. Since the TC3's design needed to withstand everything from subzero temperatures to extreme heat, ThermoLift designers would need to design the overall structure and select materials with close attention to detail.

WELDING AND PRODUCTION ROADBLOCKS

With its unique and intricate design, the TC3 presented a significant production challenge. Hundreds of small, intricate welds are required for each heat pump—welds that typical welding tools and non-expert welders cannot handle with the quality, reliability, and rapid turn-around times ThermoLift required. For welding each end of the tubes alone, each unit required 240 high-precision welds. The heat pump needed some of the other welds throughout the unit to be welded at an angle, both on inside and outside geometries.



"As you execute these welds, you have to make sure to balance the heat load on the part," said Schwartz. "That means you can't weld more than two tubes around the same location at once; otherwise, you have a very hot area, and the part will deform."

When dealing with so many small, precise welds, the production time was an issue. Especially in the early stages of prototyping, ThermoLift found that it was forced to wait weeks for a fully fabricated heat pump. This was partly due to the time-intensive welding process and other parts simply not being ready for production. Even before moving into the welding phase, parts would require re-machining or additional sanding to avoid compromising the rest of the design.

Finding the right material was also a challenge. The go-to metal was 316 stainless steel, but using 316 stainless meant the TC3 was far too heavy and difficult to weld. Since one wrong move could ruin a weld, and thus the entire unit, you could be throwing out days' worth of work if you made a mistake, particularly after your weld count totaled over 200 of the 240 welds needed.

Together, these welding and production challenges forced the TC3 to remain stuck in an early prototyping stage instead of market commercialization, as ThermoLift searched through different welders and manufacturing partners. While the benefits of the TC3 had been theoretically proven, the lack of a full-service welding solution nearly kept the novel air-source heat pump from becoming a reality.

EB INDUSTRIES PROVIDED THE ANSWERS FOR A DIFFICULT WELDING CHALLENGE

After other welders failed to fabricate the TC3, the team at ThermoLift knew that they needed a partner skilled in high precision welding and other value-added production capabilities. EB Industries, known for its high precision laser welding and electron beam welding solutions, was ideal for the job partly due to its prior success in precision work on products designed for the energy market.

To produce the TC3 economically and reliably, EB Industries would need to do more than utilize its precision welding capabilities. EB Industries would need to collaborate with ThermoLift designers to select either electron beam or laser welding as the right welding technology for the job. In this case, laser welding was the better option since it was quicker and more efficient. On-time delivery was already a concern, and e-beam welding proved to be more time-intensive without any significant advantages for this application.

After choosing the right type of welding, EB Industries could now provide the hundreds of small, intricate welds necessary to produce the TC3. For any inside, angled welds, EB Industries was able to tilt its five-axis laser to still achieve a high-quality weld on even the most challenging and hard-to-reach areas.

"There aren't many companies in the United States, let alone the world, that have both e-beam and laser welding equipment, along with the long-term expertise and capabilities that EB Industries has," said Schwartz. "That's what makes them unique."

EB Industries also assisted on the materials science side of production. EB engineers looked at the welded materials, analyzing how they mated and cooled together. If this could be optimized, the welds would not fail or crack in the future, leading to even more significant long-term durability of the TC3. Instead of choosing 316 stainless steel, EB Industries experimented with and settled on aluminum in order to achieve a more lightweight material that was easier to weld.

In addition to its welding expertise, EB Industries provided ideas for overall process improvements. With in-house fabrication capabilities, EB Industries fixed and re-machined any faulty parts received from other manufacturers that worked on earlier stages of the assembly. This included manually machining domes and sanding down tubes.

EB Industries also deployed its advanced testing equipment on the project, allowing engineers to test and subsequently fix parts without needing outside assistance. EB Industries' AWS QC1-certified inspectors performed dye penetrant inspections and x-ray inspections of the parts. Inspectors utilized the Keyence VHX-900F Microscope for enhanced detail and accuracy. The level of detail that can be seen and measured with this scope allowed the smallest defects to be detected and fixed. Combine that with EB Industries' ability to fabricate in-house assemblies, and its engineers were able to drastically improve production times for a much quicker and efficient prototyping process.

"EB Industries is a valued partner in the manufacturing development process as it relates to laser welding," said Schwartz when asked his thoughts on working with EB Industries as a whole.

BRINGING THE TC3 TO MARKET

Through high precision welding, EB Industries helped ThermoLift create the air-source heat pump that it had always envisioned in its earliest design stages. This allowed ThermoLift to move past the prototyping stage and fully prepare the TC3 for commercial and industrial markets, beginning to roll them out in 2021.

In the end, Thermolift could not have brought its product to market without partnering with EB Industries. The collaborative approach brought many intelligent people together, with Thermolift focusing on product functionality, and EB Industries focusing on delivering an innovative welding solution that is feasible and delivered on time to get the product to market.